Climate Change Adaptation Plan

October 22, 2021

Cabinet Approval

Contents

Introduction

The Climate Change Adaptation Plan (hereinafter the “Adaptation Plan”) has been revised in accordance with the provision of Article 8, paragraph 1 of the Climate Change Adaptation Act (Act No. 50 of 2018; hereinafter the “Adaptation Act”).

Climate change and its impacts are being felt all across Japan as the nation has seen rising mean temperatures and more frequent heavy rainfall in recent years cause deterioration in the quality of agricultural products, more frequent natural disasters, and a higher risk of heat illness. Such negative impacts of climate change are called a “climate crisis” that shakes the foundations of human survival and the survival of all other living things. In 2018, Japan was hit by two major rainfall events, namely the Heavy Rain Event of July 2018 and Typhoon Jebi (T1821), as well as record extreme heat. More disasters related to heavy rain and named tropical cyclones followed, including Typhoon Faxai (T1915) and Typhoon Hagibis (T1919) in 2019 and the Heavy Rain Event of July 2020. These events took a heavy toll of human lives and caused massive damage to Japan's society and economy, as well as people’ lives. In August 2021, again, wide areas in western to eastern Japan experienced downpours, and a stationary linear mesoscale convective system formed in the northern Kyushu region and the Chugoku region brought record rainfalls. Although it is not easy to determine how each of these weather events is linked to global warming, the risk of such extreme heat and rainfall is projected to increase as global warming progresses further.

As the entire world faces the historical crisis of COVID-19, how to balance infection control and socioeconomic activity is a common challenge across the globe. Meanwhile, growing emissions of greenhouse gases are expected to warm the Earth further and increase the frequency of extreme weather events, such as downpours. There are serious concerns over the impact on future generations, including more frequent and intense disasters from heavy rains and other weather events. Such concerns have also been voiced by young generations who will be at the center of society around 2050. Some call for a systemic change based on climate justice across regions, genders, and generations.[1] At a major turning point of an era that can be characterized by the COVID crisis and the climate crisis, we need to achieve a transformation into a sustainable and resilient social system instead of returning to the pre-pandemic society.

In October 2018, the Intergovernmental Panel on Climate Change (IPCC) published a report titled “Global Warming of 1.5°C: An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty,” which is known as the 1.5°C

[1] February 26, 2021, third joint meeting of the Subcommittee on Mid- Long-term Climate Change Countermeasures of the Global Environment Committee under the Central Environment Council; and the Working Group on Global Warming Countermeasures of the Subcommittee on Global Environment of the Committee on Industrial Science and Technology Policy and Environment under the Industrial Structure Council

Special Report. It suggests that to prevent the global mean temperature rise from greatly exceeding 1.5°C, global CO_2 emissions need to reach net zero around 2050. Japan aims to reduce its greenhouse gas emissions by 46% in FY 2030 from its FY 2013 levels, setting an ambitious target which is aligned with the long-term goal of net-zero by 2050. Furthermore, Japan intends to continue strenuous efforts in its challenge to meet the lofty goal of cutting its emissions by 50%. Nevertheless, even if climate change actions are implemented steadily to achieve a carbon-neutral 2050, successfully limiting the warming to around 1.5°C, changes such as extreme heat events (e.g., heat waves) and heavy rains will be unavoidable. It is crucial that diverse stakeholders join hands and make concerted efforts to take climate change adaptation measures to avoid or reduce observed or projected damage.

Mitigation measures (measures mainly to reduce greenhouse gas emissions) and adaptation measures are two complementary driving forces of climate change action. The government will steadily take climate change action in accordance with two laws paired with two plans: the Act on Promotion of Global Warming Countermeasures (Act No. 117 of 1998) and the Plan for Global Warming Countermeasures established under it; and the Adaptation Act and the Adaptation Plan.

(International Trends in Climate Change Adaptation)

Since its establishment in 1988, the IPCC has been evaluating the latest scientific findings on climate change and compiling the results into reports.

An international development based on the scientific findings on climate change provided by the IPCC is that the Paris Agreement was adopted in December 2015 and came into effect in November 2016 under the United Nations Framework Convention on Climate Change (UNFCCC). In addition to the mitigation goal of holding the increase in global mean temperature from pre-industrial levels well below 2°C and pursuing efforts to limit it to 1.5°C, the Paris Agreement set forth the goal of strengthening the global response to the threat of climate change, including adaptation, i.e., increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience.

In October 2018, the IPCC published its Global Warming of 1.5°C Special Report. The report was prepared in response to the request made of the IPCC to provide a special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways during the 21st UNFCCC Conference of the Parties (COP21), where the Paris Agreement was adopted. The report suggested that climate-related risks to health, livelihoods, food security, water supply, and economic growth would increase with just a 1.5°C warming and increase even more with a 2°C warming. On the other hand, it was also pointed out that there were wide-ranging adaptation options that could reduce climate-related risks and that most adaptation needs would be lower in a 1.5°C world compared to a 2°C world.

The IPCC published a report titled “Climate Change and Land: an IPCC special report on

climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems" (Land Special Report) in August 2019 and another titled "IPCC Special Report on the Ocean and Cryosphere in a Changing Climate" (Ocean and Cryosphere Special Report) in September 2019. The Land Special Report showed that since the pre-industrial period, the land air temperature has risen almost twice as much as the global mean temperature and that climate change creates additional stresses on land, exacerbating existing risks to livelihoods, biodiversity, human and ecosystem health, infrastructure, and food systems. The Ocean and Cryosphere Special Report indicated observations of reductions in snow depth, cover, and period, as well as in Arctic sea ice extent and thickness, and increased permafrost temperature; and that melting ice sheets and glaciers are major contributors to the accelerating rise in global mean sea level.

In August 2021, the Summary for Policymakers of the Working Group I contribution to the IPCC Sixth Assessment Report was released. The report suggested that it is unequivocal that human influence has warmed the atmosphere, ocean, and land; that widespread and rapid changes in the atmosphere, ocean, cryosphere, and biosphere have occurred; and that many changes in the climate system (increases in the frequency and intensity of hot extremes and heavy precipitation, an increase in the proportion of intense tropical cyclones[2] in some regions, etc.) become larger in direct relation to increasing global warming. For the IPCC Sixth Assessment Report, the Working Group II contribution (impacts, adaptation, and vulnerability), the Working Group III contribution (mitigation measures), and a synthesis report will be released in due course.

In September 2015, the Sustainable Development Goals (SDGs), consisting of 17 goals and 169 targets to be pursued for a sustainable world, were adopted by the UN General Assembly. Japan has also launched initiatives toward the SDGs. The SDGs include many adaptation-related goals such as food, health, water and sanitation, infrastructure, and ecosystems, in addition to climate change. Ahead of the adoption of the SDGs, the Sendai Framework for Disaster Risk Reduction 2015-2030 was adopted during the Third UN World Conference on Disaster Risk Reduction in March 2015 to strengthen disaster risk reduction (DRR) systems in countries around the world. The adaptation under the Paris Agreement, the SDGs, and the Sendai Framework for Disaster Risk Reduction have the common goal of building a resilient and sustainable society that can cope with climate change. The importance of coordinating the goals of these frameworks has been stressed in the international community.

(Japan's Efforts under the 2015 Adaptation Plan, etc.)

In light of the development of investigation and research on climate change impacts and adaptation in Japan, along with international trends, the government formed a Climate Change

[2]There is no general definition of an intense tropical cyclone, and its definition may vary between articles. However, in this document it generally refers to a tropical cyclone that is comparable to a tropical cyclone that is classified as "Typhoon" (with a maximum wind velocity of 33 m/s to less than 44 m/s) or stronger categories by the Japan Meteorological Agency.

Impact Assessment Subcommittee under the Global Environment Committee of the Central Environment Council in July 2013 to summarize climate change projections and impact assessments based on existing studies and comprehensively discuss the assessment of the impacts and risks of climate change on Japan. The Subcommittee defined 30 categories and 56 subcategories in seven sectors (agriculture, forestry and fisheries; water environment and water resources; natural disasters and coastal areas; ecosystems, human health; industrial and economic activities; and life of the citizenry and urban life) and studied more than 500 articles and projections of climate change and its impacts to assess the impacts of climate change by three perspectives: significance, which concerns how climate change will impact Japan, to what extent, with how much likelihood, etc.; urgency, which concerns when the impact will manifest itself, when adaptation efforts need to be started, and when key decisions need to be made; and confidence, which refers to the certainty of the evidence. Based on the results, the Central Environment Council completed a report titled "Report on Assessment of Impacts of Climate Change in Japan and Future Challenges" in March 2015 and submitted it to the Minister of the Environment.

In light of this document, the Cabinet approved in November 2015 the National Plan for Adaptation to the Impacts of Climate Change (hereinafter the "2015 Adaptation Plan"), which set forth the vision for society and other basic principles to be followed by the entire government in comprehensively and systematically implementing measures to adapt to climate change impacts, along with basic approaches, basic directions for measures in each sector, and fundamental and international measures. Subsequently, ministries and agencies have steadily been conducting climate change adaptation measures in sectors such as agriculture, forestry and fisheries, water environment and water resources, ecosystems, natural disasters, human health, industrial and economic activities, and life of the citizenry in accordance with the 2015 Adaptation Plan. Relevant ministries and agencies worked together to establish in August 2016 an information platform for Japan's climate change adaptation, called the Climate Change Adaptation Information Platform (A-PLAT), which has been operated since then by the National Institute for Environmental Studies (NIES). In addition, in July 2017, the Regional Adaptation Consortium Project was launched through joint efforts by relevant ministries and agencies. Under the project, regional councils were formed in six blocks across Japan, where local administrative organs of the national government, prefectural governments, governments of ordinance-designated cities, experts, local research institutions, and others concerned take part to allow regional stakeholders related to climate change impacts and adaptation to share information and conduct collaborative initiatives.

(Efforts under the Adaptation Act)

Japan's efforts related to climate change adaptation have advanced step by step, going from investigation and research on climate change impacts and adaptation, to assessment of impacts, to the establishment and implementation of the 2015 Adaptation Plan. In the course

of this, the Adaptation Act was promulgated on June 13, 2018, and came into force on December 1 of the same year to set a legal framework for climate change adaptation and to promote climate change adaptation more extensively. In November 2018, just before the implementation of the Adaptation Act, the Climate Change Adaptation Plan (hereinafter the "2018 Adaptation Plan") was formulated in accordance with the provisions of that law.[3] In December 2018, NIES established the Center for Climate Change Adaptation to collect, organize, analyze, and provide information on climate change impacts and adaptation, as well as to offer technical advice and support to local governments and Local Climate Change Adaptation Centers(LCCACs). In addition, Regional Councils on Climate Change Adaptation were organized in seven regions across the country to discuss climate change adaptation measures and associated issues in the local context through collaboration and cooperation among a wide range of stakeholders in the areas.

The progress of the 2018 Adaptation Plan is followed by the Climate Change Adaptation Promotion Council, which consists of relevant ministries and agencies and has assessed and published the progress of measures in FY 2018 and FY 2019. To keep track of the progress of measures as planned, relevant ministries and agencies were required to set appropriate output indicators and observe changes in the indicators in each fiscal year.

In December 2020, the government compiled and published an Assessment Report on Climate Change Impacts in Japan (hereinafter the "2020 Impact Assessment Report"), based on the latest scientific findings from the observation, monitoring, projection, and assessment of climate change and its impacts in various sectors. Based on scientific findings, this report assessed the impacts of climate change on 71 categories in the seven sectors (agriculture, forestry and fisheries; water environment and water resources; natural disasters and coastal areas; ecosystems; human health; industrial and economic activities; and life of the citizenry and urban life) from three perspectives: significance, urgency, and confidence. A total of 1,261 reference documents were used as the basis for the report, which is approximately 2.5 times the number in the previous assessment in 2015, and confidence increased for 31 categories. As a result, confidence was at a medium or higher degree in 55 categories (77%). Concerning significance and urgency, additional three categories were assessed as "exposed to particularly significant impacts" and eight categories were assessed as having "high urgency for response."

The Adaptation Plan has been revised, taking into consideration the latest scientific findings provided in the 2020 Impact Assessment Report, after going through processes such as coordination among relevant ministries and agencies, reporting to the Climate Change Impact Assessment Subcommittee under the Global Environment Committee of the Central Environment Council, and inviting public comments.

[3]Article 2 of the Supplementary Provisions of the Adaptation Act states that the government may formulate the Climate Change Adaptation Plan prior to the enforcement of this Act.

Chapter 1. Basic Directions of Measures for Climate Change Adaptation

Section 1. Goals

The purpose of the Adaptation Act is to promote climate change adaptation and thereby contribute to the health and cultural life of the Japanese people both at present and in the future, in recognition of the impact that climate change has had on daily life, society, economics, and the natural environment, and the risk that this impact will increase over the long term.

In light of this, the Adaptation Plan is aimed at comprehensively and systematically implementing measures related to climate change adaptation based on scientific findings. By doing so, it seeks to create a society that ensures safety, security, and sustainability by preventing and reducing damage from climate change-induced impacts, stabilizing people's lives, promoting the sound development of society and the economy, preserving the natural environment, and building national resilience.

In implementing climate change adaptation, the government will expand scientific findings and develop information platforms that bring together the knowledge of research institutions and other organizations in Japan to ensure that diverse stakeholders can cooperate to pursue climate change adaptation effectively in each field, based on reliable detailed information. As a matter of course, such efforts should be focused on preventing and reducing damage from current and future climate change impacts, while taking into consideration vulnerable groups and regions in Japan and abroad. In addition, in view of climate change projections further ahead, other perspectives should also be incorporated into adaptation measures to drive sound development of regional societies and economies, such as the branding of agricultural, forestry and fishery products and building communities resilient to natural disasters. Aside from socioeconomic perspectives like the shrinking population and a post-pandemic world, it is also essential to note emerging ideas. One example is "Adaptive Recovery," which involves adaptation to climate change by implementing resilient measures including land-use controls while learning from traditional wisdom that has taken advantage of nature's characteristics to cope with natural disasters; and another is nature-based solutions (NbS), which harness the power of nature.

Section 2. Term of the Adaptation Plan

Under the Adaptation Act, the Adaptation Plan charts Japan's basic strategies for climate change adaptation and the basic directions of the government's climate change adaptation measures over the next five years or so, while looking over the long term through the end of the 21st century.

Section 3. Basic Roles of Stakeholders

In the implementation of climate change adaptation, diverse stakeholders, including not only the national government but also local governments, business operators, and citizens, are

expected to play their respective basic roles as described below, closely working together, thereby generating synergies.

1. Basic roles of the national government

(1) Comprehensively promoting climate change adaptation

The national government comprehensively and systematically implements measures related to climate change adaptation in accordance with the Adaptation Plan. The national government also seeks to enhance scientific findings about climate change and foster the efficient and effective use of such knowledge and encourages the national and local governments, business operators, citizens, and all other actors to adapt to climate change by building an information platform on which to gather, organize, analyze, and provide information related to climate change and thus securing a system to reach these goals. In addition, the national government promotes the development of methods to more accurately monitor and evaluate the progress of climate change adaptation. The national government periodically ascertains the implementation status of the Adaptation Act by the national and local governments and discusses issues related to the implementation of the law.

(2) Taking the initiative in implementing measures related to climate change adaptation

Through cooperation among relevant administrative agencies, the national government proactively incorporates climate change adaptation into DRR measures, agriculture, forestry and fisheries promotion measures, biodiversity conservation measures, and other related measures to take the initiative in implementing measures related to climate change adaptation in each field.

(3) Promoting and ensuring collaboration on climate change adaptation among diverse stakeholders

The national government fosters an understanding of climate change adaptation among local governments, business operators, citizens, and other diverse actors through dissemination of information on climate change adaptation measures and specific initiatives, as well as public relations and awareness activities, and thereby encourages each actor to adapt to climate change. Through frameworks such as the Regional Councils on Climate Change Adaptation, the national government ensures wide-scale collaboration among local administrative organs of the national government, local governments, business operators, LCCACs, and other regional stakeholders of climate change adaptation.

(4) Promoting international cooperation

The national government builds a system to internationally share climate change information and promotes international cooperation, such as technical cooperation on climate change adaptation in developing regions.

(5) Enhancing and using scientific findings and assessing climate change impacts

The national government promotes the development of technology for the observation, monitoring, projection, and assessment of climate change and its impacts in various fields, for associated investigation and research, and for climate change adaptation; and fosters the enhancement of scientific findings to strengthen the climate change information platform and uses such scientific findings for measures related to climate change adaptation. Based on these latest scientific findings, the national government comprehensively assesses the impacts of climate change, taking into consideration the opinions of the Central Environment Council.

2. Basic roles of local governments

(1) Promoting climate change adaptation according to the natural, economic, and social circumstances of each local areas

Local governments strive to establish their local climate change adaptation plans[4] in consideration of the Adaptation Plan to implement climate change adaptation measures according to the natural, economic, and social circumstances of the areas. In doing so, through cooperation among relevant departments, local governments strive to proactively incorporate climate change adaptation into DRR and national resilience measures, agriculture/forestry/fisheries promotion measures, biodiversity conservation measures, and other related measures, and to implement climate change adaptation measures in each field. In particular, prefectural governments strive to take the initiative in implementing climate change adaptation measures and provide technical advice, etc. to municipal governments within their jurisdiction in order to encourage them to conduct climate change adaptation measures and establish their own local climate change adaptation plans.

(2) Promoting climate change adaptation by local stakeholders

Local governments foster an understanding of climate change adaptation among local business operators, local citizens, and other diverse actors through dissemination of information on climate change adaptation measures and specific initiatives, and thereby encourage each actor to adapt to climate change. Local governments strive to effectively promote climate change adaptation in the areas by fostering wide-scale collaboration among local administrative organs of the national government, other local governments, business operators, the LCCAC, and other regional stakeholders of climate change adaptation through such means as participation in the Regional Council on Climate Change Adaptation.

[4] The Adaptation Act does not necessarily require local governments to establish an independent local climate change adaptation plan. Instead, they may flexibly respond to this issue, such as by including an adaptation plan in their basic environment plans, or in local government action plans required under the Act on Promotion of Global Warming Countermeasures, among other options.

(3) Enhancing and utilizing scientific knowledge in the local areas

Local governments strive to establish a LCCAC as a hub for gathering, organizing, analyzing, and providing information on climate change impacts and adaptation and for providing technical advice; foster the local enhancement of scientific findings; and use them for climate change adaptation measures.

3. Basic roles of business operators

(1) Implementing climate change adaptation based on the characteristics of their business

To ensure smooth business operations, business operators strive to implement climate change adaptation according to the nature of their business and to cooperate on climate change adaptation measures conducted by the national and local governments. By sharing their best practices for climate change adaptation and providing climate change information, business operators are expected to contribute to the promotion of climate change adaptation by the national and local governments, citizens, and other business operators.

(2) Expanding adaptation business

Promotion of climate change adaptation offers an opportunity for new business activities (adaptation businesses), such as providing technologies, products, and services related to adaptation. Business operators engaged in adaptation business are expected to contribute to the promotion of climate change adaptation by the national and local governments, citizens, other business operators, and other countries, especially developing countries, through expansion of their adaptation business in Japan and abroad.

4. Basic roles of citizens

(1) Recognizing and understanding the importance of climate change adaptation

As climate change may affect the life of each citizen, citizens strive to recognize climate change impacts as a relevant issue and to deepen their awareness and understanding of the importance of climate change adaptation.

(2) Cooperating on climate change adaptation measures

As the implementation of adaptation measures formulated by the national or local government requires public cooperation, citizens strive to cooperate with measures related to climate change.

5. Roles of NIES in the promotion of climate change adaptation

(1) Developing information platforms on climate change impacts and adaptation

To help the national and local governments, business operators, citizens, and all other actors implement climate change adaptation based on scientific knowledge, NIES enhances

and strengthens A-PLAT, an information platform on climate change adaptation, and combines it with the Data Integration and Analysis System (DIAS) to collect, organize, analyze, and provide information on climate change impacts and adaptation. In doing so, NIES takes the initiative in research and technology development on climate change impacts and adaptation; works with national agencies or incorporated administrative agencies engaged in research or technology development on climate change and related issues such as weather, DRR, agriculture, forestry, fisheries, biodiversity, human health, or with LCCACs, and performs joint research as necessary, thereby enhancing and strengthening A-PLAT by collecting relevant research results, data, and information from these institutions. In addition, noting the usefulness of information on climate change impacts that individual citizens obtain in their daily lives, NIES appropriately collects, organizes, analyzes, and uses such information in cooperation with local governments, LCCACs, etc.

(2) Technical support for local governments

NIES provides technical advice and other support to prefectural and municipal governments in the development or promotion of local climate change adaptation plans in consideration of their intents, through such means as the active use of scientific knowledge available on A-PLAT.

(3) Technical support for LCCACs

NIES exchanges views with LCCACs and provides technical advice and other support to them by providing information and know-how needed for promoting observation, monitoring, projection, and assessment of local climate change impacts, research on these activities.

Section 4. Basic Strategies

Japan has established basic strategies as stated below to promote measures related to climate change adaptation comprehensively and systematically based on scientific findings and to achieve the goals set in the Adaptation Plan. Within the national government, relevant ministries and agencies collaborate closely to effectively implement the sectoral measures described in Chapter 2 and the basic measures described in Chapter 3 under these basic strategies.

1. Incorporation of climate change adaptation into measures

Basic Strategy 1: Incorporate climate change adaptation into every relevant policy

In implementing climate change adaptation measures, it is essential to coordinate them with other relevant measures, such as those for DRR, agriculture/forestry/fisheries, and biodiversity conservation. Many countries' national strategies for climate change adaptation

adopt the approach of mainstreaming adaptation by integrating climate change adaptation into existing government initiatives and regulatory frameworks.

Considering this trend, the government should, through collaboration among relevant ministries and agencies, incorporate climate change adaptation into all relevant measures, such as those for DRR, agriculture/forestry/fisheries, and biodiversity conservation, to effectively and efficiently implement climate change adaptation measures and seek to mainstream adaptation in its policies. Likewise, local governments need to foster collaboration among relevant departments through the formulation of their local climate change adaptation plans and incorporate climate change adaptation into their relevant measures.

The IPCC Fifth Assessment Report presents a wide range of specific approaches, both structural and non-structural, to climate change adaptation, including disaster risk management through early warning systems, hazard mapping, diversified water resources, rainwater/wastewater management with sewerage, and road infrastructure improvements; ecosystem management through maintaining wetlands and urban green spaces and reduction of habitat fragmentation; land-use planning through managing development in flood-prone and other high risk areas; structural/physical approaches based on seawalls and flood levees, water storage facilities, new crop varieties, water saving, nature restoration, ecological corridors, soil conservation, and tree planting; institutional approaches based on insurance and building standards; and social approaches based on awareness raising. In determining specific approaches to take, it is essential to recognize the need to comprehensively implement adaptation in a manner that ensures the soundness and connectivity of social and natural systems to allow them to be resilient. For this purpose, an appropriate combination of various approaches needs to be sought, such as engineering/ecological approaches, land use, and social/institutional approaches, to suit Japan's socioeconomic and environmental situation, regional characteristics, sectoral characteristics, the degree of climate change impacts, and other relevant factors. The awareness of the time frame is also crucial in developing and implementing adaptation measures. In sectors where the impacts of climate change have already been observed, the government should recognize relevant actions, including those already in place, as adaptation measures to accelerate their implementation. Even for potential future impacts, various events should be assumed in sectors where such climate change impacts, if materialized, can seriously affect society, the economy, and the natural environment, and the development of countermeasures and possible preliminary actions should be considered. In particular, for the steady implementation of improvement, maintenance, and renewal of facilities and equipment used over the long term, consideration should be given to adoption of designs that accommodate future changes in climate change impacts so that the effective and efficient implementation of adaptation measures can be ensured.

In view of concerns over the potential increase in the intensity and frequency of natural

disasters due to climate change, Japan should seek to build national resilience, or make the country strong yet flexible. This means that even if the largest possible flood disaster occurs with ensuing compound disasters, making the worst-case scenario into a reality, the nation can avoid casualties, minimize economic damage, and quickly recover from the catastrophe, without bringing economic activities to a halt. To realize this, the government makes the country more resistant to disasters by systematically building national preparedness and resilience. This includes steadily implementing the Five-Year Acceleration Plan for Disaster Prevention, Disaster Mitigation, and Building National Resilience, which sets forth measures to prepare for intensifying wind and flood disasters. It is also important to integrate the approach of the synergy between climate action and DRR into this action, which refers to the state where every actor in every sector comprehensively takes climate change measures and DRR measures. Rather than simply restoring the affected areas to its pre-disaster state, Japan aims to build a society that can skillfully deal with disaster and recover quickly. This is reflected in the concept called "Adaptive Recovery," which involves adaptation to climate change by implementing resilient measures including land-use controls while learning from traditional wisdom that has taken advantage of nature's characteristics to cope with natural disasters. This highlights the importance of pre-disaster recovery planning to "build back better," which specifically refers to an approach in which communities discuss and share the vision for a post-disaster society or town, even before a disaster occurs, from forward-looking perspectives to be better prepared to quickly act after a disaster.

Japan's Fifth Basic Environment Plan (approved by the Cabinet on April 17, 2018) states that the government will embody efforts toward integrated improvement of the environment, economy and society. This approach is also suggested in the IPCC Fifth Assessment Report. The report points out that adaptation strategies should include actions that bring synergies (co-benefits) to other goals, and that strategies and actions that can be pursued now will increase resilience to various potential future climate scenarios, while helping to improve the quality of human health, livelihoods, social and economic well-being, and the environment.

Japan should also implement measures that bring adaptation and co-benefits, or in other words, measures designed to meet multiple policy objectives, including adaptation. For example, in the food and agriculture/forestry/fisheries sectors, efforts to build a sustainable food system that withstands disasters and climate change are ongoing under the Strategy for Sustainable Food Systems "MeaDRI", which was established by the Ministry of Agriculture, Forestry and Fisheries on May 12, 2021.

Integration of the concept of NbS is also important. This includes focusing on Ecosystem-based Disaster Risk Reduction (Eco-DRR) and Ecosystem-based Adaptation (EbA), noting that maintaining and restoring healthy ecosystems, typically by creating ecological networks, contributes not only to mitigation measures through their function as emission sinks but also to adaptation measures, including DRR. In this endeavor, attention should be paid to the fact that the G7 2030 Nature Compact, which was adopted by the G7

Summit in 2021, stipulates that the G7 nations support new global targets to conserve or protect at least 30% of global land and at least 30% of the global ocean by 2030 and lead by example, conserving or protecting the same percentage in their own countries. Based on this, it is necessary to expand protected areas, establish other effective area-based conservation measures, and improve the quality of these areas, and this will lay the groundwork for the implementation of NbS. Another important perspective is to pursue mitigation/adaptation and biodiversity conservation in an integrated manner as mentioned in the National Biodiversity Strategy of Japan (approved by the Cabinet on September 28, 2012). Climate change is a direct driver of the loss of biodiversity, and if biodiversity is lost due to climate change, ecosystems' contribution to climate change countermeasures will be compromised, which will then accelerate climate change, creating a negative cycle. Taking into consideration these NbS concepts, Japan should develop green infrastructure across society, which will make the country and its cities and communities sustainable and attractive by using the diverse functions of the natural environment in both structural and non-structural aspects (e.g., social infrastructure building and land use). This will require cooperation across different sectors and public-private sector collaboration.

More and more countries are addressing climate change as a national security issue. For example, the shortage of water, food, or land arising from compound climate change factors can trigger or deteriorate disputes over limited land or resources and even lead to mass migration, thus inducing social or political tension and conflict. This suggests the need to pursue climate change adaptation measures with an awareness that climate change is a critical matter related to national and human security.

To protect people's lives, society and the national land from the impacts of climate change, the government should, in implementing its policies, share findings and information across society through inclusive risk communication and develop decision-making and consensus-building processes that consider gender equality and vulnerable groups and regions so that every actor and every stakeholder in every sector can work together and act responsibly.

2. Enhancement and use of scientific findings on climate change, etc.

Basic Strategy 2: Promote climate change adaptation based on scientific findings

Climate change measures should be appropriately implemented based on scientific findings on climate change and its impacts. Keeping up with the latest scientific findings is crucial because the projection and assessment of future climate change and its impacts include uncertainty and vary by changes in the socio-economic situation of countries and the implementation status of mitigation measures at the international level.

Therefore, the government promotes the observation, monitoring, projection, and assessment of climate change and its impacts in various fields, as well as associated investigation and research, and expands scientific findings on climate change projections, etc.

based on the latest research results. The government also works to enhance findings on "compound disaster impacts," which are produced in a situation where the interactions of multiple factors make the damage wider and severer than that from a single factor, and "cross-sector cascading impacts," which refer to a phenomenon where an impact in one sector induces other impacts in other sectors, creating cascading impacts, or where the successive occurrence of impacts in different sectors intensifies the overall severity of the impacts. In view of the latest scientific findings available from investigation and research results and scientific articles, the government obtains opinions from the Central Environment Council, which mainly consists of experts in climate change and its impacts in various fields, and periodically performs a comprehensive assessment of climate change impacts.

For observation and monitoring, the government effectively combines different methods, such as fixed-point terrestrial observation, observation of diverse ecosystems in the alpine to coastal zones, ocean and polar observation by ship and Argo Floats, and observation by aircraft, observation using remote sensing satellites and other technologies. For projection and assessment, the government works to develop more advanced climate models and more accurate impact models, while paying attention to IPCC and other international developments. In doing so, the government promotes joint research projects involving many investigation and research institutions, in addition to investigation and research conducted by individual institutions, with the goal of consolidating the assessments of climate change impacts in various fields in a manner that fosters accurate and comprehensive assessments. To promote climate change impact assessments at the local level, the government will also focus on joint research between national investigation and research institutions, such as NIES, and local research institutions, mainly LCCACs.

To accelerate climate change adaptation efforts by the national and local governments, business operators, and other stakeholders, the government focuses on the development of technologies related to climate change adaptation in areas such as DRR, water resource management, farming support, biodiversity conservation, and health, and works to use such technologies proactively. As the effective and efficient implementation of climate change adaptation requires the accurate monitoring and assessment of the progress of adaptation, the government enhances the knowledge needed for quantifying the effectiveness of adaptation measures.

3. Establishment of system for collection, organization, analysis, and provision of climate change information

Basic Strategy 3: Consolidate the knowledge of research institutions in Japan and develop information platform

Climate risk information, such as data and scientific findings from the observation, monitoring, projection, and assessment of climate change and its impacts, and information on technologies and best practices concerning climate change adaptation provide the foundations

on which the national and local governments, business operators, citizens, and other actors work on climate change adaptation. It is of prime importance that each of these actors can easily access climate risk information and climate change adaptation information, and can obtain such information in an accurate and easily understandable form.

Meanwhile, climate risk information covers, in addition to climate change-related data (e.g., temperature and precipitation), wide-ranging issues in the context of climate change, such as rice yields, water quality of lakes and swamps, distribution of plant and animal species, likelihood of flooding in river basins, and risk of heat illness. In addition, the spatial dimension can range from the global level to the national, prefectural, or municipal level. For example, when a local government considers adaptation measures, it may require high-resolution climate projection data produced by downscaling, and impact assessment information based on that. Furthermore, various time scales can be used, including the past, present, near future, and the period through the end of the 21st century. The confidence of each piece of information also ranges widely from high to low.

Therefore, the government seeks to enhance and strengthen A-PLAT, an information platform for climate change adaptation built around NIES; and DIAS, an information system contributing to the resolution of climate change and other global issues.

It will also be necessary to share and use all relevant information with a view to leveraging emerging technologies in rapidly developing information sectors, including using the fifth generation mobile communications system (5G) and other information and communications technologies, obtaining information by new means (e.g., IoT, satellites, and drones), and processing the obtained big data with AI, as well as digital technologies such as contactless or remote options that have become widespread in society, particularly in the context of combating COVID-19.

In cooperation with NIES, the government works to aggregate relevant information, including climate change data and information on real-world examples of climate change adaptation efforts, which are held by local governments, business operators, private organizations, and citizens, into A-PLAT and make it available for sharing. In the future, the LCCACs should preferably play the central role in the system to collect, organize, analyze, and provide information related to local climate change. The government ensures that NIES will smoothly provide technical support to the LCCACs by offering the necessary assistance to NIES.

4. Promotion of climate change adaptation measures by local governments

Basic Strategy 4: Promote climate change adaptation according to local background

The nature and scale of climate change impacts vary significantly depending on local characteristics, such as the climate conditions, geographical conditions, and socioeconomic conditions. Sectors that require urgent actions also differ by region/local areas. An important perspective is to see adaptation to climate change as an opportunity to make communities

resilient and sustainable based on their characteristics through the creation of a Regional Circular and Ecosystem Sphere, a model presented in Japan's Fifth Basic Environment Plan. Therefore, in local implementation of climate change adaptation, the local government familiar with the local characteristics should take the initiative to conduct measures suited to the local situation.

Many local governments have already committed to climate change adaptation measures. A large number of prefectures and ordinance-designated cities have taken steps to establish a local climate change adaptation plan and a LCCAC. However, more encouragement is needed for municipalities to accelerate their efforts because they are the closest governments to citizens.

For local governments, it is not easy to perform all the tasks at the local level, including gathering scientific findings on climate change, assessing climate change impacts, and integrating adaptation into policies to conduct climate change adaptation measures. The national government helps them develop and implement their local climate change adaptation plans by securing a system to collect, organize, analyze, and provide information related to climate change, which will be built around A-PLAT and work with DIAS, as well as by providing local governments with manuals and training that help them smoothly establish their climate change adaptation plans. This will include analyzing and sharing effective and efficient approaches, such as joint development of an adaptation plan by multiple municipalities, coordination with other relevant measures established by local governments (e.g., local biodiversity strategy), ways to set up a LCCAC, and ways to implement adaptation measures exclusively designed for certain sectors that are key to the community.

The government supports the LCCACs in cooperation with NIES to ensure that the Centers can adequately gather, organize, analyze, and provide information on local climate change impacts and adaptation, and that the Centers can offer associated technical advice. To help NIES smoothly provide technical support to the Centers, the government also offers necessary assistance to NIES. Furthermore, through the framework of the Regional Councils on Climate Change Adaptation, the government fosters information sharing among local stakeholders of climate change adaptation and helps them cooperate to gather scientific findings and develop adaptation measures at the local level.

In addition to the above, the government periodically evaluates local governments' implementation status of the Adaptation Act and informs them of the analysis results to accelerate their efforts. To help municipal and other local governments fully understand the Adaptation Act and the Adaptation Plan and allow them to implement local climate change adaptation measures, briefings to and discussions with local governments will be effectively held.

5. Promotion of climate change adaptation by business operators and business activities contributing to climate change adaptation

Basic Strategy 5: Deepen public understanding and promote climate change adaptation corresponding to business activities

Public understanding is essential for implementing climate change adaptation measures. As climate change affects people's lives, citizens should also deepen their awareness and understanding of the importance of climate change adaptation and act for climate change adaptation on their own. However, public understanding of climate change adaptation does not seem to be sufficient at present.

To address this, the government provides citizens with various kinds of information needed for the implementation of adaptation measures, such as disaster risk information, while focusing on public education, public relations/awareness activities, and other efforts to deepen public awareness and understanding of the importance of climate change adaptation. Recognizing that these efforts need local campaigns, the government will seek cooperation from local governments and relevant private organizations as necessary. With the goal of deepening public understanding, further discussions will be held on the ways to gather and use information on climate change impacts that each citizen has gained in his or her everyday life, in view of the usefulness of such information.

Climate change also affects corporate business activities. An important perspective is that business operators should work toward climate change adaptation on their own in a manner that suits the nature of their business, in an effort to facilitate their own business activities. In addition, when business operators roll out adaptation businesses based on technologies, products, and services addressing climate change adaptation, they can find new business opportunities and even help accelerate climate change adaptation measures implemented by the national and local governments, as well as climate change adaptation efforts by other business operators. At present, there are not many business operators that consciously integrate climate change adaptation into their business. To encourage business operators to adapt to climate change and expand adaptation businesses, it is crucial to help them better understand the risks that climate change can pose to their business and ways to respond to them, and to disseminate pioneering practices by leading business operators. In recent years, companies are asked by investors and other stakeholders to disclose their climate change risks. Since the Task Force on Climate-related Financial Disclosures (TCFD) of the Financial Stability Board (FSB) published a final report, known as the TCFD proposal, in June 2017, a growing number of companies, especially large ones, have acted in support of the proposal and have become eager to analyze their climate-related risks and opportunities and disclose the findings in their environmental, financial, or other reports. With wind and flood disasters becoming more frequent and massive, businesses are also realizing the need to consider weather-related disasters in their business continuity plans (BCPs).

In response to these developments, the government will ensure that business operators can

adequately adapt to climate change by providing guidance on voluntary climate change adaptation by business operators. The guidance will include approaches to information disclosure in accordance with the TCFD proposal and ways to integrate climate change adaptation into business continuity management (BCM) to support corporate efforts toward efficient and effective climate change adaptation. The government will also search for best practices (e.g., technologies, products, and services) related to climate change adaptation by business operators and proactively share such information in Japan and abroad to disseminate them; and support adaptation finance, including encouraging the issuance of green bonds for financing climate change adaptation efforts, with the aim of helping to expand private-sector projects and businesses that capitalize on technologies, products, and services related to climate change adaptation.

6. Development of international collaboration and cooperation on climate change

Basic Strategy 6: Contribute to enhancing the adaptive capacity of developing countries

Many developing countries generally lack the capacity to adapt to climate change impacts. Least developed countries and small island developing states, in particular, are highly vulnerable to current and future climate change. The impacts of climate change may be more severe for them because many of these countries have economic structures that depend on agriculture, forestry, and fisheries, which are easily affected by climate change, and because widespread poverty in these countries limits their adaptive capacity. The IPCC Fifth Assessment Report points out some relevant impacts, including increased flooding in riverside, coastal, and urban areas, higher mortality risk associated with heat stress, and increased water and food shortages due to drought in Asia; and sea level rise in small island developing states.

In the future, the impacts of climate change, such as more frequent and intense floods and extreme weather events, may lead to food shortages, changes in import prices of agricultural and fishery products, and supply chain disruptions due to overseas production sites being directly impacted by climate change. If these become a reality, they may adversely affect the Japanese economy and society. Even in terms of human security, addressing climate change impacts experienced by developing countries is an imminent and material issue.

Recognizing this, the Japanese government announced during the G7 Summit in Cornwall in June 2021 that Japan would provide climate finance, both public and private, totaling 6.5 trillion yen over the next five years (2021 to 2025) in support of developing countries in addressing climate change, with emphasis on adaptation. Japan will use the Asia-Pacific Climate Change Adaptation Information Platform (AP-PLAT), which was launched to support climate change risk-informed decision-making and highly effective climate change adaptation in the Asia-Pacific region, in order to improve scientific findings related to climate change risks, to provide stakeholders with support tools, to strengthen capacity related to climate change impact assessment and climate change adaptation, in collaboration with countries and

relevant institutions in the region, while taking into consideration vulnerable groups and regions. In addition, Japan will promote technical cooperation in developing countries in the observation, monitoring, projection, and assessment of climate change and its impacts, as well as in climate change adaptation in the fields of DRR, agriculture, and water resources, through various international cooperation frameworks and relevant technologies (e.g., meteorological satellites). Collaborations with universities in these countries will also be fostered to allow the results of research and technology development to be used for developing initiatives for strategic responses to future climate change impacts in the local context.

The government will also help Japanese business operators globally expand their adaptation businesses by offering technical cooperation based on AP-PLAT, DIAS, etc. In addition, the government will enhance international activities and cooperation through public-private sector collaboration by using Japan's knowledge, such as findings from observation, monitoring, projection, and assessment of climate change and its impacts, Japan's disaster experience, and Japan's climate change adaptation technologies in DRR, agriculture and other fields.

7. Development of collaboration and cooperation among relevant administrative agencies in implementation of climate change adaptation measures

Basic Strategy 7: Ensure a system for close collaboration among relevant administrative agencies

In implementing climate change adaptation measures, attention should be paid to coordinating them with other relevant measures, such as those for DRR, agriculture, forestry and fisheries promotion, and biodiversity conservation. Climate change adaptation measures need to be conducted effectively in every sector, based on common scientific findings on climate change. These sectoral measures are under the charge of many relevant ministries and agencies at the national level and many local government departments at the local level. For comprehensive and systematic implementation of climate change adaptation measures, the national and local governments should formulate a system that facilitates close collaboration among relevant ministries and agencies and among relevant departments, respectively. This system should be used to build and implement a national or local climate change adaptation plan, and the national and local governments should work in coordination toward climate change adaptation.

At the national level, to ensure the steady implementation of the Climate Change Adaptation Plan, the Climate Change Adaptation Promotion Council, which is chaired by the Minister of the Environment and consists of representatives of the relevant ministries and agencies, shall engaged in inter-ministerial coordination to promote government-wide cooperation on the implementation of climate change adaptation measures, and shall periodically check the progress.

Considering that many national research institutions conduct studies on climate change impacts and adaptation, collaboration and cooperation among them will be fostered through the Liaison Meeting of Research Institutions on Climate Change Adaptation, for which NIES serves as the secretariat.

For the promotion of climate change adaptation in the local context through collaboration among relevant local administrative agencies, the Regional Councils on Climate Change Adaptation will serve as the platform of cooperation, bringing together representatives of local administrative organs of the national government, prefectural governments, municipal governments, LCCAC, business operators, and other stakeholders from the given region.

With the goal of establishing and steadily implementing a local climate change adaptation plan, local governments are expected to ensure a system for collaboration and cooperation among relevant local administrative agencies and implement local climate change adaptation measures. To achieve this, a local government may set up a meeting body consisting of its relevant departments, while looking at the developments at the national-level Climate Change Adaptation Promotion Council.

Section 5. Management and Assessment of the Progress of the Climate Change Adaptation Plan

To pursue climate change adaptation effectively, the emphasis should be placed on flexible actions based on an adaptive approach that involves the assessment of climate change impacts, progress management of the Climate Change Adaptation Plan, and review of that plan according to the progress. The government will conduct the assessment of climate change impacts, the progress management and review of the Climate Change Adaptation Plan, and the development of related assessment methods, as described in this section.

1. Assessment of climate change impacts

Climate change adaptation measures should be conducted in consideration of the latest scientific findings on climate change and its impacts.

For this reason, the government will work on observation, monitoring, projection, and assessment, as well as investigation and research, of climate change and its impacts in various sectors. Based on the latest scientific knowledge obtained from investigation and research results and scientific articles, the government will perform a comprehensive assessment of climate change impacts at intervals of about five years. Deliberations to prepare a report on this comprehensive assessment of climate change impacts shall be conducted by a committee consisting mainly of experts in climate change and climate change impacts in various sectors after consultation with the Central Environment Council.

The next assessment of climate change impacts shall be performed in FY 2025, about five years after the last assessment.

Noting that an effective comprehensive assessment of climate change impacts requires

investigation and research over several years, with the IPCC's and other international developments in view, such investigation and research shall be launched systematically from an early stage.

2. Review and progress management of the Climate Change Adaptation Plan

The Climate Change Adaptation Plan should be reviewed based on the comprehensive assessments of climate change impacts and evaluations of climate change adaptation measures in different sectors to ensure that the Adaptation Plan addresses the latest climate change impacts supported by scientific evidence. For effective implementation of climate change adaptation measures, evaluating and prioritizing measures is essential, such as prioritizing sectors rated high in significance and urgency in the comprehensive assessments of climate change impacts, and accelerating investigation and research in sectors with scarce scientific findings.

In addition to the above, the review of the Climate Change Adaptation Plan requires adequate progress management through a PDCA cycle, such as periodically or constantly monitoring the progress of measures against the plan and evaluating the progress as necessary. For managing the progress of short-term measures, KPIs[5] will be set in relation to the sectoral and basic measures to keep track of yearly changes in indicators. Together with this, follow-up activities by The Climate Change Adaptation Promotion Council, consisting of relevant ministries and agencies, will be used to accurately evaluate the progress of individual measures according to the Adaptation Plan. Indicators to evaluate the progress of medium- to long-term climate change adaptation will also be established to determine the effectiveness of adaptation measures every five years (and to prepare an interim report in the middle year of the period). To help climate change adaptation take root and become widely recognized at the national, municipal, and public levels, the government will set up indicators and targets concerning the promotion of efforts by relevant ministries and agencies, support for the establishment of systems by local governments, and a wider understanding among citizens (see the table below); and manage their progress toward the targets.

The government aims to review the Adaptation Plan in FY 2026 in consideration of the climate change impact assessment expected in FY 2025, the progress of relevant measures, and the escalation of climate change. However, the government will consider reviewing the Adaptation Plan before that as necessary, if it encounters such cases as the advent of a new issue affecting the entire Plan and the acquisition of new findings that affect the basic adaptation measures in each sector.

[5] Key performance indicators: Priority indicators aimed at tracking the short-term progress of the government's adaptation efforts. They are used to measure the degree of achievement of the targets and relevant measures in as much a quantitative manner as possible.

Table: Indicators and targets set to help climate change adaptation take root and become widely recognized at the national, municipal, and public levels

Indicator	Target (Target year: FY 2026)	Remarks
[Promotion of efforts by relevant ministries and agencies] ① Percentage of high-significance and high-urgency categories with KPIs set for sectoral measures	100%	89% (At the time of establishment of the Adaptation Plan)
[Support for the establishment of systems by local governments] ② Percentage of prefectures and ordinance-designated cities with their local climate change adaptation plans in place	100%	88% (End of July 2021)
③ Percentage of prefectures and ordinance-designated cities with their LCCACs established	100%	52% (End of July 2021)
④ Percentage of administrative plans of prefectures and ordinance-designated cities (e.g., comprehensive plans, local disaster management plans) that incorporate the perspective of climate change adaptation into DRR measures	100%	-
[Wider understanding among citizens] ⑤ Public awareness of climate change adaptation efforts (percentage of citizens who recognize both the term “climate change adaptation” and efforts made toward it)	25%	11.9% (March 2021 public opinion poll by the Cabinet Office)

3. Development of assessment methods

For the effective implementation of the Climate Change Adaptation Plan, the government should quantitatively ascertain and assess the effectiveness of climate change adaptation measures, such as how much each measure has contributed to the avoidance and reduction of damage from climate change impacts. However, there have been no established methods of ascertaining and assessing the effectiveness of climate change adaptation measures in Japan or elsewhere in the world for reasons such as the difficulty of setting adequate indicators and

the long period needed to assess the effectiveness.

To address this, the government will develop methods to more accurately ascertain and assess the progress of climate change adaptation resulting from the implementation of the Climate Change Adaptation Plan. Specifically, this will involve organizing the latest findings from investigations and research on indicators and methods relating to the assessment of how adaptation measures have contributed to the reduction of climate change impacts, and collecting information on international trends, initiatives by other countries, and efforts by local governments on this topic to push forward with studies on a more appropriate PDCA approach to the Adaptation Plan.

For the categories that are assigned the ● symbol in both significance and urgency (i.e., recognized as being exposed to particularly significant impacts or having high urgency for response),[6] the government will set KPIs for measures that address greater climate change risks or elimination of obstacles to the progress of adaptation in the given sector, to ascertain the progress of adaptation measures.

The time needed for implementing adaptation measures, limits to implementation, vulnerability, and other factors will be considered in determining the content, implementation time frame, and priorities of the measures:

The following points should be noted in the implementation of adaptation.

- The projection of impacts requires the establishment of methods of accurately projecting and assessing the impacts, as well as the development of plans that incorporate uncertainties as preconditions.
- Sufficient coordination is needed to prevent mitigation measures from narrowing the range of possible adaptation. This can be achieved by studying the effects that adaptation measures being put into practice will have on global warming and evaluating synergies and trade-offs between adaptation and mitigation measures.
- The "limits to adaptation," the extent to which adaptation measures can help reduce impacts, vary depending on geographical region. Therefore, visualizing the limits to adaptation is essential.
- As any adaptation measure has its limits, having various options, including changing crop varieties and production stabilizing technologies, is essential.
- Necessary actions are different between short-term perspectives for immediate implementation and medium- to long-term perspectives, which view the effectiveness over the next several decades. An essential approach is to implement both short-term and medium- to long-term actions in parallel.
- Adaptation measures based on ecosystem functions should be considered positively because they bring benefits such as simultaneously contributing to adaptation measures in multiple sectors.

Section 1. Agriculture, Forestry, and Fisheries

1. Basic adaptation measures for agriculture

(1) Overview of agricultural production

[Impacts]

○ In general, agricultural production is sensitive to climate change. A decrease in growth and a decline in quality presumably attributable to climate change have been observed in a

[6] See the "Assessment Report on Climate Change Impacts in Japan" (December 2020, Ministry of the Environment) for the results of climate change impact assessment in each sector, detailed descriptions of the information provided in the [Impacts] section for each sector, supporting documents, and other information relevant to this chapter.
http://www.env.go.jp/earth/tekiou.html

number of crop varieties.

[Basic approach to adaptation]

○ Although projection of impacts has been conducted with a focus on major crops, it is necessary to conduct further research on future impacts.

[Basic measures]

Efforts are underway in overall agricultural production, including guidance for dissemination of adaptation measures to farmers and the demonstration of new adaptation technologies (e.g., introduction of adaptation technologies for avoiding and mitigating impacts of higher temperature and cultivars resistant to heat).

Furthermore, in cooperation with local governments (or related institutions), the impacts of global warming are monitored and information related to adaptation measures is offered in the Global Warming Impact Study Reports and on the website of the Ministry of Agriculture, Forestry and Fisheries.

○ Avoid and reduce damage from climate change by working on mitigating risks to agricultural production, including developing and disseminating production stabilizing technologies and adaptable technologies (including a shift to adaptable varieties and crops) and enabling farmers to manage climate change risks on their own. <Ministry of Agriculture, Forestry and Fisheries>

○ Give higher priority to paddy field rice, fruit trees, plant pests, and weeds, which are the areas that the Assessment Report on Climate Change Impacts in Japan recognized as particularly high in significance and high in urgency and confidence. <Ministry of Agriculture, Forestry and Fisheries>

○ Regarding other crops, in addition to continuing ongoing measures, develop new adaptable varieties and cultivation management technologies or conduct basic research in consideration of future projections of impacts. <Ministry of Agriculture, Forestry and Fisheries>

○ In continued cooperation with local governments (or related institutions), monitor global warming impacts and offer information related to adaptation measures in the Global Warming Impact Study Reports and on the website of the Ministry of Agriculture, Forestry and Fisheries. <Ministry of Agriculture, Forestry and Fisheries>

(2) Paddy field rice

[Impacts]

<Current status>

○ Some impacts have already been observed nationwide, such as declines in quality due to higher temperature (including white immature grains[7] and a decreased ratio of first-grade

[7] Rice grains that look cloudy due to insufficient accumulation of starch.

rice). In some regions and in extremely warm years, decreased yields have also been observed.

○ In some regions, earlier growth due to higher temperatures has exposed paddy field rice to unusual weather conditions around the grain ripening period, causing an impact.

<Projected impacts>

○ Rice yields will continue to rise nationwide until around 2061 to 2080 before beginning to decline by the end of the 21st century. The ratio of rice highly susceptible in terms of quality to high-temperature risks is projected to markedly increase in the RCP[8] 8.5 scenario.

○ Changes in the yields of rice varieties less susceptible to high-temperature risks (i.e., relatively high in quality) analyzed by region suggest that there will be a wider polarization between regions with increased yields (e.g., northern Japan and hilly and mountainous areas in the Chubu region westward) and those with decreased yields (e.g., plains in the Kanto and Hokuriku regions westward).

○ In both the RCP 2.6 and the RCP 8.5 scenarios, the occurrence of the milky white rice kernel is projected to increase in the 2040s compared with the 2010s, most likely resulting in a significant increase in economic losses from reductions in the area capable of growing first-class rice.

○ Free-air CO_2 enrichment (FACE) experiments demonstrated that the rise in carbon dioxide concentration would increase rice yields due to its fertilizing effects. However, these fertilizing effects from higher carbon dioxide concentrations may decline as temperature rises.

○ Future changes in rainfall patterns are assumed to change annual rice productivity, possibly beyond the impact of temperature. Flood testing of various growth stages of rice indicated that flooding during the ear emergence period would cause the biggest decline in rice yield and the lowest whole grain rate.

・Paddy field rice [Significance (RCP 2.6/8.5): ●/●; Urgency: ●; Confidence: ●]

[Basic approach to adaptation]

○ Due to high temperatures after the ear emergence period, high heat damage with frequent occurrence of white immature grains have often been observed. Therefore, it is necessary to strive to avoid the impact of high temperature during the grain ripening period by introducing high temperature-resistant varieties[9] or by planting varieties with different

[8] RCP scenarios assume typical concentrations of greenhouse gases and are used in the climate model projections in the IPCC Fifth Assessment Report. There are four RCP scenarios: RCP 2.6, RCP 4.5, RCP 6.0, RCP 8.5. Projections show that global warming in these scenarios is highly likely to fall within 0.3 to 1.7°C, 1.1 to 2.6°C, 1.4 to 3.1°C, and 2.6 to 4.8°C, respectively.

[9] Rice varieties that are less likely to decline in quality and yield of unpolished rice even when exposed to high temperature.

ripening seasons.

○ The early onset of pests, increases in pest populations, and the expansion of pest-occurrence areas have been seen due to the impact of global warming. Therefore, appropriate pest control measures need to be taken.

[Basic measures]

With efforts ongoing to adapt to high temperatures by fully adopting basic technologies for soil and water management and developing and disseminating high-temperature-resistant varieties, the land devoted to such varieties has been expanding gradually (the percentage of the areas where high-temperature-resistant varieties are planted stood at about 11.2% according to the 2020 Global Warming Impact Investigation Report[10]). Moreover, for measures against pests, efforts such as well-timed outbreak prevention and control of pests based on pest forecast information are promoted. In addition to the above efforts, the following measures will be taken:

○ Focus development efforts on varieties with high-temperature resistance, which are less likely to be damaged by high temperatures <Ministry of Agriculture, Forestry and Fisheries>

○ Considering that decreased yields have already been evident in unusually warm years, develop varieties and breeding materials capable of maintaining fertility against high-temperature sterility[11] to prevent yield declines even in the warmer weather conditions expected in the future. <Ministry of Agriculture, Forestry and Fisheries>

○ Continue efforts to fully adopt basic technologies for soil and water management adapted to high temperatures, and expand the planted areas of high-temperature-resistant varieties by supporting demonstration projects jointly conducted by farmers and consumers to introduce such varieties. <Ministry of Agriculture, Forestry and Fisheries>

(3) Fruit trees

[Impacts]

<Current status>

○ Fruit trees are hardly adaptive to climate change. The 2003 nationwide survey of warming impacts revealed that warming impacts were evident on fruit trees ahead of other crops.

○ After planting trees, fruit farmers grow fruits on the same trees for 30 to 40 years. This means that many of them have been dependent on the same trees since the 1980s, when temperatures were lower, with little change to the varieties and cultivation methods. They are often unable to adapt to the rise in temperature since the 1990s.

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[10] Planted area of staple rice crops for 2020 (nationwide): 1,366,000 ha; planted area of high-temperature-resistant rice varieties for 2020: 152,804 ha.

[11] Being unable to accumulate starch in grains as a result of fertilization being hindered by high temperatures during the flowering period.

○ Fruit growth problems arising from recent warmer climates, such as the peel puffing[12] and physiological dropping (abscission) of citrus fruits, poor coloring and sunburn of apples, poor budding with Japanese pears, water core of peaches, poor coloring of grapes, and softening of persimmons, are observed in almost all tree species and regions.
○ Regarding apples, although the taste is being improved, the flesh is becoming softer, leading to reduced storability.
○ For some fruit tree species, suitable production areas are expanding in some regions due to higher temperatures.

<Projected impacts>
○ For satsuma mandarin oranges, suitable production areas are projected to move northward and expand into inland regions. Projections based on the RCP 8.5 scenario suggest that their suitable production areas may shift inland on the Pacific side of the Kanto region westward of Japan by the end of the 21st century.
○ Regarding apples, it is projected that by the end of the 21st century, temperatures in main producing plains of the Tohoku region and Nagano Prefecture (RCP 8.5 scenario) and some of the plains in main producing prefectures in the central and southern parts of the Tohoku region (RCP 2.6 scenario) will become higher than those in suitable areas and that Hokkaido will have larger suitable areas.
○ The main producing prefectures of grapes, peaches, and cherries are expected to experience growth problems due to higher temperatures. Projections based on the RCP 4.5 scenario indicate that Kyoho grapes grown outdoors will see a significant decline in coloration from 2040 onward.
○ In some areas, cumulative chill hours, which are needed for Japanese pears to break dormancy, may decrease, making a growing part of coastal areas unable to grow varieties with high minimum chill hours by the end of the 21st century.
○ In cold regions that have been unsuitable for growing fruit trees, areas suitable for fruit tree cultivation are projected to expand. If the average global land surface temperature increases 2°C from the levels in the 1990s, Hokkaido may have larger areas suitable for vineyards in its low-altitude regions. Japan currently has limited areas suitable for growing the Tankan subtropical citrus fruit but may see an increase in such areas as the country becomes warmer.

・Fruit trees [Significance (RCP 2.6/8.5): ●/●; Urgency: ●; Confidence: ●]

[Basic approach to adaptation]
○ Fruit trees are perennial crops, which require a certain period to produce fruit, and are prone to price fluctuations due to supply and demand imbalances. Therefore, long-term measures

[12] The phenomenon in which the peel separates from the flesh, resulting in declined fruit quality.

are more keenly needed for them than for other crops. A network that connects major producing regions and prefectures must be developed to ensure that information on global warming impacts and adaptation measures are shared and that action plans are appropriately discussed in producing regions.

○ Efforts should be made to disseminate the practice of spraying gibberellin[13] combined with prohydrojasmon[14] to mitigate peel puffing in satsuma mandarin oranges; the introduction of irrigation and reflective sheets as measures against poor coloring and sunburn of apples; the use of production stabilization technologies like girdling[15] to improve grape coloring; and the use of a germination promoter to mitigate damage caused by poor budding with Japanese pears.

○ In addition, demonstrations and other projects should be promoted to help conversion from satsuma mandarin oranges to medium late ripening citrus fruits, conversion to superior colored varieties of apples and grapes, and introduction of high value-added subtropical and tropical fruit trees.

[Basic measures]

To suppress the occurrence of sunburn on satsuma mandarin oranges due to high temperatures and strong sunlight, the thinning of the fruits in the upper part of the tree crown, which are exposed to direct sunlight, has been recommended. To reduce the occurrence of peel puffing, the use of plant growth regulators such as calcium compounds has been promoted. The spraying of Figaron,[16] which is used for the fruit thinning, has also been promoted as a measure against poor coloring.

Replanting has also been promoted to help farmers switch from satsuma mandarin oranges to medium late ripening citrus fruits (such as the Shiranui and blood orange) that are suitable for warmer climates.

Regarding apples, in addition to planting superior colored varieties (e.g., Akibae) and yellow-colored varieties to address poor coloring, the introduction of irrigation and reflective sheets has been fostered to suppress sunburn and poor coloring.

Common measures against drought used for fruits trees (including peach and cherry trees) are the wider implementation of water evaporation control with mulching sheets and deep plowing and application of organic matter during dormancy to maintain soil moisture. Measures against frost damage, which can be caused by late frosts or other cold events during the flowering period, will also be implemented, such as the establishment of a frost damage alert system through technology guidance and updates, and support for the installation of

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[13] A plant growth regulator used on fruit trees to accelerate growth, induce flowering, and enlarge fruit size.

[14] A plant growth regulator used on fruit trees to accelerate the coloring of fruit and suppress peel puffing in satsuma mandarin oranges.

[15] A technique used to improve the coloring of fruit. It involves peeling off the bark around a trunk to concentrate the nutrients produced in leaves on fruit clusters by preventing them from moving down to the sections below the peeled part.

[16] A plant growth regulator used on citrus fruits for faster ripening, fruit thinning, and the mitigation of peel puffing.

anti-frost equipment (e.g., frost fans).

A common measure applicable to various fruit crops to address poor coloring caused by climate change is to proactively use poorly colored fruits to make fruit juice. To enable this, the government is establishing a production and distribution system for fruits for processing.

In addition to the above efforts, the following measures will be taken:

○ For satsuma mandarin oranges, foster the widespread use of cultivation management technologies, such as the spraying of gibberellin combined with prohydrojasmon to suppress the occurrence of peel puffing and the effective use of shading materials that protect fruits from sunburn. For stabilizing the flower setting, foster the dissemination of production stabilizing technologies, such as improved fertilizer application and water management to constantly achieve good flower setting. <Ministry of Agriculture, Forestry and Fisheries>

○ Regarding apples, foster the widespread use of cultivation management technologies that can reduce the occurrence of poor coloring and sunburn of fruits at high temperature. In view of the projected shift in suitable areas for production, provide support for cultivation demonstrations that are aimed at cultivation in higher-altitude areas and for replanting to alternative varieties. <Ministry of Agriculture, Forestry and Fisheries>

○ Regarding grapes, promote the introduction of superior-colored varieties (e.g., Groß Krone) and yellow-green-colored varieties (e.g., Shine Muscat) to address poor coloring. At the same time, accelerate the dissemination of production stabilizing technologies such as girdling to mitigate coloring problems due to higher temperatures during the ripening period. <Ministry of Agriculture, Forestry and Fisheries>

○ For Japanese pears, mitigate damage caused by poor budding by focusing on the introduction and dissemination of technology-based measures, such as using germination promoters and changing the fertilizers application timing. <Ministry of Agriculture, Forestry and Fisheries>

○ On the breeding side, develop breeding materials adaptive to high temperature conditions and grow the resultant varieties for introduction in producing areas through demonstrations. <Ministry of Agriculture, Forestry and Fisheries>

○ In addition to the above, to prepare for the projected future where climate change will make the country warmer, allowing more areas to grow subtropical and tropical fruits in facilities, work on demonstrations to introduce high value-added subtropical and tropical fruits (e.g., atemoyas, avocados, mangoes, and lychees) and promote conversion from existing fruit trees in line with local producers' selection. <Ministry of Agriculture, Forestry and Fisheries>

○ If the temperature zone favorable to the cultivation of apples or other fruits moves northward as climate in Japan becomes warmer, forming production areas in new regions would be possible. When developing such new production areas, promote establishment of low-cost and labor-saving orchards. <Ministry of Agriculture, Forestry and Fisheries>

(4) Barley/wheat, soybeans, and other land-extensive crops

[Impacts]

<Current status>

○ Regarding wheat, delayed sowing season and early ear emergence have been observed nationwide due to warmer winters and springs, leading to shorter growth periods.

○ Regarding soybeans, some regions have reported a decline in 100-bean weight due to hotter summers and a decreased number of pods and declined quality under continued hot and dry conditions.

○ For tea plants, reported growth problems include inhibited growth of the second and third crops due to hot and dry summers, and the reshooting of winter buds and the delayed budding for the first crop due to warmer winters.

○ In Hokkaido, as soil frost depth decreases, how to deal with volunteer potatoes, or potato plants that emerge like weeds from potatoes left in the field after harvest, has become an issue.

<Projected impacts>

○ Regarding wheat, a statistical analysis of autumn-sown wheat in Hokkaido has revealed that temperatures during the growth period have negative correlations with the length of stems and ears and with 1000-grain weight, creating concerns that higher mean temperature during the period from ear emergence to ripening may decrease yields.

○ Other issues that have been pointed out include a higher risk of frost damage due to accelerated growth caused by high temperatures after sowing and a reduced protein content associated with higher concentrations of carbon dioxide.

○ Studies suggest that in soybean cultivation in cold regions, although higher temperature does not significantly affect yields, higher concentrations of carbon dioxide accelerate photosynthesis, thus increasing seed weight. On the other hand, in soybean cultivation in warm regions, a higher temperature may lead to a decline in yield.

○ In Hokkaido, although yields of sugar beets, soybeans, and red beans may increase in the 2030s, they may face pests as well as a decline in quality. Wheat and potatoes are projected to see a decline in yield and quality.

○ Meanwhile, some studies estimate that potential crop yields will decrease for potato production in Hokkaido if 2°C warming alone is considered, although they will increase if a longer cultivation period enabled by higher temperatures, along with higher concentrations of carbon dioxide, are taken into account.

○ In the Kanto region, the rise in mean temperature by 2°C is projected to increase the risk of winter-killing of oats throughout the plain areas.

○ Regarding tea plants (Yabukita cultivar), it is estimated that in the Kanto region, including Shizuoka Prefecture, the time with a high risk of frost damage will move forward as the

picking season of the first crop comes earlier and that the lack of exposure to cold temperatures during autumn and winter will lead to more evident declines in the yield of the first crop throughout the Nansei Shoto Islands.

・Barley/wheat, soybeans, forage crops, etc. [Significance: ●; Urgency: ▲; Confidence: ▲]

[Basic approach to adaptation]

○ The yields of crops such as barley/wheat, soybeans, red beans, and sugar beets easily fluctuate with precipitation, temperature, and other weather conditions, and can decline from moisture damage, plant pests, etc. This indicates the importance of securing stable production and supply systems through the introduction of farming technologies adapted to climate change and the development of varieties highly resistant to plant pests.

○ Regarding potatoes, as soil frost depth decreases due to more snow cover in early winter in Hokkaido, how to deal with volunteer potatoes, or potato plants that emerge like weeds from potatoes that have been left in the field after harvest and survived the winter, has become a serious issue because they hamper the growth of follow-up crops and continuous cropping and attract pests. Actions are needed to prevent unharvested potato crops from surviving the winter.

○ For tea plants, emphasis will be placed on measures to prevent frost damage, such as the introduction of energy-efficient frost fan systems and other frost prevention technologies. Other measures include soil moisture evaporation control (with grass mulch, etc.) and irrigation to address drought, and replacement with pest-resistant varieties for better pest control.

[Basic measures]

○ For barley and wheat, take measures against heavy rainfall and moisture damage, including fully adopting basic techniques such as drainage measures, well-timed control of fusarium head blight (FHB), and well-timed harvesting; and converting to varieties more resistant to FHB, pre-harvest sprouting[17], and other problems. To prevent frost damage, develop and disseminate varieties and breeding materials adapted to climate change and production stabilizing technologies. <Ministry of Agriculture, Forestry and Fisheries>

○ For soybeans and red beans, take measures against heavy rainfall, high temperature, and drought by fully implementing drainage measures and disseminating ground-water-level control systems. To control pests and weeds, develop and disseminate pest-resistant varieties and breeding materials, as well as weed control techniques. Also, develop cultivation systems less likely to be affected by climate change, such as the application of

[17] The phenomenon in which germination occurs before harvest when the kernel is still in the ear, which is mainly caused by rainfall during the harvest period.

organic matter and crop rotation, which mitigates pest occurrence risk. <Ministry of Agriculture, Forestry and Fisheries>

○ Regarding sugar beets, take pest control measures by disseminating varieties resistant to multiple diseases most likely caused by high temperatures. To adapt to high temperatures, focus efforts on periodically monitoring and surveying the production status in fields and on accumulating knowledge needed for selecting the optimal varieties, along with drainage measures against heavy rainfall. <Ministry of Agriculture, Forestry and Fisheries>

○ Regarding potatoes, control volunteer potatoes in Hokkaido by encouraging snow-breaking and snow-compaction practices in post-harvest fields to foster soil frost and the frost-kill of tubers and thus prevent unharvested potato crops from surviving the winter. <Ministry of Agriculture, Forestry and Fisheries>

(5) Vegetables

[Impacts]

<Current status>

○ Past surveys have revealed that impacts of climate change are evident in 40 or more prefectures, indicating that climate change impacts are widespread across Japan.

○ Harvest seasons are coming earlier for some open field vegetables, particularly leafy vegetables such as cabbage, root vegetables such as daikon radish, and fruit vegetables such as watermelon, and the occurrence of growth problems is increasing for them.

○ For leafy vegetables such as spinach, spring onion, cabbage, and lettuce, poor growth and physiological disorders caused by high temperatures or rainy/dry weather have been reported. Physiological disorders and declined quality, presumably caused by stress from high temperatures, dryness, or strong sunlight, have also be reported in broccoli.

○ For fruit vegetables such as tomato, eggplant, cucumber, and green pepper, poor fruit bearing and poor growth due to high temperatures, heavy rainfall, etc. have been reported.

○ For root vegetables such as daikon radish, carrot, and taro, poor growth and poor sprouting due to high temperatures, heavy rainfall, etc. have been reported.

○ For strawberries, delay in flower bud differentiation for higher temperatures has been reported in crops for winter to spring harvest, and unstable flower bud formation on crops for summer to autumn harvest.

○ Among ornamental plants, earlier or delayed flowering and poor growth due to high temperatures have been reported with chrysanthemums, roses, carnations, eustomas, autumn bellflowers, and lilies.

○ In recent years, climate change has been intensifying weather-related disasters in both scale and frequency. Tropical cyclones, heavy snow, and other natural disasters have had impacts, such as collapsed greenhouses.

<Projections>

○ It is assumed that cultivation of leafy and root vegetables, with relatively short growth periods, will most likely be sustainable if cultivation periods are shifted.
○ For cabbage, lettuce and other leafy vegetables, accelerated growth due to higher temperatures, the northward shift of viable growing areas, and heavier crops associated with higher concentrations of carbon dioxide are projected.
○ For fruit vegetables (tomato and bell pepper), higher temperatures may affect the size and yield of fruit.

・Vegetables [Significance: ◆ ; Urgency: ● ; Confidence: ▲]

[Basic approach to adaptation]
○ Regarding open field vegetables, adaptation efforts should be focused on introducing varieties and cultivation techniques adapted to warmer conditions.
○ For open field ornamental plants, efforts should be focused on promoting appropriate irrigation and disseminating varieties and cultivation techniques adapted to warmer conditions.
○ For vegetables and ornamental plants grown in greenhouses, making greenhouses more weather-resistant and improving the emergency preparedness of farmers are needed to respond to more frequent weather-related disasters.

[Basic measures]
○ For open field vegetables, develop and disseminate varieties adaptable to warmer conditions and promote the selection of suitable varieties, adjustment of cultivation periods, and well-timed pest control. Also, help farmers better prepare for drought by deep plowing and the application of organic matter to maintain soil moisture and by building field irrigation facilities, securing water, and laying mulching sheets to suppress soil moisture evaporation. Promote well-timed pest control against spider mites, aphids, powdery mildew, and other pests highly likely to occur in droughts. <Ministry of Agriculture, Forestry and Fisheries>
○ For open field ornamental plants, promote appropriate watering in the early morning and early evening according to the growth of plants to adapt to high temperatures; the establishment of irrigation facilities to secure water to address droughts; surface soil cultivation and mulching to prevent soil surface evaporation; and well-timed pest control against pests emerging during drought. Also, select varieties adaptable to warmer conditions and develop and disseminate cultivation techniques adapted to warmer conditions. <Ministry of Agriculture, Forestry and Fisheries>
○ For vegetables and ornamental plants grown in greenhouses, make greenhouses more weather-resistant by promoting the introduction of low-cost, weather-resistant greenhouses that can withstand natural disasters, the reinforcement of greenhouses built with pipes, and the introduction of backup power sources. To address high temperatures, focus on

appropriate ventilation and shading, and the introduction of mulching for ground temperature control, fog cooling machines, pad and fan systems,[18] circulating fans, and heat pumps[19]. To prepare for natural disasters, encourage farmers to establish business continuity plans (BCPs). <Ministry of Agriculture, Forestry and Fisheries>

(6) Livestock farming and forage crops

[Impacts]

<Current status>

(Livestock farming)

○ Decrease in milk yields and milk components of dairy cows, decline in the growth and meat quality of beef cattle, hogs, and meat-type chickens, and decrease in the egg-laying rate and egg weight of egg-laying chickens during summer have been reported.

○ In the record hot summer of 2010, the number of livestock which died or had to be culled due to heat stress was higher than that in the previous year across all livestock species in all regions, according to reports.

○ Studies on dairy cows show that lactation volume decreases as temperature and humidity rise and that breeding performance and calf growth decline as temperature rises. Studies also show that the digestion and absorption ability of hogs and the delivery rate of pregnant pigs decrease as temperature rises and that the feed intake of egg-laying chickens decreases at higher temperatures, resulting in the decline in the number of laid eggs and egg quality.

(Animal infectious diseases)

○ An epidemic of cow infections with arboviruses (arthropod-borne viruses), which are distributed in tropical and subtropical regions and had not been previously found in Japan, as well as a distribution of *Culicoides brevitarsis*, which serves as an arbovirus vector and which was considered to inhabit only the Nansei Shoto Islands, has been confirmed in the Kyushu region.

○ It is reported that the Akabane virus, a strain of arbovirus, directly entered the Tohoku region and that the birth of abnormal calves due to infection with the virus has spread even to Hokkaido.

(Forage crops)

○ Reports on forage crops show that in some parts of the Kanto region, the dry matter yield of forage corn continued a year-on-year increase during the 2001 to 2012 period.

<Projected impacts>

[18] A system that combines a moist cooling pad and a cooling fan to cool an agricultural greenhouse through evaporative cooling.

[19] A technology designed to efficiently use thermal energy with limited energy input (e.g., electricity).

(Livestock farming)

○ Although the degree of impact may vary by livestock species and breeding method, as the climate become warmer, wider areas will see growth performance of livestock and fowls decline, including daily gains of dairy cows and fattening hogs, and meat production of meat-type chickens, and the extent of such decline is expected to increase.

○ For dairy cows, projections suggest that high temperatures will further increase negative impacts, such as mortality risk, the risk of reduced milk yields, and the risk of reduced conception rates.

(Forage crops)

○ Higher temperature may increase the risk of summer growth depretion and winter-killing for some crops.

○ Projections on forage crops (forage corn) indicate that suitable production areas for the double cropping of forage corn will expand in the Kanto to Kyushu regions by the 2080s.

・Livestock farming [Significance: ●; Urgency: ●; Confidence: ▲]

・Barley/wheat, soybeans, forage crops, etc. [Significance: ●; Urgency: ▲; Confidence: ▲]

[Basic approach to adaptation]

○ Adaptation efforts should be focused on making livestock and fowls feel cooler through improved rearing density and sprinkling mist to their bodies, and on improving the livestock barn environment by ventilating the barn with fans, shading with cheesecloth or reed screens, lining the roof with heat insulator, sprinkling the roof with water, or applying slaked lime. The animals should also be provided with favored and nutritious feed, as well as clean, cold water.

○ Japan should pursue a shift to solid feed production based on the domestic feed production infrastructure while adapting to global warming and considering the situation of the production infrastructure.

[Basic measures]

○ For livestock and fowls, secure an adequate livestock barn environment by disseminating summer heat control measures, such as water/mist sprinkling in the livestock barn, ventilation of the barn, and application of lime and water sprinkling to the roof; and guide and recommend livestock farmers to avoid close rearing, properly conduct clipping, and use adequate feeding management techniques, such as supplying cold water and feedstuff of good quality. Also, develop and disseminate productivity improvement techniques to prevent the decline in the rate of gain and fertility in summer through adequate nutrition management. <Ministry of Agriculture, Forestry and Fisheries>

○ To address animal infectious diseases, consider risk management, including effective measures to prevent arthropod-borne livestock infectious diseases, and conduct surveys of wild birds to prevent avian influenza. <Ministry of Agriculture, Forestry and Fisheries; Ministry of the Environment>

○ Regarding forage crops, focus on measures to adapt to heat, such as establishing cultivation systems adapted to climate change (e.g., mitigating the impact of reduced yields due to unseasonable weather by planting multiple grass varieties to diversify harvest time) and developing and disseminating cultivation management technologies along with varieties and breeding materials with heat resistance and wider ripening periods. Also, address pest control by developing and disseminating pest-resistant varieties and breeding materials. <Ministry of Agriculture, Forestry and Fisheries>

(7) Plant pests, weeds, etc.

[Impacts]

<Current status>

(Insect pests)

○ Southern green stink bugs and golden apple snails, which are mainly found on rice plants in southwestern parts of Japan, (i.e., relatively warm areas such as southern Kyushu), have been recently found in wide areas of western Japan and some parts of the Kanto region, and this has been pointed out to be an impact of warming.

○ The number of plant hoppers, a common rice insect pest that migrates to the Kyushu region from abroad, depends on wintering in northern Vietnam and the frequency of strong upper level winds.

○ For insect pests other than those related to rice plants, there have been reports and indications of the northward shift and expansion of distribution, increased populations, and the possibility of wintering, resulting from higher temperature.

(Diseases)

○ Field testing reports show that the infection rate and the relative lesion height to plant height regarding rice sheath blight were higher in years when temperature was higher around the ear emergence period.

○ Some regions reported the occurrence of lettuce root rot and corn browning root rot due to high temperatures.

○ The occurrence areas of ryegrass blast are moving northward, and some researchers point out that this is related to global warming.

(Weeds)

○ It has been reported that some of grass weed variety that grew on the Amami Islands and further south are now able to survive the winter and have invaded Kyushu in recent years.

○ In the Tohoku region, higher temperatures have affected the distributive characteristics of the ecosystem of the cogon, a grass weed variety.
○ The expanded distribution of the Madagascar ragwort, an invasive alien species, is estimated to be closely related to the mean temperature of the hot quarter.

(Mycotoxins)
○ A nationwide survey of the distribution of aflatoxin-producing fungi in soil has suggested that temperature contributes to their distribution.

<Projected impacts>
(Insect pests)
○ Due to higher temperatures, an increase is expected in the number of annual generations (number of annual cycles of growth from egg to adult) of parasitic natural enemies, some parasitoids, and pests; and as a result, changes are expected to occur in the composition of rice paddy pests and natural enemies.
○ Southern green stink bugs, rice stem borers, and rice green leafhoppers, which are rice paddy pests, are projected to increase in population due to higher temperatures. The Tohoku and Hokuriku regions are projected to face a higher potential risk of the occurrence of small brown plant hoppers and rice stripe disease transmitted by them.
○ Some studies project that the risk of pecky rice damage will increase as the peak date of the occurrence of adult sorghum plant bugs, a rice paddy pest, approaches the ear emergence period of rice.
○ For pests other than rice paddy pests as well, studies have indicated the potential increase of damage due to the northward shift and expansion of the winter survival range and suitable habitats, and increase in annual generational cycles.
○ Some researchers have pointed out that hotter summers may cause high heat damage to southern green stink bugs and some species of aphids.

(Diseases)
○ Some studies project increases in the incidence of disease, based on experiments under higher CO_2 conditions (200 ppm higher concentrations than current levels).
○ Some studies project that higher temperature will increase damage from rice sheath blight.
○ Other studies suggest that the decline in rainfall frequency will reduce leaf surface wetness, while the increase in rainfall intensity will wash off pathogens, resulting in a lower infection risk.

(Weeds)
○ Projections point out that higher temperatures may allow some species, such as jungle rice and naturalized morning glories, to expand their establishment ranges and move northward.

○ Some researchers suggest that in Hokkaido, higher temperatures will increase the number of days that meet the germination conditions for Powell's amaranth, a naturalized weed, and these days will come earlier than before, possibly increasing the occurrence of the weed after the sowing of crop seeds.

(Mycotoxins)

○ There is concern that higher temperatures may increase the population density of aflatoxin-producing fungi in soil.

・Plant pests, weeds, etc. [Significance: ●; Urgency: ●; Confidence: ●]

[Basic approach to adaptation]

○ To prevent the emergence and spread of plant pests in Japan, adaptation efforts should be focused on promoting well-timed pest control based on pest forecast information, early detection and control of invasive pests, and stricter plant movement restrictions, as well as on advancing pest control techniques.

○ Concerning weeds, technology to mitigate weed-related damage should be developed.

○ With regard to mycotoxins, efforts should continue to investigate occurrence data, establish and disseminate measures to improve safety in cooperation with producers and verify their effects after a certain period.

[Basic measures]

○ Regarding pests occurring within Japan, noting that accurately ascertaining the occurrence and the situation of damage is essential, continue to implement the pest forecasting project for the plants and animals designated as harmful species[20] to investigate changes in the status of the occurrence and damage; and disseminate such information to foster timely and proper pest control. Also, review the list of plants and animals designated as harmful species covered by the pest forecasting project according to climate change; and establish a pest control system adapted to climate change. <Ministry of Agriculture, Forestry and Fisheries>

○ Regarding serious pests[21] that are absent, or present but not widely distributed, in Japan, continue phytosanitary measures in order to prevent the introduction of pests from overseas, domestic quarantines for preventing serious pests from spreading in Japan, and surveillance and control of the entry of serious pests; and implement further risk assessment of pests based on information available in Japan and abroad. Also, work on reviewing phytosanitary measures based on the results of risk assessment of pests. <Ministry of Agriculture,

[20] Insect and disease pests that are specified by the Minister of Agriculture, Forestry and Fisheries under Article 22 of the Plant Protection Act (Act No. 151 of 1950) as those distributing in Japan beyond the local level with the tendency of spreading quickly to do material harm to crops.

[21] Insect and disease pests that can possibly do material harm to useful plants if they spread within the country.

Forestry and Fisheries>

○ As for long-range migratory pest insects,[22] establish technology for evaluating changes in migration trends from overseas, (i.e., the period of migration and the number of migrating insects), and technology for projecting changes in distribution ranges in Japan (i.e., northward expansion of the winter survival range and earlier occurrence and migration). <Ministry of Agriculture, Forestry and Fisheries>

○ Promote the elucidation of the effects of disease pests expected to increase in occurrence in rice paddies, such as rice sheath blight and rice stripe disease, on rice yields, and the development of techniques to prevent such diseases. <Ministry of Agriculture, Forestry and Fisheries>

○ Continue surveys on mycotoxin contamination of domestic agricultural products and forage crops to adapt to climate change impacts. If increased mycotoxin contamination of agricultural products and forage crops can adversely affect human and livestock health, develop technologies to suppress contamination and disseminate them to producers. Periodically verify the effectiveness of mycotoxin contamination suppression measures and review them to incorporate new knowledge. <Ministry of Agriculture, Forestry and Fisheries>

(8) Agricultural production infrastructure

[Impacts]

<Current status>

○ Regarding changes in the temporal and spatial distribution of precipitation that can affect agricultural production infrastructure, analysis of the maximum rainfall amounts on three consecutive days from 1901 to 2000 found a trend toward intense rainfall over short periods, and that in particular this trend is getting stronger in Shikoku and southern Kyushu.

○ Also, for the 10-year moving coefficient of variation for annual precipitation, the moving average was found to be increasing year after year, with the trend being progressively larger toward the south.

○ Reservoir management organizations across Japan face issues arising from more frequent periods with scarce rainfall (or snowfall), such as insufficient recovery of the reservoir water level or water shortages in beneficiary areas. Operators of drainage pump stations across Japan have also seen changes, such as the increase in annual pump operation time due to heavy rains and floods.

○ High heat damage to crops has also been observed (e.g., a decline in rice quality), and in

[22] Insect pests that travel from several hundred to several thousand kilometers using not only their own flying capability but also large-scale weather phenomena. These include many insect pests harmful to agriculture such as plant hoppers, aphids, and owlet moths. Insect pests such as the rice brown plant hopper and the white backed plant hopper are known to migrate mainly to western Japan across the sea from mainland China by a low-level jet stream that develops during the rainy season (known as the Baiu) in Japan.

response there have been impacts on the way water resources are used, including a shift in the rice-planting season and irrigation periods, as well as the use of surface flooding irrigation.

<Projected impacts>

○ Regarding impacts on agricultural production infrastructure mainly from water shortages and accelerated snow melt, there are projections of a reduction in runoff from snow melt due to higher temperatures, with impacts on water intake for agricultural water control facilities. Specifically, in the RCP 2.6 scenario, the amount of available water will decrease during the puddling season for paddy rice cultivation in northern Japan (Tohoku and Hokuriku regions) by the end of this century; in the RCP 8.5 scenario, similar decreases are projected in western Japan (Kinki and Chugoku regions) and Hokkaido as well.

○ Flood risk is projected to increase nationwide during the June-October period, which covers the rainy season (known as the Baiu) and the typhoon season. Regarding impacts on agricultural production infrastructure from floods due to increased intensity of rainfall, the risk of damage to farmland is expected to increase due to longer periods of low-elevation rice paddies being submerged, according to projections that take into account uncertainties about the characteristics of future heavy rainfall events.

○ A nationwide analysis of the impact that medium- to long-term precipitation changes due to climate change will have on reservoirs for flood control shows that in both the RCP 2.6 and RCP 8.5 scenarios, the manpower needed for reservoir management will increase as the precipitation thresholds for a heavy rain advisory will be exceeded more frequently by end of the 21st century. Also, in both scenarios, the likelihood of reservoir water levels exceeding the flood level during heavy rainfall is projected to increase by end of the 21st century. On the other hand, there will be more dry days, possibly affecting the recovery of reservoir water amounts.

・Agricultural production infrastructure [Significance: ●; Urgency: ●; Confidence: ●]

[Basic approach to adaptation]

○ In order to respond appropriately to more frequent and intense rainfall and other disasters and to achieve stable farming as well as safe and comfortable living in farming villages, the government should appropriately combine structural measures, such as the lifespan extension of agricultural irrigation facilities, water-resistant measures, and the establishment of emergency power sources, with non-structural measures such as the creation of hazard maps and activities to raise the awareness of local residents, based on the Fundamental Plan for National Resilience (approved by the Cabinet in June 2014; revised in December 2018) and the Basic Plan for Food, Agriculture and Rural Areas (approved by the Cabinet on March 31, 2020).

[Basic measures]

○ Conduct investigations needed for the development of adaptation measures for agricultural production infrastructure in accordance with the Global Warming Measures in Agricultural and Rural Development, and promote the development of technologies that contribute to responding to global warming in accordance with the technology development plan concerning agricultural and rural development. <Ministry of Agriculture, Forestry and Fisheries>

○ Consider the impacts of higher temperatures, reduced runoff from snow melt, and other phenomena projected in the future; and effectively secure and use agricultural water by appropriately combining structural and non-structural measures, including saving irrigation water by automated water management and pipelined waterways, and effectively using existing water resources by changing the way reservoirs for flood control and agricultural dams are operated. <Ministry of Agriculture, Forestry and Fisheries>

○ Work to maintain and enhance DRR capacities in rural areas. For this purpose, appropriately combine structural and non-structural measures, including preventing farmland flooding by developing drainage pump stations and drainage canals to prepare for increasing torrential rainfalls; identify facilities and areas highly vulnerable to inundation; conduct risk assessment activities, such as formulating hazard maps; and promote the development of business continuity plans by facility managers. Take these measures effectively by utilizing the existing facilities and deploying local communities' functions. <Ministry of Agriculture, Forestry and Fisheries>

○ Project and assess medium- to long-term impacts, based on new scientific findings obtained through the future advancement of climate change research. <Ministry of Agriculture, Forestry and Fisheries>

○ Establish the method of assessing impacts on agricultural production infrastructure based on new scientific findings and climate models, thus providing the grounds for infrastructure building in line with projections, and then consider how infrastructure building should be addressed in the future. <Ministry of Agriculture, Forestry and Fisheries>

2. Basic adaptation measures for forestry

(1) Timber production (planted forests, etc.)

[Impacts]

<Current status>

○There have been reports on decline of Japanese cedar forests in some regions, and some studies have attributed this phenomenon to an increase in water stress in cedar trees resulting from a drier atmosphere. However, there is no clear evidence that the decline of Japanese cedar forests was caused by climate change including warmer temperature, more frequent rainless periods, and drier atmosphere and soils. It is also unclear what extent of

soil drought will induce water stress in cedar trees.

○ There have been reports on the higher risk of damage from pine wilt disease associated with higher temperature and on the expansion of the northern limit of distribution for this disease. However, careful verifications are needed because non-temperature factors may be related to the damage from pine wilt disease.

<Projected impacts>

○ Some studies have pointed out that an increase in air temperature by 3°C above current levels would enhance the transpiration rate of Japanese cedar trees, and consequently, the vulnerability of Japanese cedar planted forests to drought may increase, especially in areas with low annual rainfall.

○ Some studies have shown no clear increase in biomass growth rate associated with temperature increase for Japanese cypress seedlings; other studies have found that the 3°C warming will inhibit the growth of red pine seedlings.

○ An ongoing study tries to estimate the net primary production in Japanese cedar planted forests at national scale by developing process models which include physiological and physical processes in forest ecosystems such as photosynthesis, evapotranspiration, and nutrient cycling. As for Kyushu region, some study projected that average annual warming of 0.9°C by 2050 would reduce the net primary production in Japanese cedar planted forests, whereas other estimates suggested that global average warming of 4.5°C by 2100 would increase the net primary production of the planted forests in large areas of the region.

○ Observations of carbon flux in the forest floor (e.g., soil respiration, microbial respiration, photosynthesis by forest floor vegetation) conducted in Japanese larch planted forests found that annual cumulative carbon emissions increased as annual average soil temperature rose. This suggests that if soil temperatures increase due to higher atmospheric temperature, carbon dioxide emissions from Japanese larch planted forests may also increase.

○ Several studies have predicted that warmer climates would expand the distribution areas for pests and disease including pine wilt disease, Sakhalin fir aphids, and brown tea root disease. Other studies also suggested that the future warming would increase the number of generations per year of spruce bark beetles, which might enhance damage and mortality of spruce species, and that of sugi bark borers.

・Timber production (planted forests, etc.) [Significance: ●; Urgency: ●; Confidence: ▲]

・Planted forests [Significance: ●; Urgency: ●; Confidence: ▲]

[Basic approach to adaptation]

○ Investigation and research on the impacts of climate change on forests and forestry should

be promoted.

○ To prevent the spread of forest pests, the national government will continue pest control in cooperation with prefectural governments in accordance with the Forest Pest Control Act (Act No. 53 of 1950).

○ To respond to the risk of spreading the distribution ranges of insects that can be invigorated by higher temperature, the government will promote studies on climate change impacts and measures against insects damage and continue the monitoring of damage to forests.

○ To assess impacts of climate change on forestry, the government will investigate adaptation abilities of major planted forest species such as Japanese cedar and Japanese cypress to environmental changes (e.g., higher temperature and drought) by common garden experiments. The government will also monitor the impacts on the growth of these planted trees as well as their surrounding environments (e.g., lower-layer vegetation), and assess risks to long rotation-period forests management under such conditions.

[Basic measures]

○ To prevent the spread of forest pests, continue pest control in cooperation with prefectural governments in accordance with the Forest Pest Control Act. <Ministry of Agriculture, Forestry and Fisheries>

○ Continue to monitor damage to forests by pests and diseases. <Ministry of Agriculture, Forestry and Fisheries>

(2) Non-wood forest products (mushrooms, etc.)

[Impacts]

<Current status>

○ It is being confirmed that damage caused by *Trichoderma harzianum*, a pathogen of shiitake mushrooms that is found frequently in bed log laying yards for shiitake, increases in high temperature environments.

○ There have been reports on emerging damage to shiitake from the *Hypocreales* genus of fungus in producing areas of Kyushu where bed logs cultivation is used. Damage has also been reported from regions that were previously free of such damage, including Chiba, Ibaraki, Shizuoka, and Aichi Prefectures, suggesting the growth of affected areas.

○ It has been reported that higher summer temperatures may be contributing to increasing damage from the *Hypocreales* fungus.

<Projected impacts>

○ Regarding shiitake bed log cultivation, there have been reports pointing out the relationship between higher summer temperatures and the outbreak of disease-causing fungi, as well as a decrease in the amount of the fruiting body of shiitake mushrooms.

○ The impacts that higher winter temperatures have on shiitake bed log cultivation are not yet

known.

○ Some studies project the earlier occurrence of *nakamon-namikikobae* (*Mycetophila ruficollis*) and increased occurrences of *murasaki-atsuba* (*Diomea cremata*), both insect pests for shiitake cultivated on bed logs.

・Non-wood forest products (mushrooms, etc.) [Significance: ●; Urgency: ●; Confidence: ▲]

[Basic approach to adaptation]

○ Promote the development and improvement of technologies that help adaptation to climate change through sustainable use and efficient production.

[Basic measures]

○ Make efforts such as ascertaining climate change impacts on shiitake bed log cultivation, including the status of damage caused by disease-causing fungi and the infection route, the occurrence of damage caused by fungus gnat pest insects, and the influence on yields under high temperature conditions in summer; and examining a cultivation method that can suppress temperature rise in a bed log laying yard by spreading cheese cloth as a sunshade. <Ministry of Agriculture, Forestry and Fisheries>

○ Promote accumulation of data on outbreaks of disease-causing fungi and influence on yields due to warming; and development, verification and dissemination of shiitake cultivation techniques and breeds adapted to warmer climates. <Ministry of Agriculture, Forestry and Fisheries>

3. Basic adaptation measures for fisheries

(1) Migratory fish stocks (marine fisheries)

[Impacts]

<Current status>

○ The rise in ocean temperature since the 20th century has been pointed out as a factor for the decline in the total allowable catch worldwide.

○ Today, changes in the distribution ranges of marine organisms associated with global warming are observed around the world. Listed below are changes in the distribution ranges of major aquatic resources (migratory fish stocks) in waters around Japan and associated changes in the fishing season and grounds.

- Spawning grounds for chub mackerel have shifted northward along with the rise of ocean surface temperature, delaying the end of the spawning season.
- Catches of yellowtail are increasing across Japan. One presumable factor is an increased number of fish due to high ocean temperature maintained in the warming regime or the formation of fishing grounds driven by changes in the distribution/migration range.

・Catches of Japanese Spanish mackerel are increasing in the Sea of Japan and waters off the Pacific coast of the Tohoku region.
・The proportion of chum salmon returning has fallen presumably because of the change of the time when water temperature range is suitable for young salmon in early stages of their oceanic life.
・The occurrence and survival of Japanese flying squid decreased due to higher water temperatures in their spawning grounds.
・For Pacific saury, fishing and spawning grounds have moved off the coast, which is presumably attributable to changes in the flow patterns of the Oyashio and the Kuroshio Currents.
・The number of Alaska pollack may have reduced in waters around Hokkaido and in the Sea of Japan.

○ In some regions, these changes arising from higher water temperatures have even affected the processing and distribution sectors.

<Projected impacts>

○ The total allowable catch is projected to decrease worldwide. Some projections suggest that in the RCP 8.5 scenario, the total allowable catch at the end of the 21st century will be about 20% less than that at the beginning of the same century.

○ For migratory fish stocks in waters around Japan, there have been many reports projecting impacts on the distribution/migration range and body size. Specific impacts on some fish species are described below.

・For salmons and trouts, some studies project that higher water temperatures will lead to the reduction in the distribution range.
・For Pacific saury, fishing grounds will more likely be formed in international waters, creating concern about the impact on fishing by Japanese fishery workers.
・For Japanese flying squid, waters with low distribution densities are expected to expand off the coast of northern Honshu by 2050 and off the coast of Hokkaido by 2100. Some projections indicate smaller sizes and a shift in the spawning season in the Sea of Japan.
・For Japanese sardine, some studies project a northward shift of the distribution of adult fish and sea areas suitable for the survival of larval and juvenile fish, in response to increasing sea surface temperature.
・For yellowtail, the distribution is projected to expand northward, along with changes in wintering ranges, and there is concern over decline in quality in existing producing regions.

・Migratory fish stocks (ecology of fishes) [Significance: ●; Urgency: ●; Confidence: ▲]
(Related categories)

・Marine ecosystems [Significance: ●; Urgency: ▲; Confidence: ■]
・Coastal ecosystems (subtropical zone) [Significance: ●; Urgency: ●; Confidence: ●]
・Coastal ecosystems (temperate/subarctic zone) [Significance: ●; Urgency: ●; Confidence: ▲]

[Basic approach to adaptation]
○ To foster resource management based on scientific evaluations, appropriately assessing the impacts of environmental changes is essential.
○ To address this, efforts should be focused on enhancing the accuracy of fishing ground forecast and stock assessment through marine environmental surveys. Based on the results, measures should be implemented to enable adaptive fishery production activities according to environmental changes.

[Basic measures]
○ Improve the accuracy of ocean condition forecast models by upgrading the method of assimilating various observational data obtained from research vessels and satellites. Based on such information, work to improve the accuracy and efficiency of the acquisition and projection of stock abundance in the changing environment, as well as the forecast of fishing grounds. <Ministry of Agriculture, Forestry and Fisheries>
○ Regarding highly migratory species (e.g., tunas and bonitos) that require resource management through international efforts, seek to collect various data (e.g., information on stock, genomes, and the ocean) and develop a system to integrate and analyze such data, with the goal of estimating the carrying capacity of marine ecosystems, which is considered to fluctuate due to climate change impacts. <Ministry of Agriculture, Forestry and Fisheries>
○ Identity climate conditions and marine environmental conditions contributing to the outbreak of harmful plankton and develop a system to promptly provide real-time information to relevant institutions, based on a variety of coastal observation information, concerned with real-time monitoring. <Ministry of Agriculture, Forestry and Fisheries>
○ Noting that changes in the marine environment affect the survival of released juvenile salmon and other species, develop releasing methods for juvenile salmon and other species that are adaptable to changes in the marine environment. <Ministry of Agriculture, Forestry and Fisheries>

(2) Propagation and aquaculture (mariculture)
[Impacts]
<Current status>
○ There have been reports of a mass mortality of scallops due to high water temperatures and more dead oysters in years with relatively high water temperature and less rain.

○ As for cultivated nori seaweed, annual harvests have been decreasing in many regions due to a later start of seeding caused by high water temperature in autumn. There have also been reports on feeding damage caused by fish.
○ Regarding cultivated wakame seaweed, some regions have experienced declines in yield partly because higher water temperatures in autumn and the harvest season (February to March) have caused a delay in the time for planting seedlings in the sea and adverse effects to growth and quality in the peak harvest season. As in the case with cultured nori seaweed, there have been reports on feed damage caused by fish.
○ For harmful/poisonous plankton, there have been reports of the northward expansion of the northern limit of occurrence, the occurrence of warm water species in cold regions, and earlier occurrence. In addition, the distribution ranges of toxified fish and southern poisonous fish species that can cause ciguatera fish poisoning may be expanding.

<Projected impacts>
○ Some sea areas that produce farmed fish are expected to become unsuitable for fish farming due to increasing water temperatures in summer.
○ Regarding nori seaweed cultivation, in the RCP 2.6 scenario, higher water temperatures will make the start of seedling culture about 20 days later in the 2050s than it is today. In the RCP 8.5 scenario, the start of seedling culture will be pushed backward by the 2050s and further by the 2090s, creating concerns over the reduced number of crops and lower yields.
○ Regarding wakame seaweed cultivation, in the RCP 8.5 scenario, the sprouting season will be about a month later by the end of the 21st century than it is today. A shorter harvest season is expected as well.
○ IPCC reports have presented concern over the impact of ocean acidification on shellfish aquaculture.
○ Harmful algal blooms related to rising sea temperatures are expected to increase the risk of bivalve die-offs.

・Propagation and aquaculture [Significance: ●; Urgency: ●; Confidence: ▲]
・Coastal and inland fishing ground environment [Significance: ●; Urgency: ●; Confidence: ▲]

(Related categories)
・Marine ecosystems [Significance: ●; Urgency: ▲; Confidence: ■]
・Coastal ecosystems (subtropical zone) [Significance (RCP 2.6/8.5): ●/●; Urgency: ●; Confidence: ●]
・Coastal ecosystems (temperate/subarctic zone) [Significance: ●; Urgency: ●; Confidence: ▲]

[Basic approach to adaptation]

○ Regarding nori seaweed cultivation, efforts should be focused on developing high-water-temperature-tolerant culture breeds for adaptation to a shift in the harvest season due to higher water temperatures. Effective measures to prevent feed damage should also be considered for nori seaweed cultivation.

○ To prevent and mitigate damage to fisheries caused by harmful algal blooms and oxygen-deficient water masses, it is crucial to quickly provide information on such phenomenon. The occurrence of harmful algal blooms and oxygen-deficient water masses should be detected in real time with automatic observation devices or other systems to help relevant research institutions develop wide-area monitoring technologies and provide trend forecasts. It is also necessary to establish technologies to directly eliminate harmful algal blooms, as well as techniques and fishing gear for avoiding harmful algal blooms.

○ While addressing harmful algal blooms, Japan's adaptation measures should be focused on conducting scientific studies on the relationship between nutrient salts and fishing ground productivity and on surveys needed to restore and maintain fishing ground productivity (especially for bivalves, small fish, and nori seaweed, etc.), including studies on nutrient salts (water quality) management appropriate to the fisheries and aquaculture operations in the waters involved.

[Basic measures]

○ Continue investigation and research on the occurrence of harmful algae, which seriously affects aquaculture, in relation to climate change; and develop technologies for prediction and control of harmful algal blooms by understanding the physiological and ecological characteristics of harmful algae. <Ministry of Agriculture, Forestry and Fisheries>

○ Address concerns over decreasing growth in the mariculture areas by continuing efforts to develop culture breeds, including those resistant to high water temperatures. As for seaweed, in particular, focus on developing high-water-temperature-tolerant breeding materials by using new nori seaweed breeding techniques based on previously developed cell-fusion techniques; and developing a breeding technique by separating a high-temperature-tolerant strain of large-sized algae such as wakame seaweed. <Ministry of Agriculture, Forestry and Fisheries>

○ Formulate control guidelines for fish diseases that are expected to frequently occur in warm water, as well as fish diseases that may invade Japan from tropical and subtropical waters along with the rise in water temperatures, and develop various control technologies. <Ministry of Agriculture, Forestry and Fisheries>

○ In consideration of the increasing possibility of occurrence of unknown fish diseases due to higher water temperatures, be ready to respond quickly to the occurrence of unknown fish diseases by systematizing and enhancing the development of a series of technologies related to dealing with infectious diseases caused by unknown pathogens, including technologies for identifying such pathogens and diagnosing and controlling such diseases.

Noting successful development of vaccines against various fish diseases, develop and disseminate vaccines that can prevent a wider variety of fish diseases. <Ministry of Agriculture, Forestry and Fisheries>

○ While implementing the above measures to control fish diseases, use the latest breeding techniques to create strains resistant to various fish diseases that are expected to occur in warmer climates, and aim to introduce such strains to aquaculture. <Ministry of Agriculture, Forestry and Fisheries>

○ In addition to the aforementioned technology development, work to elucidate the characteristics of pathogens, the action mechanisms of vaccines, the molecular mechanism of disease tolerance and resistance. <Ministry of Agriculture, Forestry and Fisheries>

○ Proceed with monitoring and ecological surveys of species that occur as water temperature rises, such as the longheaded eagle ray, which eats short-neck clams and other bivalves, to develop management technologies to prevent adverse impacts on ecosystems and aquaculture; and develop efficient capturing methods and utilization and value-adding technology for such harmful species to contribute to regional development. <Ministry of Agriculture, Forestry and Fisheries>

○ Noting that the partial pressure of carbon dioxide, which affects seawater pH, is known to exhibit wide daily fluctuations in coastal waters, with the way it affects living organisms remaining unknown, elucidate this mechanism to project the impacts of acidification on bivalve aquaculture and other activities, and develop technologies to control such impacts based on the projections. <Ministry of Agriculture, Forestry and Fisheries>

(3) Propagation and aquaculture (inland fisheries and aquaculture)

[Impacts]

<Current status>

○ The impacts of climate change on inland fisheries and aquaculture are not visible yet. However, in some lakes and swamps, a weaker circulation of lake water has been observed due to warm winters, causing a decline in dissolved oxygen at the lake bottom and resulting in a lack of oxygen.

○ Some reports attribute a sharp drop in the population of willow minnow and round crucian carp in Lake Biwa, Shiga Prefecture, to the compound action of a late circulation due to warmer winters, anthropogenic water level control, anthropogenic modifications of the lakeshore environment, etc.

○ There have been reports of dead Japanese smelt due to high water temperatures.

<Projected impacts>

○ Declined catches of Japanese smelt are projected in lakes and swamps due to high water temperatures.

○ Around the end of the 21st century, the season of upstream migration of ayu will come

earlier, and with smaller numbers of fish, due to higher water temperatures in the ocean and rivers.

・Propagation and aquaculture [Significance: ●; Urgency: ●; Confidence: ▲]
・Coastal and inland fishing ground environment [Significance: ●; Urgency: ●; Confidence: ▲]

(Related categories)

・Freshwater ecosystems (lakes/swamps, rivers, and marshlands) [Significance: ●; Urgency: ▲; Confidence: ■]

[Basic approach to adaptation]

○ Efforts should be focused on research and development of technologies for propagation of inland aquatic resources and dissemination of resultant technologies for wide application, such as habitat improvement techniques and seed production technologies with high stocking efficiency.

[Basic measures]

○ Assess the impacts that climate change-induced environmental changes in rivers and lakes/swamps cause to the habitat and stock abundance of important resources in inland waters such as salmon and ayu. <Ministry of Agriculture, Forestry and Fisheries>

○ For ayu, for which the season of upstream migration is projected to come earlier, and with smaller numbers of fish, due to higher water temperatures in the ocean and rivers, increase and recover stock by analyzing how coastal and river water temperature affects upstream/downstream migration of the fish and the growth of individual fish released, studying the appropriate time and water temperature for release based on the analysis results, and developing effective release techniques. <Ministry of Agriculture, Forestry and Fisheries>

○ For Japanese smelt, whose catch is projected to decrease due to high water temperatures, upgrade feeding and releasing techniques by stabilizing, scaling up, and simplifying seed production through developing an efficient production technique of plankton bait, discovering the optimal rearing density and bait density for seed production, and developing extensive and mass-productive seed production techniques. <Ministry of Agriculture, Forestry and Fisheries>

○ Collect Information on the outbreak of diseases caused by high water temperatures. As for inland fish diseases, which are expected to cause growing damage due to higher water temperatures, conduct research on the characteristics and onset factors of pathogens, and develop control technologies based on the research results. <Ministry of Agriculture, Forestry and Fisheries>

(4) Coastal and inland fishing ground environment (artificial fishing grounds)

[Impacts]

<Current status>

(Marine fisheries of non-migratory species)

○ There have been reports on the increase in the number of southern fish species and the decrease in the number of northern fish species in many parts of Japan.

○ Regarding abalone, some cases have been reported where major catches have shifted from native species to small-sized species common in warm seas.

○ Regarding short-neck clams, some studies show that the rise in water and soil temperature is affecting stock abundance and summer survival.

○ There have been reports on the decrease in catches of Japanese spiny lobster and abalone, which are highly dependent on seaweed beds as a habitat, due to decreasing seaweed beds.

○ In the Seto Inland Sea, higher water temperature has affected Japanese sand lance and other species forming ecosystems in the Seto Inland Sea and led to the increased population of southern species, which are causing feed damage to bivalves and seaweed beds.

(Seaweed and seaweed beds)

○ The decrease of seaweed beds and changes in the species forming them have been observed in many parts of Japan, presumably because of the direct impact of higher water temperatures on algae productivity and indirect impact in the form of more active feeding of algae-eating fish. Changes in the geographical distribution of seaweed beds are also observed.

○ There have been reports of poor harvests of naturally grown wakame seaweed due to high water temperatures and the decline in the biomass of Japanese sea tangle due to higher water temperatures.

(Harmful/poisonous plankton and fish)

○ For harmful/poisonous plankton, there have been reports of the northward expansion of the northern limit of occurrence, the occurrence of warm water species in cold regions, and earlier occurrence. In addition, the distribution ranges of toxified fish and southern poisonous fish species that can cause ciguatera fish poisoning may be expanding.

<Projected impacts>

(Marine fisheries of non-migratory species)

○ Distribution ranges of many commercially fished species are projected to move northward although no impact assessments have been performed using ecosystem models and climate projection scenarios.

○ The catches of rocky shore stocks (e.g., abalone) are projected to decline due to changes in the species composition and abundance of seaweed beds resulting from higher water

temperature.

(Seaweed and seaweed beds)

○ There are projections that higher water temperatures will significantly move northward the distribution ranges of all the 11 main species of tangle in coastal waters of northern Japan or even lead to the disappearance of suitable habitat. In the RCP 8.5 scenario, distribution ranges for the entire species will reduce by 0 to 25% in the 2090s compared with those present in the 1980s; even in the RCP 4.5 scenario, four of the 11 species of tangle may disappear from waters around Japan.

○ In the northwestern Pacific Ocean, higher water temperature is projected to move northward the distribution of *akamoku* (*Sargassum horneri*), an alga belonging to the genus *hondawara* (*Sargassum fulvellum*), and make it disappear from wide water areas along Honshu by 2100.

○ In the RCP 2.6 scenario, the only impact that will materialize for the distribution of *kajime* (*Ecklonia cava*) algae in coastal waters of Japan will be feed damage caused by algae-eating fish. In the RCP 8.5 scenario, a combination of physiological impacts from high water temperature and impacts of feed damage will make the waters that have been suitable for distribution of this algae species no longer inhabitable by the 2090s.

○ In the RCP 2.6 scenario, the distribution of kajime algae from the Seto Inland Sea to waters along the Kuroshio Current may be able to maintain the current abundance of seaweed beds through the 2050s, whereas in the RCP 8.5 scenario, the species may be significantly reduced in abundance throughout the Seto Inland Sea.

(Harmful/poisonous plankton and fish)

○ Harmful algal blooms related to rising sea temperatures are expected to increase the risk of bivalve die-offs.

・Coastal and inland fishing ground environment [Significance: ●; Urgency: ●; Confidence: ▲]

・Propagation and aquaculture [Significance: ●; Urgency: ●; Confidence: ▲]

[Basic approach to adaptation]

○ For effective and efficient conservation and creation of seaweed beds and tidal flats, which play a major role in propagating aquatic resources based on their function of nurturing abundant ecosystems, efforts should be focused on accurately understanding the factors of declines in seaweed beds and tidal flats in different sea areas and implementing wide-area measures that integrate structural measures of local governments (e.g., formation of seaweed beds and tidal flats) and non-structural measures led by fishery workers and local citizens (e.g., conservation activities).

○ To stabilize fishery production according to environmental changes, adaptation measures should be focused on enhancing the monitoring system and improving or developing fishing grounds that serve as the habitat and spawning ground of marine creatures in a manner that takes into consideration their life history, while coordinating these efforts with infrastructure building and resource management adapted to the changing distribution ranges of fish and seaweed.

[Basic measures]

○ For forming seaweed beds, sow or transplant heat-tolerant species suitable for local conditions; after formation, implement more effective measures based on adaptive control approaches, such as monitoring algae growth and the activity of phytophagous animals, and implementing measures against feed damage, such as removing phytophagous fish, according to the situation. <Ministry of Agriculture, Forestry and Fisheries>

○ Accurately ascertain future changes in the distribution ranges and habitats of marine creatures resulting from the rise in water temperatures; improve or develop fishing grounds that serve as the habitat and spawning ground of marine creatures according to the ascertained changes; enhance the monitoring system to capture the marine environment more accurately; build a collaborative structure with local research institutions; enhance surveys and demonstrations; and increase the disaster preparedness of fishing grounds (e.g., by establishing a BCP that assumes heavy rainfall and other natural disasters). <Ministry of Agriculture, Forestry and Fisheries>

○ Lay the groundwork for the formation of fishing grounds adapted to climate change by developing methods of assessing the impacts that climate change has on the growth of fish and seaweed and identifying the distribution of fish and seaweed. <Ministry of Agriculture, Forestry and Fisheries>

○ Develop a seaweed bed formation method that uses seaweed species adapted to environmental changes (e.g., higher water temperature) by taking into account the distribution of seaweed beds and tidal flats and factors of rocky-shore denudation in each sea area. <Ministry of Agriculture, Forestry and Fisheries>

4. Other basic adaptation measures for agriculture, forestry, and fisheries

(1) Impacts from wildlife (wildlife damage)

[Impacts]

<Current status>

○ Chronological comparative research confirmed that distribution area of sika deer and wild boar have expanded across Japan.

○ It has been observed that wintering places of sika deer have expanded to higher elevations due to a decrease in snow depth. Suitable habitats for sika deer were estimated to expand about 1.7 times in land area during the 25-year period from 1978 to 2003, which accounts

for 47.9% of the national land area. Some researchers have suggested that this increase would be largely affected by a decrease in snow depth rather than by land use changes.

○ Increased populations of sika deer have been attributed to complex factors, including a reduction in hunting pressure, changes in land use and a decrease in snow depth. Some studies reported that the expansion of distribution area of sika deer would enhance feeding and bark-stripping damages on vegetation as well as distribution area of land leeches.

<Projected impacts>

○ Some study predicted that the decrease in snow depth associated with climate change and the expansion of abandoned arable fields will enlarge suitable habitats of sika deer, which will cover more than 90% of the national land area by 2103.

○ Meanwhile, there have been no confirmation about future impacts of climate change, such as changes in distribution ranges of wild boar and other wild species.

・Impacts from wildlife [Significance: ●; Urgency: ●; Confidence: ■]

[Basic approach to adaptation]

○ To address intensifying and widening wildlife damage to forests and agricultural crops along with the expansion of wildlife habitats, relevant ministries should cooperate to strategically combine different measures and strengthen wildlife damage countermeasures. The government should focus on strengthening wide-area hunting and development of associated human resources under the Act on Special Measures for the Prevention of Damage due to Wildlife (Act No. 134 of 2007), as amended in 2021.

○ Efforts should continue to develop and demonstrate effective and efficient capture and safeguard techniques and to conduct hunting control and guard fence installation in cooperation with local stakeholders, such as those in forestry, while coordinating these efforts with wildlife conservation and control measures.

○ Forests prone to damage should be designated as forest areas for wildlife damage prevention in municipal forest management plans to ensure the implementation of necessary measures.

[Basic measures]

Measures that have been taken to date to protect agricultural crops include providing support for activities to prevent damage caused by sika deer, wild boar, and other wild species, such as installation of entry prevention fences, hunting, and improvement of the farming environment. For forests and forestry, ongoing measures include installing guard fences to protect planted trees and vegetation, and conducting pilot projects for wide-area strategic population control under the initiative of the forestry community. For fisheries, measures have been taken to remove great cormorants, capture Steller sea lions with hunting guns for

preventing and mitigating damage to fisheries, and promote the introduction of improved fishing gear, such as that employing reinforced fiber protective nets.

○ Continue efforts to install entry prevention fences, strengthening hunting activities, advance hunting and damage countermeasures techniques based on ICT and drones and other technologies; and focus on wide-area measures jointly conducted by local governments, mobilizing diverse human resources, developing human resources with expert knowledge and experience, and disseminating the results of technology development. Also, continue the collection of information on wildlife activity and the monitoring of damage to agriculture, forestry, and fisheries. <Ministry of Agriculture, Forestry and Fisheries>

○ Under the Wildlife Conservation, Control, and Hunting Management Act (Act No. 88 of 2002), promote scientific and planned conservation and control of wildlife by enhancing population control of wildlife (e.g., sika deer) by prefectures and training individuals involved in wildlife population control. <Ministry of the Environment>

(2) Food supply and demand

[Impacts]

<Current status>

○ Impacts that climate change is having on crop yields, especially the yields of major crops (wheat, soybean, corn, and rice), have been reported worldwide. Reports show that decreasing yields are particularly evident in regions at low latitudes as potential evapotranspiration increases due to summer heat and rising temperatures and that climate change is causing global declines in average yields despite fertilizing effects of higher carbon dioxide concentrations and simple adaptation measures being taken (e.g., shifting the sowing date).

○ Adaptation has been ongoing worldwide at different stages. This includes not only relatively simple measures involving modified cultivation management, such as shifting the sowing date or replacing crop varieties, but also some large-scale measures, such as a transition to other crops or a relocation of cultivation areas.

○ Here are some recent examples of how reduced grain yields have affected society and the economy. A global decrease in production caused by extreme weather, such as droughts in Australia, contributed to the surge in grain prices from 2006 to 2008. A short supply of wheat due to heat waves and droughts in Russia in 2010 triggered riots in the Middle East and North Africa. Reduced production of corn and soybeans in 2012 in the U.S. due to hot and dry weather increased their international prices to reached highest levels ever. During the 27-year period (1983 to 2009), three-fourths of the cultivation areas for major grain products had experienced drought damage. Some studies have estimated the amount of damage caused by yield reduction.

○ Some studies indicate that although the yearly variation of climate (natural variation of the climate system) is the major contributor to grain yield fluctuations, human-caused climate

change has been disturbing this yearly variation of the climate system, with some regions experiencing impacts on crop production as a result of intensifying droughts.

<Projected impacts>

○ Research that examined a large number of documents has confirmed that the projected rise in temperature will reduce the yields of rice, wheat, soybeans, and corn worldwide. Meanwhile, the extent of the projected climate change impact on yields varies by region, crop, assumed carbon dioxide concentration, and whether adaptation measures are implemented.

○ Projections for rice, wheat, soybean, and corn yields in major producing/exporting countries are described below.

・Regarding rice, in the RCP 4.5 scenario, 13 major producing countries will see a decline in average yield in 2080 to 2089. In the RCP 8.5 scenario, high vulnerability is projected for Thailand, a major exporting country.

・Regarding wheat, the U.S., a major exporter, will see its yields in 2067 to 2099 decrease 70% from those in 1981 to 2004 in the RCP 8.5 scenario. In the RCP 4.5 and RCP 8.5 scenarios, Australia can expect increased yields in the 2050s by taking the adaptation measures of shifting sowing dates and selecting appropriate varieties, whereas in the RCP 8.5 scenario, the country may face in the 2090s the situation where yield declines due to decreased suitable production areas will surpass the positive effects of higher carbon dioxide concentrations and adaptation measures.

・Regarding soybeans, the U.S., a major exporter, will see its yields in 2067 to 2099 decline 70% from those in 1981 to 2004 in the RCP 8.5 scenario. In Canada, higher temperatures will shorten the cultivation time. Yields will slightly increase in 2041 to 2070, although they will decrease in 2071 to 2100 in the RCP 8.5 scenario. In Brazil, in the RCP 8.5 scenario, a shorter rainy season will result in a 10% decrease in farmland suitable for double-cropping in 2031 to 2050, compared with 2013 to 2030.

・With regard to corn, the U.S., a major exporter, will see its yields in 2021 to 2050 decline 20 to 50% from those in 1970 to 1999; in the RCP 8.5 scenario, yields in 2067 to 2099 will be 71% less than those in 1981 to 2004. In the RCP 4.5 and RCP 8.5 scenarios, the decrease in yield will be greater in the Midwest in 2085 to 2094 due to dry weather.

・Food supply and demand [Significance: ◆; Urgency: ▲; Confidence: ●]

[Basic approach to adaptation]

○ To prepare for unexpected situations, the government should ensure comprehensive food security by constantly analyzing and assessing climate change impacts and other factors, investigating and analyzing Japan’s future food supply and demand, and developing reviewing measures to tackle identified issues.

[Basic measures]

○ Collect and analyze in an integrated manner information on trends in food supply and demand in Japan and abroad, and analyze the impacts on stable food supply in Japan. Provide such information continuously and widely. <Ministry of Agriculture, Forestry and Fisheries>

○ Noting collaboration with the Japan Aerospace Exploration Agency (JAXA) to supplement and enhance information on overseas food supply trends, through which satellite earth observation data (including analyzed images) on soil moisture and other topics has recently been made available to the public, consider additional ways to leverage this collaboration. <Ministry of Agriculture, Forestry and Fisheries>

○ Consider appropriate risk responses in view of Japan's future food supply and demand, based on extra-long-term forecasts for global food supply and demand obtained by using forecast models that take into account climate change, economic growth, population increase, and other factors suggested in the IPCC fifth assessment results. <Ministry of Agriculture, Forestry and Fisheries>

○ For the purpose of developing strategies toward securing a stable food supply over the medium to long term, continuously conduct medium- to long-term forecasts for global food supply and demand in cooperation with the Policy Research Institute of the Ministry of Agriculture, Forestry and Fisheries, taking into account climate change impacts and other countries' economic growth and policy trends. <Ministry of Agriculture, Forestry and Fisheries>

Section 2. Water Environment and Water Resources

1. Basic adaptation measures for water environment

[Impacts]

<Current status>

(Lakes/swamps and dam reservoirs for flood control)

○ A survey of water temperatures in lakes and swamps across Japan in FY 1981 to FY 2007 found a warming trend at 76% of the 265 observation points in summer and at 94% in winter.

○ Although changes in water quality along with the rise in water temperatures have been pointed out, some studies have reported that water temperature changes cannot clearly be attributed to climate change impacts at present.

○ On the other hand, there have been reports indicating that the probability of occurrence of blue-green algae increases if the annual mean temperature exceeds 10°C. This topic requires long-term analysis to be performed.

(Rivers)

○ A survey of water temperatures in rivers across Japan in FY 1981 to FY 2007 found a warming trend at 73% of the 3,121 observation points in summer and at 77% in winter.
○ Although changes in water quality due to higher water temperatures have been pointed out, increasing river water temperatures can also be affected by factors such as urban activities (artificial exhaust heat and wastewater) or reductions in river flow, it is necessary to quantitatively analyze the magnitude of impact of climate change.
○ It is reported that an increased frequency of rapid and concentrated rainfall and shorter intervals between heavy rainfalls increase sediment runoff in the Nagara River.
○ Reports indicate that record storm surges in Typhoon Jebi (T1821) caused salt water intrusion in the Yodo River, allowing raw water at the water purification plant to be contaminated with salt water and that salt water intrusion occurred in the Shinano River due to reduced flows caused by summer droughts, forcing some of the floodgates to be closed.
○ Regarding recent river flow trends, some studies project the escalation of polarization in tributaries of the Ashida River between the flood period, when massive runoff of nutrient salts occurs in response to the flow rate, and the drought period, when runoff reduces.
○ The rise in spring water temperature since the late 1980s has been confirmed in the Masugata-no-Ike Pond due to higher temperature.

(Coastal areas and enclosed coastal seas)
○ From an analysis of sea surface temperature data from the 1970s to 2010s, a significant increasing trend has been reported at 132 of 207 sites nationwide (ave. 0.039°C/year, min. 0.001°C/year, max. 0.104°C/year). It should be noted that there may be anthropogenic impacts at some of the measurement sites where this increasing trend was observed.
○ There are also other research reports stating that no significant warming or cooling trend was observed in seawater temperatures in the coastal waters around Okinawa Island.
○ From an analysis of pH data obtained at 289 sites in coastal waters across Japan in 1978 to 2009, a significant acidification trend has been confirmed (0.0014/year to 0.0024/year).

<Projected impacts>
(Lakes/swamps and dam reservoirs for flood control)
○ Research based on the RCP 2.6 and RCP 8.5 scenarios has estimated that among 37 dam reservoirs in Japan, the number of dam reservoirs classified as eutrophic water bodies will increase in the 2100s, especially in eastern Japan.
○ Although on a limited basis, some studies estimate that in the RCP 8.5 scenario, the rise in surface and bottom water temperature and increased salinity due to sea-level rise will be observed in Lake Shinji and Nakaumi Lagoon by the end of the 21st century.
○ RCP 8.5-based research on dams in the Tohoku region projects that higher inflows into the dam expected in the future will increase suspended solids (SS), leading to a longer

discharge period of turbid water. However, it is suggested that the impact that higher temperature and longer duration of sunshine has on the turbidity of reservoir water may vary by the level of the annual water turnover rate of the reservoir.

○ Studies to forecast the impacts that changes in river flows caused by climate change-induced changes in precipitation and its spatial and temporal distribution, as well as the increased frequency and intensity of extreme weather events, can have on lakes/swamps and dam reservoirs have been limited, and therefore further studies are needed.

(Rivers)

○ Projections of water temperature in the Omono River indicate that water temperature will increase from 11.9°C in 1994 to 2003 to 12.4°C in 2030 to 2039, with particularly greater impacts expected in winter.

○ There are projections that suspended sediment levels will increase by 8 to 24% nationwide by 2090, that an increased occurrence of intense tropical cyclones and other factors will bring suspended sediment to the highest level in September, and that a 5 to 75% increase in precipitation in August will change river flow rates by 1 to 20%, possibly increasing sediment production by 1 to 30%.

○ Other projections include lower levels of dissolved oxygen (DO) due to higher water temperatures, accelerated organic matter decomposition and nitrification by microorganisms associated with DO consumption, and an increase in abnormal odors and taste due to increased populations of phytoplankton.

○ Impacts are also expected on increased aquifer temperatures on the Sendai plain.

(Coastal areas and enclosed coastal seas)

○ A study for projecting future changes in the physical and thermal environment of the Seto Inland Sea suggested that in the RCP 8.5 scenario, the warming trend is stronger in summer, with the greatest increase in sea surface temperature expected in June at 3.58°C and the smallest in December at 2.84°C.

○ Projections on the Seto Inland Sea describe the impacts on water quality in Osaka Bay like this: Sea surface chlorophyll-a concentrations declined due to the inhibiting effects of high summer temperatures, leading to an increasing trend of bottom layer DO levels and less oxygen deficiency in summer to autumn. However, some reports have mentioned the possibility of longer periods prone to oxygen-deficient water masses, suggesting that climate change may affect the occurrence of disturbances to the water environment.

○ A study for projecting future water temperatures in Ise Bay indicates that water temperatures will rise by 2°C or more, and the warming will be particularly evident in coastal waters.

○ A study on Tokyo Bay suggests that the duration of strong southwestern winds (southwestern winds with a velocity of 10 m/s or more based on AMeDAS observation)

may decrease in 2046 to 2065 and projects potential difficulty for DO levels to recover.

○ Changes in water quality are projected, including lower DO levels due to higher water temperatures, accelerated organic matter decomposition and nitrification by microorganisms associated with DO consumption, and an increase in abnormal odors and taste due to increased or decreased populations of phytoplankton.

・Lakes/swamps and dam reservoirs [Significance(RCP 2.6/8.5): ◆/●; Urgency: ▲; Confidence: ▲]
・Rivers [Significance: ◆; Urgency: ▲; Confidence: ■]
・Coastal areas and enclosed coastal seas [Significance: ◆; Urgency: ▲; Confidence: ▲]

[Basic approach to adaptation]

○ Recognizing projected changes in water quality and other aspects due to climate change, adaptation measures should be focused on continuing to promote investigation and research on the monitoring and projection of water quality, as well as water quality conservation measures.

○ In the category of "Lakes/swamps and dam reservoirs," efforts should be focused on water quality conservation based on water quality monitoring and projections, as climate change impacts, such as increased chlorophyll-a concentrations in dam reservoirs, are expected to materialize by the 2050s.

○ In the "Rivers" category, where research reports on the impacts of climate change on water quality are limited, efforts should be focused on the accumulation of scientific findings.

○ In the category of "Coastal areas and enclosed coastal seas," where climate change will exert impacts on water quality and aquatic ecosystems, it is necessary to pursue the accumulation of scientific findings and hold steady discussions for the implementation of measures addressing these impacts.

○ In the Seto Inland Sea, in particular, investigation and research are needed on issues such as the relationship between nutrient salts and aquatic resources, taking into consideration climate change impacts.

[Basic measures]

(Lakes/swamps and dam reservoirs for flood control)

○ In lakes and swamps, which will see changes in phytoplankton and worsening water quality associated with higher water temperatures and changes in rainfall, promote measures to reduce the inflow loads, including measures for wastewater from factories and business premises and measures for domestic wastewater; and continue monitoring and develop new technologies to properly ascertain changes in phytoplankton. <Ministry of the Environment>

○ Consider bottom-layer environmental changes associated with changing water temperature

in lakes and swamps, and conduct projections relating to the risk of occurrence of bottom-layer oxygen deficiency, as well as harmful algal blooms and blue tides. <Ministry of Land, Infrastructure, Transport and Tourism; Ministry of the Environment>

○ In deep water layers of stratified lakes and swamps, where incomplete circulation is projected to occur in winter due to changes in water temperature, consider appropriate measures to improve dissolved oxygen (DO) levels in bottom layers. <Ministry of the Environment>

○ Based on prior analysis, consider appropriate adaptation measures for lakes and swamps nationwide; endeavor to obtain the latest scientific findings and improve the accuracy of water quality projections for lakes and swamps by using the latest climate models and emissions scenarios; and based on the results, consider other necessary adaptation measures. <Ministry of the Environment>

○ Regarding reservoirs for flood control (i.e., dam reservoirs for flood control), continue to implement water quality conservation measures, including the use of selective water intake equipment and aeration-circulation equipment; and consider actions to take, including the review of operational rules for water quality conservation equipment adaptable to climate change-induced changes in water quality. <Ministry of Land, Infrastructure, Transport and Tourism>

(Rivers)

○ Regarding climate change-induced impacts on rivers and related environments, although some research is underway to make projections of changes in the water quality and water temperatures of specific rivers, the quantity of examples is not yet sufficient, and the certainty of projections is assessed to be low. It is currently difficult to ascertain and project the changes occurring in river environments overall. Therefore, continue to conduct actions including monitoring of river water quality, and endeavor to collect more scientific findings. <Ministry of Land, Infrastructure, Transport and Tourism; Ministry of the Environment>

(Coastal areas and enclosed coastal seas)

○ Collect scientific findings on the impacts of climate change, including those on water quality and biodiversity, and promote investigation and research on adaptation measures. <Ministry of the Environment>

○ Consider changes in the bottom-layer environment associated with changes in water temperature in port areas and inner bay areas; and consider projections relating to the risk of occurrence of bottom-layer oxygen deficiency, as well as harmful algal blooms and blue tides. <Ministry of Land, Infrastructure, Transport and Tourism; Ministry of the Environment>

2. Basic adaptation measures for water resources

[Impacts]

<Current status>

(Water supply [surface water])

○ The spatial and temporal distribution of precipitation is changing, as demonstrated by droughts occurring in various areas in Japan due to a long period of little or no rain, resulting in water supply restriction.

○ A trend toward an earlier snowmelt period was observed in the alpine zone in 1980 to 2009, although there were wide yearly variations depending on the valley. In snowy regions like Hokuriku, increased snowmelt in winter has been reported. In the basin of the Tedori River, it is suggested that a reduced frequency of snowfall can lead to a shortage of irrigation water in early spring.

○ There are no specific studies at present regarding the impact of climate change-induced droughts on the river maintenance flow (a flow rate that must be maintained even during drought) and the expansion of the intrusion range of seawater (salt water) in river estuaries due to sea level rise.

(Water supply [groundwater])

○ There are no specific studies at present regarding the current state of changes in groundwater levels associated with climate change-induced changes in daily precipitation and precipitation trends over time.

○ There are many areas experiencing continued ground subsidence, and excessive groundwater withdrawal during drought can cause ground subsidence. Some reports show that in some waterfront areas, in particular, excessive groundwater withdrawal caused groundwater salinization through seawater intrusion into the aquifer and damaged drinking water, industrial water, agricultural crops, etc. With regard to groundwater salinization due to sea level rise, there are no specific studies at present, but reports point out that global warming-induced events, such as sea level rise, high tide flooding, and more frequent and longer droughts, can shrink the freshwater lenses on small islands and that in some cases, the shrinkage has actually occurred due to excessive pumping of groundwater.

(Water demand)

○ As for the relationship between increasing temperature and water usage, it has been shown that water usage in Tokyo does increase as the temperature rises.

○ In the agricultural sector, there have been reports on increased water demand for actions taken in response to high heat damage, including a shift in the rice-planting season and irrigation periods, as well as use of irrigation by surface flooding.

<Projected impacts>

(Water supply [surface water])

○ There are projections of intensifying drought in the near future (through 2039) except in northern Japan and central mountain areas. Earlier snowmelt will cause a reduction of river flow during periods of high water demand, and a resultant mismatch between water supply and demand, which will affect many sectors, including drinking water, agricultural water, and industrial water, exerting a substantial socioeconomic impact.

○ Research involving the survey of changes in the way salt water intrusion occurs in the Shinkushiro River due to sea level rise project the possibility that intrusion of dense salt water may constantly occur in the downstream parts of the river. It is also projected that if the range of salt water intrusion in the river extends, facilities sourcing water from the river may be affected. In the Yura River, the salinity around water intake stations will be higher at the end of the 21st century than it is now, even in a relatively high flow scenario, and an extended intrusion range is expected as well.

○ Although there are no studies providing quantitative projections at present, there is concern over potential events such as impacts on the river maintenance flow (the flow rate that must be maintained even during drought) and hindrance to water intake caused by the intrusion of seawater (salt water) in river estuaries due to sea level rise.

(Water supply [groundwater])

○ In the basin of the Kurobe River, monthly precipitation, snowmelt, and groundwater penetration will be higher than today in November to April and lower in May to June at the end of the 21st century, creating concern over the impact on areas using groundwater resources. A study on the alluvial fan of the Isawa River indicates that groundwater levels will be lower during the irrigation period for rice farming in 2081 to 2100.

○ There are no specific studies at present regarding the phenomenon in which increased use of groundwater due to drought causes ground subsidence.

○ Although there are no studies providing quantitative projections at present, there is concern that sea level rise may cause salinization of groundwater, consequently affecting water intake. Regions where groundwater salinization affects the water source will be limited because rivers are the major source of water for irrigation and drinking water supplied to Japan’s large cities situated on alluvial plains. However, municipalities that rely on groundwater may be more seriously affected by salinization.

(Water demand)

○ A reduction in potential water resources is projected in the 2030s in Kyushu due to an increase in evapotranspiration from paddy fields. In other areas as well, demand for agricultural water will increase as temperature rises.

・ Water supply (surface water) [Significance(RCP 2.6/8.5): ●/●; Urgency: ●; Confidence: ●]

・Water supply (groundwater) [Significance: ●; Urgency: ▲; Confidence: ▲]
・Water demand [Significance: ◆; Urgency: ▲; Confidence: ▲]

[Basic approach to adaptation]

○ Efforts should be focused on conducting assessments of water supply safety levels and drought risks for existing facilities, which will provide the basis of measures to prevent and mitigate damage from droughts; and on preparing for droughts through drought risk information sharing based on collaboration among different actors, including the national government, local governments, water users, companies, and residents.

○ To promote adaptation measures to deal with droughts, the government should work with other stakeholders to develop scenarios for drought impacts and damage, and to formulate drought response timelines (timeline action plans) that stipulate measures to reduce damage from droughts and other plans.

○ In the "Water supply (groundwater)" category, recognizing that excessive withdrawal of groundwater driven by droughts may lower groundwater levels by the end of the 21st century, the national and local governments should closely cooperate to promote groundwater management according to the local situation.

[Basic measures]

1) Assessment of disaster risks

○ Allow residents, companies, and other stakeholders to prepare for droughts on their own by assessing the safety of water supplies from existing facilities; helping stakeholders assess drought risks, including the scenario for the gradual deterioration of the situation from early stages of a drought and assumption of impacts and damage to socioeconomic activities, welfare and healthcare services, public facilities and services, and people's livelihoods, according to the development of the situation; and presenting the findings in comprehensible ways for sharing among stakeholders, including the national government, local governments, water users, companies, and residents. <Ministry of Land, Infrastructure, Transport and Tourism>

2) Measures to prevent damage from relatively common droughts

A. Optimal use of existing facilities

○ In areas where water resources development infrastructure needs to be improved, promote initiatives for water resource development; and consider other options to increase the capacity of existing facilities, including dam heightening and excavating or dredging deposited sediments in reservoirs for flood control. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Maintain the capacity of existing facilities by conducting systematic maintenance, management, and upgrades, including the steady implementation of measures against aging

facilities. <Ministry of Land, Infrastructure, Transport and Tourism>

○ While taking into account factors such as each dam's water reserves and precipitation conditions, consider the potential for efficient dam operations, including the integrated use of multiple dams located in the same river basin. <Ministry of Land, Infrastructure, Transport and Tourism>

B. Use of rainwater and reclaimed wastewater

○ Under the Act on the Promotion of Rainwater Utilization (Act No. 17 of 2014), foster the installation of facilities for using rainwater. <Ministry of Land, Infrastructure, Transport and Tourism>

○ According to local needs and other factors, install faucets at wastewater treatment plants, and encourage the use of treated wastewater for applications including road maintenance and tree watering, and even in times of emergency; and promote the reuse of water by considering standardization, including international standardization of Japanese water reclamation technologies. <Ministry of Land, Infrastructure, Transport and Tourism>

C. Information provision and awareness raising

○ Promote information dissemination and encouragement to save water both during normal times and at an early stage of a potential drought, through collaboration with relevant institutions and the media. <Ministry of Land, Infrastructure, Transport and Tourism>

○ To promote efficient water use, conduct educational and awareness-raising activities to deepen the public's awareness and understanding of the importance of water. <Ministry of Land, Infrastructure, Transport and Tourism>

3) Measures to mitigate damage from droughts exceeding the capacity of facilities

A. Establishment of systems for drought management through collaboration among stakeholders

○ Encourage stakeholders to prepare for drought by considering water sharing and special water delivery systems during drought; and promote formulation of drought response timelines that stipulate measures to reduce intensifying damage from droughts and other action plans, based on guidelines that serve as a basis for developing drought control measures, through collaboration among stakeholders. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Endeavor to improve drought projection technologies, including the utilization of medium- and long-term precipitation forecasts; and consider the potential for actions such as preliminary implementation of water intake restrictions according to the circumstances, taking into account factors such as the drought impacts and damage scenarios indicated in the above-mentioned drought response timelines. <Ministry of Land, Infrastructure, Transport and Tourism>

B. Measures to minimize damage from crisis-level droughts

○ To prepare for a crisis-level drought, conduct assessments of drought risks and the safety levels of water supplies from existing facilities; take into account the assumed impacts and damage to socioeconomic activities, healthcare and welfare services, public facilities and services, and people's lives; and consider actions to be taken, such as unified responses by different functions of the government, drought responses by companies, and prioritization of where to supply water through special water deliveries or other means. <Ministry of Land, Infrastructure, Transport and Tourism>

C. Monitoring and information gathering relating to river environments during times of drought

○ Monitor the river environment during drought and gather findings, recognizing the concern that reductions in river flows during times of drought may affect river environments, such as water quality and ecosystems, including aquatic flora and fauna that inhabit and grow in the river. <Ministry of Land, Infrastructure, Transport and Tourism>

D. Groundwater use during times of drought and assessment of the groundwater situation

○ Groundwater is not only used during normal times but can also serve as an emergency alternative water source during droughts. However, excessive groundwater withdrawals can lead to problems such as ground subsidence and groundwater salinization, and generally these types of issues are highly localized in nature. Therefore, the national government should cooperate with local governments and other local stakeholders to promote groundwater management, including development of rules for sustainable groundwater conservation and use according to local conditions. <Ministry of Land, Infrastructure, Transport and Tourism>

○ The national government should conduct technology development to help understand groundwater conditions in order to facilitate studies on groundwater use as an emergency alternative water source; and create an institutional environment, such as formulating rules for the shared use of a variety of groundwater data collected by entities including the national and local governments. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Use this data to understand the groundwater balance and behavior, and relationships between factors such as groundwater withdrawals, ground subsidence, and salinization. <Ministry of Land, Infrastructure, Transport and Tourism>

4) Measures in the agriculture and forest/forestry sectors

○ In the agriculture sector, effectively secure and use agricultural water by appropriately combining structural and non-structural measures, including saving irrigation water by automated water management and pipelined waterways, and effectively using existing

water resources by changing the way reservoirs for flood control and agricultural dams are operated. <Ministry of Agriculture, Forestry and Fisheries> [Listed again]

○ For the purpose of contributing to flood control measures throughout the basin of a river through the maintenance and enhancement of headwater resource conservation functions of forests, strengthen forest soil conservation in conservation forests in the upstream river basin by combining forest management, terracing works on mountain slopes, and other techniques; and promote construction of forest road facilities adapted to more frequent localized heavy rainfalls. <Ministry of Agriculture, Forestry and Fisheries>

5) Promotion of investigation and research

○ Promote investigations and research on drought risks, including climate change-induced impacts on water resources and on society. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Noting that sub-surface structures where groundwater is present are highly diverse and regionally unique, promote research regarding poorly understood aspects, including the condition of groundwater reserves, groundwater balance and behavior, and the relationships between surface water and groundwater; and promote investigation and research into the impacts of climate change on groundwater. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Study other countries' use of water bank systems and of water pricing systems as part of emergency water saving strategies, and promote investigation and research on their applicability. <Ministry of Land, Infrastructure, Transport and Tourism>

Section 3. Natural Ecosystems

1. Common activities

Considering that land, freshwater, coastal, and marine ecosystems are closely interconnected and that entire ecosystems will change in response to climate change, Section 3 on Natural Ecosystems sets out the following basic approach and common activities.

[Basic approach to adaptation]

○ Ecosystems as a whole will change in response to climate change. Therefore, it is impossible to control ecosystem changes extensively by anthropogenic measures. In addition, it is necessary to recognize that ecosystem conservation on its own functions as an adaptation measure for the aforementioned issues in agriculture, forestry, and fisheries.

○ The basic adaptation measures applicable to natural ecosystems are to identify changes in the ecosystems and species by conducting long-term continuous monitoring or other investigations; to look at sources of stress from non-climate change factors in addition to stress from climate change factors for reducing these sources of stress and for building an ecological network among protected areas and other effective area-based conservation measures; and thereby to promote the conservation and recovery of healthy ecosystems that

are highly adaptable to climate change.

- In particular, it is also important to focus on strengthening conservation and management in the areas that are expected to contribute to adaptation in natural ecosystems (areas into which organisms can retreat to survive [i.e., refugium] under climate change and areas that can be sources of the supply of individuals), expanding such areas on the whole, securing connectivity among them, and implementing measures addressing the use of the natural environment to prevent lowland organism species from expanding unnecessarily into highlands.
- When building ecological networks, it is important to increase the connectivity and soundness of ecosystems from both a country-wide geographical perspective and a local perspective in order to establish a resilient country against environmental changes due to climate change, etc.
- From the broader geographical perspective, in consideration of the fact that it was determined to support new global targets to conserve or protect at least 30% of global land and at least 30% of the global ocean by 2030 and to lead by example, effectively conserving or protecting at least the same percentage in the G7 nations, in the G7 2030 Nature Compact, which was adopted by the G7 Summit in 2021, it is necessary to expand protected areas and establish other effective area-based conservation measures at the most effective areas and to improve the quality of these areas, in order to maintain the sustainability of ecosystem services through connections among forests, the countryside, rivers, and the sea.
- From the local perspective, methods to increase the quality of local ecosystems in supporting the life cycle of living organism are needed, such as those to secure diverse habitats and food resources. In particular, insects are fundamental in supporting ecosystems through their biomass and pollination and are important for the resilience of ecosystems. Therefore, it is also important to support the life cycles of these species in small green spaces in cities, farmland in the countryside, and other natural environments close to human settlements.
- Active intervention may be conducted to maintain ecosystems, species, and ecosystem services to a limited extent; however, such intervention requires a very careful study in advance, taking into account the impact on ecosystems, etc. and the burden of management. Creating refugia to avoid impacts on ecosystems is a possible option, although it should be noted that there are species that can be transferred quickly and others that cannot be transferred, with the effects varying by species. It is also important to examine other measures based on the expected effects.
- When developing adaptation measures, the government should focus on collecting basic information on the subject regions/areas, determine assessment indicators for existing visible impacts or expected impacts, projecting future impacts using these indicators, and then establishing measures based on the obtained projections; and establishing a plan

related to use and conservation based on local circumstances through discussions with local stakeholders, building consensus, and taking comprehensive actions through collaboration and the sharing of roles with these stakeholders. When establishing measures, it is necessary to examine options according to the situation, such as whether climate change is projected to impact the distribution of species to be conserved in the subject areas and on other living things that have an adverse impact on the species to be conserved and whether there is a refugium for them. In addition, when implementing measures, it is essential to engage in adaptive management, which involves monitoring changes in the subjects of assessments and reviewing the plan regularly. It is also necessary to develop human resources for the management and investigation/research of the natural environment from the long-term perspective to ensure appropriate and effective implementation of adaptation measures.

○ Attention should be paid to maximize synergy and minimize trade-offs with biodiversity conservation. The functions performed by healthy ecosystems include DRR, mitigation of heat stress in cities, actions against the degradation of water quality in coastal areas and enclosed coastal seas, and they contribute to adaptation measures in various fields. This concept is called Ecosystem-based Adaptation (EbA) or Ecosystem-based Disaster Risk Reduction (Eco-DRR) as part of NbS and is important as an approach that brings multiple benefits. In particular, to increase local resilience, the government should focus on avoiding land use that is vulnerable to natural disasters based on the local landscape and ecological conditions, encourage a shift in residency from areas with high disaster risks to areas with low risks, and strengthening local disaster resilience by effectively using diverse functions of the natural environment.

○ The impact of climate change is highly uncertain and advances over the long term. Therefore, it takes time before obvious changes are seen in the distribution and abundance of species and ecosystem services. These changes need to be determined from a long-term perspective and it is impossible to judge the impact based on short-term monitoring results alone. For this reason, there is a need to continue long-term monitoring and other investigations, and enhance and expand them as necessary.

○ Concerning categories with low confidence, noting that past studies are limited and that there are anthropogenic impacts and impacts from land use, efforts should be focused on accumulating scientific findings by promoting investigation and research to identify the impact of climate change on biodiversity, etc. and by disseminating and sharing appropriate information.

[Basic measures]

○ More accurately ascertain climate change-induced changes in ecosystems and species distribution by continuing, and enhancing as necessary, monitoring and other investigational efforts. <Ministry of the Environment>

○ Promote investigation and research to ascertain the impacts of climate change on biodiversity and ecosystem services. Engage in dissemination and awareness raising of the adaptation approaches in the natural ecological field to allow them to be incorporated into various plans relating to the natural environment. <Ministry of the Environment>

○ Foster dissemination of adaptation approaches in the natural ecosystem field in accordance with documents such as the Guide to Developing Climate Change Adaptation Measures in National Parks and Other Protected Areas; and strive to allow these approaches to be incorporated into various plans relating to the natural environment, including those concerning the management of protected areas. <Ministry of the Environment>

○ Continue efforts to reduce stresses from non-climate change factors (e.g., development, environmental pollution, overuse, invasion of alien species) to conserve healthy ecosystems. Also, endeavor to avoid and minimize the negative impacts on biodiversity when implementing adaptation measures. <Ministry of the Environment>

○ Not only secure routes for flora and fauna to migrate and spread, but also expand protected areas and establish other effective area-based conservation measures to allow them to serve multifaceted functions; and thereby promote the formation of ecological networks that include small green spaces in cities, farmland in the countryside, and other natural environments close to human settlements. Also, promote the restoration of damaged ecosystems as necessary. <Ministry of Agriculture, Forestry and Fisheries; Ministry of Land, Infrastructure, Transport and Tourism; Ministry of the Environment>

○ Consider reviewing as necessary the conservation objectives, targets, and methods included in the ecological conservation measures by taking account of climate change impacts; and build a system needed to promote flexible adaptation measures in view of monitoring results and other data. <Ministry of the Environment>

○ Only where there are significant negative impacts from climate change-induced loss of biodiversity and decline in ecosystem services, consider proactive intervention to a limited extent, such as management to maintain existing ecosystems and species, ex-situ conservation, and management to promote adaptability to climate change. In considering such intervention, give careful thought to impacts on ecosystems and the burden of management. <Ministry of the Environment>

○ Collect findings and practices concerning NbS, including Eco-DRR and EbA initiatives that take advantage of ecological functions, and investigate and research methods of assessing these functions. Create a guide that summarizes the directions of such efforts, and perspectives and technical findings to be considered, to foster incorporation into local activities. <Ministry of the Environment>

○ Promote dissemination, sharing, and awareness-raising of information on the relationships between climate change and biodiversity/ecosystem services. <Ministry of the Environment>

2. Basic adaptation measures for terrestrial ecosystems

[Impacts]

<Current status>

(Terrestrial ecosystems [alpine/subalpine zone])

○ In the alpine and subalpine zones, there have been reports on changes and shifts in distribution of vegetation, plant community types, and species composition due to environmental changes such as higher temperatures and earlier snowmelt. Large-scale vegetation changes that have been reported include shifts in the elevation of forest belts, expanded distributions of some species (e.g., Japanese stone pine and Chishima zasa) in the alpine zone, intrusion of wild boar and sika deer into the alpine zone, and degeneration of alpine bog plant communities.

○ Earlier and shorter flowering seasons for alpine plant communities have been observed, causing mismatches between the active period of pollinating insects and the plant flowering season (disruption of mutual relationships due to phenological shifts).

(Terrestrial ecosystems [natural/secondary forests])

○ Regarding the shift and expansion of suitable habitats for natural/secondary forests, there have been reports on changes in life form-specific biomass of trees near the southern/northern limits of different vegetation zones, and declining trends in the growth rate of conifers, as well as increasing trends in the growth rate of broad-leaved trees, in natural coniferous-deciduous mixed forests in Hokkaido over the years.

○ Areas where deciduous broad-leaved trees have presumably been replaced to date by evergreen broad-leaved trees due to higher temperatures have been confirmed in multiple regions of Japan.

○ Regarding radial growth of trees, acceleration of early wood growth has been reported with some tree species.

○ In Hokkaido, it has been confirmed that the flowering season for spring plants comes earlier than visitation by pollinating insects in years with early snowmelt, causing a mismatch with pollinators (phenological mismatch) and declining seed setting rates.

(Terrestrial ecosystems [countryside ecosystems])

○ Extension has been reported near the upper altitudinal limit and the northern limit of the distribution of moso bamboo and Japanese timber bamboo due to higher temperatures.

○ There are no extensive studies at present regarding changes in the composition of species in countryside ecosystems except for moso bamboo and Japanese timber bamboo, although an increase in southern butterflies has been reported in some areas.

(Terrestrial ecosystems [planted forests])

○ There have been reports on decline of Japanese cedar forests in some areas due to increased

water stress caused by higher temperatures and changes in the spatial and temporal distribution of precipitation.

(Terrestrial ecosystems [wildlife])

○ Chronological comparative research confirmed that distribution area of sika deer and wild boar have expanded across Japan.

○ It has been observed that wintering places of sika deer have expanded to higher elevations due to decrease in snow depth. Suitable habitats for sika deer were estimated to expand about 1.7 times in land area during the 25-year period from 1978 to 2003, which accounts for 47.9% of the national land area. Some researchers suggested that this increase would be largely affected by a decrease in snow depth rather than by land use changes.

○ Increased populations of sika deer have been attributed to complex factors, including a reduction in hunting pressure, changes in land use and a decrease in snow depth. Some studies reported that the expansion of distribution area of sika deer would enhance feeding and bark-stripping damages on vegetation as well as distribution area of land leeches.

(Terrestrial ecosystems [material balance])

○ There are limited studies on climate change-induced impacts on material balance.

○ With regard to the soil greenhouse gas (GHG) fluxes in Japanese forests, an increase has been confirmed in the release of carbon dioxide and nitrous oxide and the absorption of methane for the period from 1980 to 2009.

○ Regarding carbon flux in the forest floor of Japanese larch forests in the foothills of Mount Fuji, it has been confirmed that annual cumulative carbon emissions increase as annual average soil temperature rises. Studies have also confirmed that photosynthesis by forest floor vegetation is significantly influenced by changes in the light environment of the forest floor, caused by canopy disruption by tropical cyclones.

○ Changes to the spatial and temporal distribution of precipitation may affect the water balance and sediment dynamics of forests, but the lack of long-term data makes it difficult to ascertain the status of such changes.

<Projected impacts>

(Terrestrial ecosystems [alpine/subalpine zone])

○ Suitable habitat areas for plant species/vegetation, and animals (ptarmigan) in the alpine/subalpine zone are projected to change or shrink. For example, the suitable habitat areas are expected to decrease from the current levels for the Japanese stone pine, northern Japanese hemlock, and Veitch's silver fir by the end of the 21st century.

○ In some areas, local populations of alpine plants will disappear as the snowmelt period comes earlier.

○ As higher temperature during the growth period will accelerate the growth of alpine plants,

competition among plant species will intensify, resulting in vegetation changes such as reduced species diversity and wider distribution of shrubs and Chishima zasa.

○ Higher temperature during the growth period and earlier snowmelt will result in earlier and shorter flowering seasons for alpine plant communities, increasing the risk of a (phenological) mismatch between the appearance of pollinating insects and the flowering season of the plants they visit.

(Terrestrial ecosystems [natural/secondary forests])

○ Suitable habitats for many of the component species of cool temperate forests will shift to higher latitudes and higher altitudes, resulting in the reduction of the suitable habitat range. In particular, it has been shown that the area of the suitable habitat for beech forests will decrease by the end of the 21st century compared to the current level.

○ Suitable habitats for many component species of warm temperate forests will shift to higher latitudes and higher altitudes, resulting in the expansion of the suitable habitat range.

○ However, there are many factors of uncertainty. For example, there are also projections of the shrinkage of actual distribution due to terrain factors, land use, and constraints on the expansion of distribution.

○ An increase in atmospheric carbon dioxide concentrations is thought to affect the biological processes of trees, such as the rate of photosynthesis and stomatal response.

(Terrestrial ecosystems [countryside ecosystems])

○ Suitable habitats for moso bamboo and Japanese timber bamboo are projected to extend to higher latitudes and higher altitudes due to climate change. In a 4°C warming scenario, the northern limit of their distribution can move about 500 km northward from where it is today.

○ Some studies project small impacts of climate change in natural grassland vegetation zones in the warm temperate zone or further south. Suitable habitats for secondary-forest species constituting countryside landscapes, including loose-flower hornbeam and Asian hornbeam, may shrink in low mountain elevations and in southwest Japan.

○ However, climate change impacts on countryside ecosystems have not been verified sufficiently because they are formed under anthropogenic impacts, and more research is needed in the future.

(Terrestrial ecosystems [planted forests])

○ Studies show that if the temperature increases by 3°C above current levels, the transpiration rate will increase and the vulnerability of Japanese cedar planted forests may increase, especially in areas with low annual rainfall, although only a small proportion of the planted forest area will become unsuitable for growth.

○ A projection of impacts through 2050 across the entire country found a negative effect on

the carbon stock and absorption rate, based on the high proportion of planted forests (which are high in forest respiration) in Shikoku and Kyushu, and on a large proportion of 40- and 50-year-old planted forests, which are high in both carbon stock and respiration rates. However, that projection did not take into account the impacts of increasing carbon dioxide concentrations in the atmosphere. Further research is needed regarding the physiological responses of trees to project impacts on cedar tree planted forest ecosystems. A study that estimated the primary production of Japanese cedar planted forests in Kyushu by using a process model, projected that an increase in primary production due to warming would be unlikely in current high-productivity areas, although with some difference depending on suitability for growth.

(Terrestrial ecosystems [wildlife])

○ Some study predicted that the decrease in snow depth associated with climate change and the expansion of abandoned arable fields will enlarge suitable habitat of sika deer, which will cover more than 90% of the national land area by 2103.

○ Meanwhile, there have been no confirmation about future impacts of climate change, such as changes in distribution ranges of wild boar and other wild species.

(Terrestrial ecosystems [material balance])

○ Higher annual mean temperatures and longer rainless periods may result in the reduction of moisture content in forest soils, leading to the drying of surface soil, then more runoff of fine sediment and prolonged time to reduce river turbidity, and ultimately shorter rainfall-runoff response times. However, these are inferences based on circumstantial evidence, and further consideration is needed.

○ Soil warming experiments in various parts of Japan have indicated that soil respiration increases as soil temperature rises and produced multiple findings that support positive feedback effects. On the other hand, some findings show that the extent of increase in soil respiration associated with the rise in soil temperature decreases over a number of years mainly due to the adaptation of soil microorganisms to the changed climate. This suggests that the impact that higher soil temperature has on soil respiration may vary by the type and location of the forest ecosystem.

○ For forest soil carbon stocks, a 14% increase in net primary production and a 5% decrease in soil organic carbon are projected.

・ Terrestrial ecosystems (alpine/subalpine zone) [Significance: ●; Urgency: ●; Confidence: ▲]

・ Terrestrial ecosystems (natural/secondary forests) [Significance(RCP 2.6/8.5): ◆/●; Urgency: ●; Confidence: ●]

・ Terrestrial ecosystems (countryside ecosystems) [Significance: ◆ ; Urgency: ●;

Confidence: ■]

・Terrestrial ecosystems (planted forests) [Significance: ●; Urgency: ●; Confidence: ▲]

・Terrestrial ecosystems (impacts from wildlife) [Significance: ●; Urgency: ●; Confidence: ■]

・Terrestrial ecosystems (material balance) [Significance: ●; Urgency: ▲; Confidence: ▲]

[Basic approach to adaptation]

○ Concerning forests, efforts should be focused on promoting the conservation and management of primary natural forests and forests where rare wildlife lives and grows, as well as investigation and research on the impact of climate change on forests.

○ Intensive long-term monitoring and other investigations are needed in alpine zones and other areas that are highly likely to be affected.

○ To conserve and restore healthy ecosystems with high adaptability to climate change, it is necessary to promote the creation of a nationwide ecological network by designating protected areas and establishing other effective area-based conservation measures and implement conventional measures against the loss of biodiversity due to non-climate change factors by prioritizing them in consideration of adaptation to climate change.

○ In particular, activities to strengthen the conservation of areas that are expected to mitigate the impact of climate change and to prevent lowland species from excessively expanding to highlands are important.

○ Regarding material balance, a climate change-induced rise in soil temperature is projected to increase soil respiration, possibly resulting in increased carbon dioxide released to the atmosphere and accelerating climate change. There are not sufficient findings to forecast when such impacts will materialize, and further investigation and research are needed.

[Basic measures]

In accordance with the basic approach to adaptation measures described in item 1 of this section, activities for common purposes will be implemented along with the following specific initiatives:

○ For conservation and management of natural forests, conduct continuous monitoring; and foster collaboration between national and private forests to preserve and restore forest ecosystems, protect and administer rare forest ecosystems scattered across the country, and ensure the continuity of these forests. <Ministry of Agriculture, Forestry and Fisheries>

○ In national forests and fields where conservation areas are designated, such as the Protected Forests, which are aimed at protecting primary natural forests and the habitat of rare wildlife, and the Green Corridors, which serve as migratory pathways for wildlife, promote appropriate conservation and management by accurately ascertaining the situation through continuous monitoring surveys and working to form forest ecological networks integrated with forests along mountain streams. <Ministry of Agriculture, Forestry and Fisheries>

○ Strive to capture the impacts of climate change particularly through intensive monitoring and assessments in alpine zones and other areas that are highly likely to be affected and through continuous wildlife monitoring in national parks and protected forests in national forests. <Ministry of Agriculture, Forestry and Fisheries; Ministry of the Environment>

○ To conserve and restore healthy ecosystems with high adaptability to climate change, endeavor to bolster ongoing measures to protect biodiversity by considering the projected impacts of climate change, including measures such as reviewing and properly managing protected areas in national and quasi-national parks; controlling the populations of and damage from sika deer and other wildlife species that are growing in population and distribution and having significant impacts on ecosystems; conducting control and border measures for alien species; and conducting protection and reproduction programs for rare species. <Ministry of the Environment>

○ Create ecological networks around national and quasi-national parks, nationally designated wildlife conservation areas, protected forests in national forests and other effective area-based conservation measures; and promote the formation of forest ecological networks integrated with forests along mountain streams. <Ministry of Agriculture, Forestry and Fisheries; Ministry of the Environment>

○ Incorporate adaptation measures into the management of protected areas, based on investigation and research results on climate change adaptation measures for vulnerable ecosystems (e.g., alpine vegetation). <Ministry of the Environment>

3. Basic adaptation measures for freshwater ecosystems

[Impacts]

<Current status>

(Freshwater ecosystems [lakes/swamps])

○ Lake and swamp ecosystems are affected by the nutrient salt loads from land uses in their basins, making it difficult to isolate the impacts of climate change, and there are limited studies in Japan that have revealed direct impacts of climate change.

○ However, in Lake Ikeda (Kagoshima Prefecture), it has been confirmed that the circulation period has disappeared due to warm winters, resulting in decreased dissolved oxygen levels at the lake bottom and causing a trend toward oxygen deficiency. Some reports attribute a sharp drop in the population of willow minnow and round crucian carp in Lake Biwa (Shiga Prefecture) to the compound action of factors such as a late circulation due to warmer winters, anthropogenic water level control, and anthropogenic modifications of the lakeshore environment.

○ Some reports indicate that the species composition of water grass changed in lakes and swamps across Japan in the early 1900s to the 2000s and point to shifts in temperature and rainfall patterns as a factor.

○ In lakes and swamps in Hokkaido, shorter ice formation periods and associated earlier

blooms of phytoplankton have been observed.

(Freshwater ecosystems [rivers])

○ As rivers in Japan are under water intake and flow control, it is difficult to detect impacts of climate change on river ecosystems, and there are no research results available at present on direct impacts of climate change. Meanwhile, there have been reports on phenomena that may have been induced by climate change-related shifts in water temperature, such as earlier and longer fish breeding periods and a northward shift of temperate/tropical aquatic life distributions.

(Freshwater ecosystems [marshlands])

○ Marshland ecosystems are strongly affected by anthropogenic impacts other than climate change, and there are limited studies directly dealing with the impacts of climate change.

○ In some marshlands, it has been pointed out that drying marshlands may be attributable to decreased humidity, increased evapotranspiration, and reduced snow depth due to climate change.

<Projected impacts>

(Freshwater ecosystems [lakes/swamps])

○ Although there are limited studies showing quantitative projections of impacts in Japan, for deep lakes and swamps where eutrophication is progressing, there is concern over vertical circulation disruption and oxygen deficiency due to higher water temperature, as well as the resulting impacts on benthic organisms, including shellfish, and further eutrophication.

○ The increase in lake water temperature is projected to increase the population of phytoplankton forming blue-green algae, presumably resulting in worsened water quality and causing adverse effects on the initial growth of aquatic plants after germination.

○ Laboratory experiments have shown that the rise in lake water temperature and carbon dioxide concentration reduce the growth of zooplankton.

(Freshwater ecosystems [rivers])

○ If the mean temperature increases by 3°C from current levels, suitable habitats for the cold-water fish of the white-spotted char and the Honshu char (*nikko iwana* [*Salvelinus leucomaenis pluvius*], *yamato iwana* [*Salvelinus leucomaenis japonicus*], and gogi [*Salvelinus leucomaenis imbrius*]) will reduce to about 70% of the current range. In the Chugoku and Kinki regions, even a 1°C increase in mean temperature will reduce suitable habitats to about half the current range.

○ In some rivers, climate change will negatively affect suitable habitats for the stoneflies in the source basin, summer survival environments for cherry salmon (masu salmon), the upstream migration of ayu, leading to the shrinkage or disappearance of suitable habitats

and reductions in migration.

○ Although there are no studies providing quantitative projections at present, the following impacts are assumed:

- Impacts on river biota that move upstream, move downstream, and spawn, timed with snowmelt runoff, due to changes in the timing and magnitude of snow cover and snowmelt runoff
- Impacts on the river bed environment from turbidity elements due to increased frequency of large floods caused by changes in the spatial and temporal distribution of precipitation, and resultant impacts on fish, benthic organisms, attached algae, and other creatures
- Impacts on river organisms due to increases in water temperature and reductions in dissolved oxygen associated with drought

(Freshwater ecosystems [marshlands])

○ In the Kushiro Marshland, increases in sediment and nutrient salt loads coming from the basin are projected due to intensifying extreme rainfall events. In addition, sea level rise will increase the salt water intrusion range, causing impacts on the composition of species in the marshland ecological.

○ Changes in precipitation and lower groundwater levels will have impacts on plant communities in high marshlands that are nourished by rainwater.

○ Although there are no studies providing quantitative projections at present, the following impacts are assumed:

- Impacts on marshlands in Hokkaido, which account for about 80% of the area of all marshlands in Japan
- Transition from marshlands herbaceous communities to woody plant communities in low marshlands due to basin loads (sediments and nutrient salts) caused by climate change; and increases in evapotranspiration

・Freshwater ecosystems (lakes/swamps, rivers, and marshlands) [Significance: ●; Urgency: ▲; Confidence: ■]

[Basic approach to adaptation]

○ Recognizing that the risk of species extinction has been increasing in inland water ecosystems over the long term, the government should emphasize the long-term implementation of monitoring and other surveys of important inland water bodies.

○ To conserve and restore healthy ecosystems with high adaptability to climate change, efforts should be focused on securing the connectivity of water bodies by designating protected areas and establishing other effective area-based conservation measures; promoting the creation of ecological networks that enables flora and fauna to move around; and

implementing conventional measures against the loss of biodiversity due to non-climate change factors by prioritizing them in consideration of adaptation to climate change.

○ Regarding the lake/swamp ecological, higher water temperatures are projected to increase the population of phytoplankton forming blue-green algae and worsen water quality in specific lakes and swamps by the mid-21st century. Since the nature of impacts and the urgency of adaptation depend on the situation of individual lakes or swamps, it is necessary to conduct monitoring and develop and implement measures based on the monitoring results.

○ Regarding the river ecosystem, suitable habitats for cold-water fish and aquatic insects are projected to significantly decrease in some regions by the mid-21st century or as a result of a 1°C rise in annual mean temperature. Since the nature of impacts and the urgency of adaptation depend on the situation of individual rivers, it is necessary to conduct monitoring and develop and implement measures based on the monitoring results.

○ Regarding the marshland ecosystem, reductions in the area of marshlands have been reported in alpine/subalpine marshlands in some regions presumably as a result of decreased snow cover. Keeping in mind the high urgency of the issue, it is necessary to work to develop and disseminate relevant adaptation measures.

[Basic measures]

In accordance with the basic approach to adaptation measures described in item 1 of this section, activities for common purposes will be implemented along with the following specific initiatives:

○ More accurately ascertain changes in ecosystems and species distribution by continuing, and enhancing as necessary, monitoring and other investigational efforts in important inland water bodies; and promote associated investigation and research to ascertain the impacts of climate change. <Ministry of the Environment>

○ To conserve and restore healthy ecosystems with high adaptability to climate change, endeavor to bolster ongoing measures to protect biodiversity by considering the projected impacts of climate change, including measures such as reviewing and properly managing protected areas in national and quasi-national parks, conducting control and border measures for alien species, and conducting protection and reproduction programs for rare species; and restore ecosystems in marshlands as necessary. <Ministry of the Environment>

○ In addition to expanding protected areas and establishing other effective area-based conservation measures, promote the creation of ecological networks centered around river systems through which flora and fauna can move around by securing the connectivity of water bodies (e.g., rivers, lakes/swamps, marshlands, springs, reservoirs for flood control, waterways, and paddy fields). <Ministry of Agriculture, Forestry and Fisheries; Ministry of Land, Infrastructure, Transport and Tourism; Ministry of the Environment>

○ As for inland fish diseases, which are expected to cause broader damage due to higher water

temperatures, conduct research on the characteristics and onset factors of pathogens, and develop control technologies based on the research results. <Ministry of Agriculture, Forestry and Fisheries>

4. Basic adaptation measures for coastal ecosystems

[Impacts]

<Current status>

(Coastal ecosystems [subtropical zone])

○ In the Okinawa region, the bleaching of subtropical corals has been increasing in frequency due to higher seawater temperature. In 2016, a large-scale coral bleaching event occurred around the Sekisei Lagoon off Ishigaki Island, presumably due to high water temperature in the summer.

○ The distribution of temperate corals in the Pacific Ocean has been moving northward in areas south of the Boso Peninsula and along the west and north coasts of Kyushu.

○ Laboratory experiments have pointed out the possibility that the amount of calcification is decreasing in some reef-building coral species.

○ Some mangroves were found dead in Iriomote Island presumably due to more frequent submersion associated with sea level rise.

(Coastal ecosystems [temperate/subarctic zone])

○ In various places along the coast of Japan, a transition has been confirmed to be underway from cool-temperature to warm-temperature species as seawater temperature increases.

○ Observations have found the northward shift of the distribution of subtropical reef-building corals near their northern limit and declines in seaweed beds near the southern limit of their distribution range, suggesting a transition from seaweed beds to coral reefs.

○ Seawater pH in coastal waters of Japan varies widely by sea area but is generally decreasing, indicating the progress of ocean acidification.

○ Dissolved oxygen levels in coastal waters of Japan also vary widely by sea area but are confirmed to be decreasing in general.

○ It is said to be difficult at present to attribute ongoing changes in marine ecosystems to the impacts of ocean acidification.

○ The populations of some seabirds living around Japan have been found to be decreasing over the long term, and climate change-induced feed shortages have been pointed out as a factor.

<Projected impacts>

(Coastal ecosystems [subtropical zone])

○ In a 4°C warming scenario, sea areas suitable for the growth of tropical and subtropical reef-building corals will disappear from Japanese coastal waters due to an increase in

seawater temperature and ocean acidification. In a 3°C warming scenario, some suitable habitats will remain even at the end of this century. In sea areas outside suitable habitats, an increase in coral bleaching and other stressors and reductions in the amount of calcification will occur, although there are no projections as to whether this will lead to the complete disappearance of the existing coral reefs outside the suitable habitats.

○ Mangroves, which form another ecological characteristic to subtropical coastal waters, are projected to see a shrinkage and an inland shift of distribution ranges due to sea level rise. More adverse impacts are expected especially where the hinterland is fragmented by structures or other objects, hindering the availability, movement, and dispersion of sediment. There are limited findings on the future of mangrove forests in Japan at present: some studies indicate that higher temperature will increase the mortality rate, while others project that no growth inhibition will occur as physiological characteristics will adapt to temperature. Further studies are awaited.

(Coastal ecosystems [temperate/subarctic zone])

○ With an increase in seawater temperature, it is expected that there will be a shift toward warm-water species (e.g., in the case of sea urchins, from *ezobafununi* [*Strongylocentrotus intermedius*] to *kitamurasakiuni* [*Strongylocentrotus nudus*]) and that this may lead to impacts on entire ecosystems, although there are limited quantitative studies.

○ In the medium- to high-emissions scenarios, ocean acidification will bring a substantial risk to vulnerable marine ecosystems, especially in polar regions and coral reefs. Many species of mollusks, echinoderms, and reef-building corals that have calcium carbonate skeletons or shells are sensitive to ocean acidification. As a result, adverse effects may extend to species constituting fishery resources. Although the situation is complex due to interactions between simultaneously occurring factors, such as rising water temperature and lower oxygen levels, the impacts may be amplified.

○ Higher water temperature and a northward shift of the phytophagous fish distribution will cause deterioration of the seaweed bed ecological and its transition to the tropical coral reef ecological.

○ There are also concerns that changes in coastal ecosystems could impact species that provide resources for coastal fisheries. There will also be impacts on local culture, as fishing villages often depend on coastal natural scenery, such as seaweed beds, and fisheries harvest species living there.

○ Sea level rise is expected to have impacts on salt marshes in coastal areas.

・Coastal ecosystems (subtropical zone) [Significance: ●; Urgency: ●; Confidence: ●]

・Coastal ecosystems (temperate/subarctic zone) [Significance: ●; Urgency: ●; Confidence: ▲]

[Basic approach to adaptation]

○ Efforts should be focused on implementing intensive long-term monitoring and other investigations on tidal flats, salt marshes, seaweed beds, eelgrass beds, and coral reefs, which are highly likely to be affected. In addition, noting that coastal areas have a strong relationship with land areas through rivers, etc., it is necessary to expand observation through the entire river basin.

○ To conserve and restore healthy ecosystems with high adaptability to climate change, it is necessary to ensure the continuity of coastal ecosystems mainly by effectively allocating marine protected areas, etc. for various purposes; form ecological networks; and implement ongoing measures against the loss of biodiversity due to non-climate change factors by prioritizing them in consideration of adaptation to climate change.

[Basic measures]

In accordance with the basic approach to adaptation measures described in item 1 of this section, activities for common purposes will be implemented along with the following specific initiatives:

○ Implement intensive monitoring and conduct assessments of climate change impacts on tidal flats, salt marshes, seaweed beds, and coral reefs that are highly likely to be affected. <Ministry of the Environment>

○ To conserve and restore healthy ecosystems with high adaptability to climate change, endeavor to bolster ongoing measures to protect biodiversity by considering the projected impacts of climate change, including measures such as reviewing and properly managing protected areas in national and quasi-national parks, conducting control and border measures for alien species, conducting protection and reproduction programs for rare species, and restoring ecosystems in tidal flats. <Ministry of the Environment>

○ Also, conserve and restore coastlines, tidal flats, salt marshes, seaweed beds, coral reefs, etc., while expanding protected areas and establishing other effective area-based conservation measures, to promote the creation of ecological networks. <Ministry of the Environment>

○ Regarding the occurrence of harmful algae, continue investigation and research on its relationship with climate change. <Ministry of Agriculture, Forestry and Fisheries>

○ Implement efforts to incorporate adaptation measures into the management of protected areas, based on investigation and research results on climate change adaptation measures for vulnerable ecosystems (e.g., coral reefs). <Ministry of the Environment>

5. Basic adaptation measures for marine ecosystems

[Impacts]

<Current status>

○ In the waters around Japan, particularly in the Oyashio region, Kuroshio region, and mixed

water region, phytoplankton biomass and primary productivity may have begun to decline.

○ It is known that dissolved oxygen levels are continuously decreasing in the near-surface layer (100 to 1,000 m deep) of the ocean, and dissolved oxygen concentrations are declining in the near-surface layer in almost every water area around Japan. On the other hand, as dissolved oxygen concentrations have been relatively high in waters around Japan, direct impacts on marine creatures have not been detected except in some bottom-dwelling fish.

○ In subarctic water areas in the western North Pacific Ocean, a northward shift of the distribution of warm-water copepods has been observed due to the recent rise in surface water temperature.

<Projected impacts>

○ Climate change may induce changes to phytoplankton biomass. Globally, phytoplankton biomass is projected to decrease in tropical and subtropical waters and increase in subarctic waters. However, for the sea around Japan, current projection models are not reliable enough to provide projections for future changes. Likewise, projections on changes in zooplankton biomass in waters around Japan are not very reliable. It is also difficult at present to project regional impacts arising from these changes.

○ There are projections suggesting the vulnerability of marine protected areas around Japan to climate change.

・Marine ecosystems [Significance: ●; Urgency: ▲; Confidence: ■]

[Basic approach to adaptation]

○ Some projections indicate that in 88% of Japanese coastal waters, climate change expected through 2035 will be greater than the extent of previously experienced changes, although many uncertainties remain as to the impacts that climate change-induced phenomena, such as seawater temperature rise, sea level rise, ocean acidification, will have on ecosystems. Moreover, there is still much to be scientifically understood about ecosystems in offshore waters. Noting that there is not as much accurate scientific information on these ecosystems as available for coastal water ecosystems, efforts should be focused on expanding relevant monitoring and projections, especially in marine protected areas and sea areas highly valuable for their biodiversity.

○ To conserve and restore healthy ecosystems with high adaptability to climate change, it is necessary to ensure the continuity of marine ecosystems mainly by effectively allocating marine protected areas, etc. for various purposes; form ecological networks; and implement ongoing measures against the loss of biodiversity due to non-climate change factors by prioritizing them in consideration of adaptation to climate change.

[Basic measures]

In accordance with the basic approach to adaptation measures described in item 1 of this section, activities for common purposes will be implemented along with the following specific initiatives:

○ Continue investigation and research on the relationship between the occurrence of harmful algae and climate change. <Ministry of Agriculture, Forestry and Fisheries>

○ Accumulate accurate scientific information and conduct continuous monitoring mainly in Offshore Seabed Nature Conservation Areas and *Ecologically or Biologically Significant marine Areas identified Japan*. <Ministry of the Environment>

○ Promote the creation of ecological networks by expanding protected areas and establishing other effective area-based conservation measures. <Ministry of the Environment>

6. Basic adaptation measures for phenology and shifts in distribution and populations

[Impacts]

<Current status>

(Phenology)

○ There have been many reports of shifts in the phenology of flora and fauna, such as earlier flowering of plants and earlier initiation of calling by animals.

(Shifts in distribution and populations)

○ Climate change has been identified as a third factor of the change brought to global natural ecosystems in the past 50 years, following changes in land and ocean use and direct exploitation (logging, fishing, etc.). Some reports also indicate that climate change is deteriorating the impacts from other direct factors.

○ There are confirmed cases of shifts in distribution and changes in life cycles for insects and birds, such as expansion of northern distribution limits and wintering places to higher latitudes, which could be explained as impacts of climate change-induced increases in temperature. However, a variety of factors other than climate change could also be involved, and it is therefore difficult to determine to what extent the observed changes are a result of climate change.

○ For some insect species, such as the lawn ground cricket and Zigzag ladybird beetle, shifts in life-history stages and northern distribution limits have been found through field surveys and comparisons with past specimens. As trends in these changes correspond with trends in temperature changes, it is highly likely that these insects have expanded their distribution range in line with temperature rises.

<Projected impacts>

(Phenology)

○ Impacts on various species are projected, including the earlier flowering of Yoshino Cherry

trees, a longer in leafy season for deciduous broad-leaved trees, shifts in the day on which leaves start to change color, and deterioration of the way leaves are colored.

○ The impacts will not be limited to individual species but will extend to various interactions between species.

(Shifts in distribution and populations)

○ Climate change could lead to the extinction of certain species by causing shifts in species distribution and changes in their life-cycles, by causing further adverse impacts from changes in inter-species interactions due to species migration or localized extinction, and by making species unable to shift their distribution to adapt to climate change due to fragmentation of habitats. With an increase of temperature by more than 2°C by 2050, it is projected that more than 30% of all species on Earth would be at risk of extinction.

○ For the oriental honey-buzzard, a migratory bird, some researchers project that climate change-induced changes in wind direction and other factors will cause their suitable migration destinations currently on the East China Sea to fragment or disappear.

○ Some projections indicate the possibility that secondary contact, a process in which habitats of two geographically separated and isolated populations of a species are reunited, may occur as a result of changes in their distribution ranges.

○ Researchers have pointed out that climate change fosters the establishment and expanded distribution expansion of alien species, suggesting concern over the potentially increased risk of damage to ecosystems from alien species. Although there are limited studies providing quantitative projections at present, it is expected that climate change will increase the probability of invasion and establishment of some invasive alien species.

・Phenology [Significance: ◆; Urgency: ●; Confidence: ●]

・Shifts in distribution and populations (native species) [Significance: ●; Urgency: ●; Confidence: ●]

・Shifts in distribution and populations (alien species) [Significance: ●; Urgency: ●; Confidence: ▲]

[Basic approach to adaptation]

○ Monitoring and other investigational efforts to identify phenological shifts, including those involving public participation, should be implemented continuously, based on the awareness that phenological studies provide useful basic data for investigation of the impacts that ecological changes and climate change have on ecosystems and that there is a cultural value in sensing the four seasons by observing living things.

○ To identify changes in the distribution of species and populations more accurately, it is necessary to implement continuous long-term monitoring and other investigations.

○ To secure pathways for species to move and spread, it is necessary to promote the creation

of ecological networks that connect protected areas and other effective area-based conservation measures and implement conventional measures against the loss of biodiversity due to non-climate change factors by prioritizing them in consideration of adaptation to climate change.

○ Based on information obtained from monitoring and new scientific findings, it is necessary to take appropriate actions on species that pose an increased risk of damaging ecosystems by considering climate change impacts when assessing invasive alien species.

[Basic measures]

In accordance with the basic approach to adaptation measures described in item 1 of this section, activities for common purposes will be implemented along with the following specific initiatives.

○ Continue to conduct, and enhance and expand as necessary, monitoring and other studies to ascertain phenological changes, such as the flowering of plants. <Ministry of the Environment>

○ Promote participative monitoring in cooperation with other organizations, such as research institutions and NPOs, while working toward finding and developing relevant human resources. <Ministry of the Environment>

○ Continue, and enhance and expand as necessary, monitoring and other investigational efforts, including those involving public participation, to identify shifts in phenology, species distribution and populations more accurately. Implement intensive monitoring and assessments on species living in alpine zones and coastal areas that are highly likely to be affected, as well as wildlife such as the sika deer, which are having serious impacts on ecosystems due to increase in population and distribution, and alien species. <Ministry of the Environment>

○ To conserve and restore healthy ecosystems with high adaptability to climate change, endeavor to bolster ongoing measures to protect biodiversity by considering the projected impacts of climate change, including measures such as controlling the populations of sika deer and other wildlife, conducting control and border measures for alien species; and conducting protection and reproduction programs for rare species. <Ministry of Agriculture, Forestry and Fisheries; Ministry of the Environment>

○ Promote the creation of ecological networks to secure pathways for flora and fauna to migrate and spread by expanding protected areas and establishing other effective area-based conservation measures. When doing so, consider the risk of expanding the distribution ranges of alien species and sika deer, as well as potential impacts on native species. <Ministry of Agriculture, Forestry and Fisheries; Ministry of the Environment>

○ For national programs such as the protection and reproduction program plan for each nationally rare species of wild fauna/flora, develop objectives and measures at the next program review, taking into account the impacts of climate change. In particular, in

conserving rare species vulnerable to climate change impacts, such as species distributed only in an isolated island or the alpine zone, accelerate the development of measures for reinforcement (adding some individuals into an existing population of the same species), ex-situ conservation, and preservation of reproductive cells, taking into account impacts on the ecosystem and the burden of management. <Ministry of the Environment>

7. Basic adaptation measures for ecosystem services

[Impacts]

<Current status>

○ On the global scale, there have been reports indicating that climate change-induced shifts in the species composition of ecosystems, the phenology of such species, and inter-species interactions have affected ecological structure and functions, already resulting in impacts on ecosystem services.

○ Meanwhile, there are few studies explaining the impacts of climate change on ecosystem services, and more studies are awaited on this topic.

○ Studies have shown that a coral reef bleaching event that occurred in the Sekisei Lagoon in 2016 has reduced the economic value of ecosystem services provided by the local coral reefs (fish supply to fisheries and aquariums, recreational diving, and seaweed control).

<Projected impacts>

○ A review of studies projecting climate change-induced impacts on ecosystem services found that about 60% of the studies reviewed projected that climate change would have negative impacts on ecosystem services.

○ In the basin of the Teshio River, Hokkaido, climate change will increase the influx of nitrogen, phosphorus, and other nutrient salts into the river.

○ Estimates show that ecosystem services provided by coral reefs in Japan are annually worth 239.9 billion yen in tourism and recreational value, 10.7 billion yen in fishery (commercial marine product) value, and 7.52 to 83.9 billion yen as shore conservation function. These ecosystem services may reduce or disappear when projections of climate change-induced reductions in suitable habitats for coral are taken into account.

○ The stress that bleaching and ocean acidification place on coral reefs not only prevents coral reefs from keeping up with sea level rise but also reduces the effects of seabed friction as a result of dead corals. All together, these events may seriously affect the breakwater function of coral reefs.

○ Suitable habitats for sika deer are expanding due to the impacts of climate change. Regarding the Ashiu research forest of Kyoto University, multiple studies led to the assumption that one of the primary factors of the decrease in pollinator population can be the decline of nectar-rich plants as a result of a marked increase in grazing pressure from sika deer. The pollination services that Japan’s agriculture receives from flower-visiting

insects were worth about 470 billion yen in 2013, of which 330 billion yen came from wild pollinators. Given that sika deer are increasing all across Japan, the possibility is undeniable that the same situation as described above is happening in other parts of the country. If this is the case, decreasing wild bees may be resulting in declining pollination services.

・ecosystem services (river basin functions to retain nutrient salts and suspended sediments) [Significance: ●; Urgency: ▲; Confidence: ■]
・ecosystem services (function of coastal seaweed bed ecosystems to supply aquatic resources) [Significance: ●; Urgency: ●; Confidence: ▲]
・ecosystem services (Eco-DRR function of coral reefs) [Significance: ●; Urgency: ●; Confidence: ●]
・ecosystem services (recreational functions associated with natural ecosystems) [Significance: ●; Urgency: ▲; Confidence: ■]

[Basic approach to adaptation]

○ In addition to quantitative assessment and visualization of the various social benefits of NbS and other ecosystem services, it is necessary to promote investigation and research on changes in the benefits and social impacts of climate change and to gather scientific findings on which development of efforts toward sustainable ecosystem services should be based. Focus should also be placed on the implementation of regional efforts.
○ There is concern that changes in the distribution of pollinating insects due to climate change and mismatches between their visitation and plant blossoming times may affect pollination services. Based on this awareness, it is important to secure habitat size and continuity, even for common species.

[Basic measures]

○ Promote investigation and research on the visualization of ecological functions to strengthen the water retention and other functions of the entire river basin through restoration of former flood plains and marshlands. Also, compile and disseminate technical findings to foster the development of communities that are resistant to disasters and harmonized with nature. <Ministry of the Environment>
○ Promote the creation of ecological networks by expanding protected areas and establishing other effective area-based conservation measures, and secure the scale and continuity of habitats for pollinating insects, including common species. <Ministry of the Environment>
○ Incorporate ecosystem services provided by coral reef ecosystems in control plans in a manner that enhances the public understanding of such services and climate change-induced changes to them; and foster the implementation of community-based efforts to protect the benefits from these ecosystems. <Ministry of the Environment>

Section 4. Natural Disasters and Coastal Areas

1. Basic adaptation measures for rivers

[Impacts]

<Current status>

(Floods)

○ An analysis of past rainfall data has revealed that the frequency of relatively frequent heavy rainfall events is increasing over time.

○ Inundation areas have generally been decreasing over time, compared with those recorded during Japan's high economic growth period. Advancement of flood control measures is a key factor to explain this trend. However, more recently, inundation areas have generally remained unchanged. There is concern that climate change may increase the frequency and intensity of floods as the relative population in flood risk zones is increasing amid shrinkage of Japan's population, and the number of locations where a flood exceeding the flood risk water level has occurred is on the rise both among state-controlled rivers and prefecture-controlled rivers.

○ The preparedness levels of existing flood control facilities are still below the targets set under the current plans.

○ Japan is still vulnerable to water hazards from river flooding. If climate change results in more severe rainfall events, the impacts may become considerably high.

○ Increased evaporation rates associated with global warming are assumed to have contributed to disasters during the Heavy Rain Event of July 2018, in which rain continued for record long hours, with short-duration intense rainfall occurring across a wide area, simultaneously causing river flooding and inland flooding in many areas.

(Inland waters)

○ An analysis of past rainfall data has revealed that the frequency of relatively frequent heavy rainfall events is increasing over time. There has been a significant increase over the past 50 years in the intensity of rainfall concentrated over short durations with an annual probability of exceedance of 1/5 or 1/10.

○ Although Japan's safety against flood disasters has steadily improved according to the planned targets through past efforts to improve sewer systems, these efforts should continue.

○ Inland flooding accounts for about 40% of the nationwide cost of flood disasters (average for 2005 to 2012) and even higher percentages in Tokyo, Aichi, Osaka, and Fukuoka, which are prefectures with big cities.

○ The increasing frequency and intensity of such short-duration intense rainfall events may have contributed to the more frequent inland flood damage occurring in recent years in urban areas where only a low level of measures against inundation has been achieved.

Increased evaporation rates associated with global warming are assumed to have contributed to disasters during the Heavy Rain Event of July 2018. Reports show that about 90% of inundation above or below floor level due to inland flooding during the event occurred in districts with incomplete drainage facilities in the sewer system.

<Projected impacts>

(Floods)

○ According to projections in scenarios such as RCP 2.6 and RCP 8.5, in major river basins in Japan, heavy rainfall events that can cause floods will increase significantly by the end of this century from current levels.

○ Multiple articles have indicated that both the flood peak flow and the probability of flooding will increase (or be amplified) more than flood-causing precipitation increases. It is expected that the degree of this amplification will be far larger for the probability of flooding than for flood peak flow.

○ Japan and the world will see increases in damage from flooding associated with higher temperatures.

○ Research has found that if the probability of flooding significantly increases in an area protected from flooding with levees (land-side area), inundation damage tends to increase there.

○ In low-lying coastal areas, it is expected that sea level rise will lead to an increased likelihood of river flooding and longer periods of inundation due to flooding.

(Inland waters)

○ Inland flooding projections for Saitama Prefecture in the RCP 8.5 scenario have indicated the possibility that even if a sewer system capable of handling rainfall of an annual probability of exceedance of 1/5 is in place, as assumed in the current plans, inland inundation will increase in both range and depth by the end of the 21st century, and so will the population that will be affected by inundation from inland flooding. Meanwhile, when future population changes are taken into account, a declining population will have a large impact, suggesting that the population at inundation risk will be smaller than that under the current population conditions.

○ Research estimating the expected cost of inland food damage throughout Japan in the RCP 8.5 scenario has found that the cost will be about twice as large as that in current climate in 2080 to 2099.

○ In low-lying areas and other locations near rivers or coasts, it is expected that an increased frequency of higher river levels or sea level rise will make it difficult for sewer systems to discharge rainwater and increase the probability of inland flooding, leading to longer inundation durations.

○ Urban areas will be more seriously affected due to their special vulnerability to flooding

and inundation, if short-duration intensive rainfall events increase due to impacts of climate change, combined with higher sea levels.

○ Apart from urban areas, increases in heavy rainfall will also cause inundation damage to farmland or other rural areas.

・Floods [Significance (RCP 2.6/8.5): ●/●; Urgency: ●; Confidence: ●]
・Inland waters [Significance: ●; Urgency: ●; Confidence: ●]
・Storm surges and high waves [Significance: ●; Urgency: ●; Confidence: ●]

[Basic approach to adaptation]

○ Projections of future climate change suggest increases in the frequency and intensity of heavy rain, increases in total precipitation, mean sea level rise, and increases in extremes of storm surges and high waves. In addition to more intense and frequent flood disasters, there is concern about the occurrence of large-scale disasters in new forms due to complex factors, such as sediment-laden flood, and combined high tide and river flooding. Despite some variation, these climate change projections indicate the urgent need to review river improvement plans and town development plans to promptly incorporate climate change considerations. As such plans require a long time to implement, unless steps are taken in consideration of the assessments of future changes arising from climate change, etc., necessary river improvement plans may take even longer due to the need to review plans and implement additional actions.

○ Efforts should be focused on reviewing the plans to incorporate climate change considerations related to more frequent and intensifying water disasters driven by climate change; promoting the concept of “River Basin Disaster Resilience and Sustainability by All,” in which all stakeholders of the entire river basin work together, including the national government, prefectural governments, municipal governments, local companies, and residents; and implementing comprehensive DRR measures that include structural and non-structural measures.

○ Regarding intensifying and more frequent water disasters associated with climate change, given the speed of infrastructure development against increasing natural hazards, it is not easy to increase flood control safety levels according to plans based solely on conventional infrastructure development focused on river areas under the leadership of water authorities. For this reason, while implementing existing preliminary DRR measures under the leadership of water authorities, the government will implement the River Basin Disaster Resilience and Sustainability by All policy, which is aimed at mitigating damage to the entire river basin, including basins, rivers, and flood areas, with the participation of all people in the river basin, including those who have not previously been involved. This will help understand the water flow, where rainfall flows into a river and then causes floods, as a single system.

○ Concerning the River Basin Disaster Resilience and Sustainability by All policy, measures should be implemented through the participation of all people in the river basin in the following three categories according to river basin characteristics, assuming the occurrence of any type of flood up to a flood of a maximum possible scale:

- Measures to prevent and mitigate flooding as much as possible (hazard control)

  Implement installation of flood control facilities so that flooding can be prevented as much as possible

- Measures to reduce the targets of damage (exposure control)

  Measures to reduce the targets of damage, such as town development with restrictions on land use and improving the ways of living to avoid damage, based on the idea of "not living on dangerous land," assuming the occurrence of massive flooding that exceeds the capacity of flood control facilities

- Measures for damage mitigation and early recovery/reconstruction (vulnerability control)

  Measures to mitigate damage, such as enhancing the system to allow people to evacuate adequately and appropriately in response to the occurrence of flooding, and measures for early recovery and reconstruction in affected areas

These measures should be implemented in a comprehensive and multi-layered manner.

○ To address increases in precipitation, rising tidal levels, and similar events caused by climate change, the following measures should be implemented through cooperation among relevant ministries, agencies, local governments, and public and private entities, in addition to flood control measures under the leadership of water authorities:

- Strengthen the flood control function of existing dams and reservoirs for flood control, including water supply dams
- Use the rainwater storage and infiltration function of paddy fields, reservoirs for flood control, etc.
- Eliminate areas where no information is available on local flood disaster risks
- In cooperation with government departments in charge of urban planning, construction, etc., help local governments impose joint restrictions on land use with other local governments, guide residents to live in safer areas, devise better ways of living, and propose other forms of town development for DRR
- Enhance preparedness for emergency operations, business continuity, etc.

These measures that integrate structural and non-structural approaches should be implemented.

○ When promoting "River Basin Disaster Resilience and Sustainability by All," emphasis should be placed on using green infrastructure that capitalizes on the diverse functions of the natural environment to secure and increase rainwater storage and infiltration functions provided by retarding basin improvement and other facilities; and creating ecological networks by proactively conserving or reproducing ecological functions that contribute to

mitigating disaster risks.

○ To respond to water disasters that are becoming more severe and frequent, it is also important to strengthen non-physical measures, such as strengthening weather observation systems and increassing forecast accuracy for tropical cyclones as well as localized heavy rainfalls typically brought by stationary linear mesoscale convective systems. Efforts should be focused on reducing the number of casualties by weather-related disasters by encouraging resident evacuation behavior through technical improvements in the issuance of heavy rain emergency warnings and with the real-time risk map, called “Kikikuru,” which shows the risk of disaster occurrence; and by further strengthening and promoting normal-time activities to ensure appropriate use of these warnings and information.

○ To ensure the continued operation of the meteorological satellite observation system for the sake of people’s safety and security, including monitoring and forecasting tropical cyclones and heavy rains, ensuring the safe navigation of aircraft and vessels, and monitoring the global environment and volcanic activities, the manufacturing of a successor satellite will be started in FY 2023, with the aim of putting it into operation in FY 2029. High-density observation and other latest technologies should be incorporated into the successor satellite to mitigate damage from natural disasters through advanced DRR and weather information.

○ When promoting these measures, it is important to avoid exposure by understanding the local geography and ecosystems and adopting the concepts of Eco-DRR (Ecosystem -based Disaster Risk Reduction), where vulnerability is reduced using the functions of healthy ecosystems, and green infrastructure.

[Basic measures]

1) Review of flood control plans considering the impacts of climate change

○ Gradually review the basic policy for river improvement plans to incorporate increased precipitation and other changes induced by climate change, using the projected magnitude of future precipitation changes and the future hyetographs obtained by ensemble simulations, based on scientific and technological advancement and an accumulation of rainfall projection data. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Aim for the early achievement of the current river improvement plans plans that assume previously experienced floods; and review them to consider increased precipitation and other changes induced by climate change. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Prepare for intensifying and more frequent localized heavy rains by promoting the establishment of inundation prevention measures and plans that use sewer systems in both structural and non-structural aspects, based on detailed disaster risk assessments through inundation simulations, etc. <Ministry of Land, Infrastructure, Transport and Tourism>

2) Assessment of disaster risks

○ Noting that the key actors in the implementation of measures, including local governments, businesses, and residents, should conduct measures with an awareness of what kind of damage may occur and how frequently, provide detailed disaster risk information that is comprehensible for each actor. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Prepare and provide inundation scenarios for not just one but various magnitudes of natural hazards, and present information on the frequency of occurrence of inundation above floor level and potential risks to human life, as well as on other aspects such as the capacity and preparedness of facilities. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Make use of various fora in which various actors participate to share disaster risk information and to implement measures. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Regarding detailed damage scenarios needed for each actor to implement measures, consider local conditions, including the concentration of population and property on flood plains; the location of infrastructures, lifelines, hospitals, and welfare facilities; the structure and location of industries; and the aging of the population. <Ministry of Land, Infrastructure, Transport and Tourism>

○ To consider measures that include worst-case scenarios, target the largest magnitude natural hazards conceivable in the inundation risk zones, and target not only inundation from flooding but also that from inland water and storm surges. When doing so, provide information on not only depth but also duration of inundation to enable local governments, businesses, residents' associations, and residents to consider evacuation and other actions. <Ministry of Land, Infrastructure, Transport and Tourism>

3) DRR measures to address relatively frequent natural hazards

Regarding relatively frequent natural hazards, efforts should be focused on steadily implementing DRR measures that can reliably prevent water disasters by continuing ongoing improvements to facilities and conducting facility maintenance and upgrades as appropriate.

A. Steady improvement of facilities

○ Continue steady improvement efforts, including embankment, and improvement of flood control facilities and sewer systems. In doing so, foster effective and efficient improvement, based on disaster risk assessments. Also, review facility improvement plans and targets as necessary, considering factors such as the recent increase in the frequency of heavy rains. <Ministry of Land, Infrastructure, Transport and Tourism>

B. Improvements in capacity of existing facilities

○ Endeavor to further improve the capacity of existing stock through actions such as dam refurbishing, which involves strengthening the flood control capacity of existing dams while they are in operation, and strengthening, repairing, and maintaining existing sewer

facilities; and improving rainwater storage facilities. <Ministry of Land, Infrastructure, Transport and Tourism>

C. Enhancement of maintenance and upgrades

○ Leverage information and communications technology (ICT) to ascertain in detail the condition of river infrastructure and sewer systems. Also, use video surveillance systems, such as CCTV, to obtain information on flood and inland water. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Maintain and secure the required water storage capacity by continuing to promote measures to cope with sedimentation in dam reservoirs. <Ministry of Land, Infrastructure, Transport and Tourism>

D. Installation of remote control for facilities such as water gates

○ Promote the modernization of the operation of water gates and other facilities by making them remotely controlled or automated to ensure their reliable operation and the safety of operators. <Ministry of Land, Infrastructure, Transport and Tourism>

E. Design of facilities to avoid rework

○ Endeavor to design facilities in a manner that can avoid rework to the greatest extent possible and make them adaptable to future increases in natural hazards, such as through the selection of structural designs that can easily be modified and the preliminary reinforcement of foundations and other components. The goal is to make it easier to respond to potential increases in natural hazards due to climate change that would require modification or other improvements to facilities. <Ministry of Land, Infrastructure, Transport and Tourism>

F. Comprehensive sediment control

○ Implement comprehensive sediment control that seamlessly covers all landscapes from mountains to coasts through collaboration among relevant institutions. Understand sediment dynamics through monitoring; establish a comprehensive sediment control plan; and implement efforts to ensure the continuity of sediment transport, such as building slit dams, returning the sediment deposited in dam reservoirs into downstream rivers, and coastal erosion prevention with sand bypassing. <Ministry of Land, Infrastructure, Transport and Tourism>

4) DRR measures to address natural hazards exceeding the current capacity of facilities

Natural hazards exceeding the current capacity of facilities will be addressed through DRR based on improvements to facility operation, design, and maintenance procedure; and through DRR measures aimed at minimizing damage by full implementation of effective

actions, such as urban and community development focused on disaster risks and enhanced preparedness for adequate evacuation, smooth emergency operations, and business continuity.

(i) Improvement of facility operation, design, and maintenance procedure

Natural hazards exceeding the current capacity of facilities will be addressed through steady implementation of ongoing measures that consider factors such as past floods exceeding design levels; and through disaster risk reduction based on improvements to facility operation, design, and maintenance procedure.

A. Operation that makes the most use of existing facilities

○ Regarding existing dams, including water utilization dams, achieve the maximum performance from their flood control capabilities by promoting activities related to preemptive release of water. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Work to further optimize dam operation by improving the forecast accuracy of precipitation in the upstream basins and flow volumes into dam reservoirs. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Regarding inland water control, consider sewer pipe networks and drainage pump operation that make use of resources such as information on water levels. <Ministry of Land, Infrastructure, Transport and Tourism>

B. Integrated operation of river infrastructure and sewer systems

○ Foster integrated operation of river infrastructure and sewer systems by promoting improvements such as culverts to connect existing river infrastructure and sewer systems, and water storage facilities commonly used for river infrastructure and sewer systems. <Ministry of Land, Infrastructure, Transport and Tourism>

C. Levee designs to delay collapse

○ Consider levee designs that can delay collapse and ensure the longest time possible for evacuation and other actions, taking into account improving the reliability of existing levees. <Ministry of Land, Infrastructure, Transport and Tourism>

D. Promotion of projects to build levees meeting more stringent specifications

○ Promote the construction of levees that meet more stringent specifications to ensure the capability to prevent collapse in overflows, penetration, or other events caused by flooding above the capacity of flood control facilities in low-lying areas (e.g., below-sea-level areas) of Tokyo and Kinki metropolitan areas where population and property are densely concentrated. <Ministry of Land, Infrastructure, Transport and Tourism>

E. Inspection of large structures

○ Regarding large structures such as dams and weirs, conduct inspections for any possible damage and/or its impacts on the structure, considering the possible occurrence of natural hazards exceeding the design capacity, such as the maximum possible hazard, and implement measures as required. <Ministry of Land, Infrastructure, Transport and Tourism>

(ii) Integration with urban and community development

DRR should be promoted in urban areas as well as hilly and mountainous regions through the promotion of urban and community development that considers disaster risks, by taking advantage of urban or community reconstructing initiated to cope with population declines.

A. Comprehensive measures against inundation

○ Promote comprehensive measures against inundation, such as conserving, securing, and enhancing the water retention and storage capacity of river basins. <Ministry of Land, Infrastructure, Transport and Tourism>

B. Flood control measures considering land use conditions

○ Promote flood control measures that consider land use conditions through collaboration among relevant departments, while considering local opinions, for example, by combining structural improvements (e.g., ring levees) and non-structural measures (e.g., land use regulations). <Ministry of Land, Infrastructure, Transport and Tourism>

C. Providing/Sharing detailed disaster risk information

○ Provide disaster risk information in a form that is easy for recipients to understand, in order to contribute to urban and community development and private sector investment, and to bring more ingenuity to the way people live, while promoting initiatives to provide such information at every possible opportunity in cooperation with relevant institutions. <Ministry of Land, Infrastructure, Transport and Tourism>

D. Safe town development and safe living based on disaster risk analysis

○ Along with the promotion of compact town development, appropriately analyze disaster risks, develop location optimization plans and DRR guidelines based on analysis results, and encourage transfer of residents and urban functions to areas with low disaster risk. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Create 3D representations of disaster hazard information by using the 3D city models PLATEAU to visualize disaster risks and thus enhance public awareness of DRR; and advance DRR measures, for example, by developing DRR plans based on such 3D information. <Ministry of Land, Infrastructure, Transport and Tourism>

E. Measures to reduce inundation coordinated with urban and community development

○ In areas where urban functions and housing are already concentrated but with relatively high disaster risk, promote river improvements to reduce disaster risk, based on appropriate allocation of roles, with emphasis on actions such as installation of rainwater storage and infiltration facilities and waterstops by municipal governments and private entities. <Ministry of Land, Infrastructure, Transport and Tourism>

F. Suppression of flood propagation coordinated with urban and community development

○ Consider frameworks to suppress flood propagation that are coordinated with urban and community development, such as conservation of secondary levees, natural levees, and continuous dikes, as well as the construction of banking structures that serve as secondary levees by municipalities and other bodies. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Noting that high concentrations of population and property exist in below-sea-level areas and that a vast expanse of land will remain inundated in such places for a long period of time once a large flood disaster occurs, promote “town development on high ground,” which refers to securing key elements of the community on high ground and connecting them linearly or widely with roads and paths located above the expected depth of inundation to ensure residents safety and minimum quality of life during evacuation or even to enable residents to evacuate to outside of the inundation zone. <Ministry of Land, Infrastructure, Transport and Tourism>

G. Measures against inundation in underground spaces

○ Promote measures against inundation and measures to secure evacuation of underground spaces to allow time to evacuate from underground spaces, such as encouraging the operators of underground shopping centers and facilities to install waterstops and provide appropriate evacuation guidance. <Ministry of Land, Infrastructure, Transport and Tourism>

(iii) Promotion of the use of green infrastructure in realizing the River Basin Disaster Resilience and Sustainability by All policy

When promoting the River Basin Disaster Resilience and Sustainability by All policy, focus on using green infrastructure that capitalizes on the diverse functions of the natural environment to secure and increase rainwater storage and infiltration functions provided by retarding basin improvement and other facilities; and creating ecological networks by proactively conserving or reproducing ecological functions that contribute to mitigating disaster risks. <Ministry of Land, Infrastructure, Transport and Tourism>

A. Construction of rainwater storage and infiltration facilities

○ Designate rivers and basins, develop flood control plans for basins, and build rainwater

storage and infiltration facilities as required under the Act on Countermeasures against Flood Damage of Specified Rivers Running Across Cities. By extension, contribute to healthy water circulation through rainwater storage and infiltration. <Ministry of Land, Infrastructure, Transport and Tourism>

B. Creation of Ecological Networks in the River Basin Disaster Resilience and Sustainability by All policy

○ Under the River Basin Disaster Resilience and Sustainability by All policy, promote the concept of green infrastructure, which capitalizes on the diverse functions of the natural environment and proactively conserve or restore ecological functions that contribute to disaster risk reduction. Also, focus on creating attractive waterfront spaces under the concept of river-based community development, conserving and creating diverse river landscapes and intrinsic functions of rivers as habitats and the growth/breeding environment for creatures, and restoring marshlands. <Ministry of Land, Infrastructure, Transport and Tourism>

C. Expansion of the activity of Green Infrastructure Public-Private Partnership Platform

○ Promote the construction of green infrastructure in society through cross-sectoral, public-private collaboration by expanding activities such as the dissemination of green infrastructure in society through Green Infrastructure Public-Private Partnership Platform, in which diverse entities participate from industry, government, and academia; investigation and research on green infrastructure technologies; and studies on ways to finance such technologies. Also, foster technology development related to green infrastructure planning, building, and maintenance, and conduct local model demonstrations to accelerate introduction to communities. Work to increase green finance and ESG investments by expanding real-world application of green infrastructure technologies and consequently using private fund-raising methods (e.g., green bonds). <Ministry of Land, Infrastructure, Transport and Tourism>

D. Eco-DRR

○ Avoid exposure to hazardous natural phenomena by restoring former marshlands and flood plains, while enhancing the water retention and storage capacity of ecosystems throughout the basin by creating a map of ecological function potential and providing technological findings and other information to help local governments in the basin implement their efforts. <Ministry of the Environment>

(iv) Preparedness for evacuation, emergency operations, business continuity

Regarding natural hazards that exceed the capacity of facilities, efforts should be made to enhance preparedness for actions such as appropriate evacuations, smooth emergency

operations, and business continuity. In particular, to prepare for natural hazards far above the capacity of facilities, stakeholders, including the national government, local governments, public utilities, and businesses, should voluntarily collaborate to develop measures with an emphasis on non-physical approaches, assuming worst-case scenarios.

A. Enhancing observation and other functions

○ Endeavor to improve and deploy observation equipment to reliably observe parameters such as water levels of rivers and sewer systems. <Ministry of Land, Infrastructure, Transport and Tourism>

B. Enhancing and strengthening flood defense systems

○ During flood events, provide flood defense managers with detailed information about locations that are critical for flood prevention and high-risk locations. Also, provide notification about water levels of not only river flooding but also inland water and storm surges. In addition, improve facilities that serve as bases for response to river flooding, inland water, storm surges, and tsunami, and stockpile flood defense supplies, equipment, and materials. <Ministry of Land, Infrastructure, Transport and Tourism>

C. Securing shelters using river management facilities

○ To contribute to smooth and rapid evacuations, endeavor to secure shelters and evacuation routes, using facilities such as river management facilities, including levees and river DRR stations. <Ministry of Land, Infrastructure, Transport and Tourism>

D. Enhancing pre-disaster initiatives to facilitate and accelerate evacuation

○ Strive to make flood hazard maps more understandable to residents and set up signs in different places of communities that show, for each place, information such as the expected inundation depth, height above sea level, evacuation direction, name of the nearest shelter, and distance to the shelter. <Ministry of Land, Infrastructure, Transport and Tourism>

E. Helping disaster response organizations, public utilities, etc. formulate business continuity and related plans

○ Ensure that disaster response organizations and other relevant entities can continue activities such as emergency operations and recovery/reconstruction activities by considering measures to encourage the implementation of inundation prevention, the preparation of backup functions, and the formulation of business continuity plans for important facilities (e.g., municipal offices and other government buildings, fire stations, police stations, and hospitals). <Ministry of Internal Affairs and Communications; Ministry of Land, Infrastructure, Transport and Tourism>

○ Consider measures to encourage public utilities to participate in disaster response timelines in order to minimize damage as much as possible and expedite recovery. <Ministry of Land,

Infrastructure, Transport and Tourism>

F. Providing easy-to-understand information to facilitate evacuation

○ Communicate more clearly to residents about the urgency of risks such as rising river water levels due to increasing rainfall or flooding and storm surges from tropical cyclones or low pressure systems by providing information in forms that are easily understandable to recipients (e.g., providing well organized information on the relationship between disaster risk information and the degree of urgency). <Ministry of Land, Infrastructure, Transport and Tourism>

G. Enhancing preparedness for emergency operations and business continuity

○ Take advantage of urban development events to promote district-level shared energy use and improve the stability of energy supply needed for continuous operation during emergency. <Ministry of Land, Infrastructure, Transport and Tourism>

H. Enhancing preparedness for evacuation and rescue

○ Have disaster response timelines jointly formulated by relevant stakeholders, such as national and local governments, and public utilities, based on damage assessments, such as the number of fatalities and possibility of persons being isolated during times of large-scale water disasters, so that these institutions can cooperate on evacuations, rescue and emergency operations, and emergency transportation. <National Police Agency; Ministry of Land, Infrastructure, Transport and Tourism>

I. Supporting municipal mayors in appropriately issuing evacuation information

○ Enhance the structure/system through which the national and prefectural governments support municipalities in times of emergency and provide detailed disaster risk information (e.g., hazardous locations) even during normal times. <Ministry of Land, Infrastructure, Transport and Tourism>

J. Strengthening the support systems for municipalities during times of disaster

○ Strengthen the system for support provided to municipalities through the Technical Emergency Control Force (TEC-FORCE), Disaster Waste Treatment Support Network (D.Waste-Net), etc. <Ministry of Land, Infrastructure, Transport and Tourism; Ministry of the Environment>

K. Suppressing flood propagation and draining floodwater

○ Recognizing the prime importance of quickly draining floodwater in a large-scale water disaster to suppress flood propagation and expedite recovery and reconstruction, plan floodwater drainage in advance and promote efforts such as improving drainage gates for

rapid floodwater drainage, waterproofing equipment, including drainage pumping stations, securing access routes for purposes such as fuel replenishment, and securing auxiliary electrical power supplies and fuel stockpiles. <Ministry of Land, Infrastructure, Transport and Tourism>

L. Improving DRR awareness among businesses and having them prepare BCPs for flood damage

○ Reduce damage to businesses and help them quickly resume business after a flood event by considering ways to encourage them to prepare business continuity plans (BCPs) to cope with water disasters and implement actions against inundation. <Ministry of Land, Infrastructure, Transport and Tourism>

M. Improving institutional arrangements for disaster response through collaboration among all actors

○ Develop collaborative water disaster response timelines involving various stakeholders, including national and local governments, and public utilities, assuming events such as large-scale flooding due to natural hazards far above the capacity of facilities. <Ministry of Land, Infrastructure, Transport and Tourism>

N. Enhancing preparedness for the management of disaster waste, etc.

○ Promote the formulation of contingency plans for waste management, such as those considering the continuity of domestic waste treatment operations during a disaster. Build resilient waste management systems that can handle disaster waste, etc. appropriately, smoothly, and quickly by conducting initiatives at the local-government, regional-block, and national levels. <Ministry of the Environment>

O. Promoting investigation and research

○ Focus efforts on such fields as improving climate change projection technologies, recognizing the need to have detailed scenarios for the impacts of climate change when designing facilities in ways that will minimize rework. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Clarify the increased risk of damage from storm surges and high waves associated with climate change-induced sea level rise, as well as impacts that constrained inland drainage conditions will have on inundation. Also, study climate change-induced changes in sediment and woody debris runoff and other associated topics. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Noting projections of increase in sediment runoff, promote research on impacts on river channels, etc. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Address increased risks of water disasters due to climate change by promoting research on

the potential for new adaptation measures outside the box of existing programs and methods, through efforts such as analysis of the state of use of flood insurance. <Ministry of Land, Infrastructure, Transport and Tourism>

5) Measures in the agriculture sector

○ Work to maintain and enhance DRR capacities in rural areas. For this purpose, appropriately combine structural and non-structural measures, including preventing farmland flooding by developing drainage pump stations and drainage canals to prepare for increasing torrential rainfalls; identify facilities and areas highly vulnerable to inundation; conduct risk assessment activities, such as formulating hazard maps; and promote the development of business continuity plans by facility managers. Take these measures effectively by utilizing the existing facilities and deploying local communities' functions. <Ministry of Agriculture, Forestry and Fisheries> [Listed again]

6) DRR measures based on observation, forecast, and information provision

○ To respond to water disasters that are becoming more severe and frequent, it is also important to strengthen non-physical measures, such as strengthening weather observation systems and increasing forecast accuracy for tropical cyclones as well as localized heavy rainfalls typically brought by stationary linear mesoscale convective systems. Efforts should be focused on reducing the number of casualties by weather-related disasters by encouraging resident evacuation behavior through technical improvements in the issuance of heavy rain emergency warnings and with the real-time risk map, called "Kikikuru," which shows the risk of disaster occurrence; and by further strengthening and promoting normal-time activities to ensure appropriate use of these warnings and information. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Ensure the continued operation of the meteorological satellite observation system for the sake of people's safety and security, including monitoring and forecasting tropical cyclones and heavy rains, ensuring the safe navigation of aircraft and vessels, and monitoring the global environment and volcanic activities, by starting the manufacturing of a successor satellite by FY 2023, aiming to put it into operation in FY 2029. Incorporate high-density observation and other latest technologies into the successor satellite to mitigate damage from natural disasters through advanced DRR and weather information. <Ministry of Land, Infrastructure, Transport and Tourism>

2. Basic adaptation measures for coastal areas (against storm surges, high waves, etc.)

[Impacts]

<Current status>

(Sea level rise)

○ It has been reported that sea levels near Japan have been on an increasing trend (+2.8 [1.7 to

4.0] mm/year in 1993 to 2015; +4.19 [−1.10 to +8.20] mm/year in 2004 to 2019), based on an analysis of tidal observation records.

(High waves and storm surges)

○ At present, there are no confirmed phenomena or research results that indicate sea level rise and intensifying tropical cyclones associated with climate change have effects on storm surges and high waves, or on damages from them.

○ Regarding storm surges, it has been pointed out that the occurrence of extremely high tidal levels may have been increasing globally since 1970.

○ Regarding high waves, observations indicate that the maximum significant wave height is increasing along the Sea of Japan in winter and along Tohoku's Pacific coast in autumn, although there is no scientific evidence that these trends are climate-change induced.

(Coastal erosion)

○ At present, there are no confirmed phenomena or research results that indicate whether sea level rise and intensifying tropical cyclones associated with climate change have already had an impact on coastal erosion.

<Projected impacts>

(Sea level rise)

○ Studies found that there is a high possibility that compared to the average for the years 1986 to 2005, the rise in global mean sea level from 2081 to 2100 will be in the range of 0.26 to 0.53 m in the RCP 2.6 scenario and in the range of 0.51 to 0.92 m in the RCP 8.5 scenario, suggesting that some sea level rise will be inevitable even if greenhouse gas emissions are suppressed.

○ If sea level rises by 80 cm, the impacts will extend to all of Japan's coastlines, with the area of below-sea-level land around the three major bays in Japan (Tokyo, Ise, and Osaka Bays) increasing to 1.6 times the current area.

○ If sea-level rise occurs, disaster risk from storm surges, high waves, and tsunami, along with vulnerability to coastal erosion, will increase compared with the present, even without increase in the intensity of tropical cyclones and low pressure systems.

○ Sea level rise will deteriorate or damage the functions of intake facilities along rivers, coastal disaster prevention facilities, and harbor and fishing port facilities, causing impacts such as submergence/inundation of coastal areas, accelerated coastal erosion, disturbances to harbor and fishing port operations, and ecological impacts in the tidal zones of tidal flats and rivers.

(High waves and storm surges)

○ The possibility is extremely high that sea levels will rise due to climate change and the risk

of inundation from storm surges will increase.

○ Tropical cyclones are the main factor of storm surges, and technologies are being intensively developed to forecast behavior of tropical cyclones (e.g., track and scale) in the context of climate change and incorporate the forecasts into projected future changes of storm surges. Many of the studies based on these technologies support higher storm surge heights as a result of climate change.

○ Tropical cyclones and intense winter low pressure systems are the main factor for high waves, and technologies are being intensively developed to forecast behavior of tropical cyclones (e.g., track and scale) in the context of climate change and incorporate the forecasts into the forecast of high waves. It is projected that changes in intensity and tracks of tropical cyclones may increase the risk of high waves.

○ Projections show that an increasing number of structures, such as intake facilities along rivers, coastal disaster prevention facilities, and harbor and fishing port facilities, will become unable to secure safety if tide deviation and wave height increases as sea level rises and as more intense tropical cyclones and winter low pressure systems develop.

(Coastal erosion)

○ The possibility is high that climate change-induced sea level rise will cause coastal erosion. Specifically, some reports have projected that on average, 62% (173 km^2) and 83% (232 km^2) of sandy beaches along Japan's coast will disappear by 2081 to 2100 in the RCP 2.6 and RCP 8.5 scenarios, respectively.

○ If climate change intensifies tropical cyclones, wave height during stormy weather will increase. However, some studies indicate that mean wave height will decrease over the long term. Although both the increase in wave height during stormy weather and the decrease in mean wave height should be taken into account, the impact that long-term changes in wave properties have on sandy beaches will highly likely be smaller than the impact of sea level rise, indicating the high probability that climate change will accelerate the erosion of sandy beaches.

○ If the supply of sediments from rivers increases with the rise of the frequency and intensity of extreme rain events due to climate change, reduced erosion and more sediment deposition may occur on coastlines, especially around estuaries.

・Sea level rise [Significance: ●; Urgency: ▲; Confidence: ●]
・Storm surges and high waves [Significance: ●; Urgency: ●; Confidence: ●]
・Coastal erosion [Significance(RCP 2.6/8.5): ●/●; Urgency: ▲; Confidence: ●]

[Basic approach to adaptation]

(1) Harbors and ports

○ In harbors and ports, due to their characteristics coming from their being located at the

border between land and sea, adaptation to climate change is inevitable over the coming years. Therefore, it is natural to consider that the new facilities to be developed and existing facilities that will remain in service for some years are highly likely to suffer impacts during their service lives.

○ Based on the Disaster Risk Reduction Measures by Integrating Structural and Non-Structural Measures in Future Harbors and Ports (August 2020, Council for Transport Policy Report) and while considering socioeconomic activities and land use on the water side of the embankment and its hinterland, efforts should be focused on controlling increases in risks from storm surges and other events on both the water-side and land-side areas, and maintaining port and harbor activities, by strategically and adaptively promoting the optimal combinations of structural and non-structural adaptation measures according to the priority of the risks to be mitigated. Climate change adaptation measures should also be incorporated into various types of programs and plans to allow adaptation measures to be effectively implemented (i.e., the mainstreaming of adaptation measures) in coordination with a variety of other policies and efforts.

(2) Coastlines

○ The government should focus on suppressing increases in disaster risk from storm surges and other events and conserve land along coastlines, by accurately identifying signs of impacts from climate change through monitoring of oceanic phenomena; considering the medium- and long-term trends in socioeconomic activities and land uses in areas protected by embankments (hinterland); and driving conversion from the “single line of defense” by breakwaters and seawalls to “multiple lines of defense” by using all structural and non-structural measures to strategically and adaptively implementing them in optimal combination.

○ Projected increases in natural hazards due to climate change include higher mean sea levels and increased tide deviations, which are related to the design high-tide level, and stronger ocean waves, which are related to the design waves. For this reason, it is necessary to review these natural hazards targeted in shore conservation to change from those based on past tidal levels and other records to those in consideration of projected tidal levels.

○ Efforts should be made to implement the River Basin Disaster Resilience and Sustainability by All policy, which is aimed at mitigating damage for the entire river basin, including basins, rivers, and flood areas and with the participation of all people in the river basin, including those who have not previously been involved. Around estuaries, adjustment and consideration are necessary to secure the continuity of conservation functions between rivers and coastlines, such as connecting river dikes and sea dikes, and setting the water levels used for river planning.

(3) Fishing ports and villages

○ Located in coastal areas, fishing ports are expected to be seriously affected by climate change-induced sea level rise and increases in tide deviation and wave height in terms of the safety and convenience of their facilities. Therefore, strategic and flexible adaptation measures should be implemented for them.
○ The creation of disaster-resilient fishery areas should be pursued by engaging in DRR measures to prepare for potentially intensifying disasters from tropical cyclones and low pressure systems

(4) Coastal disaster prevention forests
○ The development and conservation of coastal disaster prevention forests should be promoted.

(5) Airports
○ The impact on airport facilities from increasing natural hazards associated with climate change, such as mean sea level rise and high waves should be studied to reflect it in DRR measures for airports.

[Basic measures]
(1) Harbors and ports
1) Common measures for ports and harbors (monitoring, impact assessments, information provision, etc.)
○ Monitor weather and oceanic phenomena to regularly assess the impacts of climate change through simulations, such as projections for inundation due to storm surges and high waves, and provide the obtained information to relevant institutions. Use hazard maps and other means to inform port and harbor users of increased disaster risks due to sea level rise, as well as higher storm surge heights and stronger waves associated with an increasing number of intense tropical cyclones; and assess the impacts of these changes, such as decreased cargo handling efficiency associated with sea level rise. <Ministry of Land, Infrastructure, Transport and Tourism>
○ Encourage the formulation of plans relating to evacuation for businesses operating on the water side of the embankments and residents living on the hinterland, as well as evacuation drills. In addition, in water-side areas, coordinate evacuations and operational rules for land locks (formulated by coastal management authorities) to support smooth evacuation actions by users and others. <Ministry of Land, Infrastructure, Transport and Tourism>

2) Adaptation measures for impacts on outlying facilities such as breakwaters and on port and harbor functions
○ If natural hazards need to be reviewed based on monitoring results and other information,

maintain the required functions of moorings and breakwaters by reviewing their designs accordingly. Promote actions, including improvements to make structures more robust, so that they can perform well for DRR even in the event of natural hazards that exceed the design forces, in cases where damage to structures such as breakwaters and seawalls may have a grave impact on human life, property, or socioeconomic activities. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Where there are concerns about the possible infilling of navigation channels and anchorages due to the impacts of climate change, implement measures to prevent infilling, including the construction of groins. Through collaboration among stakeholders, conduct drills in accordance with port and harbor business continuity plans (port BCPs) to maintain the important functions of ports and harbors even after the occurrence of a disaster and aim to enhance the BCPs through reviews as appropriate. <Ministry of Land, Infrastructure, Transport and Tourism>

3) Adaptation measures for impacts on the water-side areas (wharfs, cargo handling areas, industrial land, etc.)

○ Ascertain and assess the functions of shore conservation facilities and port and harbor facilities, including privately owned ones, and compile information that can contribute to identification of high-risk locations. Consider optimal approaches to upgrades and other actions so that adaptation can be conducted progressively without requiring large additional costs in response to gradual increases in natural hazards as a result of climate change. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Share information with related areas on observed tidal levels and waves, to contribute to evacuation decisions. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Consider providing detailed disaster risk information to encourage actions such as investments by businesses and other bodies for self-conservation and DRR. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Recognizing the risk of a substantial decline in harbor and port functions in the event of a container terminal or other facilities being flooded with storm surges, which can cause containers to drift into navigation channels or anchorages and disrupt electrical installations for cargo handling machinery, promote the formulation and implementation of phased response plans for storm surges, which summarize in chronological order the preliminary DRR actions in accordance with the Guidelines for Risk Reduction Measures for Storm Surges in Water-side Areas of Harbors and Ports (established in 2017); and enhance port preparedness for storm surges through actions such as securing containers and elevating electrical installations. <Ministry of Land, Infrastructure, Transport and Tourism>

4) Adaptation measures for impacts on the hinterland (areas protected by embankment)

○ Ascertain and assess the functions of shore conservation facilities and port and harbor

facilities, including privately owned ones, and compile information that can contribute to identification of high-risk locations. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Consider optimal approaches to upgrades and other actions so that adaptation can be conducted progressively without requiring large additional costs in response to gradual increases in natural hazards as a result of climate change. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Consider ways to effectively use privately owned facilities (e.g., seawalls, sheds, warehouses, and green zones) as facilities for evacuation and prevention/reduction of the incursion of seawater. <Ministry of Land, Infrastructure, Transport and Tourism>

○ In the medium- and long-term, reconstruct the conservation lines in coastal areas by taking advantage of opportunities such as reallocation of land use; and promote a shift toward land uses with lower risk of disasters caused by storm surges and other events. <Ministry of Land, Infrastructure, Transport and Tourism>

5) Adaptation measures for impacts on the clearance under bridges

○ If the future rise in sea levels is acknowledged to be significant, properly ascertain the degree of sea level rise; indicate traffic ban areas and times to prevent vessels from colliding with structures such as bridges and water gates; and relocate port and harbor functions, for example, by placing mooring facilities on the seaward side of bridges where there are concerns about clearance. <Ministry of Land, Infrastructure, Transport and Tourism>

(2) Coastlines

1) Strategic development of measures to address increasing natural hazards

○ Noting that climate change-induced rise in mean sea level is already becoming evident and that there are concerns about the potential impact on coastal areas from future developments such as a further rise in mean sea level and the occurrence of more intense tropical cyclones, investigate and understand regional/local natural and social conditions, the coastal environment, and the way coastlines are used, along with long-term changes in natural hazards associated with climate change; secure conservation levels appropriate to disasters assumed from the findings; and comprehensively implement a combination of facility improvements and non-physical measures to maintain and conserve the coastal environment and foster appropriate use of the coastlines. <Ministry of Agriculture, Forestry and Fisheries; Ministry of Land, Infrastructure, Transport and Tourism>

2) Response to excessive natural hazards

○ Make embankments, seawalls, and tsunami barriers more robust to reduce damage to facilities from the forces of tsunami, storm surges, and other events above design levels,

while considering the situation of the hinterland. <Ministry of Agriculture, Forestry and Fisheries; Ministry of Land, Infrastructure, Transport and Tourism>

3) Stronger responses to advancing coastal erosion

○ Ascertain the trends of changes in the entire sediment transport system and sandy beaches beyond the residential area through continuous monitoring, determine the erosion mechanism, and take measures based on projected future changes, while considering the impacts of future climate change and anthropogenic modifications. Evaluate the effectiveness of these measures through monitoring and develop next measures, following the approach of "adaptive sandy beach management based on appropriate projection." <Ministry of Agriculture, Forestry and Fisheries; Ministry of Land, Infrastructure, Transport and Tourism>

○ While enhancing coastal landform monitoring and projecting the nationwide impact of climate change on long-term topographical changes caused by coastal drift sand, implement efforts to optimize the sediment balance in the coastal zone from longshore sediment transport, including improving structure designs; and promote wide-area comprehensive measures through collaboration among diverse relevant institutions, such as coordination with comprehensive sediment control measures that address the entire sediment transport system of rivers, from upstream down to the coast, to foster appropriate sediment supply to coastlines. <Ministry of Agriculture, Forestry and Fisheries; Ministry of Land, Infrastructure, Transport and Tourism>

4) Promotion of wide-area comprehensive measures

○ Contribute to securing the safety of the entire community that engages in socioeconomic activities in an integrated manner and making the community more comfortable and convenient in such activities by considering the concentration of population, property, and social capital in the coastal hinterland, as well as land use, seaside use and environment, marine traffic, and fisheries activities; and implementing wide-area comprehensive efforts through closer cooperation with relevant administrative bodies. In particular, address climate change-induced rise in mean sea level by striving to allow the mean sea level to be shared across society as it serves as a key indicator in the implementation of such efforts from long-term perspectives. <Ministry of Agriculture, Forestry and Fisheries; Ministry of Land, Infrastructure, Transport and Tourism>

5) Promotion of investigation and research

○ Continuously share the latest findings on projections in the context of climate change to promote research activities, such as development of a system through which to integrate the latest findings into measures; investigation and research on effective DRR measures; investigation and research on the projection of wide-area coastal erosion and its impacts;

investigation and research on appropriate maintenance and repair; investigation and research on construction friendly to ecosystems and other elements of the natural environment; and research and development on new technologies, such as new construction methods. <Ministry of Agriculture, Forestry and Fisheries; Ministry of Land, Infrastructure, Transport and Tourism>

○ Share information with diverse other sectors, including the private sector, while promoting mutual technical collaborations and international technology exchanges, and strive to widely use and disseminate the results from these activities. <Ministry of Agriculture, Forestry and Fisheries; Ministry of Land, Infrastructure, Transport and Tourism>

(3) Fishing ports and villages

○ Address increasing tide deviation, wave height, and high waves associated with sea level rise and extreme weather events by monitoring tidal levels and waves to accurately capture the signs of climate change impacts; and, based on the finding, promoting the systematic improvement of fishing port facilities, while considering long-term changes in natural hazards driven by climate change. <Ministry of Agriculture, Forestry and Fisheries>

○ While considering the situation of each fisheries community and climate change-induced impacts on it, facilitate DRR measures in both structural and non-structural aspects, including building shore conservation facilities as a structural measure and creating hazard maps as a non-structural measure. <Ministry of Agriculture, Forestry and Fisheries>

○ Encourage the update of basic shore conservation plans to address long-term changes in natural hazards, such as projected sea level rise, to shift to shore conservation measures that explicitly consider climate change-induced impacts. <Ministry of Agriculture, Forestry and Fisheries>

(4) Coastal disaster prevention forests

○ Strengthen improvement of coastal disaster prevention forests and other to ensure their disaster prevention functions against tsunami and winds. <Ministry of Agriculture, Forestry and Fisheries>

(5) Airports

○ Implement measures against inundation and other disasters associated with tropical cyclones and other weather events by appropriately ascertaining climate change-induced rise in mean sea level, high waves, and other events and considering impacts on airport facilities (basic facilities,* drainage facilities, shore conservation, etc.) in the event of storm surges, etc.

* Basic facilities refer to runways, air strips, taxiways, and aprons. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Prepare for scenarios where facilities cannot be fully protected by including in airport BCPs

(see Section 7) response plans for the potential loss of different airport functions due to inundation or other events to combine structural and non-structural measures. <Ministry of Land, Infrastructure, Transport and Tourism>

3. Basic adaptation measures for mountain areas (sediment disasters)

[Impacts]

<Current status>

○ There are limited studies and reports that directly analyze the impact of climate change on sediment disasters. However, many research papers and reports have been published on the recent situation of rainfall conditions and sediment disasters and recently experienced sediment disasters, especially large-scale ones characterized by multiple deep-seated landslides and simultaneous multiple surface slope failures and debris flows, and sediment-laden flood. If the distinctive rainfall conditions that caused these large-scale sediment disasters are derived from climate change, it means that climate change-induced changes have already manifested themselves in the form of sediment disasters and these disasters will further intensify.

<Projected impacts>

○ On the assumption that rainfall conditions will become severer, the current status will change as follows (where severer rainfall conditions refer to events such as heavy rain with extreme precipitation intensity, longer durations of such precipitation intensity, heavy rain with extremely high total precipitation, and heavy rain falling across a wide area):

- Frequent occurrence of intensive collapses, landslides, and debris flows, causing impacts to social life in hilly and mountainous areas
- Relative decline in the effectiveness of structural and non-structural measures, and expansion of damage
- Increased frequency of sediment-laden flood
- Prolonged direct and indirect impacts of increased large-scale events, such as deep-seated landslides
- Propagation of damage to outside the existing sediment disaster risk areas as a result of the increase in the scale of phenomena and manifestation of new sediment transport events
- Declines in flood control and water supply functions as a result of increased sediment supply to rivers
- Damage from driftwood resulting from extremely heavy rainfall in forests
- Impact on airport operation from airport facility inundation

・Debris flows, landslides, etc. [Significance: ●; Urgency: ●; Confidence: ●]

[Basic approach to adaptation]

○ Sediment disasters occur due to interrelations between complicated contributing and causative factors, and cannot be forecast accurately. Therefore, integrated approaches that combine structural and non-structural measures should be taken, and plans to prepare for more extensive and frequent sediment disasters should be updated.

○ The risk of sediment-laden flood is assumed to have increased recently due to the simultaneous occurrence of slope failures, debris flows, and higher river flows, which are expected to become more frequent throughout Japan as the nation has been experiencing climate change-induced heavy rainfall events. The government should study and compile the assessment method of sediment and flood disaster risks, such as identifying river basins at high risk of sediment-laden flood; implement preliminary DRR measures, such as building sediment control dams and sediment-retarding basins in high-risk river basins; and thereby promote effective development of disaster preparedness.

○ The effective installation of facilities should also be emphasized to address large amounts of driftwood that flows down once sediment and flood damage, debris flows, or other disasters occur.

○ There is concern that sediment movement will occur more frequently due to changes in rainfall characteristics in association with climate change, and it may become necessary to examine and review the timing and frequency of maintenance and management of sediment control dams, etc., in addition to steadily implementing preliminary DRR, such as the installation of sediment control dams. Therefore, maintenance and management plans need to be considered.

○ Concerning sediment disasters that are increasing in frequency and intensity, efforts should be focused on combining structural and non-structural measures, such as intensively implementing measures to protect lifelines, important traffic networks, and local government offices from sediment disasters, promoting measures against sediment-laden flood that is increasing in frequency due to climate change, and disseminating risk information using sediment disaster hazard maps in accordance with the Sediment Disaster Prevention Act.

○ The government should aim to newly establish a method to appropriately assess, as a result of climate change-induced changes in rainfall characteristics, which sediment transport events will occur more frequently or manifest themselves and in which areas. The results of such assessments should be recognized across society.

○ As part of the River Basin Disaster Resilience and Sustainability by All policy, the following measures should be implemented with the participation of all stakeholders in the basin, according to the characteristics of the basin:

- Measures to prevent and mitigate flooding as much as possible (hazard control)

  Implement installation of flood control facilities so that flooding can be prevented as much as possible

- Measures to reduce the targets of damage (exposure control)

  Measures to reduce the targets of damage, such as town development with restrictions on land use and improving the ways of living to avoid damage, based on the idea of "not living on dangerous land," assuming the occurrence of massive flooding that exceeds the capacity of flood control facilities
- Measures for damage mitigation and early recovery/reconstruction (vulnerability control)

  In response to the occurrence of flooding, take measures to mitigate damage (e.g., enhancing the system that allows people to evacuate adequately and appropriately) and take measures for early recovery and reconstruction in affected areas. The above three elements should be implemented in a comprehensive and multi-layered manner.

○ The impact on airport facilities from climate change-induced increases in the frequency and intensity of heavy rainfall should be studied to reflect it in DRR measures for airports.

[Basic measures]

1) Measures to address increasing frequency of sediment disasters

○ Considering that sediment disasters are projected to occur more frequently due to climate change, prioritize the promotion of improvements in facilities and equipment in locations that can be most effective in protecting human life, and improve evacuation sites and routes, public facilities, and facilities that protect socioeconomic activities. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Utilize existing facilities effectively, such as by removing debris as appropriate from sediment control dams. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Consider rationalizing the way facilities are planned and designed, as well as the materials used for them. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Promote measures against sediment disasters that can protect the lifelines essential to local people's lives. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Promote measures against sediment disasters that can protect important traffic networks connecting key local communities. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Promote measures against sediment disasters that can protect local government offices in key local communities. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Combine structural and non-structural measures against sediment disasters to build communities resistant to sediment disasters and encourage residents to relocate from hazard areas. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Strengthen the warning and evacuation systems through actions such as supporting the formulation of hazard maps; raise hazard awareness among residents and local government

personnel; and thus promote the development of human resources that are knowledgeable about sediment disasters. <Ministry of Land, Infrastructure, Transport and Tourism>

2) Measures to prepare for sediment disasters with short warning/evacuation lead times

○ Endeavor to disseminate accurate information on sediment disasters, through realistic disaster drills and hands-on DRR education with the goal of ensuring that residents are fully aware of dangerous locations, shelter locations, and evacuation directions to allow themselves to leave high-risk locations immediately. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Consider matters such as improving the sediment disaster alert system, and effectively using various means of gathering and sharing information, including social media. <Ministry of Land, Infrastructure, Transport and Tourism>

3) Measures against sediment-laden flood

○ Based on screening results, formulate sediment and flood damage preparedness plans for river basins at high risk of sediment-laden flood. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Implement flood control projects in accordance with the combined sediment and flood damage preparedness plans in order of importance and priority. <Ministry of Land, Infrastructure, Transport and Tourism>

4) Measures against deep-seated landslides, etc.

○ Strengthen national land monitoring systems by using satellites and other equipment, and promote improvements in crisis management systems to make them more quickly detect the occurrence of events such as deep-seated landslides and blocked rivers. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Promote the use of new technologies, including airborne electromagnetic surveys. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Accelerate responses and improve the quality of response through actions such as urgently investigating events of concern that can cause significant damage, such as a blocked river, followed by the provision of findings to relevant municipalities; conducting more realistic drills in collaboration with relevant institutions; and introducing unmanned aerial vehicles (UAV). <Ministry of Land, Infrastructure, Transport and Tourism>

5) Measures against driftwood disasters

○ Consider measures such as adopting slit dams, which can effectively catch driftwood, installing log booms, and upgrading existing dams to slit dams if they currently do not have flow-through features. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Implement basin-wide driftwood management based on driftwood risk surveys in

cooperation with the Forestry Agency. <Ministry of Land, Infrastructure, Transport and Tourism>

6) Promotion of projects to build green belts in urban foothills

○ In cities where urban areas are close to the foothills of mountains, form a continuous forest zone in such foothills to build a green belt with the goal of increasing safety against sediment disasters and conserving and creating an urban environment and landscapes rich with greenery. <Ministry of Land, Infrastructure, Transport and Tourism>

7) Headwaters management

○ Strengthen national land monitoring systems by routinely accumulating detailed topographical and other data obtained through satellite and aerial laser surveys. <Ministry of Land, Infrastructure, Transport and Tourism>

8) Land use and housing that consider disaster risks

○ Encourage safer land use by promoting the designation of sediment disaster risk areas and publishing basic survey results. In particular, promote efforts to ensure the safety of disaster response centers and basic infrastructure and lifeline facilities. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Encourage relocation of housing away from areas with particularly high disaster risk to safer areas by designating special sediment disaster risk areas where building structures and housing development are regulated and implementing programs for resettlement from at-risk housing away from areas adjacent to steep slopes. <Ministry of Land, Infrastructure, Transport and Tourism>

9) Promotion of investigation and research

○ Regarding sediment disasters, promote research relating to ways to more accurately provide disaster risk information, particularly the urgency of disaster risk, to relevant municipalities and residents by combining elements such as disaster occurrence information, rainfall conditions, and sediment disaster risk areas. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Regarding avalanche disasters, noting that there have been cases of heavy snow and an extremely rapid accumulation of snow in recent years even in regions that usually do not have much snow, in addition to climate change-induced changes in both the amount and quality of snowfall, continue monitoring parameters such as snowfall and snow cover and further promote research on disaster-related impacts of heavy snowfall and avalanches. <Ministry of Land, Infrastructure, Transport and Tourism>

10) Enhanced preparedness for the management of disaster waste, etc.

○ Promote the formulation of contingency plans for waste management, such as those considering the continuity of domestic waste treatment operations during a disaster. Build resilient waste management systems that can handle disaster waste, etc. appropriately, smoothly, and quickly by conducting initiatives at the local-government, regional-block, and national levels. <Ministry of the Environment>

11) Responses to intensifying rainfall events at airports

○ Implement measures against inundation and other disasters associated with tropical cyclones and torrential rains by appropriately ascertaining climate change-induced increases in the frequency and intensity of heavy rain and considering impacts on airport facilities (basic facilities,* drainage facilities, shore conservation, etc.) during heavy rainfall.

* Basic facilities refer to runways, air strips, taxiways, and aprons. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Prepare for scenarios where facilities cannot be fully protected by including in airport BCPs (see Section 7) response plans for the potential loss of different airport functions due to inundation or other events to combine structural and non-structural measures. <Ministry of Land, Infrastructure, Transport and Tourism>

4. Basic adaptation measures for mountainous areas (mountain disasters and forest conservation/road facilities)

[Impacts]

<Current status>

○ The frequency of heavy rainfall exceeding 50 mm or more of rain per hour has increased about 1.4 times over the past 30 years or so, and the number of sediment disasters damaging housing and villages has been rising accordingly. Localized heavy rainfalls have also been frequently caused by a band-shaped precipitation system that stay for many hours. There have been many cases where such a precipitation system brought intense rain across a relatively wide area, inducing simultaneous multiple surface slope failures and debris flows in a river basin.

○ Depending on the area's topographical or geological features, vast amounts of rainwater brought by extremely heavy rains can penetrate deep into the ground, causing a collapse in deep layers beyond the reach of tree roots. Such hillside collapses over the capacity of the mountain DRR functions provided by forests have occurred, suggesting the increasing risk of losing mature forests. There have also been more frequent driftwood disasters, in which trees standing on collapsed hillsides and sediment there flow down along with other trees and sediments around the stream, creating a large flow of woody debris.

○ At present, it is not clear whether wind damage is increasing in planted forests because there are limited studies addressing this subject. However, some studies show that the dynamic

resistance of forests to strong winds declines when trees are densely packed or when large amounts of water are supplied to the soil by intense rain.

<Projected impacts>

○ Forests prevent ground surface erosion through their lower-layer vegetation and fallen branches and leaves, and prevent sediment collapse by allowing trees to spread their roots. Given that climate change is inevitably expected to cause more frequent heavy rains and more localized heavy rainfalls, more frequent mountain disasters (e.g., collapses and debris flows) will occur. If extreme rain events far exceeding the capacity of these preventive functions induce natural hazards, simultaneous multiple collapses or debris flows on mountain slopes will increase, especially in weak geological zones.

○ Researchers have pointed out that wind-fallen trees, or trees blown down by heavy rain or strong winds brought by tropical cyclones, may expand the scale of mountain disasters.

・Debris flows, landslides, etc. [Significance: ●; Urgency: ●; Confidence: ●]
(Related categories)

・Water supply (surface water) [Significance (RCP 2.6/8.5): ●/●; Urgency: ●; Confidence: ●]

[Basic approach to adaptation]

○ Considering the increasing trend of mountain disasters in intensity and frequency as a result of more frequent heavy rain and short-duration intense rainfall, as well as heavy snowfall, the government should promote forest conservation and management in accordance with its Five-Year Acceleration Plan for Disaster Prevention, Disaster Mitigation, and Building National Resilience and other policies.

○ To enhance preparedness for increases in water disaster risks due to climate change, efforts should be focused on the management and conservation of forests in the upper river basin in coordination with the River Basin Disaster Resilience and Sustainability by All policy, which aims to achieve collaboration among all stakeholders in each basin.

○ Forest conservation measures should address changes in the way disasters occur, such as increasing amounts of sediment overflow from collapsed mountain ridges, severer driftwood disasters, and river flooding in wide areas.

○ Investigation and research should be promoted on preparedness for mountain disasters by combining structural and non-structural measures and on the impact of mountain disasters on the forests and forestry industry, in light of the climate change-induced trend of increasing torrential rains.

○ More resilient and durable road networks should be built to respond to intensifying disasters, accommodate larger vehicles, and streamline the collection and transportation of unused wood material by designing routes that are closer to the ridge lines and away from riverside

areas, securing enough margin in road width and curved sections, establishing lumberyards, and enhancing drainage functions.

[Basic measures]

○ Secure public safety and security by systematically designating conservation forests to fully realize the public functions of forests, such as headwater resource conservation and disaster prevention. <Ministry of Agriculture, Forestry and Fisheries>

○ Enhance the safety of communities based on preliminary DRR approaches, by improving forest conservation facilities and forests to prevent mountain disasters and minimize damage from mountain disasters. Also, effectively conduct DRR projects by fostering coordination with local evacuation arrangements through actions such as offering information on high-risk areas designated as Mountain Disaster Danger Zones (MDDZ). <Ministry of Agriculture, Forestry and Fisheries>

○ Contribute to basin-wide flood control through the maintenance and enhancement of headwater resource conservation functions of forests by strengthening forest soil conservation in conservation forests in the upstream basin through combinations of forest management, terracing works on mountain slopes, and other techniques. <Ministry of Agriculture, Forestry and Fisheries>

○ Noting that driftwood disasters associated with hillside collapse or other events have become evident, focus on driftwood disaster risk mitigation by building slit dams designed to control erosion and catch driftwood, managing forests based on thinning and other techniques to promote root growth, cutting down dangerous trees along streams, and shifting the physiognomy of forests in a manner that considers mountain stream ecosystems. <Ministry of Agriculture, Forestry and Fisheries>

○ In the MDDZ, which are prone to sediment collapse, debris flows, and other mountain disasters, systematically designate forests that serve as conservation forests for sediment runoff prevention to regulate logging and development to some extent; and suppress sediment runoff by constructing erosion control dams in a careful arrangement. <Ministry of Agriculture, Forestry and Fisheries>

○ Enhance the DRR function of forest road facilities by promoting the construction of forest road facilities adapted to more frequent localized heavy rainfalls. <Ministry of Agriculture, Forestry and Fisheries>

○ Consider identifying MDDZ more accurately by using laser surveys and other technologies, building facilities for responding to disaster risks, and managing forests by using the DRR functions of forests, while taking into account new scientific findings and more accurate climate models. <Ministry of Agriculture, Forestry and Fisheries>

5. Basic adaptation measures for strong winds, etc.

[Impacts]

<Current status>

○ There are no studies at present that specifically mention any causal relationship between climate change-induced increases in strong winds and intense tropical cyclones, and the growth in damage from such events. However, some reports indicate that climate change has had an impact on the shift in the spatial location of the maximum intensity of tropical cyclones and the change in the tracks of tropical cyclones.

○ At present, there are no specific studies regarding the climate change-induced change in the frequency of tornadoes.

○ There have been reports indicating long-term decreases in the number of low pressure systems that rapidly develop, while the intensity of each low pressure system has been on the rise.

<Projected impacts>

○ Research based on the RCP 8.5 scenario projects that climate change will increase strong winds and the proportion of intense tropical cyclones in overall tropical cyclones through the latter half of the 21st century, but with regional variation in trends.

○ Some studies project significant increases in the frequency of strong tornadoes.

○ Although no studies have been confirmed to make quantitative projections at present, there are concerns about an increase in damage from wind-fallen trees in hilly and mountainous areas along with the increase of intense tropical cyclones.

・Strong winds, etc. [Significance: ●; Urgency: ●; Confidence: ▲]

[Basic approach to adaptation]

○ There are no confirmed studies at present that specifically mention any causal relationship between climate change-induced increases in strong winds and intense tropical cyclones, and the growth in damage from such events, suggesting the need to accumulate scientific findings in this field.

[Basic measures]

○ Noting that, as indicated above, climate change is expected to increase strong winds and intense tropical cyclones, starting in the near future (2015–2039), address intense tropical cyclones associated with climate change by continuing to promote the introduction of low-cost weatherproof greenhouses that are resistant to disasters; and address tornadoes by promoting the use of information that notifies the public when weather conditions are prone to produce violent gusts or tornadoes and encouraging people to pay close attention to the sky condition and act to protect themselves when signs of approaching cumulonimbus clouds are observed. <Cabinet Office; Ministry of Agriculture, Forestry and Fisheries; Ministry of Land, Infrastructure, Transport and Tourism>

6. Promotion of Adaptive Recovery

[Basic approach to adaptation]

○ When recovering from a disaster, we must not be confined to simply restoring the affected area to the way it was before the disaster struck; rather, taking into consideration the perspective of restraining future maintenance costs for infrastructure, it is necessary to promote the idea of "Adaptive Recovery," which considers adaptation to climate change, including land use control and relocation of residential buildings and infrastructure to low-risk areas.

[Basic measures]

○ For effective coordination of climate change measures and DRR measures, create a manual for local governments to help them mainstream the concept of the synergy between climate action and DRR and accelerate their efforts toward "Adaptive Recovery". <Ministry of the Environment>

7. Other common activities

[Basic approach to adaptation]

1) Enhanced preparedness for the management of disaster waste, etc.

○ Efforts should be made to promote the establishment of contingency plans for waste management and build a resilient waste management system.

2) Investigations and research, and technology development

○ Based on the projection of increases in natural hazards, efforts should be focused on promoting technology development for dikes and other facilities that consider the impact of such hazards, as well as investigations and research in areas such as the development of quantitative assessment methods for DRR functions of blue carbon ecosystems, etc.

[Basic measures]

1) Enhanced preparedness for the management of disaster waste, etc.

○ Promote the formulation of contingency plans for waste management, such as those considering the continuity of domestic waste management operations during a disaster. Build resilient waste management systems that can handle disaster waste, etc. appropriately, smoothly, and quickly by conducting initiatives at the local-government, regional-block, and national levels. <Ministry of the Environment>

2) Investigations and research, and technology development

○ Promote technology development for dikes and other facilities that consider the impact of any excessive natural hazards involved; and development of new technologies for coastal

erosion control. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Promote investigations and research on coastal adaptation in areas such as the development of quantitative assessment methods for DRR functions of blue carbon ecosystems, etc. <Ministry of Land, Infrastructure, Transport and Tourism>

Section 5. Human Health

1. Basic adaptation measures for heat stress

[Impacts]

<Current status>

○ Regarding mortality risk, it has been confirmed that excess mortality (an indicator of an increase in total deaths directly or indirectly attributed to the given illness) related to higher temperature is increasing across Japan.

○ The rising trend of excess deaths is particularly evident for the elderly, although some reports show that even among the population aged under 15 years old, externally caused deaths are increasing as temperatures rise.

○ The nationwide increasing trend has been confirmed, although with variation by age, in the number of patients transported by ambulance, the number of patients having visited medical institutions, and fatalities due to heat illness. By age group, the number of patients transported by ambulance and fatalities due to heat illness are higher for the elderly, with many cases occurring at home and more likely to develop into severe conditions, according to some reports. Reports also show that young and middle-aged people tend to develop heat illness while working or playing sports outdoors.

<Projected impacts>

○ Research on the risk of death in multiple countries, including Japan, has projected that higher temperature will increase cardiovascular disease deaths in future years, and that heat-related deaths of elderly people will increase in 2030 and 2050.

○ Regarding heat illness, it is projected that by the 2090s, daytime hours safe for outdoor labor will be 30 to 40% less than those available today in Tokyo and Osaka and that the number of days unsafe for outdoor labor will increase in these areas. The number of days when people need to be strictly warned against vigorous outdoor exercise will also increase.

○ The rate of increase in the heat illness incidence rate will be high in Hokkaido, Tohoku, and Kanto, but low in Shikoku, Kyushu, and Okinawa for both the 2031–2050 and the 2081–2100 periods. A projection based on the RCP 4.5 scenario indicates that the risk of heat illness in the 2050s will be 2.4 times that in the 2000s in Tokyo's 23 wards and Sendai City. By age group, the rate of increase in the heat illness incidence rate will be the highest for the elderly aged 65 years and over. Given the future aging of Japan's population, the impact will be even more serious.

・Mortality risk [Significance: ●; Urgency: ●; Confidence: ●]
・Heat illness [Significance: ●; Urgency: ●; Confidence: ●]

[Basic approach to adaptation]

○ The nationwide increasing trend has been confirmed in the number of patients transported by ambulance, the number of patients having visited medical institutions, and fatalities due to heat illness, and the heat illness risk is projected to increase further. These suggest the need to warn people of the risk of heat illness and to disseminate risk information to relevant organizations. In such risk communication, it is effective to implement measures in combination with awareness raising on actions to be taken by individuals.

○ In particular, based on the awareness that elderly people account for a large part of heat illness patients transported by ambulance and heat illness fatalities and that heat stress will increase the number of fatalities and the heat illness incidence rate among the elderly, it is important to disseminate information related to heat illness prevention to elderly households. Although measures targeting elderly people are important, attention must also be paid to other people at risk, including those working or playing sports outdoors.

○ It has also been reported that heat illness often occurs to people working outdoors. Therefore, measures to prevent heat illness should be taken for people working under severe conditions (e.g., intense sunlight), including reducing the intensity of physical labor by mechanization, shortening continuous working hours, or shifting working hours. It is also necessary to consider development and improvement of technologies to build machines that contribute to lighten the load of outdoor workers.

○ Emphasis should also be placed on continuously collecting and assessing information related to successful results from actual introduction of adaptation measures and gathering information on pioneering practices.

○ To address the aforementioned issues, the government upgraded the Liaison Conference of Ministries and Agencies Concerned with Heat Illness and renamed it the Heat Illness Prevention Conference in March 2021 for the further promotion of heat illness measures, followed by the establishment of a Heat Illness Action Plan. It is essential that the national government, local governments, industry, various organizations, and people should implement heat illness prevention measures together.

[Basic measures]

○ Continue to strive to accumulate scientific findings on heat-related risks induced by climate change. <Ministry of the Environment>

○ Taking the impact of climate change on heat illness into consideration, the national government takes actions such as appropriate provision of information related to weather and Wet-Bulb Globe Temperatures (WBGT), reminders to raise awareness of prevention

and remedy for heat illness, and occurrence status for each occasion of emergency services, education, healthcare, physical labour, agriculture, forestry and fisheries, sports, sightseeing, daily life, and other scenes, in cooperation with the relevant ministries and agencies under the Heat Illness Prevention Conference. <Cabinet Office; Ministry of Internal Affairs and Communications; Ministry of Education, Culture, Sports, Science and Technology; Ministry of Health, Labour and Welfare; Ministry of Agriculture, Forestry and Fisheries; Ministry of Economy, Trade and Industry; Ministry of Land, Infrastructure, Transport and Tourism; Ministry of the Environment>

○ In order to have people take preventive actions against heat illness, the government is operating the "Heat Stroke Alert" nationwide from April 2021, which was implemented in advance in the Kanto-Koshin region in the summer of 2020, and it continues to implement measures to prevent heat illness. <Ministry of the Environment; Ministry of Land, Infrastructure, Transport and Tourism>

○ Raise public awareness and encourage initiatives by businesses and local governments by holding heat illness seminars and preparing heat illness brochures. <Ministry of the Environment>

○ Continue efforts to survey and publish the number of heat illness patients transported by ambulance and public awareness campaigns for heat illness prevention. <Ministry of Internal Affairs and Communications>

○ To address heat illness at schools, continue reaching out to the boards of education and other school bodies to bring attention to prevention of heat illness incidents, including the handling of summer holidays at school. <Ministry of Education, Culture, Sports, Science and Technology>

○ Continue promoting measures to address heat illness in the workplace, including in the manufacturing and construction industries. <Ministry of Health, Labour and Welfare>

○ Inform foreign tourists and others visiting Japan of heat illness risks through websites and other media and give them push messages warning of heat illness via the Safety tips app. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Request prefectures and other related organizations to notify farmers, forestry workers and fishermen of heat illness precautions, such as frequently drinking water and taking in salt, and wearing clothing made of perspiration-absorbing and quick-drying materials; and prepare posters and flyers to raise awareness through the Heat Illness Prevention Project, a private-public initiative. <Ministry of Agriculture, Forestry and Fisheries>

○ Promote awareness and guidance on heat illness prevention for farmers, forestry workers, and fishermen, for example, by encouraging them to use the MAFF app with an added capability to show Heat Stroke Alert messages, through collaboration among relevant ministries and agencies, as well as cooperation with prefectural governments and other relevant organizations. <Ministry of Agriculture, Forestry and Fisheries>

○ Noting that labor in agriculture, forestry, and fisheries is often performed under severe

working conditions, such as intense sunlight and steep slopes, strive to lighten the load of these workers by promoting the development of technologies to automate outdoor farming during the hot season and actively introducing robotics technology and ICT. <Ministry of Agriculture, Forestry and Fisheries>

2. Basic adaptation measures for infectious diseases

[Impacts]

<Current status>

(Water- and food-borne diseases)

○ There have been reports that as sea surface temperature rises, the number of Vibrio parahaemolyticus present in seafood during summer is increasing in many parts of Japan.

○ A correlation has been reported between outdoor temperature and the risk of infectious gastroenteritis, and it is confirmed that higher outdoor temperatures have led to a longer rotavirus season in many parts of Japan. Some articles have also reported that lower outside temperatures increase the incidence of acute diarrhea.

(Arthropod-borne diseases)

○ It has been confirmed that the habitat of the Asian tiger mosquito, which is a vector of dengue fever, expanded to Aomori Prefecture by 2016.

○ Given that cases of mosquito-borne infectious diseases imported into Japan have been increasing, there is concern that cases of imported infectious diseases may trigger a chain of infections in Japan, especially when shifts in the habitat and population density of disease-carrying mosquitoes are taken into consideration.

○ In fact, a domestic case of dengue virus infection occurred in Kyoto or Nara Prefecture in September 2019, and it led to the onset of dengue fever. As people infected with the dengue virus move around, such sporadic cases may occur across Japan.

○ The number of cases reported and the area of occurrence have also been confirmed to be expanding nationwide for Infectious diseases transmitted by ticks (Japanese spotted fever, scrub typhus, etc.).

(Other infectious diseases)

○ There have been reports pointing out changes in the seasonality of infectious diseases, such as influenza, hand-foot-and-mouth disease, varicella, and tuberculosis, as well as relationships between occurrence and meteorological conditions (temperature, humidity, precipitation, etc.).

○ However, it should be noted that social and biological factors have a large impact on the onset of these infectious diseases (water-/food-borne and arthropod-borne diseases).

<Projected impacts>

(Water- and food-borne diseases)

○ Projections show that contamination of drinking water sources with sewage as a result of heavy rainfall can cause gastrointestinal diseases.

○ Projections based on the RCP scenarios show that diarrheal disease morbidity will decline across Japan through the end of the 21st century in the RCP 4.5 and RCP 8.5 scenarios.

(Arthropod-borne diseases)

○ A projection using the RCP 8.5 scenario indicates the possibility that the distribution range of the Asian tiger mosquito will extend to some areas of Hokkaido by the end of the 21st century, as these areas will meet the temperature requirements for the habitat of the Asian tiger mosquito.

○ The day on which Asian tiger mosquitoes start bloodsucking activity is correlated with the mean temperature in early spring, and this date may come earlier as the climate warms.

○ As the climate warms, the active season for Asian tiger mosquitoes and common house mosquitoes may extend.

○ Researchers have also pointed out that rising temperatures may expand the distribution range of alien mosquitoes that transmit the Japanese encephalitis virus in the Amami and Okinawa regions.

○ Although arthropods other than disease-carrying mosquitoes may be affected by climate change impacts, there are no studies specifically and directly addressing the expansion of the risk of infectious disease in Japan at this point.

(Other infectious diseases)

○ Climate change may cause changes to the seasonality of various infectious diseases and to the risk of their occurrence.

○ There have been many reports on the correlation between meteorological factors (e.g., precipitation) and outbreaks of influenza, and findings on this correlation are regarded as important, even in the context of future precipitation changes projected for Japan.

○ Meanwhile, there are limited articles dealing with various infectious diseases caused by climate change, including but not limited to influenza. To perform more projections, further progress in research on quantitative risk assessment is awaited.

・Water- and food-borne diseases [Significance: ◆; Urgency: ▲; Confidence: ▲]
・Arthropod-borne diseases [Significance: ●; Urgency: ●; Confidence: ▲]
・Other infectious diseases [Significance: ◆; Urgency: ■; Confidence: ■]

[Basic approach to adaptation]

○ Regarding arthropod-borne diseases that are transmitted by mosquitoes, efforts should be focused on preventing occurrence and spread of the diseases and ascertaining trends in their

occurrence.

○ Since there are limited studies on the relationship between infectious diseases and climate change-induced risk of infection, efforts are needed to accumulate more scientific findings.

[Basic measures]

○ Noting that since there are limited studies on the relationship between infectious diseases and climate change, leaving many factors with uncertainty, and that climate change is projected to cause temperature rise, strive to accumulate scientific findings on aspects such as the relationship between an increase in temperature and changes in the risk of occurrence of infectious diseases. <Ministry of the Environment>

○ For the prevention of the occurrence and spread of mosquito-borne infectious diseases, have prefectural governments and other bodies implement measures such as continuous fixed-point observation in areas where disease-carrying mosquitoes occur, larvae control, extermination of adult mosquitoes, and encouragement of mosquito control measures in accordance with the Special Guidance on Mosquito-borne Diseases (April 28, 2015); and have them make efforts to monitor trends in the occurrence of infectious diseases. <Ministry of Health, Labour and Welfare>

3. Warmer winters

[Impacts]

<Current status>

○ At present, there are no specific studies indicating that warmer winters are leading to declines in mortality in winter.

○ Meanwhile, deaths and mortality associated with low temperatures have been increasing in Japan since the 1990s, especially among the elderly, although the figures are decreasing for young and middle-aged people.

○ The relative risk of heat stress has been declining in recent years, while that of low temperature has been increasing. There have been reports showing the possibility that under extreme low temperature conditions, the risk of all diseases, cardiovascular diseases (cerebral stroke, out-of hospital cardiac arrest, and myocardial infarction), and respiratory diseases is higher.

<Projected impacts>

○ In the RCP 4.5 scenario, Japan’s mean temperatures in winter will be higher in 2030 than in the 2000s nationwide, and cold-related deaths as a proportion of total deaths (non-accidental) will be lower. However, due to the increase in the elderly population, which will be affected most, the actual number of cold-related deaths is projected to increase.

○ Likewise, global projections indicate that in the RCP 8.5 scenario, cold-related deaths will

decrease from the levels in 2010 in East Asia, including Japan, along with temperature rise.

・Mortality in winter [Significance: ◆; Urgency: ▲; Confidence: ▲]

[Basic approach to adaptation]

○ Since there are limited studies at present that specifically mention the causal relationship between climate change and cold-related deaths, efforts are needed to accumulate more scientific findings.

[Basic measures]

○ Noting that no existing findings have been confirmed on the manifestation of decreased deaths in winter due to climate change, strive to accumulate scientific findings in this field. <Ministry of the Environment>

4. Basic adaptation measures for other human health impacts

[Impacts]

<Current status>

(Compound impacts of warming and air pollution)

○ Regarding the combined impacts of warmer climates and air pollution, there have been reports of changes in the atmospheric concentrations of various pollutants, including particulate matter, due to factors such as reactions leading to their formation being promoted by higher temperatures.

○ Many reports of recent years indicate increases over time in the concentration of photochemical oxidants (Ox), typically ozone (O_3), suggesting that warmer climates may be a contributor.

○ Higher O_3 concentrations associated with warming may increase O_3-related deaths (total deaths, cardiovascular disease deaths, and respiratory disease deaths).

(Impacts on vulnerable groups [elderly people, children, people with underlying diseases, etc.])

○ Many reports have indicated the impact of heat stress on elderly people. These include elderly people being at higher risk of sunstroke and heatstroke and more likely to develop severe conditions, and the risk of out-of hospital cardiac arrest being increased by higher temperatures.

○ There are articles confirming that the risk of onset of heat illness and the risk of death from heat illness are higher for those in their twenties to sixties, who are more likely to be exposed to an outdoor heat stress environment than older people, with many reporting links to living standards such as income and social status.

○ Regarding people with underlying diseases, reports show that for elderly respiratory disease

patients, the heat stress environment during sleep has an impact on the deterioration of their feeling of breathing difficulty and physical condition. Reports also indicate that hyperglycemic patients, in addition to elderly people, are more vulnerable to the impact of low temperatures and are at high risk of death from cardiovascular diseases in a cold environment.

(Other human health impacts)

○ There have been reports that higher temperatures lead to the occurrence or increase of health effects, such as decreased sleep quality, lassitude, fatigue, and feverishness.

○ Some reports link high/low temperatures to the onset of cardiovascular and respiratory diseases and ambulance transportation due to such diseases.

○ Although findings in this field are limited in Japan, studies conducted outside Japan have reported the occurrence of acute kidney injury, reduced labor productivity, and natural disaster-related mental illness in high temperature environments, suggesting that similar effects may occur in Japan.

<Projected impacts>

(Compound impacts of warming and air pollution)

○ If current levels of air pollution continue in urban areas, where oxidant concentrations are high due to industrial and traffic concentration, the warming may push oxidant concentrations even higher, causing more health problems.

○ Estimated excess mortality related to ozone and PM2.5 under multiple RCP scenarios indicate that in East Asia, excess mortality will reach a peak in 2050 under the RCP 6.0 scenario and in the 2030s under other RCP scenarios, followed by a shift to a downward trend.

○ A study targeting Japan projects that premature deaths due to ozone and PM2.5 will increase by the 2020s.

(Impacts on vulnerable groups [elderly people, children, people with underlying diseases, etc.])

○ Regarding the impacts on vulnerable groups, although some articles project increases in the number of elderly deaths due to heat stress, information on the impact on people with underlying diseases and children is limited.

(Other human health impacts)

○ An article projecting health impacts in August in the 2070s points out that heat stress contributes to lassitude, fatigue, and insomnia.

○ Research based on past statistics estimates that the warming will lead to an increase in the numbers of various crimes (murder, assault, theft, etc.) and suicides.

○ Higher temperatures are assumed to affect the efficiency of labor, education, and learning and lead to extreme events (intense tropical cyclones, heat waves, cold spells, flooding, etc.) which may affect mental and physical stress. Given that articles on these topics are limited, research on relevant quantitative risk assessments is awaited.

- Compound impacts of warming and air pollution [Significance: ◆; Urgency: ▲; Confidence: ▲]
- Impacts on vulnerable groups [Significance: ●; Urgency: ●; Confidence: ▲]
- Other human health impacts [Significance: ◆; Urgency: ▲; Confidence: ▲]

[Basic approach to adaptation]

○ Heat illness prevention information should be provided to elderly households, in light of projections for impacts on vulnerable groups, such as that elderly people will account for a large part of heat illness patients transported by ambulance and the deaths from heat illness, and that heat illness-related deaths and heat illness incidence will increase among the elderly.

○ Scientific findings should be collected through research on relationships between environmental information and existing data (e.g., mortality data), consideration of the establishment of a system to collect, accumulate, and manage information on health problems and medical consultations, study on the way outdoor labor should be performed, collection of successful practices for heat stress management by local governments, and study on quantitative risk assessments.

[Basic measures]

○ Noting that recent research has reported that higher temperatures can be a contributor to changes in the concentration of particulate matter, as well as oxidants, work toward accumulation of scientific findings and continue promoting measures to control air pollution caused by oxidants, particulate matter, and other substances. <Ministry of the Environment>

○ Address the impacts on public health, water quality conservation, and landscapes from the overflow of combined sewer systems due to localized torrential rainfall by continuing water quality improvement measures, such as those aimed at combined sewer systems. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Recognizing the lack of knowledge about climate change-related impacts in some areas, such as those on vulnerable groups and those not causing clinical symptoms, make efforts to collect scientific findings. <Ministry of the Environment>

Section 6. Industrial and Economic Activities

1. Basic adaptation measures for finance and insurance

[Impacts]

<Current status>

○ Along with more frequent and intense natural disasters and penetration of insurance coverage for natural disasters, it has been confirmed that the amount of claim payments has significantly increased as a recent trend, with a constantly rising probability of losses from natural disasters. Among the ten largest claim payments resulted from the typhoons and floods in the past, seven occurred in 2014 or later, with Typhoon Jebi (T1821) having recorded the largest claim payment for losses at 1 trillion yen in 2018.

○ As non-life insurance companies found difficulties in projecting future losses by utilizing traditional risk measuring methods, it is necessary to establish a risk assessment method taking into account the future impacts of climate change and the uncertainties.

○ There are no specific studies identified regarding the impacts on Japan's financial sector.

<Projected impacts>

○ Increased natural disasters and relevant insurance losses will possibly drive up claim payments and reinsurance premiums. However, at present, there are few number of studies on this topic in Japan.

・Finance and insurance [Significance: ●; Urgency: ▲; Confidence: ▲]

[Basic approach to adaptation]

○ To address natural disaster risks, it is important to enhance risk management at non-life insurance companies; provide the financial and insurance industries with floods risk information and initiatives to avoid and reduce losses caused by floods; and integrate relevant scientific findings.

○ Given that increasing global losses from natural disasters are expected to affect the insurance industry, it is important to develop the adaptation measures for this industry.

[Basic measures]

○ Continue to encourage non-life insurance companies to enhance their risk management for natural disaster risks and to advance FSA's monitoring method. <Financial Services Agency>

○ Continue efforts to accumulate scientific findings on the impacts of climate change. <Ministry of the Environment>

2. Basic adaptation measures for tourism

[Impacts]

<Current status>

○ Leisure industries that utilize natural resources (e.g., forests, snowy mountains, sandy beaches, and tidal flats) may be affected by the rise in temperature, changes in the amount of rainfall and snowfall, changes in the spatial and temporal distribution of precipitation, and sea level rise. However, at present, there are limited studies dealing with any of these issues except for the impact on ski resorts.

○ There have been reports on impacts on tourism resources, such as less frozen falls, fewer numbers of ice floes, and reduced snow depths at ski resorts, as well as growing damage to Itsukushima Shrine from tropical cyclones and storm surges.

<Projected impacts>

○ Projected impacts include the nationwide reduction or local disappearance of suitable habitats for species such as the alpine ptarmigan, alpine plants, and the cold-water char fish, shifts in the distribution and growth of forest constituent tree species, expanded distribution of sika deer and other species to higher latitudes and elevations, reduction or disappearance of the suitable distribution ranges of coral reefs in subtropical zones, among other changes in natural ecosystems. These can affect outdoor leisure activities, such as mountaineering and diving.

○ For skiing, snowfall and maximum snow depth will decrease in Japan between 2031 and 2050 with the exception of some inland areas in Hokkaido and Honshu, and as a result, almost all ski resorts will see a reduction in snow depth. Decreased snow cover will lead to reductions in the number of visitors and operating income.

○ Some studies project that shrines and temples will receive more visitors as decreased snow cover can mean improved traffic access.

○ A loss of sandy beaches will occur due to sea level rise, with impacts expected on leisure industries in coastal areas.

・Tourism [Significance: ◆; Urgency: ▲; Confidence: ●]

・Tourism (leisure businesses based on natural resources, etc.) [Significance: ●; Urgency: ▲; Confidence: ●]

[Basic approach to adaptation]

○ For ski resorts and leisure businesses dependent on coastal natural resources, which are projected to negatively affected by 2050 (typically, in the form of a loss of tourism resources), considering adaptation measures suited to regional characteristics is essential. Therefore, scientific findings should be collected on regional impacts of climate change.

[Basic measures]

○ Establish a system at the Japan National Tourism Organization's call center to offer

multilingual support services; enhance the functionality of the Safety tips app to provide more push messages informing international tourists of the occurrence of a disaster and emergency guidance functions to better help them in disaster situations; and disseminate accurate disaster information via websites and other media to minimize damage caused by disaster-related rumors. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Encourage local governments to conclude agreements with hotel industry associations to ensure that hotels, inns, and other lodging establishments can quickly function as shelters during times of disaster. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Noting the importance of considering adaptation measures for tourism businesses (e.g., related to skiing and marine leisure) according to regional characteristics, collect scientific findings on regional impacts of climate change. <Ministry of the Environment>

3. Basic adaptation measures for industrial and economic activities outside the financial, insurance, and tourism industries

[Impacts]

<Current status>

(Manufacturing)

○ Although climate change is expected to have various impacts on manufacturing industry, there are only a few studies at present that address this topic.

○ However, water disasters cost the manufacturing industry 13.1 billion yen in damage in 2017, and it is pointed out that water disaster risks are increasing as the number of heavy rainfall events rises.

○ Responses to the CDP[23] climate change questionnaire in 2017 showed that in the manufacturing sector, many companies saw impacts of climate change as risk factors, but at the same time as opportunities, for their business.

○ In the manufacturing industry, it should be noted that supply chains and other international factors affect Japanese manufacturers.

(Food manufacturing)

○ Agricultural, livestock, and aquatic products are susceptible to climate change. As food manufacturers use these resources as raw materials, they are assumed to be susceptible, especially in terms of raw material procurement and quality. The impacts of climate change on them can take the form of declines in the quality of agricultural crops and yields, and supply chain disruptions due to a disaster. There have been reports of cases in which these impacts are already being felt.

(Energy supply and demand)

[23] A London-based international NGO that assesses companies' activities in the categories of climate change, forests, and water.

○ Only a few studies have specifically addressed climate change-induced impacts on energy supply and demand.
○ There are reported cases in which heat waves pushed electricity demand above the expected levels.
○ It has been reported that energy supply was suspended when energy supply infrastructure was damaged by an intense tropical cyclone or other event.

(Commerce)
○ There have been reports indicating relationships between the number of beverages or air conditioners sold and the rise in temperature.
○ There have been reports that sudden changes in temperature and more frequent heavy rain are making it difficult to project supply and demand of seasonal products, and that heavy rain and tropical cyclones are causing sales increases or declines, as well as unscheduled closures, of department stores and supermarkets.

(Construction)
○ Due to higher temperatures in summer, the time of year when hot weather concreting is required to maintain concrete quality is extending.
○ Both mortality and casualties due to heat illness in the workplace in the past five years (2016 to 2020) were the highest in the construction industry.

(Healthcare)
○ At present, there have been some reports on the impacts on the healthcare industry as follows:
  ・Research reports on the impact on dialysis from the suspension or turbidity of water supply and on the relationship between temperature and the number of patients transported by ambulance, etc.
  ・Domestic cases of infection with pathogenic bacteria present in tropical or subtropical regions.
  ・Cases of damage to medical institutions into which flood water intruded.

<Projected impacts>
(Manufacturing)
○ Although few studies project that climate change will have a large impact on the manufacturing industry, some reports indicate that companies recognize climate change as risks and opportunities.

(Energy supply and demand)
○ There are some studies that have quantitatively assessed the future impacts of climate

change on energy supply and demand. However, based on the currently available findings, the overall impact on energy supply and demand cannot be substantial, although there will be some positive or negative impact depending on the region.

(Commerce)

○ How commerce will be affected by climate change cannot be assessed at present because there are few studies addressing this topic.

- Manufacturing [Significance: ◆; Urgency: ■; Confidence: ■]
- Manufacturing (food) [Significance: ●; Urgency: ▲; Confidence: ▲]
- Energy supply and demand [Significance: ◆; Urgency: ■; Confidence: ▲]
- Commerce [Significance: ◆; Urgency: ■; Confidence: ■]
- Commerce (retail) [Significance: ◆; Urgency: ▲; Confidence: ▲]
- Construction [Significance: ●; Urgency: ●; Confidence: ■]
- Healthcare [Significance: ◆; Urgency: ▲; Confidence: ■]

[Basic approach to adaptation]

○ Regarding the construction industry, recent situations of damage from localized heavy rainfalls indicate increasing water disasters beyond the assumptions on which buildings are planned and designed. There are technical and financial limits to flood-prevention and waterproofing measures that can be integrated into buildings alone. Therefore, in addition to taking building-level evacuation measures, which are a non-structural approach, it is necessary to combine and coordinate them with district-level measures that incorporate civil engineering and urban design perspectives.

○ To protect construction workers from heat illness, information provision and awareness raising are necessary. In the medium- to long-term, technologies for labor saving and full automation should be developed as well.

○ Efforts to enhance the resilience of power infrastructure and systems (electricity resilience) should be promoted, with the awareness of cases of damage to power infrastructure and systems from natural disasters, which are increasing recently and putting power supply at risk.

○ To reduce damage from a disaster and resume operation quickly, companies should establish business continuity management (BCM) and a business continuity plan (BCP).

○ Companies should be encouraged to work on climate-related information disclosure in light of the guidance and practices shown in the TCFD recommendations.

○ The food manufacturing industry is expected to be affected, especially in raw material procurement and quality, as a result of the deteriorated quality or yield of agricultural crops or impacts on the supply chain from a disaster. In view of some reports of already emerging impacts, adaptation measures suited to the characteristics of business operation should be

developed.

○ Globally increasing demand for raw materials, along with climate change, is expected to drive shortages of imported raw materials. To ensure continuous and stable procurement of raw materials, studies are needed on ways to reduce supply-chain losses and diversify and back up procurement sources.

○ There are no or limited studies that specifically address climate change-induced impacts on manufacturing, commerce, construction, and healthcare, and scientific findings should be accumulated in these fields.

[Basic measures]

1) Adaptation measures in the fields of manufacturing, energy supply and demand, commerce, construction, and healthcare

○ Continue promoting measures to address heat illness in the workplace, including in the manufacturing and construction industries. <Ministry of Health, Labour and Welfare> [Listed again]

○ Noting that there are only a few studies at present that address the impacts of climate change on manufacturing, energy supply and demand, commerce, construction, and healthcare, accumulate scientific findings in these fields. Also, collect and organize information on climate change impacts recognized by business operators by checking environmental reports they have published and interviewing them. Based on the findings from these activities, provide information on climate change impacts and other relevant issues as part of public-private collaboration to encourage business operators to work on adaptation and develop adaptation technologies. <Ministry of Economy, Trade and Industry; Ministry of the Environment>

2) Adaptation measures for distribution

○ Ensure the smooth transportation of relief supplies, including in the last one mile, during times of disaster by improving arrangements between local governments and distribution businesses (e.g., distribution industry associations) for the transportation and storage of relief supplies and by expanding the list of private-sector logistics/distribution centers. <Ministry of Land, Infrastructure, Transport and Tourism>

○ For the promotion of freight transport by rail, allow stakeholders to work together to respond in the event of cargo transport disruptions caused by disasters such as tropical cyclones, avalanches, and landslides. <Ministry of Land, Infrastructure, Transport and Tourism>

4. Adaptation measures for other impacts (overseas impacts, etc.)

[Impacts]

<Current status>

○ There have been reports on climate change-induced impacts expected overseas. These include estimations of the declines in the global yield of major grain crops in the past 30 years arising from climate change, and reports of increases in food prices as a result of droughts experienced in overseas grain producing regions. The flooding of Thailand's Chao Phraya River in 2011 resulted in losses for many Japanese companies operating there. According to reports, among other cases, the event cost Japanese companies involved in the supply chain of hard disk drives an estimated 315 billion yen in losses, and the total insurance money paid to the affected Japanese firms by Japanese non-life insurance companies exceeded the insurance payments for the earthquake and tsunami that hit Japan in 2011.
○ There have been climate security reports and reports on the analysis and development of diplomatic policies that consider climate change impacts on the Asia and Pacific region.
○ Due to the decreasing sea-ice area in the Arctic Ocean as a result of climate change, growing attention is paid to the use of the Northern Sea Route.

<Projected impacts>
○ Studies published on how the impacts occurring overseas will affect Japan include the following, although they mainly deal with indirect impacts involving trade and other international factors:
  ・Rising temperatures may cause fluctuations in crop production on the global scale and have an impact on crop prices.
  ・Higher temperatures and precipitation changes will bring change to the trading volumes of rice, wheat, and corn. Droughts and other events in overseas barley producing areas will cause reductions in the supply of barley for beer production, resulting in declines in beer consumption worldwide, including in Japan, and increases in beer prices.
  ・The impacts of climate change on land use and labor health in import source countries will increase the vulnerability of Japan's import of farming/livestock products and industrial products.
○ In view of studies conducted in the U.K., Japan should have concerns over impacts such as fluctuations in import prices of energy and agricultural/aquatic products, direct physical impacts on overseas production sites of Japanese companies, and impacts on the spread of infectious diseases via immigrants, travelers, etc. as vectors of infectious diseases increase overseas.
○ Reports on the impacts on international relations and national security from climate change, published mainly in Europe and the U.S., project weakening international support, increasing international support burdens, and intensifying conflicts over resource management.
○ Some studies conducted mainly in Europe and the U.S. suggest that climate change can deepen the instability of the international community over issues such as resource

management, environmental migrants, and vulnerable people's compensation and human rights, and that more socially unstable regions can lead to the increase in security policy risks.

・Adaptation measures for other impacts (overseas impacts, etc.) [Significance: ◆; Urgency: ■; Confidence: ▲]
・Other impacts (others) [Significance: –; Urgency: –; Confidence: –]

[Basic approach to adaptation]
○ In view of the impacts that climate change has on food, energy, land, defense, and other aspects, the government should implement climate change adaptation measures in a manner that minimizes these impacts.
○ As there is low confidence in other impacts (overseas impacts, etc.) of climate change, scientific findings should be accumulated on these impacts.

[Basic measures]
1) Adaptation measures for overseas impacts, etc.
○ Continue investigations on the impacts of climate change on Japan's national security. <Ministry of the Environment>

2) Use of the Northern Sea Route
○ With a view towards future use of the Northern Sea Route, such activities have been undertaken as gathering useful information on the latest trends in its use and subsequent information sharing through the joint Council comprising the industry, academia, and the Government. <Ministry of Land, Infrastructure, Transport and Tourism>

Section 7. Life of the Citizenry and Urban Life
1. Basic adaptation measures for infrastructure and lifelines
[Impacts]
<Current status>
○ Impacts of heavy rains, tropical cyclones, and droughts have recently been observed on infrastructure and lifelines in many places in Japan.
○ There have been reports of disrupted transport networks due to heavy rain, resulting in isolated villages and damaged and halted electricity, gas, and water supply systems.
○ Other reported events include thunder, tropical cyclones, rainstorms, and other extreme weather events having caused damage, such as suspended power generation facilities, submerged water purification facilities, and flooded waste treatment facilities; and droughts, floods, turbid water, and storm surges having led to water intake restrictions or suspended water supply; and high waves having disrupted road traffic.

<Projected impacts>

○ Regarding the impacts that climate change has on infrastructure and lifelines, some reports have pointed out that at the global level, extreme weather events have an impact even on national security policy, in addition to bringing physical risks arising from the disruption of infrastructure networks and critical public services (e.g., electricity and water supply).

○ Projected impacts on Japan's power infrastructure include direct damage to power generation facilities from tropical cyclones, sea level rise, storm surges, and high waves; reduced power output due to the rise in the temperature of seawater used as cooling water; and impacts on hydroelectric power generation from shifts in the snowmelt runoff season.

○ Regarding water supply systems, increased fine suspended sediments in rivers will affect water quality control.

○ Regarding transportation infrastructure, the cost of maintaining, repairing, and restoring roads, harbors, and ports will increase in Japan.

○ Other projections include impacts on proper waste treatment from weather-related disasters; and production of flood-related waste and disruption of city gas supply due to river flooding.

○ Although findings on the impacts on transportation infrastructure are limited in Japan, there are projections outside Japan on impacts of extreme rainfall on railroad tracks; impacts of flood and sediment disasters on road networks; and impacts of extreme weather events on communications infrastructure.

○ If climate change drives the increase of short-duration intense rainfalls, droughts, and intense tropical cyclones in the future, their impacts could extend to the above infrastructure and lifelines.

・Water supply, transportation, etc. [Significance: ●; Urgency: ●; Confidence: ●]

[Basic approach to adaptation]

○ To deal with the impact on infrastructure and lifelines from heavy rain, tropical cyclones, droughts, and other weather events, associated facilities and systems should be made more resilient, and the concept of green infrastructure should be disseminated to put it into practice in society.

○ There is a need to implement multi-layered measures suited to the surrounding environment (e.g., building electricity storage systems and emergency water supply systems) and to consider the way infrastructure and lifelines should be built in urban waterfront areas to cope with rising sea levels.

[Basic measures]

1) Adaptation measures for distribution

○ Ensure the smooth transportation of relief supplies, including in the last one mile, during times of disaster by improving arrangements between local governments and distribution businesses (e.g., distribution industry associations) for the transportation and storage of relief supplies and by expanding the list of private-sector logistics/distribution centers. <Ministry of Land, Infrastructure, Transport and Tourism>
○ For the promotion of freight transport by rail, allow stakeholders to work together to respond in the event of cargo transport disruptions caused by disasters such as tropical cyclones, avalanches, and landslides. <Ministry of Land, Infrastructure, Transport and Tourism>

2) Adaptation measures for rail transport
○ Install waterstops and watertight doors at major flood-prone rail facilities, as well as underground station entrances, tunnels, and other facilities that are likely to be inundated in the event of a river flood or tsunami. Also, take measures to protect rail bridges across rivers from washout and inclination and to prevent sediment influx from slopes along tracks. <Ministry of Land, Infrastructure, Transport and Tourism>
○ Encourage rail companies to effectively use disaster risk information and help them start planned suspension and resumption of service in a timely manner. <Ministry of Land, Infrastructure, Transport and Tourism>
○ Minimize the risk of inundation damage to shinkansen bullet train cars by facilitating conservation of the rail yards and other critical facilities from flooding, removal of rail cars to safer locations, and expedited recovery with spare equipment. <Ministry of Land, Infrastructure, Transport and Tourism>

3) Adaptation measures for harbors and ports
○ To ensure the functioning of marine transportation, which supports Japan’s economy and citizens’ lives, maintain the essential functions of facilities such as moorings, breakwaters, and seawalls by protecting them from impacts such as inundation damage and reductions in cargo handling efficiency associated with sea level rise. <Ministry of Land, Infrastructure, Transport and Tourism>
○ To maintain port cargo handling capacity in times of disaster and to minimize the impact on the supporting industries, strive to maintain the essential functions of facilities; provide risk information to businesses and other stakeholders; and conduct drills in accordance with port and harbor business continuity plans (port BCPs). <Ministry of Land, Infrastructure, Transport and Tourism>

4) Adaptation measures for marine transportation
○ Install equipment resistant to disasters for stable operation of aids to navigation to ensure that Japan can maintain its marine transportation even in a natural disaster, such as a

tropical cyclone. <Ministry of Land, Infrastructure, Transport and Tourism>

5) Adaptation measures for airports

○ Formulate measures to secure airport functions to ensure that Japan can maintain its aviation networks even in a massive natural disaster. Work with airport officials, airport transit providers, and others concerned to respond to disasters in accordance with the airport BCP established for each airport; and enhance the effectiveness of airport BCPs by conducting drills and other activities. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Examine and revamp airport snow removal systems in consideration of factors such as changes in snow quality in recent years. <Ministry of Land, Infrastructure, Transport and Tourism>

6) Adaptation measures for roads

○ In a time of disaster, quickly assess the situation of road damage, reopen damaged roads and apply quick fixes to roads to support lifesaving activities and emergency transportation; and promote digital transformation (DX) of road systems to enable quick information collection and provision based on ICT. Also, improve the disaster risk reduction capabilities of the Michi-no-Eki roadside stations. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Recognizing the need to address the recent increase in disasters in intensity and frequency and rapidly aging road infrastructure, accelerate and deepen efforts toward disaster risk reduction and national resilience by building national highway networks resistant to disaster through activities such as building road networks meeting advanced specifications; managing aging infrastructure in radical ways; protecting riverside structures from washout; implementing road slope/embankment conservation, removing utility poles along roads; using elevated roads as emergency shelters; and strengthening the road management system based on IT. <Ministry of Land, Infrastructure, Transport and Tourism>

7) Adaptation measures based on green infrastructure

○ Promote the construction of green infrastructure in society through cross-sectoral, public-private collaboration by expanding activities such as the dissemination of green infrastructure in society through Green Infrastructure Public-Private Partnership Platform, in which diverse entities participate from industry, government, and academia; investigation and research on green infrastructure technologies; and studies on ways to finance such technologies. Also, foster technology development related to green infrastructure planning, building, and maintenance, and conduct regional model demonstrations to accelerate introduction to communities. Work to increase green finance and ESG investments by expanding real-world application of green infrastructure technologies and consequently using private fund-raising methods (e.g., green bonds).

<Ministry of Land, Infrastructure, Transport and Tourism>

○ With social interest increasing in the SDGs and ESG investment, foster effective use of private funds in initiatives aimed at, for example, restructuring urban spaces to make them innovative and attractive based on green infrastructure, and thereby help them attract human resources and private investments; and tapping unused or poorly used land, which is expanding in communities, driven by the decreasing population, to turn it into community spaces with green infrastructure that are rich in nature and can meet the needs of new lifestyles in the post-pandemic era. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Improve access to green finance by providing financial support for projects to build green open spaces, as part of efforts to revitalize downtown areas by repurposing aging resources available there; and creating an environment that fosters sustainability-related investments. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Take advantage of the World Horticultural Exhibition to be held in Yokohama in 2027 to advertise Japan's green initiatives, such as a model for sustainable community development that is integrated with green infrastructure and supported by private funds by preparing to obtain certification from the Bureau International des Expositions (BIE), including the establishment of relevant legislation and the event operator, a World Horticultural Exhibition Committee, as part of Japan's effort toward achieving the SDGs and building a green society. <Ministry of Agriculture, Forestry and Fisheries; Ministry of Land, Infrastructure, Transport and Tourism>

8) Adaptation measures for water supply infrastructure

○ Recognizing the risk that climate change may affect water supply infrastructure, improve these facilities to make them more resistant to disaster, such as by enhancing their flood preparedness in accordance with the Five-Year Acceleration Plan for Disaster Prevention, Disaster Mitigation, and Building National Resilience; formulate crisis management manuals; and build systems through which to ensure timely and appropriate emergency responses to and recovery of reduced or halted water supplies in a disaster due to damage to facilities. <Ministry of Health, Labour and Welfare>

9) Adaptation measures for waste disposal

○ Recognizing the risk that climate change may affect waste treatment facilities serving as a social infrastructure, make regional waste treatment systems more resilient for improved preparedness in normal times by encouraging municipalities and other stakeholders to make waste disposal facilities more resistant to flooding and other natural disasters and promoting the development of regional coordination and support systems among the local governments and relevant institutions. Also, prompt local governments to use the Guidelines for Local Governments on Climate Change Adaptation Measures in the Waste

and Recycling Fields, a practical handbook that helps them develop climate change adaptation measures in the waste and recycling fields. <Ministry of the Environment>

○ Promote the formulation of contingency plans for waste management, such as those considering the continuity of domestic waste treatment operations during a disaster. Build resilient waste management systems that can handle disaster waste, etc. appropriately, smoothly, and quickly by conducting initiatives at the local-government, regional-block, and national levels. <Ministry of the Environment>

10) Adaptation measures for traffic safety facilities

○ Ensure safe and smooth road traffic even in times of disaster by improving traffic safety facilities, such as traffic control centers, traffic monitoring cameras, vehicle detectors, and traffic information boards; and by quickly and effectively implementing traffic controls including road closures. <National Police Agency>

○ Also, promote the installation of additional power supply devices on traffic lights, which keep traffic lights functioning in a power failure caused by a disaster. <National Police Agency>

11) Investigation and research

○ Noting that there are few studies providing specific assessments of the impacts of climate change on infrastructure and lifelines, making the level of confidence in these impacts low, promote investigation and research to collect scientific findings. Also, collect and organize information on climate change impacts recognized by business operators by checking environmental reports they have published and interviewing them. <Ministry of the Environment>

2. Basic adaptation measures for life with cultural and historical pleasure

[Impacts]

<Current status>

○ Changes have been reported in the phenology of flora and fauna familiar to Japanese people, such as cherry trees, ginkgo trees, cicadas, and wild birds. Regarding cherry trees, in particular, earlier blossoming and faster flower-bud growth in urban areas than in suburban areas have been reported, partly due to heat island effects.

○ Reports show that phenological changes have had an impact on people’s sense of the seasons and on local traditional events and tourism, citing a case where the earlier blooming of cherry trees affected local festivals. However, no other specific studies have been confirmed.

<Projected impacts>

○ In the future, the times of cherry blossom flowering and full bloom will come earlier mainly

in northern Japan but later in western and southern parts of Japan. By the middle to end of this century, cherry trees will highly likely take fewer days to go through the stages from flowering to full boom due to higher temperatures. These changes will lead to fewer days available for cherry-blossom viewing and will effect areas that rely on cherry blossoms as a tourism resource.

○ There are projections of a shorter bloom period for the Nanko-ume tree, a variety of Japanese plum tree, because 3°C warming will cause a mismatch between the bloom time and the phenology of pollinators, thus affecting natural pollination.

○ At present, there are limited studies on the impacts on local traditional events, tourism, and local industries.

・Phenology [Significance: ◆; Urgency: ●; Confidence: ●]
・Traditional events and local industries [Significance: –; Urgency: ●; Confidence: ▲]

[Basic approach to adaptation]

○ Since there are limited studies that specifically address the climate change-induced impacts on local traditional events, tourism, and local industries, efforts are needed to accumulate more scientific findings.

○ There is a need to work on more advanced uses of phenological monitoring, including activities such as the monitoring of ecological changes and the impacts of climate change on ecosystems, and campaigns to make people more interested in seasonal changes and wildlife through observation of common creatures around them.

[Basic measures]

○ Noting that climate change can affect phenology, traditional events, and local industries, as mentioned above, and recognizing the importance of appropriately considering these issues when adaptation is pursued through regional efforts, provide communities with relevant information and encourage stakeholders to share information. <Ministry of the Environment>

○ Conduct continuous phenological monitoring of biological activities such as plant flowering and autumn foliage, encourage public participation in more advanced uses of such activities. <Ministry of Land, Infrastructure, Transport and Tourism; Ministry of the Environment>

○ Noting that there are few studies providing specific assessments of the impacts of climate change on traditional events and local industries, making the level of confidence in these impacts low, promote investigation and research to collect scientific findings. <Ministry of the Environment>

3. Basic adaptation measures for other issues (impacts on life from heat stress)

[Impacts]

<Current status>

○ The rate of temperature increase per 100 years in small- and medium-sized cities in Japan is 1.5°C, while those in major large cities are 2.6 to 3.2°C. It has been confirmed that in large cities, a combination of warming due to climate change and warming from heat island effects is behind this.

○ Heat island effects have also been observed in small- and medium-sized cities. There have been reports suggesting the possibility that heat island effects produce updrafts in urban areas, resulting in increases in precipitation over the short term, while cloud formation is inhibited in surrounding areas, leading to short-term decreases in precipitation.

○ Reports have pointed out impacts of temperature rise in large cities, especially increases in heat stress felt by people. Other impacts reported include a higher risk of heat illnesses, more patients being transported by ambulance for fever, nausea, or weakness, and more prevalent sleep disorder arising from deteriorated sleep quality.

<Projected impacts>

○ In Japan's large cities, temperatures will continue to rise due to the combined effects of existing heat islands and climate change-related warming, although a future expansion of heat islands will be limited.

○ As temperatures rise, wet-bulb globe temperature (WBGT), a measure of heat stress being felt, will highly likely increase. A projection (based on the RCP 4.5 scenario) of WBGT across Japan in August at the end of the 21st century has found that the heat stress environment will deteriorate nationwide, especially in the Tohoku region, which will see a significant increase from current levels.

○ Increasing heat stress is projected to worsen heath impacts, such as lassitude, fatigue, feverishness, and insomnia, relative to current levels. Higher daytime temperatures, in particular, will likely contribute to more lassitude and fatigue, raising concerns that the thermal environment after the rise in temperature may substantially impact urban life.

○ Increased heat stress will also decrease labor productivity, resulting in the economic loss of working hours.

・Impacts on life from heat stress [Significance: ●; Urgency: ●; Confidence: ●]

[Basic approach to adaptation]

○ The mitigation of heat island effects should be addressed through the continuous implementation of feasible measures, including securing green spaces and planting trees and plants in urban areas, combined with measures that can bring near-term benefits, such as non-structural measures.

○ Based on the fact that the mitigation of heat island effects requires a long period of time, efforts should also be focused on monitoring the actual status of heat island effects and

conducting technical investigation and research on heat island control measures.

[Basic measures]

1) Improving ground cover using vegetation and water

○ Endeavor to improve ground cover, in order to avoid rise in ground surface temperature arising from the reduction in green spaces and water surfaces (which help suppress temperature rise) and from the ground surface being covered with structures and pavements. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Promote the greening of private land and buildings by using green-area programs that require expanded or newly constructed buildings on large sites to cover at least a specified ratio of total area with greenery; promoting greening through subsidy programs relating to housing and building improvements; and using comprehensive building design systems that provide for a higher floor-area ratio for large buildings that have a certain ratio of open space. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Build urban parks, promote the greening of public spaces such as roadways and wastewater treatment plants, as well as government building grounds, and install green roofs on rental housing rebuilt by the Urban Renaissance Agency. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Recognizing that urban farmland is an important component of urban greenery and plays a role in land and environmental conservation (e.g., mitigating heat island effects), promote the conservation of such farmland in urban areas and surrounding regions. <Ministry of Agriculture, Forestry and Fisheries; Ministry of Land, Infrastructure, Transport and Tourism>

○ Expand water surface area by supporting efforts by local governments to expand the use of treated wastewater to add to small streams and river maintenance flows, and by promoting the installation of rainwater storage and infiltration facilities. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Promote efforts toward comprehensive control of temperature rise in road spaces (e.g., through road greening) and build comfortable walking spaces by providing shade trees. <Ministry of Land, Infrastructure, Transport and Tourism>

2) Reducing artificial exhaust heat from human activities

○ Promote greater energy efficiency of housing and buildings under the Act on the Improvement of Energy Consumption Performance of Buildings (Act No. 53 of 2015); promote the diffusion of next-generation automobiles that contribute to the reduction of automotive waste heat; promote the use of public transportation by improving urban rail; build a better urban environment by expanding the role of bicycle traffic; and improve the efficiency of energy-consuming equipment. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Further implement traffic flow measures, for example, by using traffic congestion control based on big data. <Ministry of Land, Infrastructure, Transport and Tourism>
○ Promote a cargo modal shift from truck transport to rail and coastal shipping, and boost the efficiency of truck transport by means such as consolidated collection and delivery. <Ministry of Land, Infrastructure, Transport and Tourism>
○ Promote the effective use of sewage heat by means such as support for the formation of projects for sewage heat utilization driven by public-private collaboration councils. <Ministry of Land, Infrastructure, Transport and Tourism>

3) Improving urban design (e.g., creation of wind paths from green spaces and water surfaces)
○ Use the Urban Design Guidelines to Mitigate Heat Island Effects, which describe considerations in using wind paths through urban areas, to promote urban planning that incorporates appropriate measures, including urban design improvements, and better ground covering, and reductions in artificial waste heat, according to the size of the target area (a region, city, or district). <Ministry of Land, Infrastructure, Transport and Tourism>
○ Promote the creation of urban water and green networks by implementing initiatives in accordance with the Grand Design of Urban Environmental Infrastructure in the Tokyo Metropolitan Area and the Grand Design of Urban Environmental Infrastructure in the Kinki Area; conserving green space through programs such as the Special Green Space Conservation Zone Program; improving green belts on urban foothills; and improving streams through the reuse of treated wastewater. <Ministry of Land, Infrastructure, Transport and Tourism>

4) Improving lifestyles
○ For lifestyle improvement, promote efforts toward improving lifestyles from the perspective of suppressing urban heat generation (e.g., by organizing citizen activities for *uchimizu*, a traditional technique of spraying water onto streets for the cooling effect; fostering the wider use of “green curtains” of living plants; promoting bicycle commuting, etc.; accelerating the installation of energy-efficient products; and encouraging people to use parasols and wear lighter clothing in summer); and foster efficient use of automobiles (through promotion of eco-driving). <National Police Agency; Ministry of Economy, Trade and Industry; Ministry of Land, Infrastructure, Transport and Tourism; Ministry of the Environment>

5) Strengthening observation/monitoring systems and promoting investigation and research
○ Provide information obtained from the observation and monitoring of heat island effects, as well as an analysis of factors contributing to heat island effects; and enhance the quality of available information. <Ministry of Land, Infrastructure, Transport and Tourism>
○ Promote the development and diffusion of the Comprehensive Assessment System for Built

Environment Efficiency (CASBEE), and conduct research and investigation on technologies relating to urban planning to help effectively control heat island effects. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Recognizing the importance of monitoring and determining changes over time of ground surface covering and use (e.g., land use and land covering) in assessing urbanization and heat island effects, prepared and published land cover classification maps with a spatial resolution of 30 m, using data from the Advanced Land Observing Satellite "DAICHI" (ALOS). In the future, work toward more accurate land cover classification maps by improvements such as upgraded algorithms. <Ministry of Education, Culture, Sports, Science and Technology>

6) Promoting adaptation measures to mitigate impacts on human health

○ With the goal of encouraging people to reduce heat stress by escaping from heat, obtain observed and projected WBGT (Wet Bulb Globe Temperature) heat indexes nationwide, which can be calculated from meteorological data, and publish the information on the heat illness prevention website of the Ministry of the Environment, together with other heat illness prevention information. <Ministry of the Environment>

○ Quantitatively assess the effectiveness of adaptation measures, determine efficient ways to implement adaptation measures so that people can realize the benefits of implementing them, and encourage local governments and business operators to implement adaptation measures according to the characteristics of their region, area, or business. <Ministry of the Environment>

Chapter 3. Fundamental Measures for Climate Change Adaptation

The implementation of Basic Strategies 2 to 6, described in Section 4 of Chapter 1, requires different actors to work on adaptation through cross-sectoral approaches. Adaptation measures and climate change risks assumed for them need regionality to be taken into account, and regionally adjusted measures are supported by basic initiatives.

As in the case with sectoral measures, KPIs that comprehensively measure government-wide and organization-level basic initiatives will be established to monitor the progress of adaptation measures.

Measures that are fundamental in implementing climate change adaptation are described below.

Section 1. Fundamental Measures for the Enhancement and Utilization of Scientific Findings on Climate Change

(Observation and monitoring)

○ At the alliance center in the global warming sector established under the Earth Observation Promotion Strategy (Comment Submission by the Council for Science and Technology Policy in December 2004), work on objectives such as gathering comprehensive data, realizing long-term continuous observation, and improving data usability through collaboration among relevant government ministries and agencies, and relevant institutions. <Cabinet Office; Ministry of Education, Culture, Sports, Science and Technology; Ministry of Land, Infrastructure, Transport and Tourism; Ministry of the Environment>

○ Perform accurate and continuous observations of temperature, precipitation, and other factors closely related to climate change (e.g., greenhouse gases, aerosols, solar/infrared radiation) not only on land but also by ship, aircraft, and satellite to provide long-term monitoring information on changes in climate in the atmosphere and the ocean, as well as detailed information on issues such as the increase in the frequency of extreme events (e.g. heavy rain) and progress of ocean acidification. <Ministry of Education, Culture, Sports, Science and Technology; Ministry of Land, Infrastructure, Transport and Tourism; Ministry of the Environment>

○ Continuously observe global carbon dioxide and methane by the GOSAT(Greenhouse gases Observing SATellites, ”IBUKI”) series and produce more scientific findings on climate change. <Ministry of the Environment>

○ Continue tidal level observation at tide observation facilities nationwide, and publish documents from the Coastal Movements Data Center (CMDC) that can help research in earth sciences, including sea level change. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Perform continuous observation by a global navigation satellite system (GNSS) and GNSS Continuously Operating Reference Stations (GNSS CORSs) installed across the country, to monitor wide-area crustal movements; and use the monitoring results as input for the

detection of sea level changes. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Monitor ground deformation by using observation data from the Advanced Land Observing Satellite-2 “DAICHI-2” (ALOS-2) and other sources, and provide obtained information to relevant institutions. <Ministry of Education, Culture, Sports, Science and Technology; Ministry of Land, Infrastructure, Transport and Tourism>

○ Enhance observation technologies by developing satellite-mounted sensors that measure the global distribution of greenhouse gases and atmospheric pollutants, and by strengthening the observation of oceans and polar regions. Regarding the Arctic, in particular, promote efforts in accordance with Japan’s Arctic Policy (decided by the Headquarter for Ocean Policy, October 16, 2015), including research and development on climate change in the Arctic. With emphasis on increasing the accuracy of climate change projections, collect data on the Arctic Ocean, where no observation data is available now, by building an Arctic research vessel and using it for international joint observation. Conduct high-precision measurements of regional parameters such as solar radiation, wind conditions, temperature, rainfall, and aerosols. Noting that understanding changes in ecosystems that are directly affected by these parameters is fundamental in the observation and monitoring of impacts of climate change on people’s lives and various industries that depend on ecosystems, strengthen and expand the monitoring of parameters related to climate change-induced changes in ecosystems. <Ministry of Education, Culture, Sports, Science and Technology; Ministry of Agriculture, Forestry and Fisheries; Ministry of Land, Infrastructure, Transport and Tourism; Ministry of the Environment>

○ Build new global long-term reanalysis data that is higher-quality and more homogeneous enough to serve as a basis for DRR and climate change measures that reflect analysis of long-term global warming and other changes in , extreme weather events, and lessons learned from past disasters <Ministry of Land, Infrastructure, Transport and Tourism>

○ Ensure seamless meteorological satellite observation systems for the purpose of monitoring tropical cyclones, heavy rains, and other global environmental issues by putting into service a successor satellite that incorporates high-density observation and other cutting-edge technologies by FY 2029. <Ministry of Land, Infrastructure, Transport and Tourism>

(Projection technologies)

○ Advance modeling technology and simulation technology based on supercomputers and other equipment to achieve higher temporal and spatial resolution and reduce uncertainties; and thereby produce accurate climate change projection information that includes the likelihood of occurrence. Also, build climate change projection data for Japan that meets the needs associated with the implementation of adaptation measures in various fields. <Ministry of Education, Culture, Sports, Science and Technology; Ministry of Agriculture, Forestry and Fisheries; Ministry of Land, Infrastructure, Transport and Tourism; Ministry of the Environment>

○ Project future climate change in climate in Japan resulting from global warming by applying the latest numerical simulation technologies; provide detailed information based on such projections, including analyses of extreme events (e.g., heavy rain); and strive to improve the quality of climate projection information to be offered. Also, provide interpretations of projections to the users of climate change projection information. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Analyze future changes in natural hazards arising from flooding and storm surge by using the latest climate change projection data and downscaled global climate models. <Ministry of Land, Infrastructure, Transport and Tourism>

(Investigation and research)

○ Contribute to the assessment of specific natural disaster risks at the local level by steadily conducting, as required by the National Land Survey Act (Act No. 180 of 1951), national land surveys, which consist of Land Classification Basic Surveys on the original land natural topography and geology, past changes in land use, and past disasters; and Water Basic Surveys for collecting basic information on surface water and groundwater; and providing survey results. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Promote investigation and research on measures that bring synergy effects to adaptation and that serve multiple policy objectives including adaptation; investigation and research on the impacts and costs of climate change and social vulnerability to climate change; investigation and research on economic assessments and social/environmental impacts of adaptation measures; and the collection of findings on ecological-based adaptation measures. Regarding water disasters, assess the impacts of climate change, based on scientific findings on climate change projections and other associated issues, propose various technical policies that help adaptation, and develop and disseminate technologies supporting these policies. <Ministry of Internal Affairs and Communications; Ministry of Education, Culture, Sports, Science and Technology; Ministry of Agriculture, Forestry and Fisheries; Ministry of Land, Infrastructure, Transport and Tourism; Ministry of the Environment>

○ Promote research and development to enhance A-PLAT and DIAS and to build information platform that enables diverse global environmental data to be shared; and promote collaborative research with domestic and international stakeholders (e.g., the Future Earth). <Ministry of Education, Culture, Sports, Science and Technology; Ministry of the Environment>

○ Expand findings on tropical cyclone-related impacts of climate change by simulating scenarios where Japan is hit by a tropical cyclone as intense as those that brought serious damage in recent years under conditions of warmer climate and assessing how such tropical cyclones would develop and affect flooding, storm surges, strong winds, etc. <Ministry of the Environment>

○ Regarding climate change impacts in snowy and cold regions, conduct investigations on changing trends of snowstorms and poor visibility associated with rapidly developing low pressure systems; on methodologies to ascertain the amount of snow cover and snowmelt in dam basins; and on impacts on river environments, water resources, and water use. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Noting that in snowy regions such as Hokkaido, there are projections of frequent sediment disasters due to rapid snowmelt or rainfall caused by temperature surges in warmer climates during the snowmelt period, consider methods to assess slope stability based on accurate projections of snowmelt amounts. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Promote investigation and research on overseas adaptation efforts, such as climate change impact assessments and climate adaptation plans. <Ministry of the Environment>

○ Promote research on the observation and monitoring of climate change impacts and the assessment of climate change impacts and vulnerability to them. <Ministry of the Environment>

○ Conduct investigations on the impacts of climate change on Japan's national security. <Ministry of the Environment>

○ Assess and analyze the impacts of climate change on Japan's national security and develop necessary actions for the Ministry of Defense. <Ministry of Defense>

○ Investigate and study the disaster mitigation effects of mangroves and other green infrastructures in the conservation of coastal areas against tropical cyclones. <Ministry of the Environment>

○ Toward comprehensive assessment of climate change impacts, promote comprehensive research on the projection and assessment of climate change impacts in various sectors, such as agriculture, natural disasters, ecosystems, and health, through cooperation among national and local research institutions. <Ministry of the Environment>

(Impact assessment)

○ Integrate scientific findings on climate change and its impacts in Japan and conduct studies to revise Japan's comprehensive assessment of climate change impacts, while obtaining expert views from the Central Environment Council and other sources. <Ministry of the Environment>

(Technology development)

○ Noting that efforts in the agriculture, forestry, and fisheries sector have been focused on technology development for adaptation to known impacts, such as deteriorated quality of paddy field rice and fruit trees, address the need to widely apply and continuously improve outstanding technologies cultivated through field practices and to develop future-oriented innovative technologies and production systems in accordance with the Strategy for

Sustainable Food Systems “MeaDRI” and in a manner that meets the regional needs. For this purpose, develop adaptable varieties and production stabilizing technologies from medium- to long-term perspectives based on projections and studies, and develop technologies to take advantage of opportunities to be brought by climate change. <Ministry of Agriculture, Forestry and Fisheries>

Section 2. Fundamental Measures for Securing Systems to Collect, Organize, Analyze, and Provide Climate Change Information

○ Have relevant ministries and agencies use A-PLAT operated by NIES to enhance and strengthen their databases and other information platforms by organically connecting them with those held by other government offices and testing and research institutions, and provide climate risk information in a form useful to each actor. Also strive to develop and operate support tools that facilitate access to the latest climate scenarios or that help impact assessment and adaptation planning, according to the needs of users; and to collect, organize, and provide excellent practices. Through these efforts, build capabilities that bridge scientific findings and policymaking. <Ministry of Education, Culture, Sports, Science and Technology; Ministry of Agriculture, Forestry and Fisheries; Ministry of Land, Infrastructure, Transport and Tourism; Ministry of the Environment>

○ Consider better applications of the Data Integration and Analysis System (DIAS), which is mentioned in Japan’s Integrated Innovation Strategy 2021 (approved by the Cabinet on June 18, 2021) as a global environmental data platform that should be more widely used to contribute to decision-making by the national and local governments, businesses, and other organizations for the purpose of fostering the accumulation and use of big data on the global environment, including greenhouse gas observation and projection information. <Cabinet Office; Ministry of Education, Culture, Sports, Science and Technology>

○ Contribute to studies on urban and local development and private sector investment by preparing inundation scenarios based on various magnitudes of natural hazards, and presenting disaster risk information, including the frequency of inundation above floor level and life-threatening risks, as well as specific cases of disaster-related damage, in a comprehensible form to the audience, such as local governments, businesses, and residents. Also, provide time-series disaster information, such as an increase in rainfall or rise in river level, from an early stage of a potential disaster, to better communicate risk urgency to residents as the situation develops. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Contribute to smooth and proper implementation of DRR measures such as preparedness for large-scale disasters and emergency response to disasters, take aerial photographs of affected areas immediately after a disaster occurs and provide them to relevant institutions. Develop, update, and provide geospatial information, such as the Digital Japan Basic Map, which is Japan’s fundamental national map, and the National Land Numerical Information,

for use as basic data for disaster analysis. <Ministry of Land, Infrastructure, Transport and Tourism>

Section 3. Fundamental Measures for the Promotion of Climate Change Adaptation Measures of Local Governments

○ Prepare and disseminate a manual for the establishment of local climate change adaptation plans to help local governments develop and enhance their local climate change adaptation plans. <Ministry of the Environment>

○ Share information and enhance cooperation on local climate change and its impacts, and local adaptation measures through the Regional Council on Climate Change Adaptation, which is formed in each region by local governments, the LCCAC, local administrative organs of the national government, local research institutions, etc. <Ministry of Agriculture, Forestry and Fisheries; Ministry of Land, Infrastructure, Transport and Tourism; Ministry of the Environment>

○ Support activities of local governments and LCCACs by offering technical advice (mainly from NIES) on ways to gather, organize, analyze, and provide information on local climate change impacts and adaptation; developing human resources for research on climate change impact projection and adaptation measures through joint research with the LCCAC, research institutions, and universities; and collecting scientific findings on climate change impacts and adaptation unique to the region. <Ministry of the Environment>

○ Help local government officials working on climate change adaptation better understand climate change impacts and climate change adaptation by developing and operating simple learning support tools, and collecting and providing excellent practices. <Ministry of the Environment>

○ Use A-PLAT and other information platforms in connection with DIAS to give access to various data and information needed by the region, such as high-resolution projection data produced by downscaling, and provide such information in a form useful to local governments. Help local governments in impact assessment and adaptation planning by developing and operating support tools, and by collecting, organizing, and providing excellent practices. <Ministry of Education, Culture, Sports, Science and Technology; Ministry of Land, Infrastructure, Transport and Tourism; Ministry of the Environment>

○ Cooperate with local governments, the LCCAC, and local research institutions and universities to collect information specific to the region (e.g., impacts of climate change on local products), project climate change impacts on the region, based on scientific findings on climate change projections, and develop specific adaptation measures for the region from such information. <Ministry of Education, Culture, Sports, Science and Technology; Ministry of Agriculture, Forestry and Fisheries; Ministry of Land, Infrastructure, Transport and Tourism; Ministry of the Environment>

○ Periodically compile and publish information on climate change observation results and

future projections at the local level. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Monitor impacts of global warming in cooperation with local governments or other related institutions, summarize impacts (e.g., high heat damage on farms) and adaptation measures, and publish that information (e.g., in a Global Warming Impact Study Report). <Ministry of Agriculture, Forestry and Fisheries>

○ For awareness raising and education on climate change and weather-related disasters, organize lectures on topics such as climate and prevention of weather-related disasters. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Raise awareness of DRR by supporting DRR education at schools and providing support tools via government portals. Also, support river environment conservation and other activities by volunteer river conservation groups and residents. <Ministry of Education, Culture, Sports, Science and Technology; Ministry of Land, Infrastructure, Transport and Tourism>

○ Disseminate accurate knowledge of sediment disasters by promoting practical disaster drills, DRR education at schools, workshops for residents, and training for local government officials. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Help municipal mayors issue evacuation instructions and other directions in a timely and appropriate manner in the following aspects: <Ministry of Internal Affairs and Communications>

- Establishment of specific and simple criteria for issuing evacuation instructions and other directions, and the definition of the affected area of such instructions
- Establishment of an integrated disaster response system throughout the local government

○ Help local governments build a system for prompt information delivery to residents and a system to support residents who require special assistance. <Ministry of Internal Affairs and Communications>

○ Ensure swift and adequate responses to intensifying and more frequent large-scale disasters by promoting wide-area fire and disaster management and supporting the registration of emergency fire response teams by local governments to enhance and strengthen fire and disaster management systems. <Ministry of Internal Affairs and Communications>

○ Enhance and strengthen local disaster management capabilities by striving to secure a sufficient number of fire service members through improved treatment, as the fire service plays a central role in the local DRR system; and by supporting the acquisition of supplies, equipment, vehicles, and facilities needed for the safety of the fire service during evacuation guidance and rescue operations, as well as the improvement of their education and training. Raise the awareness of the need to strengthen local disaster management capabilities provided by voluntary disaster management organizations; disseminate associated DRR knowledge; and support the development of local DRR leaders, especially

those belonging to voluntary disaster management organizations, by having firefighters and other fire service members train these organizations. <Ministry of Internal Affairs and Communications>

○ Promote efficient water use by conducting educational and awareness-raising activities to deepen public interest and understanding of the importance of water. <Ministry of Land, Infrastructure, Transport and Tourism>
○ Share information and raise awareness about the relationships between climate change and biodiversity, and climate change and ecological services. <Ministry of the Environment>
○ Promote measures to address disaster waste by supporting activities such as the formulation of contingency plans for waste management; implementation of pilot projects and training concerning inspection and review of these plans; and joint drills, information sharing, and personnel exchanges through regional block conferences established in eight regions across Japan. <Ministry of the Environment>
○ Encourage local governments to accelerate their efforts toward adaptation (e.g., an improved PDCA cycle for the local climate change adaptation plan), for example, by periodically assessing the progress of local governments in implementing the Adaptation Act and feeding the assessment results back to them. <Ministry of the Environment>
○ Encourage local governments to procure funds for climate change adaptation measures by issuing green bonds by establishing a system to support green bond issuance in Japan and thereby clarify the effectiveness of adaptation measures and facilitating financing for adaptation measures. <Ministry of the Environment>

Section 4. Fundamental Measures for the Promotion of Climate Change Adaptation by Business Operators, etc., and Business Activities Contributing to Climate Change Adaptation

○ Foster an understanding of climate change impacts and the importance of adaptation among the public, business operators, etc. by providing awareness-raising content via A-PLAT or other platforms. Collect and provide domestic and international climate risk information for use as reference by private businesses in their business activities. <Ministry of the Environment>
○ Collect and provide outstanding practices by domestic and international businesses for climate risk management, which refer to understanding and responding to business-related climate risks, and adaptation business, which involves offering technologies, products, and services conducive to climate change adaptation, to raise adaptation awareness among business operators and accelerate their efforts. <Ministry of Economy, Trade and Industry; Ministry of the Environment>
○ Prepare and disseminate a guide to adaptation for business operators to help them identify climate change risks and opportunities associated with their own business and take

adaptation measures suited to the nature of their business. <Ministry of the Environment>

○ Publish information on adaptation business to help private businesses that possess technologies, products, and services related to the implementation of adaptation measures in various fields (e.g., agriculture, DRR, and water resources) realize that entering domestic and international markets with their technologies, products, and services in the context of adaptation business will open up new business opportunities. <Ministry of the Environment>

○ Cooperate with local governments and organizations to organize local symposia and publish printed materials to run awareness-raising campaigns aimed at conveying simple information on the impacts of climate change faced by local communities and adaptation actions that individuals can take. <Ministry of the Environment>

○ Consider efficient ways to gather information on local climate change impacts felt by residents and other individuals in their daily life. <Ministry of the Environment>

○ Have relevant ministries and agencies mutually cooperate to launch awareness-raising campaigns aimed at conveying climate risk information to different groups of the public in an easily understandable manner through symposia, printed materials (e.g., pamphlets), the Internet, and other media. <Ministry of Education, Culture, Sports, Science and Technology; Ministry of Agriculture, Forestry and Fisheries; Ministry of Land, Infrastructure, Transport and Tourism; Ministry of the Environment>

Section 5. Fundamental Measures for Developing International Collaboration and Cooperation on Climate Change

(Support for developing countries)

○ Regarding support for developing countries, including small island developing states that are vulnerable to climate change, cooperate on their climate change impact assessments and formulation of adaptation plans, through actions such as creating collaborative frameworks with partner governments and relevant institutions, based on Japan’s experience with adaptation planning. In these efforts, pay attention to each country’s needs and policy priorities, and be mindful of the Paris Agreement rulebook under the Framework Convention on Climate Change (e.g., regarding gender consideration and participation of local residents), as well as guidelines and guidance relating to the formulation of national adaptation plans. <Ministry of the Environment>

○ Conduct and support technology development that helps Japan make international contributions to the Asia-Monsoon region and other areas that are dissimilar to the West in climate conditions and production structure, including the development of technologies to increase regional productivity, sustainability, and robustness with the goal of building a new food system. <Ministry of Agriculture, Forestry and Fisheries>

○ Promote the dissemination of measures to make mountainous river basins resilient to disasters by using the disaster risk reduction functions of forests. <Ministry of Agriculture,

Forestry and Fisheries>

○ Support the efforts toward sustainable forest management and forest conservation in developing countries and promote technology development and other initiatives that contribute to enhancing the disaster risk reduction functions of forests. <Ministry of Agriculture, Forestry and Fisheries>

○ Support the implementation of adaptation measures in developing countries, based on Japan's technologies and experience, in diverse fields where growing risks are expected due to the impacts of climate change, such as water resources, DRR, food and farming, forests and forestry, and the natural environment and ecosystems. Particularly for small island developing states and least developed countries, provide comprehensive support by sharing Japan's experience and expertise with them and helping them nurture the necessary human resources. <Ministry of Foreign Affairs; Ministry of Agriculture, Forestry and Fisheries; Ministry of Land, Infrastructure, Transport and Tourism; Ministry of the Environment>

○ Help developing countries address the risk of disasters, especially flooding and coastal disasters, that are projected to increase due to the impacts of climate change by promoting fundamental disaster risk reduction through enhanced preliminary DRR investments in structural (physical) measures. To do so, support their formulation of flood control measures, including risk assessment based on scientific findings, and shore conservation plans. Also, help them address residual risks through both structural and non-structural approaches by supporting scientific disaster risk assessment and disaster monitoring based on enhanced weather observation. After a disaster occurs, consider the implementation of fundamental risk reduction projects through support for recovery and reconstruction, following the concept of "Build Back Better." For representative river basins in Asia that are prone to water disasters, conduct water disaster risk assessments that consider climate change, and provide information needed for developing adaptation plans. <Ministry of Foreign Affairs; Ministry of Land, Infrastructure, Transport and Tourism>

○ Regarding coastal erosion and natural disasters due to climate change, make proposals and other actions for coastal conservation based on local ecosystems, such as coral reefs and mangrove forests. <Ministry of the Environment>

○ Use Japan's technologies for international cooperation in the area of adaptation through efforts such as the joint provision of technologies and know-how by industry, government and academia, which can include promoting Disaster Management Collaboration Dialogue and sharing global observation data and climate change projection data through the framework of the Group on Earth Observations (GEO), and DIAS or other systems. <Ministry of Education, Culture, Sports, Science and Technology; Ministry of Land, Infrastructure, Transport and Tourism>

○ Help developing countries solve their urban issues by promoting urban development integrated with infrastructure building, through activities such as sharing with the

international community Japan's expertise, such as urban development legislation and technologies, typically those related to transit-oriented development (TOD). <Ministry of Land, Infrastructure, Transport and Tourism>

○ Use the AP-PLAT initiative, which was built as an information platform dedicated to climate change adaptation in the Asia-Pacific region, to provide relevant information and impact assessment tools and to develop human resources. <Ministry of the Environment>

○ Advance disaster waste management measures in developing countries, especially in Asia, by offering Japan's know-how in disaster waste management and by working to build a scheme to support disaster-struck countries in cooperation with the Japan International Cooperation Agency (JICA) and other organizations. <Ministry of the Environment>

(Support and contribution through international frameworks)

○ Noting that the Board of the Green Climate Fund (GCF), to which Japan is committed to contribute 3 billion U.S. dollars, has decided on a 50:50 ratio of fund allocation to mitigation and adaptation to support developing countries, and that it has been decided that at least 50% of the adaptation funds should be allocated to least developed countries (LDCs), small island developing states, and Africa, work proactively to ensure the appropriate implementation of the project. <Ministry of Foreign Affairs; Ministry of Finance; Ministry of the Environment>

○ Contribute to human resource development in the area of adaptation by broadly sharing Japan's experience and findings through international networks such as the Asia Pacific Adaptation Network (APAN) and Global Adaptation Network (GAN). <Ministry of the Environment>

○ In view of the approval and adoption of the IPCC Sixth Assessment Report and associated reports, and the preparation of the IPCC Seventh Assessment Report and associated reports, contribute to IPCC activities and report writing by providing Japan's findings through the dispatch of Japanese experts to IPCC Plenary Sessions and various other meetings, providing report authors, and supporting their activities. <Ministry of Foreign Affairs; Ministry of Education, Culture, Sports, Science and Technology; Ministry of Agriculture, Forestry and Fisheries; Ministry of Economy, Trade and Industry; Ministry of Land, Infrastructure, Transport and Tourism; Ministry of the Environment>

○ Contribute to international standardization related to adaptation under the International Organization for Standardization (ISO) and other bodies, based on Japan's experience and technologies, while paying attention to the developments of the relevant discussions. <Ministry of the Environment>

○ For the purpose of establishing baselines for monitoring sea level rise and other changes, join international observation by Very Long Baseline Interferometry (VLBI) and develop a new VLBI observation system to achieve higher accuracy. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Expand Japan’s international presence in the field of sewer systems by organizing inter-governmental conferences and seminars, providing training for developing countries, conducting overseas projects to demonstrate Japan’s sewer technologies, launching overseas promotional campaigns through the Japan Global Center for Urban Sanitation (GCUS) based on public-private sector collaboration. <Ministry of Land, Infrastructure, Transport and Tourism>

○ Work toward achievement of the Sendai Framework for Disaster Risk Reduction 2015-2030 and the SDGs by helping other countries in climate change-related measures, disaster risk reduction projects, and initiatives to mainstream DRR. Contribute to the sharing of knowledge about adaptation measures, DRR, and reduction of disaster risk, especially the risk of increasing floods due to the impacts of climate change. To do so, take advantage of the opportunities offered by international conferences (e.g., G7 and G20) in accordance with diverse international frameworks, such as the Framework Convention on Climate Change, the SDGs, and the Sendai Framework for Disaster Risk Reduction 2015-2030. <Cabinet Office; Ministry of Foreign Affairs; Ministry of Land, Infrastructure, Transport and Tourism; Ministry of the Environment>

Appendix. The Key Points of the Assessment Report on Climate Change Impacts in Japan (2020)

This Report assesses the impact that climate change could have on Japan in 71 categories covering seven sectors based on scientific findings. The assessment is performed from three perspectives: significance, which is concerned with how climate change will impact Japan, to what extent, with how much likelihood, etc.; urgency, which is concerned with when the impact will manifest itself, when adaptation efforts need to be started, and when key decisions need to be made; and confidence, which refers to the certainty of the evidence. The Report is assumed to be used for the revision of the Climate Change Adaptation Plan, which is scheduled for FY 2021, and to be used by local governments and business operators to identify climate change impacts and develop adaptation measures.

1. Increased findings and confidence

A total of 1,261 reference documents were used as the basis for the Report, which is approximately 2.5 times the number for the previous assessment in 2015. As more scientific findings were available, the confidence rating was higher for 31 categories than in the previous assessment. As a result, medium or higher confidence levels were assigned to 55 categories (77%). This suggests the ability to assess the impacts of climate change with higher accuracy. In many of the categories where no significance or urgency assessments were available in the previous assessment, the current Report provides assessments (i.e., nine of the eleven categories for significance, and five of the seven categories for urgency). Assessments in the current Report are more detailed, as demonstrated by the fact that climate scenario-level analysis of significance was performed for eight categories where such analysis was possible.

However, there are low-confidence assessments mainly concerning natural ecosystems and industrial and economic activities, the fields where few findings are available, and further research and investigation are needed in these fields.

2. Categories with impacts assessed to be high in significance, urgency, or confidence

The reported assessments indicate that the impacts of climate change are significant and urgent. Of the 71 categories in seven sectors, 49 categories (69%) were assessed to be “exposed to particularly significant impacts,” and 38 (54%) were assessed to have “high urgency for response.” There were 33 categories (46%) that were assigned high significance and high urgency. Three categories were newly assessed as “exposed to particularly significant impacts” and eight categories were newly assessed as having “high urgency for response.”

Some of these categories are described below. There are other noteworthy impacts as well, such as categories whose rating remained high in significance, urgency, and confidence, continuing on from the previous report; and newly added categories that were assigned high

significance and urgency.

■ Categories given higher confidence than before among categories with high significance, urgency, and confidence ratings

(Categories given higher confidence than before refer to those whose confidence rating improved to "high" in this Report from "low" or "medium" in the previous report. The "heat illness" category is included among them because although its confidence remained unchanged, it was the only category in the human health sector whose significance, urgency, and confidence were all assessed as high.)

[Agriculture] Agricultural production infrastructure
<Current status> More rainless days and less winter snowfall, leading to water shortages
<Projected impacts> Impact on farmland due to less water available and frequent slope disasters

[Water resources] Water supply (surface water)
<Current status> More rainless days and other changes, leading to droughts
<Projected impacts> Hindrance to water intake caused by the intrusion of seawater (salt water) into river estuaries due to sea level rise

[Natural ecosystems (coastal ecosystems)] Subtropical zone
<Current status> Large-scale coral bleaching presumably attributable to high water temperature in summer; dead mangroves associated with sea level rise
<Projected impacts> Shrinking suitable distribution ranges of coral reefs in subtropical zones

[Natural disasters] Inland waters
<Current status> Inland flooding accounting for about 40% of water disaster losses nationwide (average for 2005 to 2012) and higher percentages in large cities
<Projected impacts> Urban flooding and inundation caused by short-duration intensive rainfall and sea level rise

[Natural disasters (mountain areas)] Debris flows, landslides, etc.
<Current status> Occurrence of large-scale sediment disasters characterized by multiple surface slope failures and debris flows occurring simultaneously in the same river basin
<Projected impacts> More frequent and massive sediment disasters associated with more frequent heavy rainfall covering wider areas

[Human health (heat stress)] Heat illness
<Current status> Nationwide increase in the number of heat illness patients transported

by ambulance and fatalities due to heat illness

<Projected impacts> Shorter hours available for outdoor labor; higher risk of heat illness

[Life of the citizenry and urban life (urban infrastructure, lifelines, etc.)] Water supply, transportation, etc.

<Current status and projected impacts> Impacts on infrastructure, lifelines, etc. from climate change-induced increases in short-duration intense rainfall, droughts, and intense tropical cyclones

■ Categories newly assessed as "exposed to particularly significant impacts" and examples of the current status

[Water resources (water supply)] Groundwater

Droughts are leading to impacts such as excessive groundwater withdrawal and lower groundwater levels.

[Human health] Impacts on vulnerable groups

Heat stress is having a health impact on the elderly, and the impact is projected to increase further.

Note: This category was newly included in the assessment.

[Industrial and economic activities] Construction

Tropical cyclones, tornadoes, and heavy snow are having an impact on buildings, leading to discussions on the need to review design conditions and standards related to the wind load, air conditioning load, etc.

Note: This category was also newly assessed as having "high urgency for response."

■ Categories newly assessed as having "high urgency for response" and examples of the current status

(Only the categories that were also rated high in significance are listed.)

[Agriculture] Livestock farming

Impacts such as declines in the productivity and reproductive function of livestock are observed.

[Natural ecosystems (terrestrial ecosystems)] Natural/secondary forests

New ongoing impacts have been confirmed, such as changes in the species composition of forests near vegetation zone boundaries.

[Natural ecosystems (terrestrial ecosystems)] Planted forests

Japanese cedar forests are degenerating in some areas due to increased water stress.

[Natural disasters] Strong winds, etc.

New ongoing impacts have been confirmed, such as shifts in the spatial location of the maximum intensity of tropical cyclones and damage from tornadoes.

[Human health] Arthropod-borne diseases

Extension of the habitat of disease-carrying mosquitoes (e.g., Asian tiger mosquitoes transporting the dengue virus) and their extended active season is observed and projected.

3. Impacts of climate change on weather-related disasters

Japan was recently hit by many catastrophic weather-related disasters, including the Heavy Rain Event of July 2018, Typhoon Jebi (T1821), Typhoon Faxai (T1915), and Typhoon Hagibis (T1919).

With total annual insurance payments associated with wind and flood disasters exceeding 1 trillion yen for two consecutive years (FYs 2018 and 2019), weather-related disasters have had a large impact on people's lives and industrial activities, driving interest in how climate change affects weather-related disasters. In June 2020, then-Minister of State for Disaster Management Takeda and Minister of the Environment Koizumi released a joint statement describing Japan's fundamental strategy for DRR measures that takes into account climate change risks. It highlighted the importance of the concept of "Adaptive Recovery", which is aimed at including adaptation to climate change in post-disaster recovery by taking flexible measures including land-use controls.

There are few studies on the impacts of climate change on previously experienced tropical cyclones, heavy rain, and other weather events. However, some reports indicate that climate change has had an impact on the shift in the spatial location of the maximum intensity of tropical cyclones and the change in the moving direction of tropical cyclones. Regarding the Heavy Rain Event of July 2018, in which a wide area was exposed to long hours of record heavy rainfall, there is a report that increased evaporation rates associated with global warming contributed to the series of rainfall events. Projections of future impacts show that Japan will experience more strong winds and intense tropical cyclones through the latter half of the 21st century as temperatures rises, although trends will vary by region. In another projection, heavy rainfall events that can cause floods will increase significantly in major river basins in Japan by the end of this century compared to the present.

4. Compound disaster impacts

It is reported that in the Heavy Rain Event of July 2017 in Northern Kyushu and the Heavy Rain Event of July 2018, landslides and river flooding simultaneously occurred and their interactions intensified the damage. Although how climate change contributed to past disasters has not been fully assessed, climate change is projected to increase the frequency of

heavy rainfall events with high total precipitation and intense tropical cyclones. Considering these projections, this Report focuses on the compound disaster impacts, which are produced in a situation where interactions of multiple factors make the damage wider and severer than that from a single factor, and describes ongoing and other impacts.

■ Previously experienced compound disaster impacts

(Heavy Rain Event of July 2017 in Northern Kyushu)

- The direct cause of the disaster was slope failures and debris flows that occurred across a wide area. However, large amounts of sediments brought by these events flowed downstream and raised the river bed to the extent that completely blocked river channels, contributing to devastating river floods.
- Large amounts of wood debris brought down by landslides, combined with fallen riverside trees, aggravated damage in the lower basin.

(Heavy Rain Event of July 2018)

- Rain continued for a record number of hours, with short-duration intense rainfall occurring across a wide area, simultaneously causing river flooding and inland flooding in many places.
- Large amounts of sediments brought down by landslides in upstream areas continued to flow into rivers due to continuous rain. The sediments built up in downstream rivers, where water flowed relatively slowly, and raised the river bed while causing downstream sediment floods, resulting in sediment-laden flood.

5. Cross-sector cascading impacts

Experts have pointed out that to appropriately deal with the impacts of climate change, it is essential that attention be paid to impacts cascading across sectors and categories, in addition to assessing and projecting sector-specific impacts. For example, it has been confirmed that some of the recent weather-related disasters damaged infrastructure and disrupted lifelines and thus had a substantial impact on society and the economy. Considering these perspectives, this Report defines “cross-sector cascading impact” as a phenomenon where an impact in one sector induces other impacts in other sectors, creating cascading impacts and intensifying the overall severity of impacts as a result of successive occurrence in different sectors, and identifies examples of these impacts, along with impacts of concern. The way these impacts occur is complex and has not been assessed yet due to the scarcity of available findings. The expansion of scientific findings in this field is awaited.

■ Examples of cross-sector cascading impacts

- Wider distribution of Asian tiger mosquitoes due to higher temperature ⇒ Higher risk of arthropod-borne diseases
- Loss of sandy beaches due to sea level rise and insufficient snow depth due to less snowfall ⇒ Impact on leisure and tourism industries
- Earlier blooming of cherry trees and Japanese plum trees due to higher temperature ⇒ Impact on traditional events and festivals held to view their blossoms

6. Importance of combining adaptation and mitigation to drive climate action

To address the aforementioned impacts of climate change, Japan has planned and implemented adaptation measures that take account of projections of future climate change impacts in various fields, including flood control, agriculture, forestry, and fisheries. As impact assessment improves in accuracy and adequacy, Japan will be able to plan and implement more rational and efficient measures. Meanwhile, the global mean temperature has increased about 1°C above pre-industrial levels to date. It is projected that if the world continues to warm at the current rate, the global temperature rise is likely to reach 1.5°C between 2030 and 2052. Experts have also pointed out that there is a threshold, or tipping point, after which changes and impacts will become serious and irreversible. In light of these issues, it is crucial to implement a combination of adaptation and mitigation measures with the goal of limiting the rise in temperature well below 2°C and pursuing efforts to limit it to 1.5°C to reduce or avoid catastrophic impacts of climate change.

Table. Classification of Sectors and Categories

Sector	Category	Subcategory
Agriculture, forestry, and fisheries	Agriculture	Paddy field rice
		Vegetables
		Fruit trees
		Barley/wheat, soybeans, forage crops, etc.
		Livestock farming
		Plant pests, weeds, etc.
		Agricultural production infrastructure
		Food supply and demand
	Forestry	Timber production (planted forests, etc.)
		Non-wood forest products (mushrooms, etc.)
	Fisheries	Migratory fish stocks (ecology of fishes)
		Propagation and aquaculture
		Coastal and inland fishing ground environment
Water environment and water resources	Water environment	Lakes/swamps and dam reservoirs for flood control
		Rivers
		Coastal areas and enclosed coastal seas
	Water resources	Water supply (surface water)
		Water supply (groundwater)
		Water demand
Natural ecosystems	Terrestrial ecosystems	Alpine/subalpine zone
		Natural/secondary forests
		Countryside ecosystems
		Planted forests
		Impacts from wildlife
		Material balance
	Freshwater ecosystems	Lakes/swamps
		Rivers
		Marshlands
	Coastal ecosystems	Subtropical zone
		Temperate/subarctic zone
	Marine ecosystems	
	Others	Phenology
		Shifts in distribution and populations
	Ecological services	River basin functions to retain nutrients and suspended sediments
		Function of coastal seaweed bed ecosystems to supply aquatic resources
		Eco-DRR function of coral reefs
		Recreational functions associated with natural ecosystems
Natural disasters and coastal areas	Rivers	Floods
		Inland waters
	Coastal areas	Sea level rise
		Storm surges and high waves
		Coastal erosion
	Mountain areas	Debris flows, landslides, etc.
	Others	Strong winds, etc.
	Compound disaster impacts	
Human health	Warmer winters	Mortality in winter
	Heat stress	Mortality risk
		Heat illness
	Infectious diseases	Water- and food-borne diseases
		Arthropod-borne diseases

Sector	Category	Subcategory
		Other infectious diseases
Sector	**Category**	**Subcategory**
Human health	Others	Compound impacts of warming and air pollution
		Impacts on vulnerable groups (Elderly people, children, people with underlying diseases, etc.)
		Other human health impacts
Industrial and economic activities	Manufacturing	
	Food manufacturing	
	Energy	Energy supply and demand
	Commerce	
	Retail	
	Finance and insurance	
	Tourism	Leisure
	Leisure businesses based on natural resources	
	Construction	
	Healthcare	
	Others	Overseas impacts
		Others
Life of the citizenry and urban life	Urban infrastructure and lifelines	Water supply, transportation, etc.
	Life with cultural and historical pleasure	Phenology, traditional events and local industries
	Others	Impacts on life from heat stress
Cross-sector cascading impacts	Impacts of disrupted infrastructure and lifelines	