Climate Change Adaptation Plan of

Ministry of Agriculture, Forestry and Fisheries

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MAFF

Ministry of Agriculture, Forestry and Fisheries

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Ministry of Agriculture, Forestry and Fisheries

Climate Change Adaptation Plan

Preface

Recently, the production and foundation of the livelihood of the agriculture, forestry, and fisheries, including mountain and fishing villages in Japan, have been put at risk by hindered growth and declining quality of agricultural and fishery products due to high temperatures, as well as large-scale disasters caused by record high temperatures, torrential rain and heavy snow.

Last year, the "Intergovernmental Panel on Climate Change (IPCC)" issued its Fifth Assessment Report forecasting that the global mean surface temperature will rise by 0.3 to 4.8°C, while the global mean sea level will rise by 26–82 cm in a hundred years by the end of this century, concurrently indicating that unless climate change adaptation measures are implemented, future climate change will bring a negative impact on the production of key crops and other similar issues.

Taking a look at other countries, the Western countries proceeded to prepare adaptation plans: the Netherlands issued an adaptation plan in 2007, and the United Kingdom did so in 2013, while a Climate Change Adaptation Plan has been issued by relevant federal government agencies in the United States.

In light of the IPCC's report and the trends of major developed countries, Japan is scheduled to prepare an adaptation plan for the whole government in 2015.

In March 2015, the Climate Change Impact Assessment Subcommittee of the Central Environment Council comprehensively assessed climate change impacts on seven fields including the agriculture, forestry and fisheries industries, and 56 items in Japan by the end of this century from the three viewpoints of significance, urgency and confidence. At the same time, it issued the "Assessment Report on Climate Change Impact in Japan" (hereinafter referred to as the "Climate Change Impact Assessment"), while indicating the significance of further promotion of impact assessment research, and local governments' efforts and assistance, etc.

The Ministry of Agriculture, Forestry and Fisheries (hereinafter referred to as "MAFF") has enhanced production sites, and maintained and demonstrated its multiple functions according to the Plan for Creating Dynamism through Agriculture, Forestry and Fishery Industries and Local Communities.[1] On the other hand, the agriculture, forestry and fisheries industries are most likely to be impacted by climate change. Unless measures for reducing and preventing negative impacts of

[1] Decision made by the Headquarters on Creating Dynamism through Agriculture, Forestry and Fishery Industries and Local Communities in December 2013. (Director-General: Prime Minister) (amended in June 2014)

climate change are appropriately implemented at the sites where agriculture, forestry and fisheries are operated, such negative impacts will pose a threat to securing a stable food supply, demonstrating multiple functions such as conservation of the national land, the development of agriculture, forestry and fisheries, and the promotion of farming, mountain, and fishing villages. Thus, it is extremely important to utilize the efforts for climate change adaptation in agriculture, forestry and fisheries. Therefore, it is necessary to implement planned measures based on assessment of future impact.

Since the land of Japan extends from the subarctic zone in the north to the subtropical zone in the south, and various climate zones exist therein, the agriculture, forestry and fisheries practiced differ from region to region. Thus, when implementing the measures, it is essential to consider the special features of each region, and it is important to promote the region's efforts in coordination with the state's efforts.

Therefore, MAFF will strongly promote impact assessment, technological development, and various other measures through cooperation between the state and local regions, by stipulating MAFF Climate Change Adaptation Plan, and by proactively positioning it in the adaptation plan used by the whole government.

Chapter I Overview

Part 1 Basic View

1. Planning in Light of the Current Condition and Future Impact Assessment

In coordination with the Climate Change Impact Assessment of the government, MAFF will formulate the plan in order to precisely and effectively respond to climate change impacts. Even regarding fields and items not subject to impact assessment at present, from the viewpoint of handling challenges at the production sites, and based on impact assessments by the end of this century, necessary measures will be mainly arranged and promoted as a plan for each field and item for the next ten years, in addition to conducting impact assessments.

Careful consideration is required for measures to be developed and disseminated in the future, so as to prevent such measures themselves from imposing a burden on the environment.

2. Responding to Climate Change Impact Including Global Warming, Etc.

For the purpose of mitigating a decline in the production volume and quality of agricultural products due to rising temperatures, MAFF will promote the research and development of adaptive technologies and breeds coping with climate change, switchover of breeds and items, the dissemination of adaptive technologies, etc.

3. Disaster Response and Disaster Prevention Due to Extreme Weather Events

By systematically promoting improvement of facilities contributing to disaster prevention, MAFF will continuously prepare for farmland flooding and devastating mountain disasters from torrential rain, and increasing risks of high tides by sea-level rise.

4. Utilization of Opportunities Brought by Climate Change

Opportunities brought by climate change will be utilized: expansion of the place of production due to the reduction of disaster caused by low temperatures; in the case of the advancement of global warming, newly implementing or switching to subtropical and tropical crops whose production has been impossible thus far; fostering of the places of production, extending the cultivation period due to a shortened period of snowfall, and increasing production volume, due to the expansion of regions.

5. Cooperation, Division of Roles and Information Sharing among Parties Concerned

Under the collaboration between relevant ministries and agencies, and in light of the efforts for adaptation and the positioning thereof in a global society, the state will mainly be responsible for the scientific assessment of current conditions and future impact of climate change in Japan, basic research and development of adaptive technologies, presenting support measures for local efforts from both hard (structural) and soft (non-structural) angles, and information collection and transmission within and outside Japan.

In consideration of climate change impacts on society and the economy, in terms of the differences in regional characteristics, local governments will be mainly responsible for the independent selection and promotion, etc., of measures by region.

Furthermore, effective execution of the adaptation plan will be managed through mutual cooperation between the state and local governments.

6. Continuous Review of the Plan and Promotion of Efforts by Optimization

In order to appropriately cope with climate change impacts accompanying the uncertainties, based on an opportunity of appropriate assessments such as new reports by the IPCC, and according to the latest knowledge, the current condition and future impact assessment will be reviewed; the progress of the efforts including measures incorporated in the adaptation plan and research results will be verified; and continuous reviews will otherwise be conducted, so that the adaptation plan will incorporate the latest background information.

Part 2 Overview of the Climate Change Forecast in Japan

According to various recently released climate change projected impacts * (refer to the Notes

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* Impact assessments stated in the following references:
・Global Warming Projection No. 8 (Japan Meteorological Agency)
・Climate Change Projection for Impact Assessment Due to Climate Change in Japan (June 6, 2014, Ministry of Environment)
・Consolidated Report on Observations, Projections, and Impact Assessment of Climate Change 2012 (Ministry of Education, Culture, Sports, Science and Technology, Japan Meteorological Agency and the Ministry of Environment)
・Climate in Japan at the End of 21st Century (Ministry of Environment and Japan Meteorological Agency)

below), major climate change that will have a huge impact on the agriculture, forestry and fisheries industries in Japan at the end of 21st century, in comparison to the end of the 20th century, is forecasted as follows:

1. Temperature

It is forecasted that the annual mean temperature will rise by 1.1–4.4°C on nationwide average. Some forecast that the annual mean value of the highest daily temperature will rise by 1.1–4.3°C on nationwide average, and the annual number of tropical temperature days (daily highest temperature of 30°C or higher) will increase by 12.4–52.8 days on nationwide average.

Looking at changes in the annual mean temperature and the highest daily temperatures for each region, a large margin of increase in northern Japan, but comparatively a small one in Okinawa and Amami, is forecasted. Also, the margin of increase of the annual number of tropical days will increase in western Japan, as well as Okinawa and Amami.

2. Rainfall

As for annual precipitation, both increases and decreases in the amounts are forecasted. Although there is no clear changing trend, it is forecasted that the amount of precipitation due to heavy rain will increase nationwide. Some forecast that the annual number of days without precipitation is likely to increase in comparison to that at the end of the 20th century (since some forecast an increase in the number of days without precipitation and in precipitation intensity but with no fluctuation in the annual precipitation amount, there is a concern for an increasing occurrence of extreme phenomena (heavy rain and droughts) caused by seasonal, temporal, and local deviations in rainfall volumes).

According to such forecasts, almost no statistically significant change is observed for each region in the changes in the amount of precipitation.

3. Snow Cover/Snowfall

Some forecast that the annual maximum snow cover/snowfall will decrease compared to that at the end of the 20th century. In particular, the amount of reduction is projected to be large in eastern Japan along the Sea of Japan, and there is a possibility of an increase in drought risk due to the reduced amount of snowfall and a decrease in stream flow during the peak demand season in the region using snowmelt.

On the other hand, in the course of the advancement of global warming, it is expected that in some parts of inland Hokkaido, snowfall will increase due to increased water vapor content accompanied by rising temperatures, thereby triggering snow damage.

4. Sea Surface Temperature

Sea surface temperatures near Japan are projected to rise in the long term; according to the

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・Assessment Report on Climate Change Impact in Japan (March 2015, Central Environment Council, Global Environment Committee, Climate Change Impact Assessment Subcommittee)

long-term changing trend by the end of the 21st century, it will rise by approximately 0.6–3.1°C per century. It is also forecasted that the margin of increase will be larger in the Sea of Japan than that in southern Japanese Seas.

5. Sea Level

According to the IPCC Fifth Assessment Report, regional distribution will be strongly reflected in sea level change by the end of the 21st century; it is forecasted that the rise of sea levels in many regions is highly likely to differ from that of the global mean sea level, while sea level changes are projected to occur within the range of ±20 percent of the global mean sea level change in approximately 70 percent of coastlines in the world. Furthermore, the sea levels off the coast of Japan are predicted to rise within the range of ±10 percent of the global mean sea level change by the end of the 21st century.

6. Typhoon

It is projected that the number of occurrences of strong typhoons, the maximum typhoon intensity, and the precipitation intensity at the time of the maximum typhoon intensity will tend to increase in today's comparison. In the South Seas of Japan, extremely strong typhoons are likely to increase compared to the present. Furthermore, such extremely strong typhoons will possibly reach the sea off Japan coasts while maintaining their relative strength.

Chapter II Measures for Each Field and Item

Part 1 Agriculture

1. Overview of Agricultural Production

(1) Impact

(i) Current Conditions

In general, agricultural production is sensitive to climate change. Decreased growth and decline in qualities, which are likely to be driven by the climate change, have been observed.

(ii) Projected Impacts

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

(2) Efforts

Efforts have been taken in overall agricultural production as follows: dissemination of adaptive measures and instructions at production sites, such as technologies for avoiding and mitigating impacts such as those of high temperatures, as well as introduction of high-temperature-resistant varieties and the demonstration of new adaptive technologies.

Furthermore, in cooperation with local governments, MAFF monitors global warming impacts, and has offered information concerning adaptive measures in the "Global Warming Impact Investigation Report" and on the MAFF's website.

MAFF will make special efforts for paddy field rice and fruit trees, and pests, diseases and weeds whose significance is especially high and whose urgency and certainty are found high in the Climate Change Projected Impacts.

Regarding other items, measures taken so far will be continuously promoted. In light of future impact assessments, MAFF will work on developing new adaptive varieties and cultivation management technologies or will conduct basic research.

Moreover, in continued cooperation with local governments, MAFF will monitor global warming impacts, and offer information concerning the adaptive measures in the "Global Warming Impact Investigation Report" and on the MAFF's website.

2. Impacts on and Efforts for Each Field and Item of Agricultural Production

(1) Paddy Field Rice

(i) Impacts

a. Current Conditions

As for paddy field rice, impacts such as declining quality due to high temperatures (white immature grain[2] and cracked grain,[3] the declining ratio of first-class rice, etc.) have been already observed nationwide. In some regions and in extremely high temperature years, declining yields have also been observed.

b. Projected Impacts

Paddy field rice yields are projected to decrease under high temperatures exceeding current temperatures by 3°C except for in northern Japan.

It is projected that a shift to high-temperature-resistant varieties[4] does not proceed, the ratio of first-class rice will decrease nationwide, due to high temperatures during the grain-filling period.

There is a report that if a shift to high-temperature-resistant varieties does not proceed, the ratio of first-class rice, particularly in the Kyushu region, will decline by nearly 30 percent by the middle of this century, and by approximately 40 percent by the end of this century.

(ii) Efforts

MAFF has put in efforts to establish basic technologies of soil and water management for adaptation to high temperatures, and to disseminate high-temperature-resistant varieties. Although the area in which high-temperature-resistant varieties are planted has increased gradually, such varieties have not fully prevailed since they do not meet actual consumers' needs

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[2] Rice grain that looks clouded due to insufficient accumulation of starch.

[3] Rice grain whose endosperm is cracked.

[4] Varieties whose brown rice and yields are unlikely to decline in high temperatures.[5] Due to high temperatures during the flowering period, insemination is hindered and starch does not accumulate in the grain.

(according to the Global Warming Impact Investigation Report 2014, the planted area of high-temperature resistant varieties was 77,500 ha).

Moreover, for pest control, MAFF has promoted pest control along with adjusting the timing, utilizing forecasting information.

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

Hereafter, varieties will be developed based on varieties with high-temperature resistance, which are less likely to be damaged by high temperatures.

We have already experienced yield decline in extremely high temperature years. Since much higher temperatures are expected in the future, MAFF will commence from 2015 onward the development of breeding materials capable of maintaining fertility under the high-temperature sterility[5] to prevent yield reduction.

MAFF will keep working on establishment of basic technologies of soil and water management. From 2016, MAFF will support efforts to spread high-temperature-resistant varieties, such as selection and demonstration of high-temperature-resistant varieties and sampling promotion, with all the stakeholders such as producers, rice wholesalers, and actual consumers working together.

MAFF also keeps promoting adjusted pest control utilizing forecasting information. And by around 2019, MAFF will aim to develop and disseminate damage mitigation technologies against pests including rice sheath blight disease and rice streak, which are expected to increase due to global warming.

(2) Fruit Trees

(i) Impacts

a. Current Conditions

In general, fruit trees, perennial crops are less adaptive to climate change compared to annual crops. Thus, fruit trees are considered vulnerable to climate change, which tend to result in declining fruit quality, exacerbating biennial bearing,[6] and acceleration of physiological fruit drop.[7]

To be specific, the following phenomena are reported: poor coloring and delayed coloring of apples and grapes at the time of ripening, peel puffing[8] of satsuma mandarin oranges due to high temperatures and heavy rain on thickening growth stage of fruit, sunburn of fruit due to high temperatures and strong solar radiation, poor sprout emergence of Japanese pears due to

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5 Due to high temperatures during the flowering period, insemination is hindered and starch does not accumulate in the grain.

6 A phenomenon where crop yields of fruit trees increase or decrease year by year.

7 A phenomenon where fruits naturally drop due to insufficient sunlight, dryness and high temperatures, etc.

8 A phenomenon where the peel separates from flesh, resulting in declining quality.

high temperatures from fall to the beginning of winter, and water core of Japanese pears due to high temperatures and dryness before the harvesting period.

b. Projected Impacts

The zone with favorable temperatures for the production of satsuma mandarin oranges and apples is predicted to move northward year by year due to climate change. Based on this prediction, the existing major production sites may possibly become unsuitable for cultivation. Consequently, there is concern that stable production of such fruits will become difficult, and the supply-and-demand balance will be unbalanced, thereby leading to a considerable rise in prices and inability to secure a stable supply to consumers at an appropriate price.

Furthermore, apples account for 70 percent of the export value of fresh fruit, and are positioned as a major agricultural item in Japan for export. Therefore, there is a concern that it may pose a problem to implementation of export strategies if apple production becomes unstable due to climate change.

It is expected that not only the existing major production sites of grapes, peaches, cherries will possibly become unsuitable for production, but also that decreased growth thereof will occur due to high temperatures.

(ii) Efforts

In order to mitigate the occurrence of sunburned fruit of satsuma mandarin oranges due to high temperatures and strong solar radiation, MAFF has promoted thinning out of the upper part of the fruit tree crown exposed to direct sunlight. For the purpose of mitigating the occurrence of peel puffing of fruit, MAFF has promoted the application of plant growth regulators such as calcium compounds. Moreover, as also a measure against poor coloring, MAFF has promoted the spraying of Figaron (ethychlozate),[9] which is used for the purpose of fruit thinning.

Replanting has been also promoted in order to switch from satsuma mandarin oranges to medium late ripening citrus fruits (Citrus reticulata Shiranui, blood orange, etc.) that prefer warm climates.

Regarding apples, in addition to introducing superior colored varieties including “Akibae” and yellow-colored varieties as measures against poor coloring, introduction of sprinkling water and reflective sheets have been promoted as measures against sunburned fruit and poor coloring.

As drought measures common for fruits including peaches and cherries, the following measures have been promoted: utilization of water evaporation control with multilayered sheets, deep plowing and feeding organic substrates at the dormant stage in order to maintain soil moisture, and adjusting controls at the proper time for spider mites and other pests that are likely to occur at the time of drought. Also, as a measure against frost damage due to late frost during

[9] Plant growth regulator used for the purpose of accelerating the ripening period, fruit thinning and mitigating peel puffing of citrus fruits.

the flowering period, establishment of a frost damage alert system has been promoted.

As a common measure against poor coloring of fruit due to climate change, MAFF has supported establishing a production and distribution system for fruits for processing use in order to proactively utilize such fruits as raw ingredients for fruit juice.

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

Regarding satsuma mandarin oranges, dissemination of cultivation management technologies will be accelerated from 2015 as follows: spraying of gibberellin [10] combined with prohydrojasmon [11] that mitigate the occurrence of peel puffing, and active utilization of light-shielding materials that prevent sunburn of fruit. For the purpose of stabilizing the flower setting, the development of production stabilizing technologies will be commenced by improving fertilizer application and water management.

Regarding apples, MAFF will commence developing cultivation management technologies from 2015, for the purpose of reducing the occurrence of poor coloring and sunburn fruits in high temperatures.

In view of prediction of the shift of suitable area for production, and in order to establish new orchards utilizing high-elevation zones, from 2016, MAFF will provide assistance for cultivation demonstration toward such efforts and replanting for switching varieties, while promoting orchard infrastructure development at high-elevation zones.

In the case of grapes, the following measures will be taken: as measures against poor coloring, MAFF will continuously promote introducing superior-colored varieties such as “Queen Nina” and yellow-green-colored varieties such as “Shine Muscat.” At the same time, in order to mitigate the coloring trouble due to high temperatures at the ripening stage, dissemination of production stabilizing technologies such as girdling[12] will be accelerated from 2015.

In the case of Japanese pears, the following measures will be taken for the purpose of mitigating damage caused by poor sprout emergence: utilization of a sprout promoter, further introduction and dissemination of technical measures such as changing the application timing of fertilizers, as well as the commencement of developing production stabilizing technologies in warm regions through soil improvement, etc.

On the other hand, in terms of breeding of satsuma mandarin oranges, apples and Japanese pears, breeding materials adaptive to high temperature conditions will be developed by or around 2019. Thereafter, said developing new varieties will be cultivated. From 2027, MAFF will aim to

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[10] Plant growth regulator used for the purpose of accelerating the growth of fruit trees, accelerating flowering and fruit enlargement, etc.

[11] Plant growth regulator used for the purpose of accelerating coloring of fruit and mitigating peel puffing, etc. of satsuma mandarin oranges.

[12] A technique leading to improvement of coloring as follows: peeling off the outer skin of a trunk, and sending nutrients made in leaves to a fruit cluster, without sending them to parts lower than the peeled part.

actually introduce such varieties to the place of production for demonstration.

In addition to the above, in the case of the advancement of global warming due to climate change, it is predicted that the area where subtropical and tropical fruits can be cultivated in facilities will expand. Thus, from 2016, highly-valuable subtropical and tropical fruits (atemoyas, avocados, mangoes, lychees, etc.) will be introduced for demonstration, and shift from the existing fruits will be promoted in line with local producers' selection.

If the temperature zone favorable to the cultivation of apples moves northward due to the advancement of global warming, it is considered possible to form the production area in a new region. When forming such a new production site, MAFF will promote establishing low-cost and labor-saving orchards.

Considering that being perennial crops, fruit trees require a certain period of time to bear fruits, and that the prices of fruits tend to fluctuate due to supply-and-demand imbalances, it is necessary to implement measures from the long-term viewpoint more so than for other crops. Therefore, it is necessary to establish a network among major production region and prefectures, in order to share precise information such as global warming impacts and adaptive measures and examine action plans at the sites of production.

(3) Land-Extensive Crops

(i) Impacts

a. Current Conditions

The following damage is observed in the case of wheat and barley: internode elongation[13] due to a warm winter, early ear emergence and frost damage due to low temperatures and late frost in the early spring thereafter, and moisture damage due to heavy rain during the overall growing period.

The following damage is observed among soybeans: flower shedding and pod shedding, as well as green stem syndrome[14] due to moisture damage caused by heavy rain during the early growing period and due to high temperatures and droughts after the flowering period.

In Hokkaido (central Hokkaido and southern Hokkaido), red beans have become smaller due to high temperatures at the time of ripening.

The following damage is observed among tea plants: growth inhibition of sprouts of second or later-picked tea leaves due to high temperatures and droughts during the growing period, early sprout due to warm winters, and frost damage due to late frost in early spring.

As for sugar beet, damage caused by disease is found to frequently occur due to high temperatures and heavy rain from summer to fall.

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[13] A phenomenon where a stem starts growing and leaves crawling near the ground start standing upright.

[14] A phenomenon where pods are poorly grown and stems and leaves do not die, even during the harvest season.

b. Projected Impact

Yield decreases and declining quality of wheat are predicted due to the following reasons: standing stems due to a warm winter, early ear emergence and increasing frost damage risk due to low temperatures and late frost in early spring, and a shortened ripening period due to high temperatures.

As for soybeans, it is predicted that if the temperature exceeds the range of the most suitable temperatures, a reduction in dry matter weight,[15] seed weight and harvest index[16] will occur.

In Hokkaido, although there is a possibility of yield increase in sugar beets, soybeans, and red beans in the 2030s, there is a concern for pests and diseases as well as declining quality. Yield decreases and the declining quality of wheat are projected.

(ii) Efforts

As for wheat and barley, the following measures have been taken against heavy rain and moisture damage: while completing basic techniques such as drainage measures, MAFF has promoted preventing fusarium head blight at an appropriate time and harvesting at an appropriate time, a shift to resistant varieties against diseases including fusarium head blight and against pre-harvest sprouting, etc.[17] As a result, certain effects have been observed. Moreover, as measures against frost damage, efforts have been taken to develop and disseminate varieties and breeding materials adaptive to climate change, as well as production stabilizing technologies.

The following measures against heavy rain, high temperatures and droughts have been taken for soybeans: completing drainage measures and promoting the dissemination of a ground-water-level control system. As a result, certain effects have been observed. In addition, as pest control, efforts have been taken to develop and disseminate varieties and breeding materials resistant to pests as well as weed control techniques. Further work has been done on developing a cultivating system less likely to be impacted by climate change, such as the application of organic manure and crop rotation, which mitigates pests and diseases occurrence risks.

In the case of red beans, the dissemination of a high-temperature-resistant variety, “Kitaasuka” has been promoted in Hokkaido (central Hokkaido and southern Hokkaido).

Regarding tea, a measure against frost damage has been promoted by implementing a frost protection technique with an energy-saving frost-protective fan system. As a result, certain effects have been observed. Moreover, the following drought measures have been implemented: soil moisture evaporation control by grass mulch and sprinkling water. As for pest control, forecasting

15 A weight obtained after being dried and having water content reduced, that is, the weight of a substance that a plant actually produced and accumulated.

16 A ratio of the dry matter weight of harvested parts against the total dry matter weight.

17 A phenomenon where a sprout comes out of a seed that grew on an ear due to rainfall, etc. before harvesting.

technology has been introduced, and replanting of varieties resistant to white peach scale[18] has been promoted.

Regarding sugar beet, pests and diseases control has been taken to develop and disseminate species resistant to diseases, which are frequently caused by high temperatures. As a result, certain effects have been observed. Measures for high temperatures also have been periodically taken to monitor and investigate the production status at the production site and to accumulate knowledge for the purpose of selecting the most suitable species. Moreover, drainage measures against heavy rain have been taken.

Measures taken so far will be continuously promoted hereafter.

(4) Horticultural Crops

(i) Impacts

a. Current Conditions

The following trends among open-field vegetables have been observed: harvesting seasons are becoming earlier among leafy vegetables such as cabbage, root vegetables such as daikon radish and fruit vegetables such as watermelons, and the frequency of decreased growth thereof is increasing.

As for vegetables grown in greenhouses, the following phenomena have been observed: poor fruit bearing, fruit cracking, poor coloring of tomatoes due to high temperatures in the summer, and a delay in flower bud differentiation of strawberries due to high temperatures during the growing period. Moreover, the following impacts have been observed: declining photosynthesis caused by shading to avoid high temperatures, declining pollination activities of bumblebees due to high temperatures and collapsing greenhouses due to heavy snow, etc.

Decreased growth is observed among ornamental plants: the advancement or delay of the flowering season due to high temperatures in the summer and fall, malformed flowers, short-stemmed flowers, and weakened stems, etc.

b. Projected Impacts

It is unlikely that the cultivation of vegetables will become totally impossible as long as the cultivation period is adjusted and appropriate varieties are selected. However, further climate change will possibly make it difficult to deliver vegetables in a planned manner.

(ii) Efforts

Regarding vegetables, while promoting the development of breeding materials adaptive to warmer conditions and the dissemination of such varieties as measures against higher temperatures, efforts have been made toward the stable supply of open-field vegetables by

[18] A major pest insect for tea, which is a parasite living in the branches and trunk of a tea plant. It causes dieback, etc., due to decaying tree vigor. In recent years, its outbreak has been frequent nationwide, but there is no clear cause-and-effect relationship between climate change and the trend.

selecting adequate varieties, adjusting the cultivation periods, and pest control at appropriate times. The following drought measures have been promoted: establishing irrigation facilities, soil moisture evaporation control with multilayered sheets, and an appropriately timed extermination of spider mites and other pests that are likely to occur at the time of drought.

As for measures against high temperatures concerning vegetables grown in greenhouses, efforts have been made to implement low-cost, nighttime air-conditioning technologies by utilizing soil temperature-controlling multilayered sheets, light-shielding materials, fog cooling machines, pads and fans,[19] circulating fans, and heat pumps[20] mainly at relatively large facilities. The following measures against typhoons and heavy snow have been promoted: implementation of a low-cost weather-resistant greenhouse, reinforcement of a pipe-framed greenhouse, installation of a backup power source. Such measures have produced certain effects.

As for measures against high temperatures concerning ornamental plants, adequate use of sprinkling water has been promoted. In addition, work has been done on disseminating varieties adaptive to hot conditions.

As for measures against high temperatures concerning ornamental plants grown in greenhouses, efforts have been made to implement low-cost night time air-conditioning technologies by utilizing soil temperature-controlling multilayered sheets, light-shielding materials, fog cooling machines, pads and fans, circulating fans, and heat pumps. In addition, the following measures against typhoons and heavy snow have been promoted: implementation of a low-cost disaster-resistant greenhouse, reinforcement of a pipe house, installation of a backup power source. Such measures have produced certain effects.

Measures taken so far will be continuously promoted hereafter.

(5) Livestock Farming

(i) Impacts

a. Current Conditions

Regarding livestock, impacts of high temperatures exceeding that of the summertime in an ordinary year are reported as follows: a fall in milk yields, milk constituent and reproductive performance of dairy cows, and a fall in the rate of gain of beef cattle, pigs, and meat-type chickens.

As for forage crops, the following impacts have been reported: a shift of locations suitable for cultivation, summer growth depression due to high temperatures and light rainfall, in the summertime, insect damage, etc.

b. Projected Impacts

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[19] A device made by combining a water-dampened cooling pad and a cooling fan, which obtains cooling effects by evaporatively cooling a greenhouse for agriculture.

[20] A technology that collects heat in the air by a small amount of input energy, in order to use it as a large amount of thermal energy.

Although differences may be seen depending on the species of livestock and breeding form, the following predictions are reported: a declining feedstuff intake caused by rising temperatures in the summertime will bring more impact on the growth of fat hogs and meat-type chickens, accompanied by the advancement of global warming: also, regions where the rate of gain declines will extend, and the extent of such declines will grow.

Regarding forage crops, although a study predicts the amount of production of meadows by region, no prediction has been made for a nationwide trend on yield increases and decreases, etc.

(ii) Efforts

As for livestock, while securing an adequate livestock barn environment by disseminating summer heat measures, such as water sprinkling and misting in a livestock barn and application of lime and water sprinkling to the roof, the following efforts have been made: avoidance of close rearing and strict enforcement of clipping, and instruction and completion of adequate feeding management techniques, such as supplying cold water and feedstuff of good quality. Moreover, efforts have been taken to develop and disseminate productivity improvement techniques to prevent a decline in the rate of gain and fertility in the summertime through adequate nutrition management, etc.

Regarding forage crops, MAFF has worked on establishing a cultivating system adaptive to climate change, developing and disseminating summer heat measures including manuring management techniques, as well as varieties and breeding materials resistant to heat. Also, disease and pest measures have been taken, such as developing and disseminating resistant varieties and breeding materials.

Measures taken so far will be continuously promoted hereafter.

3. Plant Pests, Weeds, and Animal Infectious Diseases

(1) Impacts

(i) Current Conditions

Although *Nezara viridula*, which causes serious damage to various crops such as paddy field rice, soybeans and fruits, used to be distributed in southwestern parts of Japan, i.e. relatively warm areas such as southern Kyushu, it has been expanding its range northward to part of the Kanto region in recent years. It has been pointed out that such changes have occurred due to global warming.

Meanwhile, there is no case where crop damage by disease has increased definitely due to climate change.

Regarding weeds, it became possible for grass weeds distributed in the south of the Amami Islands to pass the winter. Recently, there has been a case where grass weeds invaded various

parts of the Kyushu region.

As for animal infectious diseases, arbovirus infections (virus infection by bloodsucking arthropods), which is carried by arthropods such as mosquitos and biting midges, have spread mainly in western Japan. It is implied that climate changes affect the distribution of arthropods; the habitat has moved toward the north. As a consequence, signs of a change have been seen in the trend of the outbreak of domestic animal infectious diseases such as the expansion of an epidemic area and epidemic period.

(ii) Projected Impacts

It has been pointed out that damage to agricultural crops will possibly increase due to the increasing occurrence of pests and diseases, and the expansion of their distribution areas. Moreover, some are concerned about serious damage resulting from the introduction of pests and diseases that have never been present in Japan, triggered by climate change. Regarding paddy fields, the species composition of parasitic natural enemies, some parasitoids, and pest insects is projected to change by increasing the number of annual generations. As for vegetables, fruit trees, and tea, some point out that damage will possibly increase due to the following trends of pest insects such as Lepidoptera and Hemiptera: the overwintering area of such pest insects will expand northward, and the number of annual generations of such pest insects will increase. It is also pointed out that the period of migration and migrated populations of plant hoppers from overseas will possibly change.

Regarding crop damage due to disease, there is a case where the outbreak of diseases such as rice sheath blight disease and rice blast was projected to increase under the condition of elevated CO_2 concentration (a rise by 200 ppm from the ambient air) artificially created in an outdoor paddy field. Thus, there is a concern for increasing crop damage by other diseases due to climate change.

In the case of weeds, it has been pointed out that the area where certain types of weeds can take root will possibly expand or move toward the north due to rising temperatures. Some are concerned that the growth of agricultural products will be hindered and that agricultural products will become the host of diseases and pests.

As for animal infectious diseases, there are growing concerns about the following: the expansion of an epidemic area and change of the epidemic period due to changes in the habitat and habitation period of arthropods, which carry pathogens of domestic animal infectious diseases; and invasion by new diseases from overseas.

Furthermore, if impacts are brought on a flying pathway and in the flying period of migratory birds, which are considered as a major factor for avian influenza outbreak in Japan, there is a possibility of seriously affecting the invasion risk of avian influenza in Japan.

(2) Efforts

It is important to understand appropriately the situations of the occurrence and damage of pests present in Japan. For this reason, a pest forecasting program applicable to the specified pests[21] will be continuously implemented, and while investigating changes of the status of the occurrence and damage, such information will be transmitted for the purpose of timely and proper pest control. Moreover, in response to climate change, MAFF will commence reviewing the specified pests for the pest forecasting program and the pest control system in order to adapt to the climate change.

As for serious pests[22] that are absent, or present but not widely distributed in Japan, while continuously taking phytosanitary measures in order to prevent the introduction of pests from overseas, domestic quarantines for preventing such pests from spreading in Japan, and surveillance as well as control of the pests, MAFF will further risk assessment pests based on information in the world. Furthermore, MAFF will work on reviewing phytosanitary measures based on the results of risk assessment of pests.

Regarding serious pests that are already present in a part of Japan, efforts will be gradually taken for technical development toward the improvement of accuracy of monitoring survey for newly invading pests, the advancement of control techniques, etc.

As for long-range migratory pest insects,[23] MAFF will commence with developing a technology for clearing the change of the situations of migration from overseas, i.e. the period of migration and the number of migrated insects, and the technology for predicting the change of distribution area in Japan, i.e. northward expansion of the overwintering area and the acceleration of occurring and migration.

Regarding diseases such as rice sheath blight and rice stripe, expected to occur increasingly in paddy fields, MAFF will clarify the impacts on paddy rice yields, and develop countermeasure technologies.

Concerning weeds, while assessing the occurrence risk of spoiled grains of soybeans due to the increasing amount of weeds remaining until the harvesting season, work will be commenced on developing a technology mitigating damage on soybeans.

As for animal infectious diseases, the following efforts will be taken: selection of a vaccine candidate strain against livestock infectious diseases carried by arthropods (virus for

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21 As specified by the Minister of Agriculture, Forestry and Fisheries in Article 22 of the Plant Protection Act (Act No. 151 of 1950), pests and diseases of which distribution in Japan is not localized, and they spread quickly and tend to do material harm to crops.

22 Pests and diseases that possibly do material harm to useful plants if they spread within the country.

23 Insect pests that travel from several hundred kilometers to several thousand kilometers using not only their own flying capability, but also a large-scale weather phenomenon, including many serious-insect pests in agriculture such as plant hoppers, aphids, and Noctuidae. Insect pests such as rice brown plant hopper (*Nilaparvata lugens*) and the white backed plant hopper (*Sogatella furcifera*) are known to migrate mainly to western Japan across from mainland China by a low-level jet stream that develops during the rainy season in Japan.

manufacturing vaccine suitable for epidemic infectious diseases), examination of risk management including effective preventive measures, and investigation on risks of migratory birds, which are considered as a major factor for avian influenza invasion of Japan.

4. Water, Land and Agricultural Infrastructure

(1) Impacts

(i) Current Conditions

Regarding precipitation affecting water, land and agricultural infrastructure, the following tendencies are found: the range of fluctuation is becoming larger for both pluvial and dry years; and the frequency of heavy rain with a short duration of time is increasing. In response to declining quality of paddy field rice due to high temperatures, influences on the utilization of water resources, such as changes in rice cropping season and water management, are observed.

(ii) Projected Impacts

It is predicted that water, land and agricultural infrastructure nationwide will be affected by the increasing occurrence of extreme events (heavy rain and droughts) and rising temperatures. In regions where snowmelt is used as a water resource in particular, water intake is projected to be largely affected in April and May, when agricultural water use is in high demand, due to early snowmelts and declining snowmelt runoff volume. Moreover, risk of farmland flooding is predicted to increase due to an increase in the frequency and rainfall intensity of torrential rain.

(2) Efforts

While compiling the “Global Warming Measures in Agricultural and Rural Development” and conducting examinations and investigations of measures concerning water, land and agricultural infrastructure, MAFF promotes the development of technologies that contribute to the projected impacts of global warming and measures based on the technical development plan concerning agricultural and rural development.

In light of impacts such as rising temperatures expected to occur in the future and declining snowmelt runoff volume, agricultural water will be effectively secured and utilized by appropriately combining measures in hard (structural) and soft (non-structural) aspects as follows: reducing the amount of irrigation water by automated water management and pipelining waterways and effective utilization of existing water resources by changing the operation of reservoirs and agricultural dams.

In order to respond to increasing torrential rains, efforts will be taken for disaster prevention in rural areas, as well as the maintenance and improvement of disaster reduction functions, by appropriately combining measures in hard (structural) and soft (non-structural) aspects as follows: promoting prevention of farmland flooding, by developing drainage pumping stations and drainage canals, grasping facilities and regions highly vulnerable to inundation, conducting

risk assessment such as formulating hazard maps, and promoting the development of a business continuity plan by facility managers. In doing so, measures will be effectively taken by utilizing the existing facilities and by demonstrating local communities' functions, etc.

Under present circumstances, a climate change forecast is highly uncertain, and there are no sufficient grounds for conducting specific examinations based on a projected impacts. Thus, in light of new scientific knowledge, accompanied by the advancement of climate change research, medium- to long-term impacts will be projected and assessed.

If the grounds for improving facilities based on a projected impacts become definite in the future, due to new scientific knowledge and climate models as well as improved accuracy of the assessment method of impacts on water, land and agricultural infrastructure, MAFF will conduct examinations on desirable infrastructure improvement.

5. Securing Food and Feed Safety (Agricultural Products Including Cereal Grain and Cereal Products, and Feeds)

(1) Impacts

(i) Current Conditions

Many kinds of fungi are present in soil. Some fungi-infected agricultural products trigger plant diseases that result in declining quality and yield, and mycotoxin[24] contamination which poses problems to food and feed safety. Among mycotoxins, aflatoxins are known to be extremely toxic. Maximum levels of aflatoxins in food and feed have been established in Japan as elsewhere. Under present circumstances, a case, where serious aflatoxins' contamination exceeding the maximum level was not found in domestic agricultural products, and feeds has almost never been reported.

However, in the study of distribution of aflatoxin-producing fungi in domestic soil, it was reported that there was a high correlation between the limit of its distribution and the annual mean temperature, and that its distributional area possibly expanded compared to that of the 1970s. Regarding other mycotoxins' contamination, under present circumstances, such contamination has been confirmed to remain at a low level deemed unlikely to pose health problems on humans and livestock.

(ii) Projected Impacts

Due to the rising annual mean temperature and the increasing occurrence of heavy rain and droughts, during the growing period of agricultural products and feed crops, there is a possibility that the distribution and density of mycotoxin-producing fungi (in particular, aflatoxin-producing fungi) in field soil, will change, thereby changing the conditions of mycotoxin contamination

[24] Natural chemical substances made by mold, which bring harmful effects on humans and livestock.

within domestic agricultural products and feeds.

(2) Efforts

Through continuous surveillance of the distribution of mycotoxin-producing fungi in domestic field soil, and mycotoxin contamination of domestic agricultural products and feeds, MAFF will endeavor to grasp climate change impacts. If there is a possibility that increasing mycotoxin contamination of agricultural products and feeds will pose a health problem for humans and livestock, MAFF will develop technologies to reduce contamination and extend such measures to producers of agricultural products and feeds. Mycotoxin contamination reduction measures will be regularly verified and reviewed in consideration of new knowledge.

Part 2 Forest and Forestry

1. Mountainous Disaster and Forest Conservation Works and Forest Road Facilities

(1) Impacts

(i) Current Conditions

It is reported that the frequency of occurrence of 50 mm/hr or more of heavy rain in a short period of time has increased over the past 30 or so years, thereby resulting in an increase in the annual number of occurrences of sediment disasters damaging human habitations and villages, etc. Moreover, it has been pointed out that the occurrences of excessive high tides have been possibly increasing worldwide since 1970.

(ii) Projected Impacts

One prediction says that the annual maximum daily rainfall and the annual maximum hourly rainfall will increase by several dozens of percent compared to today. Under the premise that the rainfall conditions will become as harsh as predicted, intensive landslides and debris flow, will frequently occur, and impacts on the social life of hilly and mountainous areas will increase.

Droughts are estimated to increase by the increase in dry days and decrease of snowfall. Moreover, water supply - demand mismatch is also predicted because an earlier snowmelt period leads to decrease of river flow.

Some point out that the risk of high tides and coastal erosion will increase due to rising sea levels and increasing typhoon intensity caused by climate change.

(2) Efforts

In order to sophisticatedly demonstrate public functions of forests, such as headwater resource conservation and disaster prevention, while promoting designation of protection forests in a planned manner, MAFF has taken the following measures for protection of forests:

By means of promoting implementation of forest conservation facilities and forest management works, MAFF aims to prevent mountainous disasters or minimize the damages from those disasters and improve the safety of hilly and mountainous areas. MAFF established the

Forestry Agency Plan for Extending Service Life of Infrastructure (action plan), and appropriately maintains and updates forest conservation and forest road facilities. MAFF cooperates with regional evacuation arrangements by offering information about high-risk areas, which is the Mountain Disaster Danger Zone, and implements effective projects toward disaster risk reduction. When implementing such projects, MAFF takes local conditions into consideration and manages to conserve biodiversity, such as by installing a fish way at the forest conservation facilities.

For the purpose of contributing to stable supply of good quality water through maintaining and enhancing of headwater resource conservation functions of forests, MAFF aims to maintain and develop protection forests that contain rich forest soil having high infiltration and water-holding capacity, located in important headwaters for the upstream toe of a dam, or a headwater conservation for a village.

By promoting coastal disaster prevention forests, MAFF enhances disaster prevention functions of forests such as preventing salty damage.

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

In order to respond to the occurrences of mountainous disasters due to recent torrential rain, MAFF will review the criteria investigation standards of the Mountain Disaster Danger Zone and will figure out more precisely the zones with higher disaster risk. MAFF promotes designating forests located in the MDDZ as protection forests for sediment runoff prevention, etc., in order to improve functions for landslide prevention and sediment runoff prevention. On the protection forests MAFF imposes controls on harvesting and converting into other land use, provides forest conservation facilities and forest management activities, and develops forest roads.

In consideration of an increase in the frequency of occurrence of torrential rain in recent years, the improvement of forest road facilities will be promoted, aiming at improving disaster prevention functions of the facilities.

On the other hand, the risk of droughts is concerning because of some predictions such as increase of dry days, decrease of snowfall, and early snow. MAFF promotes forest management activities and forest conservation facilities and develops necessary forest roads in order to appropriately demonstrate water resource conservation functions, taking watershed characteristics into consideration.

In term of coastal disaster-prevention forests, MAFF will develop the growth base, which aims at preventative function against high tides and coastal erosion and enhance functions of seawalls in light of local conditions.

Based on new scientific knowledge and the improved accuracy, etc., of climate models, MAFF will examine improvement of the accuracy in grasping the Mountain Disaster Danger Zone, improvement of facilities in response to disaster risks, and the forest management utilizing

disaster risk reduction functions of forests.

2. Planted Forests

(1) Impacts

(i) Current Conditions

It is reported that cedar tree forests have been declining in some regions, due to increasing water stress caused by dry air resulting from rising temperatures and changing precipitation patterns.

(ii) Projected Impacts

Some report that areas unsuitable for growing planted cedar forests will possibly increase in regions of low rainfall. However, it is indicated that further research will be necessary for accurate predictions.

(2) Efforts

MAFF has collected information concerning climate change impacts through investigation and research on climate change impacts on forests and the forestry industry.

In order to conduct the adaptability assessment of plantation wood against changes in the growth environment such as rising temperatures and dryness, experimental planting of seeds and plants from different places of production will be widely promoted for main plantation tree species such as cedar and cypress. Furthermore, as for climate change impacts on the growth of such plantation tree species and the surrounding environment of trees such as lower-layer vegetation, MAFF will commence continuous monitoring of environmental impacts, assessment of risks on long-rotation forests, and development of varieties adaptive to climate change, such as high temperatures and dryness stress.

3. Natural Forests

(1) Impacts

(i) Current Conditions

It has been reported that alpine zone and subalpine forests have declined due to warming temperatures and the earliness of snowmelt season, etc. In some areas, it is highly likely that deciduous broad-leaved forests have been replaced by evergreen broad-leaved forests due to warming temperatures.

(ii) Projected Impacts

It has been reported that the distribution area of cool temperature tree species will narrow down, while that of warm-temperature tree species will expand. However, uncertainties still remain that physiographic factors and anthropogenic impacts such as land use change should affect the actual forest distributions.

(2) Efforts

MAFF endeavors to collect information concerning climate change impacts, including changes in the distribution area, in order to conduct projected impacts.

Moreover, MAFF promotes appropriate conservation and management of national forests, establishing “Protected Forests,” which protect a primary forest ecosystem and the growth and habitat of rare wildlife species, as well as “Green Corridors,” which serve as migratory pathways for wildlife; precisely grasping the situation through continuous monitoring surveys, etc.; and aiming to form the forest ecosystem network together with mountain streams.

Data collection, projected impact and vulnerability assessments will be conducted on the climate change impacts on the forest ecosystem of each World Natural Heritage Site, in order to examine measures. Furthermore, efforts will be taken to build a system for the purpose of conducting long-term monitoring of the climate change impacts on the surrounding environment including trees and lower-layer vegetation.

4. Pests

(1) Impacts

(i) Current Conditions

It has been reported that areas damaged by pests have possibly been expanding due to rising temperatures and declining rainfall. However, considering that factors other than temperature contribute to such damage, it is necessary to carefully verify the current impact.

(ii) Projected Impacts

Some report that there is a concern about expanding damage due to increasing risks of pests caused by rising temperatures, etc. It has been indicated that further research needs to be conducted in the future, in order to accurately predict such damage.

(2) Efforts

In order to prevent the spread of forest pests, MAFF will continuously conduct pest control in cooperation with prefectures, in accordance with the Forest Pest Control Act.

The distribution of pest-damaged area is deemed likely to expand due to intensified insect activities accompanied by rising temperatures. While continuously promoting research on climate change impacts and damage control, MAFF will continuously monitor forest damage.

Furthermore, for the purpose of mitigating forest pest damage, while developing varieties highly resistant to the pine wood nematode, etc., MAFF will promote developing an effective technique to judge the resistance of varieties.

5. Non-Wood Forest Products

(1) Impacts

(i) Current Conditions

There is a report indicating the relationship between higher temperatures in the summer, and the outbreak of disease-causing bacteria, as well as the declining amount of shiitake (mushroom) fruit bodies generated. However, there are some opinions that due to insufficient data accumulated, it will be necessary to conduct further research in the future.

(ii) Projected Impacts

Under the current circumstances of shiitake bed log cultivation, there are no clear grounds for the relationship between higher temperatures in the summer and the outbreak of disease-causing bacteria, as well as the declining amount of shiitake (mushroom) fruit bodies generated, and impacts on the shiitake bed log cultivation brought by higher temperatures in the winter. Thus, there are some opinions that further research needs to be conducted in order to make accurate predictions.

(2) Efforts

MAFF has taken efforts such as grasping climate change impacts on shiitake bed log cultivation (the status of damage caused by disease-causing bacteria and the infection route; the status of occurrence of damage caused by fungus gnats pest insects; the influence on yields under high temperature conditions in the summer) and examining a cultivation method that controls temperature rises within a bed log laying yard by utilizing a lawn that blocks out sunlight.

MAFF will promote data accumulation concerning outbreak of the disease-causing bacteria, influence on the yields due to the advancement of global warming, development, verification and dissemination of shiitake cultivation techniques and breeds adaptive to global warming, etc.

Part 3 Living Aquatic Resources, Fisheries, and Fishing Ports

1. Marine Fisheries

(1) Impacts

(i) Current Conditions

According to an analysis of climate change impacts on living aquatic resources through marine environmental research, changes in the distribution area of marine organisms were observed worldwide accompanied by changing sea temperatures. Changes in the fish catches triggered by such changes were also reported.

In the sea off Japan, an impact study was conducted on migratory fish and squid. The result reported changes in the distribution and migration area among yellowtail, Japanese spanish mackerel and Japanese common squid caused by high-water temperatures centering in the Sea of Japan, thereby resulting in a decline in the catch of such fish in some regions.

An increase in Southern Hemisphere fish species and a decrease in Northern Hemisphere fish species have been reported in coastal areas such as the Inland Sea of Seto, and the Wakasa Bay.

Catches of spiny lobsters and abalone are reported to have declined, accompanied by decreasing seaweed beds due to damage caused by algae-eating organisms.

However, it cannot be ignored that the marine ecosystem is affected by not only continuous global warming impacts, but also global-scale climate change impacts on a cycle of ten to several decades. In waters surrounding Japan, changes in the marine ecosystem caused by ocean acidification are not specified at this point.

(ii) Projected Impacts

As for marine productivity, which largely affects the growth and survival of fish and shellfish, it has been pointed out that there is a possibility of fluctuations in the standing crop and primary productivity of phytoplankton accompanying climate change. Looking at such changes on a global scale, productivity is projected to decrease in tropical and subtropical waters, and increase in subarctic waters. While such a prediction is considered moderately reliable, the credibility of the prediction is not high in waters surrounding Japan located at the border of the subarctic zone and the subtropical zone.

As suggested in a medium- to high-emission scenario (RCP4.5, 6.0 and 8.5) in the IPCC Fifth Assessment Report, ocean acidification will pose a considerable risk to the marine ecosystem, particularly the polar regions and coral reefs.

The IPCC Fifth Assessment Report indicated changes in the distribution of marine organism species on a global scale, and declining biodiversity in waters to be highly affected by climate change, which is projected to occur in the mid-21st century and thereafter.

In waters surrounding Japan, an impact assessment is reported concerning a distributed migration range and changes in the size of salmon, yellowtail, Pacific saury, Japanese common squid, sardine, whose catches are large. The distribution area is mostly projected to go north. The catch of some species is projected to decrease due to high water temperatures in adjacent waters. In coastal areas, the catch of reef resources including abalones, is projected to decline due to changes in species comprising seaweed beds and the standing crop caused by increases in sea water temperatures.

However, changes in catches and impacts on local industries are related to factors other than global warming. Thus, the accuracy of the projection is considered not high due to its high uncertainty.

(2) Efforts

MAFF will endeavor to grasp impacts on living aquatic resources due to marine environment changes, etc., by continuing marine environment studies at spawning areas and at the major fishing grounds of various living aquatic resources.

Moreover, the precision of an oceanic condition forecast model in operation will be improved by upgrading the method that assimilates various observational data obtained from research

vessels and satellites, etc. Based on such information, aiming at grasping and forecasting the amount of resources under the changing environment, and improving the precision and efficiency of fishing ground prediction, MAFF will examine measures enabling adaptive fishery production activities in response to environmental changes.

Regarding highly migratory species, such as tuna and bonito, which require resource management by international efforts, for the purpose of estimating their carrying capacity, which is considered to fluctuate due to climate change impacts, MAFF will hereafter aim to collect various data, such as resource information, genome information, and ocean information and develop a data integration and analysis system.

By specifying climate conditions and marine environment conditions that will become a factor for the outbreak of harmful plankton, and by utilizing satellite information and various coastal observation information, a system will be developed to promptly provide information agencies concerned with real-time monitoring.

Furthermore, changes in the marine environment will possibly affect the survival of released juvenile salmon, etc.; the releasing methods of juvenile salmon, etc., will be developed in response to changes in the marine environment.

2. Marine Aquaculture

(1) Impacts

(i) Current Conditions

The following phenomena, which are believed to be affected by increases in seawater temperatures, have been reported in many places: mass mortality of scallops and rising mortality rates of oysters, and changing production volume. As for cultured laver, in some cases, annual crop yields have been decreasing in some regions due to a delay in seeding caused by high water temperatures in the fall.

The following impacts through the changing ecosystem have been reported: prolonged red tide. which affects pearl oysters, etc.; toxified shellfish by tropical toxic plankton; and feeding damage caused by short-neck clam proliferation accompanied by expanding distribution area of the Southern Hemisphere fish species including Longheaded eagle ray

In waters surrounding Japan, impacts on marine aquaculture brought by ocean acidification are not reported at this point.

(ii) Projected Impacts

In yellowtail aquaculture, while there is a concern about the increasing mortality rate in the summer due to high water temperatures, enhanced growth is projected in fall and winter. Some point out slowed growth due to high water temperatures and increasing risks of developing infectious disease in red sea bream aquaculture. It is projected that locations suitable for farming

yellowtail, tiger puffer fish, and flounder will move toward the north, thereby resulting in some waters becoming unsuitable for aquaculture.

In the case of a medium to high-emission scenario (RCP4.5, 6.0 and 8.5), it has been pointed out that impacts on ocean organisms due to marine acidification will pose a considerable risk on vulnerable marine ecosystems, particularly coral reefs. Many kinds of mollusks possessing calcium carbonate frames and shells, as well as echinoderms, are likely to be affected by ocean acidification. As a result, some are concerned about impacts on shellfish aquaculture, etc.

Others are concerned about increasing risks of mortality of bivalves as a result of increasing frequency of occurrence of red tides caused by high water temperatures.

(2) Efforts

MAFF will continue surveys and research concerning the relationship between the occurrence of red tide plankton, which causes significant impacts on the aquaculture industry, and climate change.

Hereafter, while utilizing metagenome analysis technologies to develop methods that enable detecting with high sensitivity the emergence of tropical and subtropical red tide plankton, which is becoming a new threat, MAFF will grasp the physiology and biological characteristics of such plankton, and use such information for forecasting and developing preventive technologies and measure technologies.

Based on a concern for slowed growth in the aquaculture areas, MAFF will continuously work on developing high-water-temperature-tolerant culture breeds, etc. As for seaweed in particular, further work will be done as follows: developing high-water-temperature-tolerant breeding materials by utilizing a new laver breeding technique based on already developed cytogamy techniques, and developing a breeding technique by separating a high-temperature-tolerant strain of large-sized algae such as wakame seaweed.

Hereafter, MAFF will formulate measure guidelines for fish diseases that are expected to frequently occur at the time of high water temperatures, as well as fish diseases that will possibly invade Japan from tropical and subtropical waters, accompanied by rising water temperatures, and develop various measure technologies.

In consideration of the increasing possibility of occurrence of unknown fish diseases due to rising water temperatures, MAFF will aim to promptly respond to the occurrence of unknown fish diseases by systematizing and enhancing a series of technical developments including specifying pathogens, diagnosis, and measures regarding infectious diseases whose pathogens are unknown. Vaccinations for various fish diseases have already been developed. The efforts will be taken to further develop and disseminate vaccinations in response to various fish diseases.

Hereafter, in tandem with such measures for fish disease, by utilizing the latest breeding techniques, MAFF will create a strain that appears to be resistant to various fish diseases that are

expected to break out accompanied by global warming, and aim to introduce such strains at the aquaculture site.

In addition to the aforementioned technical developments, work will be done on identifying the characteristics of pathogens, the working mechanisms of vaccinations, the molecular mechanism of disease tolerance and resistance, etc.

While proceeding with monitoring and ecological surveys of breeds that appear as a result of rising water temperatures such as Longheaded eagle ray, which eat bivalves including short-neck clams, and developing management technologies to prevent adverse impacts on the ecosystem and aquaculture, MAFF will proceed with developing efficient capturing methods, contributing to regional development, application technologies and high-value-added technologies.

Although the range of diurnal variability of partial pressure of carbon dioxide that affects the pH of seawater is known to be large in the coastal areas, it is unknown how this mechanism is affecting marine organisms. Thus, while solving such a mechanism and forecasting acidification impacts on bivalve aquaculture, MAFF will develop measure technologies based on such a forecast.

3. Inland Water Fisheries and Aquaculture

(1) Impacts

(i) Current Conditions

Climate change impacts on inland water fisheries and aquaculture have not emerged yet. However, the following trend has been confirmed in some lakes and marshes: the circulation of lake water is weakened due to warm winters, causing a decline of dissolved oxygen at the bottom of lakes, thereby resulting in oxygen depression.

Regarding the ecosystem including resources applicable to fisheries in lakes and marshes, it cannot be ignored that some impacts are brought by eutrophication, not as a result from climate change.

(ii) Projected Impacts

Severe changes are projected to occur in lakes and marshes and reservoirs, compared with projected changes in rivers, such as advancement of oxygen depression due to enhanced stratification[25] within lakes and marshes and reservoirs caused by rising temperatures and water temperatures, and impacts on the species composition and the production of phytoplankton. In particular, there is a strong concern about impacts on deep lakes and marshes where eutrophication has progressed.

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[25] A phenomenon where the density of an upper layer becomes smaller than that of a lower layer, thereby making it difficult for the upper layer and the lower layer to mix. In the ocean and lakes and marshes, water temperatures and salt affect the density of water.

If the fluctuation range of rainfall depth increases, abnormal inundation and abnormal drought are projected to occur, thereby increasing the fluctuation range of river flow, increasing the flow of earth and sand as well as substances, and affecting water quality and the environment of river beds. Moreover, the flowing pattern is predicted to change due to changes in snowfall and snow melt period.

The catch of pond smelt is projected to decrease due to high water temperatures. If the highest water temperature rises by 3°C than that of today, the areas with rivers that cold-water fish can inhabit are distributed, will decrease from 40 percent to approximately 20 percent of the whole land area. The habitat of such fish will be extremely limited on the mainland of Japan, in particular.

(2) Efforts

MAFF will assess impacts on the habitat and abundance of important resources in inland waters such as Salmonidae fish and sweetfish that are brought by environmental change of rivers, as well as lakes and marshes, accompanied by climate change.

Based on a concern about slowed growth in the inland water aquaculture areas, MAFF will continuously work on developing high-water-temperature-tolerant culture breeds, etc. Particularly, a seawater immersion treatment at the larval fish period is known to be effective in selecting individual landlocked salmons tolerant to high water temperatures. Thus, a high-water-temperature-tolerant strain will be created by applying this technology to other Salmonidae fish.

In order to upgrade feeding and releasing technologies for pond smelt, whose catch is projected to decrease due to high water temperatures, while aiming at stabilization, mass-production, and simplification of seedl production, MAFF will hereafter take efforts in the following areas: developing an efficient production technique of plankton bait, discovering the most suitable rearing density and bait density at the time of seedl production, and developing extensive and mass-productive seedl production techniques.

Information concerning the outbreak of diseases caused by high water temperatures will be collected. As for diseases of inland water fish, whose damage is expected to increase due to rising water temperatures, MAFF will conduct research on the characteristics and onset factors of pathogens, and develop measure technologies based on such research.

4. Improvement and Development of Fishing Grounds

(1) Impacts

(i) Current Conditions

Regarding seaweed beds off the coast of Japan, the following phenomena have been confirmed: the southern distribution limit of algae belonging to the Kajime（*Ecklonia cava*）

family has moved toward the north, and varieties of warm sea algae have increased. In addition, some report intensified feeding behavior of phytophagous fish such as rabbitfish, and the expansion of the distribution. It has also been reported that such phenomena have caused a decrease in seaweed beds, thereby resulting in a fall in the catch of spiny lobster and abalone, which inhabit seaweed beds.

Moreover, changes are observed worldwide in the distribution areas of marine organisms accompanied by changing sea water temperatures. The following changes among migratory fish in waters surrounding Japan have been reported: changes in the distribution and migration areas due to high water temperatures among yellowtail mainly in the Sea of Japan, and changes in the catch accompanied by such changes.

(ii) Projected Impacts

Reef resources including abalone are projected to be affected by changes in species comprising seaweed beds and the standing crop due to rising water temperatures.

The distribution areas of many fishery target species are projected to move toward the north.

(2) Efforts

While precisely grasping changes in the distribution areas and the habitats of marine organisms due to increases in seawater temperatures, MAFF will hereafter work on improving fishing grounds, which will become spawning and nursery grounds of marine creatures, in response to such changes. When improving and developing seaweed beds, in addition to seeding and transplanting high-water-temperature-tolerant species according to the situation of the site, MAFF will, after making improvements, promote more effective measures by adopting an adaptive management method as follows: monitoring the condition of thickly growing algae and the movement of phytophagous animals, and implementing the measures for organisms causing feeding damage, such as removing phytophagous fish, according to the situation.

As the foundation for improving and developing fishing grounds adaptive to climate change, MAFF will analyze accumulated observational data and fish catch data in order to work on technical development concerning the method assessing climate change impacts on coastal resources in each region.

By grasping the distributive characteristics, feeding habits, seasonal changes of organisms causing rocky-shore denudation and by utilizing the global warming forecast model, changes in the distribution areas and impacts will be predicted. By selecting seaweed relatively resistant to such feeding damage, a reproduction technique will be developed. Moreover, the method for improving and developing combined seaweed beds will be developed for the purpose of regrowing seaweed beds in empty spaces within seaweed beds arising from feeding damage in a short period of time.

5. Fishing Ports and Villages

(1) Impacts

(i) Current Conditions

It has been pointed out that the risk of tidal wave damage, coastal erosion will possibly increase as a result of increasing storm surge deviation and ocean waves caused by mid- and long-term rising sea levels, and an increase in powerful typhoons, etc., due to climate change. In the case of high waves, increasing wave height has been confirmed off the Pacific coast from the fall to the winter, while an increase in the wave heights and the period of high waves has been confirmed off the coast of the Sea of Japan, due to changes in the pressure pattern in the winter.

(ii) Projected Impacts

Even in the case of controlling greenhouse gas emissions, a sea level rise to a certain extent cannot be avoided. Thus, fishing port functions may be affected due to inundation of the following facilities: berthing facilities, such as shallow draft wharves, whose crown height (height of the upper end of a structure) is low, and the difference in sea level is small between the facility and the surface of the sea; and freight handling areas.

There is a possibility of the increased risk of high waves in regions off the Pacific coast due to increasing strong typhoons, etc. Also, fishing port facilities are projected to be damaged by increasing wave heights and storm surge deviations. Furthermore, changes in wave height, wave direction, and period will possibly affect the state of calm (the state where wave height is small) within a port.

Some predict that coastal erosion will take place due to rising sea levels and increasing typhoon intensity. To be specific, if a sea level rises by 30 cm or 60 cm, approximately 50 percent or 80 percent of beaches in Japan, respectively, are predicted to disappear.

(2) Efforts

In order to respond to increasing high waves due to unusual weather, while monitoring tide levels and ocean waves for the purpose of precisely grasping signs of climate change impacts, MAFF will promote the following measures in a continuous and planned manner: raising the levees of fishing port facilities such as breakwaters and shallow draft quay, and developing tenaciously structured shore protection facilities.

In consideration of socioeconomic activities of the hinterlands and the mid- and long-term movement in land use, MAFF will strategically and adaptively take measures in hard (structural) and soft (non-structural) aspects, which are combined in the most suitable manner (best mixed) going forward.

Moreover, MAFF will develop design conditions for infrastructure facilities in response to rising water levels and increasing high waves, and a low-cost technique for improving the existing facilities.

Part 4 Common Items in All Areas

1. Global Warming Forecast Studies and Technical Development

In terms of a global warming forecast study, MAFF has so far conducted aprojected impacts of the agriculture, forestry and fisheries industries and, by presenting future impact assessments, contributed to the preparation of the IPCC and various other reports, etc. In terms of technical developments, MAFF has mainly developed techniques in order to adapt to issues that are currently occurring due to impacts such as declining quality of paddy field rice and fruit trees.

While enhancing efforts on items requiring highly accurate forecast studies on climate change impacts on the agriculture, forestry and fisheries industries, MAFF will hereafter aim to provide substantial information concerning such items, in order to provide communities with an opportunity to tackle climate change.

As for technical developments, MAFF will develop varieties and breeding materials in light of the mid- and long-term viewpoints based on forecast studies as well as production stabilizing technologies, and develop techniques in order to utilize opportunities brought about by climate change.

MAFF will continue to develop cultivation techniques adaptive to climate change and crops resistant to drought, develop techniques contributing to international contributions, and provide assistance for such technical developments.

2. Expanding Measures to Regions Based on Projected Impacts

By providing information concerning various measures indicated in a more detailed impact assessment and this Plan, which is analyzed and organized in an easy-to-understand manner for each of the regions that are similar in terms of climate conditions and production items, etc., MAFF will assist the place of production to practice and promote the measures at its own discretion and prepare for future impacts.

Climate change affects not only the supply of the products, but also the surrounding environment such as farmland, forests, and related facilities as the infrastructure in the agriculture, forestry, and fisheries industries. Thus, MAFF will promote dissemination and enlightenment activities concerning the necessity of the measures among all levels of citizens, including users of agricultural, forestry, and fishery products, as well as consumers.

3. Heat Stroke among Farmers, Forestry Workers and Fishermen

(1) Impacts

(i) Current Conditions

In recent years, there has been an upward trend in the number of deaths due to heat stroke

during operation in the agriculture, forestry and fisheries industries, including working in greenhouses, undergrowth mowing operations and field work in the summer.

(ii) Projected Impacts

The rate of incidence of heat stroke is expected to increase throughout the country in the future. According to age brackets, the rate of increase is projected to be the highest among elderly people aged 65 or over. Thus, it seems that heat stroke impact will become more serious in the agriculture, forestry, and fisheries industries where the ratio of senior citizens is high.

(2) Efforts

As the whole government's initiative for heat stroke, the government designated July as a "Heat Stroke Prevention Awareness Month" and set up a Heat Stroke-Related Liaison Conference comprised of relevant ministries and agencies for the purpose of examining and exchanging information on efficient and effective methods of ensuring heat stroke preventative measures are intensively implemented especially during the prevention month.

Prior to the prevention month, while requesting prefectures and relevant organizations to notify farmers, forestry workers and fishermen of precautions, such as frequent water intake, and wearing clothing made of perspiration-absorbing and quick-drying materials, MAFF prepares posters and flyers to raise awareness through the "Heatstroke Prevention-Communication Project", a private-public initiative

In coordination with relevant ministries and agencies, and in cooperation with prefectures and relevant organizations, MAFF will hereafter promote the dissemination and guidance concerning heat stroke prevention measures for farmers, forestry workers and fishermen including use of new technologies and instruments, such as highly breathable work clothes and a heat stroke meter, which notifies the wearer when the risk of heat stroke is high.

In some cases, workers engaged in the agriculture, forestry and fisheries industries work under harsh working conditions, such as under a scorching sun and on steep slopes. Thus, by proactively introducing robot technology and the ICT, as well as high-performance machinery, MAFF will aim to reduce the workload on such workers.

4. Wildlife Damage

(1) Impacts

(i) Current Conditions

Although a direct cause-effect relationship between wildlife damage and climate change is not clear, it is reported that expanding distribution of wildlife has caused damage to agricultural products, forest trees, and living aquatic resources and has caused soil runoff, etc.

(ii) Projected Impacts

Some have reported that expanding distribution of wildlife has caused damage to agricultural

products, forest trees and living aquatic resources, and has caused soil runoff, etc. However, at this point, there is no research projecting and assessing the cause-effect relationship between wildlife damage and climate change.

(2) Efforts

Until now, MAFF has taken the following measures in each area:

In the case of field crops, MAFF has taken efforts and provided assistance in building intrusion-preventive fences to prevent damage by wildlife, trapping, etc. In the case of forests and forestry, MAFF worked on installing guard fences to protect plantation wood and vegetation, and developing and demonstrating efficient control techniques. In the case of fisheries, MAFF implemented the following various measures: removing great cormorants, shooting northern sea lions with rifles for preventing and mitigating damage on fisheries, and promoting the introduction of improved fishing gears, etc., employing enhanced protective nets made of a new material.

While continuously working on installing exclusionary fences promoting population control, and improving techniques for controlling population and damage, MAFF will hereafter continue to grasp information on the condition of the habitats of wildlife and monitor damage on the agriculture, forestry and fisheries industries.

5. World Food Supply and Demand Forecasts

(1) Impacts to the world food balance

Due to damage caused by unfavorable climate such as frequently occurring droughts and torrential rain, the situation of the world food supply often becomes confusion. Accompanied by damage caused by unfavorable climate such as droughts in Australia from 2006 to 2007 and the subsequent export restriction, confusion such as food price hikes and riots over the food balance occurred. In 2012, the international crop prices such as corn recorded an all-time high due to high temperatures and dry conditions in the U.S., and thereafter, the international price of major crops remained high. Thus, the supply and demand of major crops is expected to be tight in the mid- and long term.

(2) Efforts

Under such conditions, in order to precisely respond to risks anticipating food supply and demand in Japan in the future, in consideration of the IPCC’s latest assessment results anticipating the situation in 2100 concerning climate change impacts on the world food supply and demand, MAFF will build a system forecasting world food supply and demand in the long term, which applies the most suitable forecast model including economic growth and population increases.

For the purpose of developing strategies toward securing a stable food supply in the midterm,

in consideration of climate change impacts and in light of social/economic trend including economic growth and the trend of policies of each country, MAFF will continuously conduct mid-term forecasts concerning world food supply and demand, in coordination with the Policy Research Institute, Ministry of Agriculture, Forestry and Fisheries.

While collecting and analyzing in an integrated manner information concerning food supply and demand overseas and impacts on stable food supply in Japan regarding the trend of world food supply and demand, MAFF will analyze the causes of impacts on stable food supply in Japan. Such information will be continuously and widely provided.

Furthermore, in order to supplement and enhance information concerning the trend of food supply overseas, MAFF will aim to obtain and accumulate earth observation data (including image analysis) such as soil moisture via satellite in collaboration with JAXA, and examine whether it is appropriate to analyze and utilize such data.

6. Continuous Review of the Adaptation Plan and Progress Management of Efforts

Taking advantage of the opportunity for obtaining the latest scientific knowledge of the IPCC, etc., and based on the latest assessment in light of the products of research, technical knowledge, and information obtained by implementing the measures, MAFF promotes this Adaptation Plan through continuous review aiming at its optimization, from the expert’s viewpoint in the agriculture, forestry and fisheries industries.

As for the measure efforts, when conducting inspections and progress management according to the system such as assessment of each project and research, it is necessary to promote such measures by appropriately incorporating the latest knowledge.

Furthermore, climate change impacts are the mid- and long-term issues accompanying the uncertainty. Thus, it is necessary to handle such issues in a flexible manner.