Tokyo Climate Change Adaptation Policy

CLIMATE CHANGE ADAPTATION

Table of Contents

1. Introduction

1.1 Background

As a result of extreme heat, heavy rains, and increasingly larger typhoons, there have been natural disasters, and increased risk of heatstroke, and deterioration in crop quality. These phenomena, which are considered to be impacts of climate change, are occurring throughout Japan and appearing here in Tokyo as well.

In recent years, natural disasters have occurred frequently, due to typhoons and heavy rains in particular. For example, record rainfall was observed during Typhoon No. 19 in 2019, particularly in eastern Japan, causing enormous damage. In Tokyo, damages included flooding and the collapse of roads due to rivers overflowing. Furthermore, these impacts are expected to expand for extended periods.

For these reasons, we have to focus on adaptation measures, with the aim of avoiding or reducing damage caused by the impacts of this inevitable climate change as well as working on, more than ever, mitigation measures to reduce greenhouse gas emissions, a factor of global warming.

The Paris Agreement, an international movement concerning climate change, was adopted in December 2015 under the United Nations Framework Convention on Climate Change, and came into effect in November 2016. The Paris Agreement aims to strengthen the global response to the threat of climate change. In addition to the mitigation goals of holding the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels, The agreement also sets the adaptation goal of increasing the capacity and resilience to adapt to the impacts of climate change.

In Japan, the Climate Change Adaptation Act was enacted in June 2018 to clarify the legal status of climate change adaptation and encourage all stakeholders to further promote climate change adaptation, and came into effect on December 1, 2018.

The impacts of climate change vary greatly, depending on regional characteristics. Therefore, it is essential that local governments familiar with regional characteristics take the initiative in systematically developing policies according to local circumstances.

1.2 Purpose of Formulating this Policy

Severe impacts of climate change, such as extreme heat and heavy rains in recent years, already affect our daily lives.

In light of this situation, the Tokyo Metropolitan Government (TMG) is promoting efforts to realize a Zero Emission Tokyo that will contribute to the goal of global net zero CO_2 emissions by 2050.

In conjunction with these efforts, and taking into account the impacts of climate change in Tokyo, we have formulated the Tokyo Climate Change Adaptation Policy. This policy shows TMG's approaches toward the formulation of our Climate Change Adaptation Plan, in order to avoid or reduce as much as possible the impacts on or damage to the lives of Tokyo residents and the natural environment in a broad range of fields, including natural disasters, human health, and agriculture, forestry, and fisheries.

By implementing various initiatives based on this policy in addition to efforts to realize a Zero Emission Tokyo, we will comprehensively develop both mitigation and adaptation measures for climate change to build a robust city that protects the lives and property of Tokyo residents from extreme changes in climate.

1.3 Positioning

This policy summarizes TMG's current approaches for formulating its Local Climate Change Adaptation Plan based on Article 12 of the Climate Change Adaptation Act.

2. Past Conditions and Predicted Future Changes in Climate

2.1 Past Climate Conditions

Past climate conditions in Tokyo are categorized in three areas: the 23 wards, the Tama area, and islands. The conditions are compiled based on the data from weather stations of the Japan Meteorological Agency. The values for the 23 wards have been taken from Tokyo Regional Headquarters, JMA, and those for Tama area are the average of three locations, Fuchu, Hachioji, and Ome. Those for the islands are the average of three locations, Miyakejima, Hachijojima, and Chichijima.

(1) Annual average temperature

The annual average temperature has been increasing in the 23 wards, Tama area, and islands.

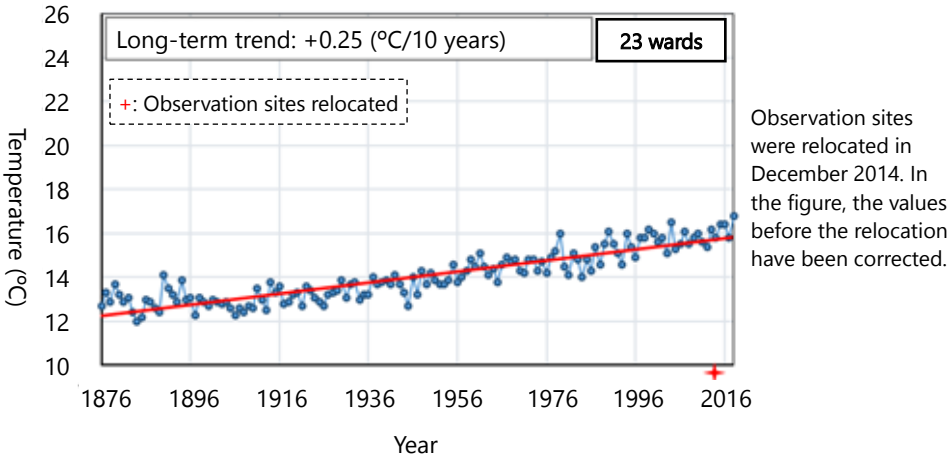


Figure 2.1.1: Yearly changes in annual average temperature (23 wards: 1876-2018)

Source: Tokyo Regional Headquarters, JMA. Report on Changes in Climate 2018 (Japanese).

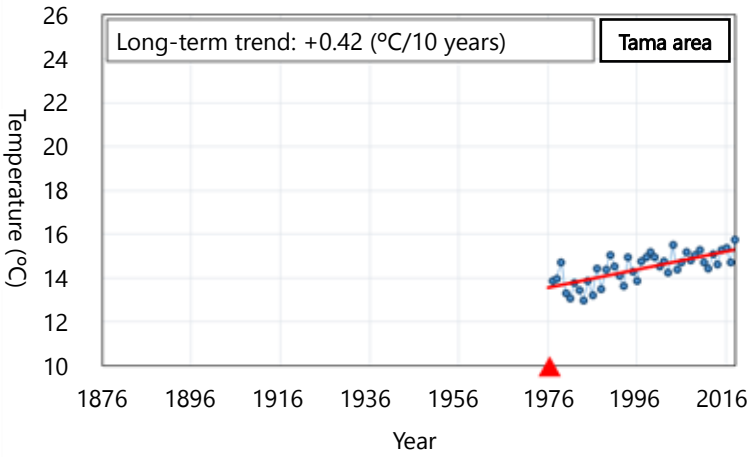


Figure 2.1.2: Yearly changes in annual average temperature (Tama area: 1977-2018)

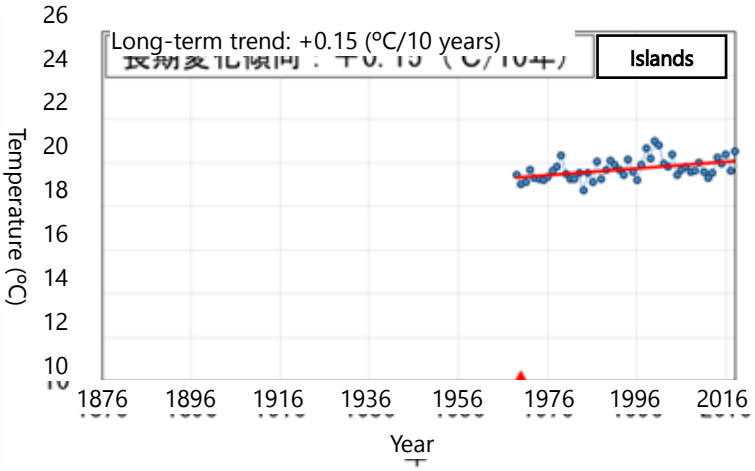


Figure 2.1.3: Yearly changes in annual average temperature (Islands: 1969-2018)

(2) Annual average daily maximum temperature and annual average daily minimum temperature

The annual average daily maximum temperature and daily minimum temperature have been increasing in the 23 wards, Tama area, and islands.

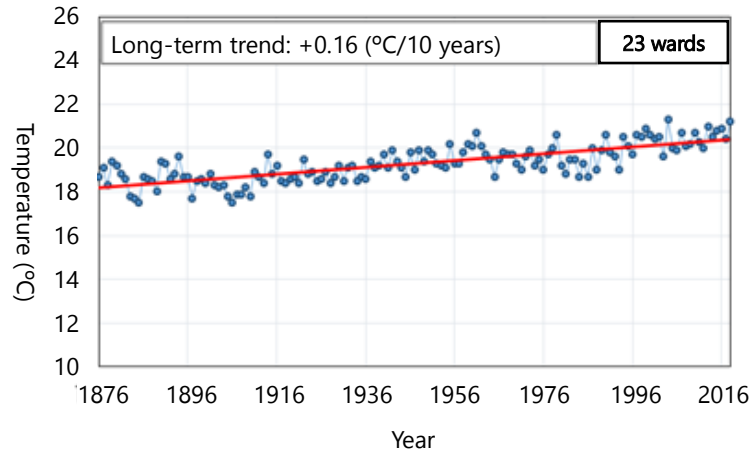


Figure 2.1.4: Yearly changes in annual average daily maximum temperature (23 wards: 1876-2018)

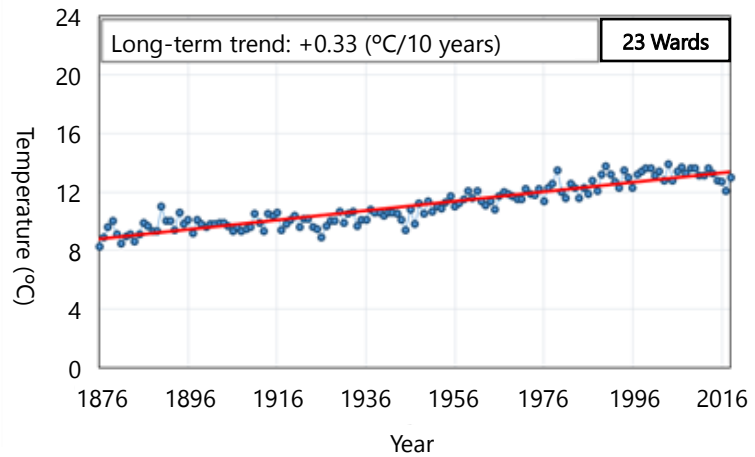


Figure 2.1.5: Yearly changes in annual average daily minimum temperature (23 wards: 1876-2018)

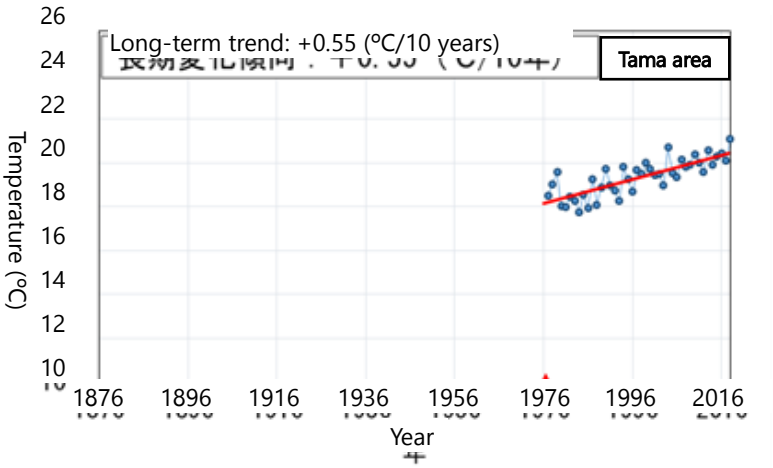


Figure 2.1.6: Yearly changes in annual average daily maximum temperature (Tama area: 1977-2018)

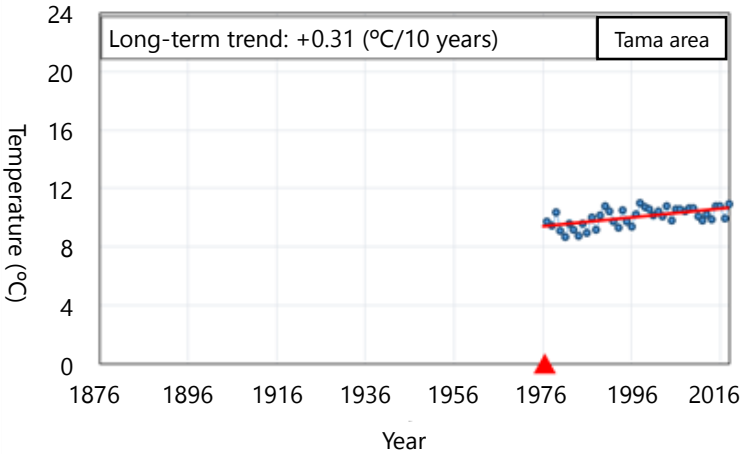


Figure 2.1.7: Yearly changes in annual average daily minimum temperature (Tama area: 1977-2018)

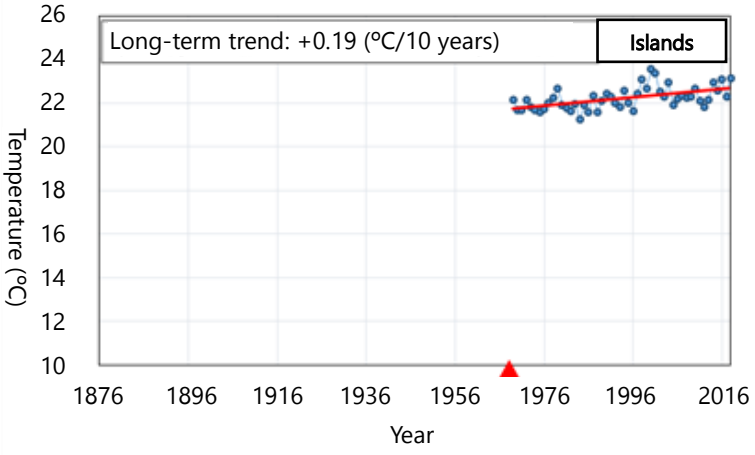


Figure 2.1.8: Yearly changes in annual average daily maximum temperature (Islands: 1969-2018)

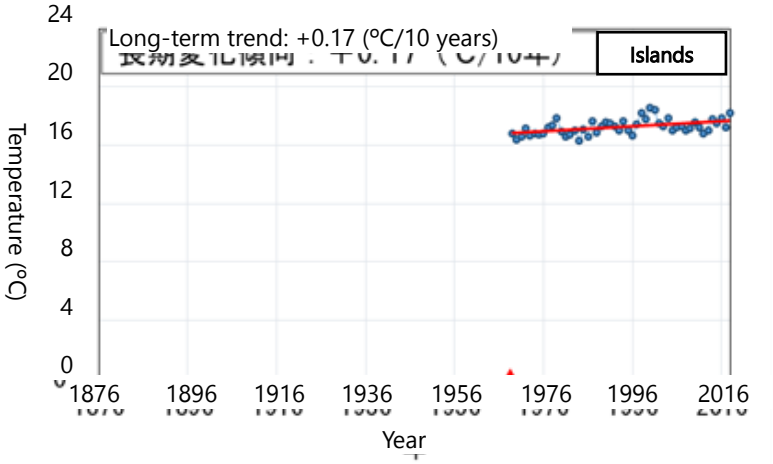


Figure 2.1.9: Yearly changes in annual average daily minimum temperature (Islands: 1969-2018)

(3) The number of sweltering days, extremely hot days, and sweltering nights[1]

The number of sweltering days (a day on which the temperature rises above 30°C) and sweltering nights has been increasing in the 23 wards, Tama area, and islands. The number of extremely hot days (a day on which the temperature rises above 35°C) has been increasing in the 23 wards and Tama area but such days have not been observed on the islands.

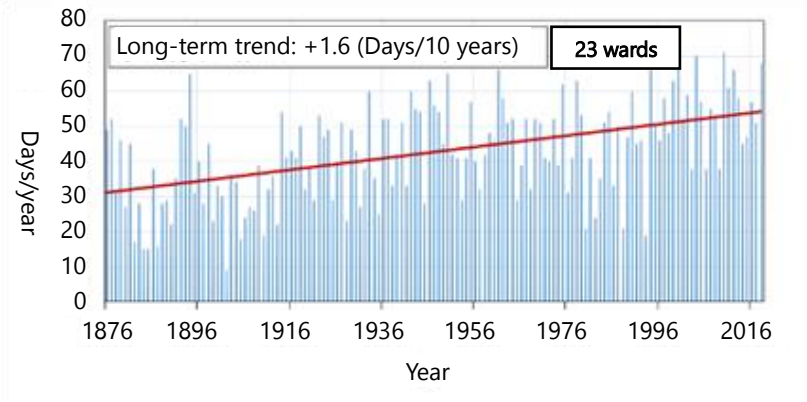


Figure 2.1.10: Yearly changes in the number of sweltering days (23 wards: 1876-2018)

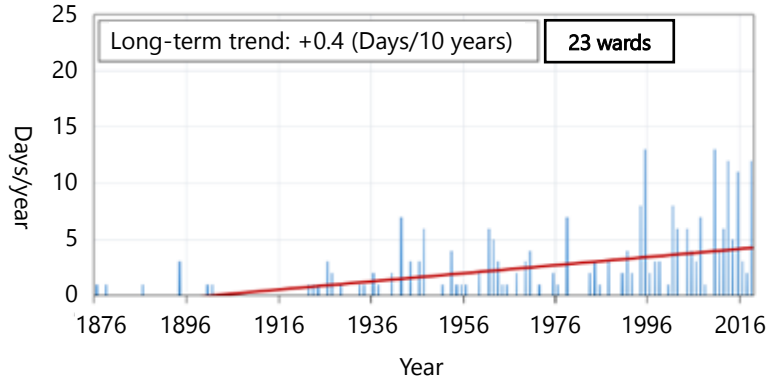


Figure 2.1.11: Yearly changes in the number of extremely hot days (23 wards: 1876-2018)

[1] A sweltering night means that the minimum temperature at night does not fall below 25ºC. This Policy considers a 24-hour period where the temperature does not drop below 25ºC as having a sweltering night.

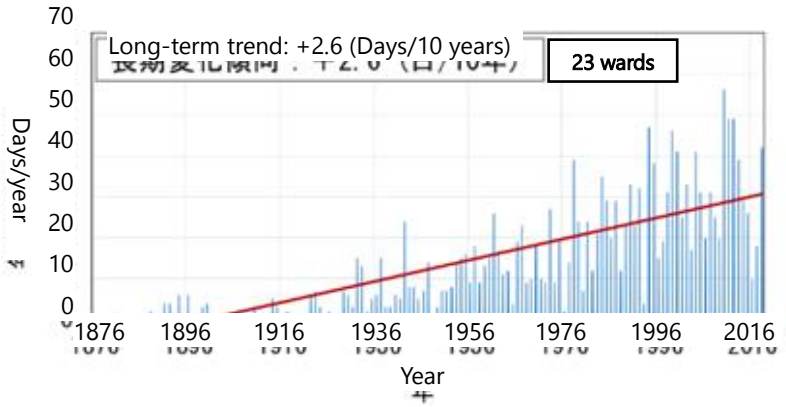


Figure 2.1.12: Yearly changes in the number of sweltering nights (23 wards: 1876-2018)

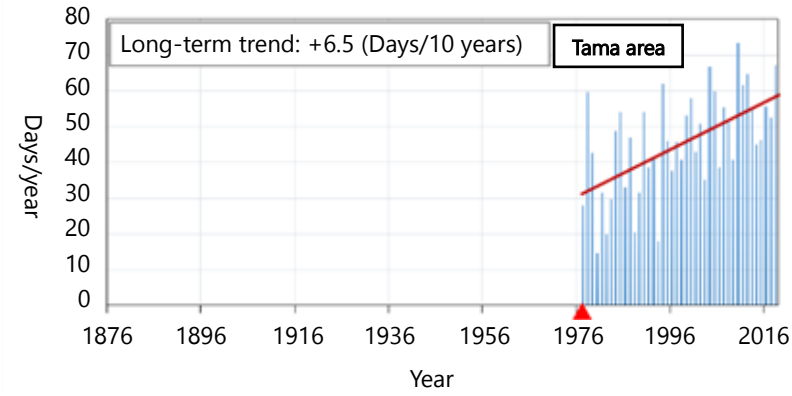


Figure 2.1.13: Yearly changes in the number of sweltering days (Tama area: 1977-2018)

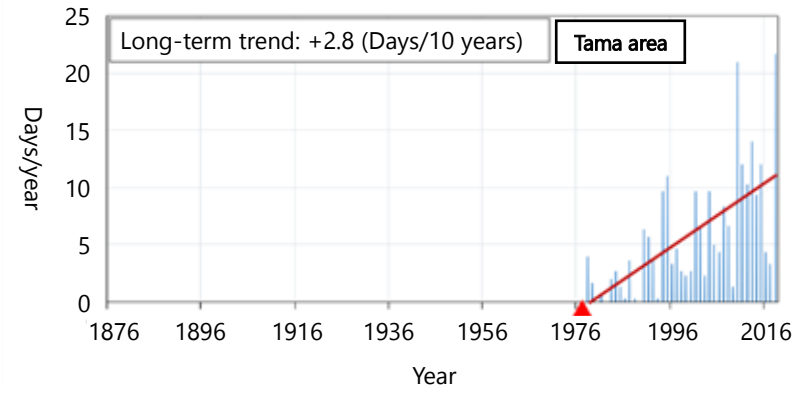


Figure 2.1.14: Yearly changes in the number of extremely hot days (Tama area: 1977-2018)

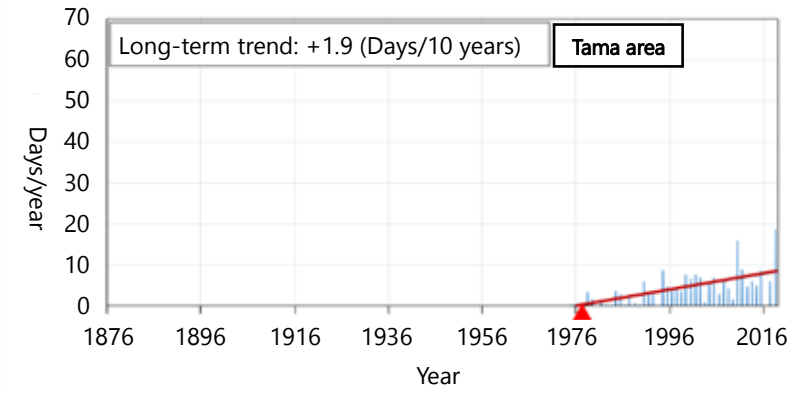


Figure 2.1.15: Yearly changes in the number of sweltering nights (Tama area: 1977-2018)

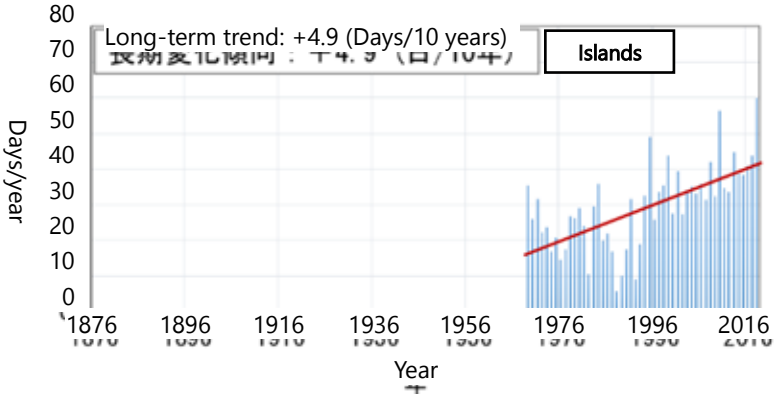


Figure 2.1.16: Yearly changes in the number of sweltering days (Islands: 1969-2018)

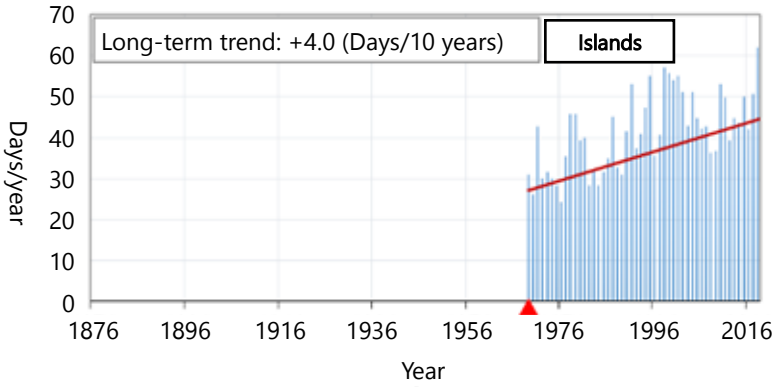


Figure 2.1.17: Yearly changes in the number of sweltering nights (Islands: 1969-2018)

(4) Precipitation and days with no precipitation[1]

Precipitation has fluctuated greatly year by year, showing no clear trend in the 23 wards, Tama area, or islands.

The number of days with no precipitation has been increasing in the 23 wards, while there is no clear trend in the Tama area or islands.

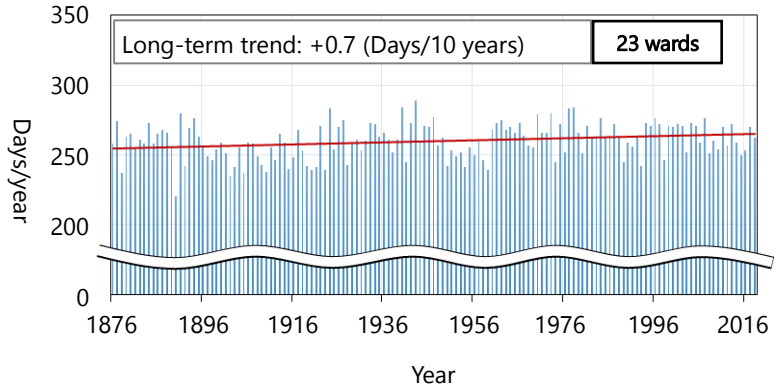


Figure 2.1.18: Yearly changes in the number of days with no precipitation (23 wards: 1876-2018)

[1] Days with less than 1 mm of precipitation are considered as days with no precipitation.

(5) Torrential rains

As there is insufficient data for the number of annual torrential rains (precipitation of 50mm or more per hour), no clear trend has been identified for the 23 wards, Tama area, or islands. However, according to the number of the occurrences at 1,300 locations throughout Japan compiled by the Japan Meteorological Agency, the average number of annual occurrences (approximately 311) during the past 10 years (2009-2018) is approximately 1.4 times the number (approximately 226) for the first 10 years (1976-1985) of statistics being compiled.

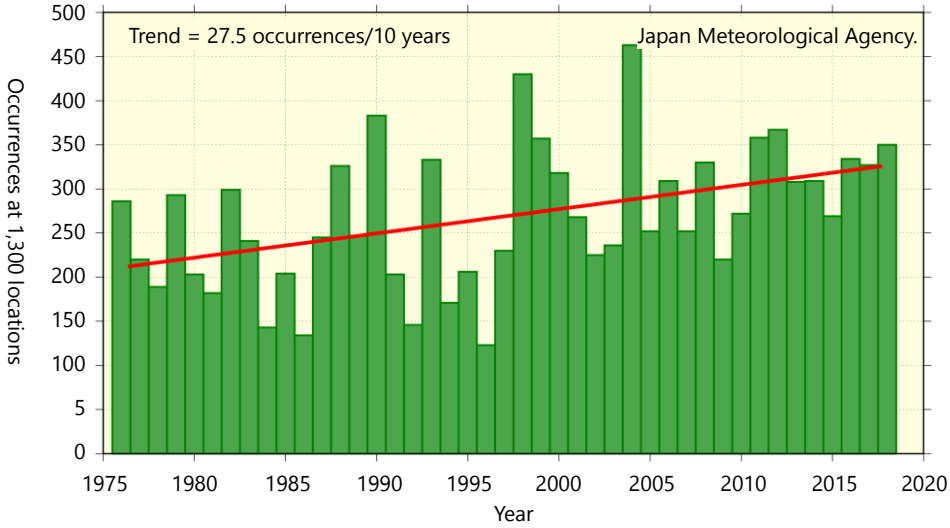


Figure 2.1.19: Yearly changes in the number of annual occurrences of hourly precipitation of 50 mm or more across Japan (1976-2018)

Source: Website of Japan Meteorological Agency.

(6) Typhoons

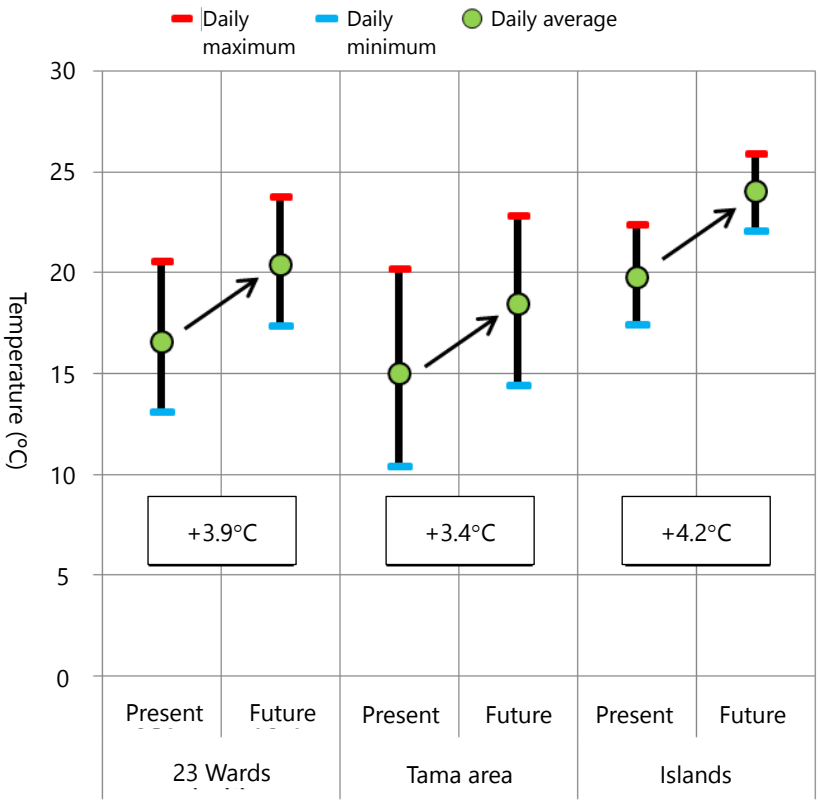
In 2018 there were 29 typhoons, which is slightly more than the average formation of 25.6 typhoons per year (average of 30 years from 1981 to 2010). Since the late 1990s, the number of years with fewer occurrences compared to previous years has been increasing. However, there have been no significant changes in the number of occurrences and landings during the statistical period from 1951 to 2018.

2.2 Predicted Future Changes of Climate

Predicated future changes of climate were forecast using the Global Warming Prediction Information Volume 9[1] (Japan Meteorological Agency), which contains forecasts based on the highest of the 4 greenhouse gas emission scenarios (RCP8.5 Scenario) used in the Intergovernmental Panel on Climate Change's (IPCC) Fifth Assessment Report. For each item (excluding (4) Typhoons), the future (10-year average for 2086-2095) and present (10-year average for 2009-2018) for the 23 wards, Tama area, and islands are compared.

(1) Temperatures

In the 23 wards, Tama area, and islands, temperatures in the future are expected to be higher than those at present. It is also predicted that daily minimum temperatures in all areas will increase more sharply than average temperatures and daily maximum temperatures.



10-year averages for 2009-2018 and 2086-2095 are used for the comparison of the present and future values.

Figure 2.4.1: Comparison of present and future temperatures

[1] The data in the Global Warming Prediction Information Volume 9 was created based on the data calculated in the Program for Risk Information on Climate Change of the Ministry of Education, Culture, Sports, Science and Technology, using a climate model developed by the Meteorological Research Institute.

(2) The number of sweltering days, extremely hot days, and sweltering nights

It is predicted that there will be more sweltering days, extremely hot days, and sweltering nights in the future than at present.

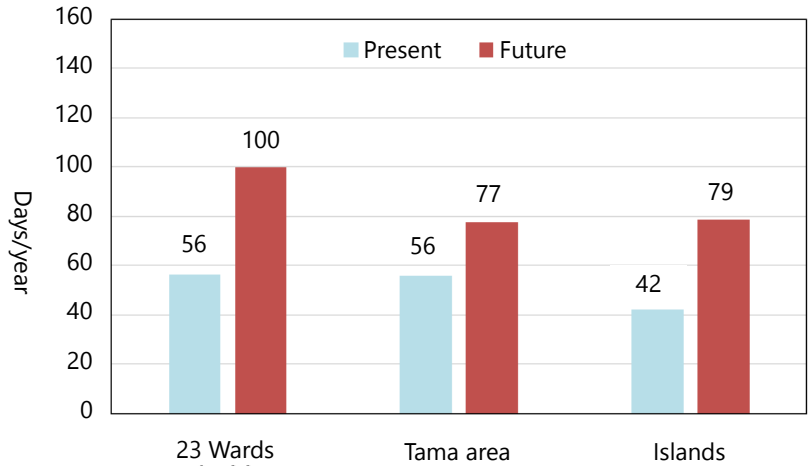


Figure 2.4.2: Comparison of the number of sweltering days at present and in the future

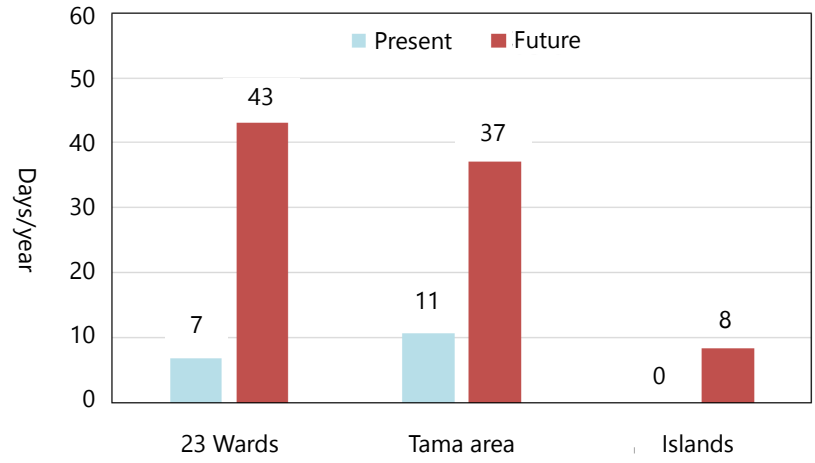


Figure 2.4.3: Comparison of the number of extremely hot days at present and in the future

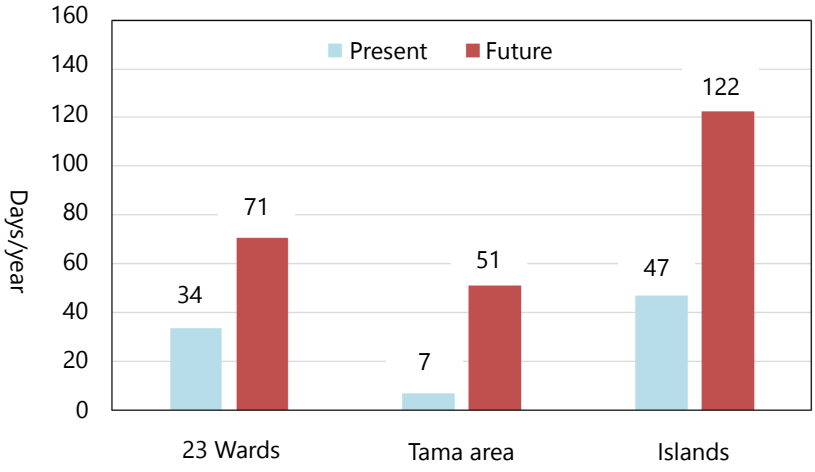


Figure 2.4.4: Comparison of the number of sweltering nights at present and in the future

(3) Annual precipitation, torrential rains, and days with no precipitation

Annual precipitation in the 23 wards and islands shows a decrease in the future while that in the Tama area shows an increase, indicating different trends between the areas.

Torrential rains and days with no precipitation show an increase in all areas.

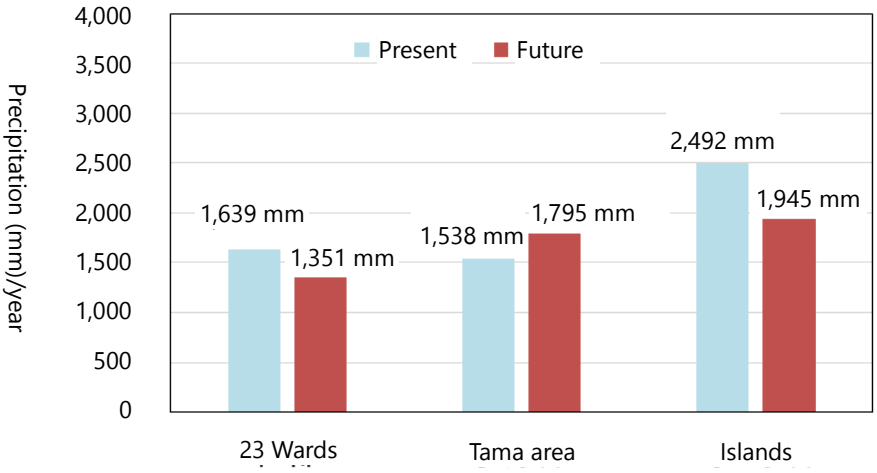


Figure 2.4.5: Comparison of present and future annual precipitation

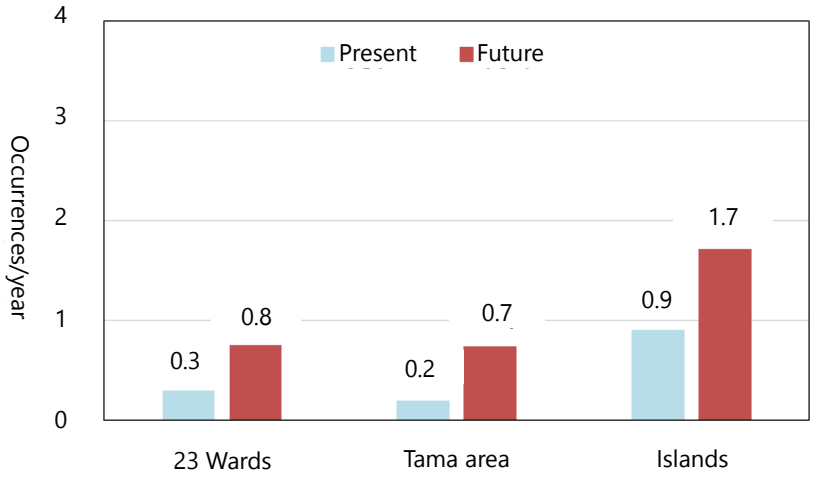


Figure 2.4.6: Comparison of the number of annual torrential rains at present and in the future

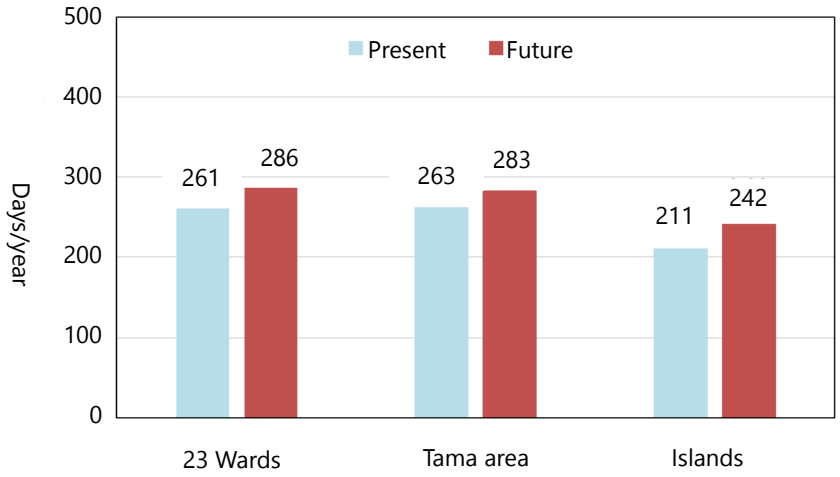


Figure 2.4.7: Comparison of the number of days with no precipitation at present and in the future

(4) Typhoons[1]

Although there is much uncertainty when it comes to future projections of typhoons, it is predicted that global warming will generally reduce the number of typhoons formed in the Northwest Pacific. Fewer typhoons will approach Japan as waters with the highest number of typhoons formed will move away from the Philippines to the east. However, it is expected that the maximum intensity of extremely strong typhoons will significantly increase and such typhoons will reach, with that intensity maintained, the middle latitude belt including Japan.

[1] *Integrated Report on the Observation, Forecast, and Impact Assessment of Climate Change 2018 - Climate Change and its Impacts in Japan*, February 2018 (Japanese).

3. Basic Approaches to Adaptation

3.1 Basic Approaches

With the increasing severity of climate change impacts, we have to steadily promote mitigation to reduce CO_2 emissions. To avoid or reduce climate change impacts that still remain after strict mitigation efforts, we must also develop adaptation at the same time.

TMG will realize a city that continues to attract people and businesses by being committed to protecting the lives and property of Tokyo residents.

3.2 Basic Strategies

To ensure the comprehensive and systematic promotion of climate change adaptation measures, we have formulated the following basic strategies under which relevant bureaus and departments will work together to effectively promote the measures.

Basic strategy (1): Implement climate change adaptation into all of TMG's initiatives.

The effects of climate change adaptation are appearing in a broad range of fields, including natural disasters, human health, and agriculture, forestry, and fisheries. TMG will address climate change impacts at present and in the future by incorporating climate change adaptation into all relevant initiatives.

Basic strategy (2): Promote climate change adaptation based on scientific knowledge.

Scientific knowledge, such as future projections of climate change and its impacts, is constantly renewed in parallel with advancements in research and study. TMG will promote adaptation measures based on the latest scientific knowledge.

In addition, we will actively utilize the latest technologies related to climate change adaptation.

Basic strategy (3): Support local efforts in cooperation with municipalities.

It is essential to develop policies according to local circumstances as the impacts of climate change vary greatly, depending on regional characteristics. TMG will support local efforts by actively providing information so that municipalities can develop their community-based initiatives.

Basic strategy (4): Promote dissemination of information, including risks, to facilitate understanding of Tokyo residents.

The understanding of Tokyo residents is indispensable for promoting initiatives for climate change adaptation. This poses the necessity of aggressively raising awareness of climate change adaptation. TMG will develop a system to collect and provide information on climate change adaptation and actively disseminate the information.

Basic strategy (5): Promote international cooperation in C40 and other organizations to accelerate intercity collaboration.

The impacts of climate change and countermeasures for the impacts have become a global challenge. TMG will accelerate intercity collaboration by utilizing organizations in which TMG has membership, such as C40, in order to share knowledge.

4. Climate Change Impacts and Policies for Response

This Policy summarizes climate change impacts and policies for response for each of the following five fields: ① natural disasters, ② health, ③ agriculture, forestry, and fisheries, ④ water resources and water environment, and ⑤ natural environment.

Climate change impacts are described mainly based on the national government's Climate Change Adaptation Plan (November 2018) and the Integrated Report on the Observation, Forecast, and Impact Assessment of Climate Change 2018 - Climate Change and its Impacts in Japan (February 2018).

4.1 Natural Disasters

4.1.1 Climate Change Impacts

(1) Floods and inland floods

Increased heavy rains, rising sea levels, and increasingly larger typhoons are likely to cause more enormous and frequent flood inundations[1]. On low-lying areas near rivers, it is anticipated that the likelihood of inland floods will increase causing longer inundation times as river water levels will rise more frequently resulting in difficulty in draining rainwater from the sewer system[2].

(2) Storm surges and high tidal waves

The rising sea levels and increasingly larger typhoons will increase the risk of inundation due to high waves.

In addition, it is predicted that the risk of high waves along the Pacific coastal area may intensify due to increasingly larger typhoons, and breakwaters at harbors and fishing ports will be damaged due to an increase in wave height and larger tide level deviations.

(3) Landslides

Increased heavy rains are likely to cause more frequent landslides. There is a concern that an increase in sudden and localized heavy rainfall will cause more landslides with shorter lead times for alerts or evacuation, and record rainfall due to typhoons will cause more deep-seated landslides.

[1] *Evaluation Report on the Impacts of Climate Change in Japan,* March 2015 (Japanese).

[2] *Report on the Evaluation of the Impacts of Climate Change in Japan and Challenges in the Future (offering of opinions),* March 2015 (Japanese).

4.1.2 Policies for Response and Main Measures

○ In response to natural threats, such as heavy rains, river flooding, landslides, and frequent tidal waves, TMG will protect the lives and property of Tokyo residents through structural and non-structural measures, including the utilization of state-of-the-art technologies and development of urban facilities.

○ To cope with increasingly larger typhoons and more frequent heavy rains in recent years, TMG will further improve our initiatives.

Structural measures (infrastructure development)

- Maintain and expand regulating reservoirs to achieve the capability to deal with rainfall of 65 or 75 mm/hour.
- Maintain river revetment, including widening of river channels and excavation of riverbeds.
- Develop stormwater storage facilities to enhance stormwater drainage capacity of sewerage systems.
- Flood control in large underground malls and subways.
- Promote the removal of utility poles to be better prepared for natural disasters, such as increasingly larger typhoons.
- Maintain facilities for protection from tidal waves.
- Prioritize erosion control work in landslide prone areas where evacuation centers are located.
- Construct wide-area water transmission pipe networks to ensure water supply in the event of a disaster.

Structural measures (maintenance of materials and equipment)

- Provide flood control materials and equipment to volunteer fire corps.
- Install or enhance private power generation facilities at purification plants.
- Support the installation of an emergency power supply at local government buildings.
- Improve the maintenance of private power generation facilities at disaster base hospitals.
- Promote the spread of residential solar power generation and storage batteries.
- Install restrooms of public schools used as evacuation centers in the event of a disaster.

Non-structural measures (preparation)

- Ensure broader spread of "Tokyo My Timeline."
- Enhance the Disaster Preparedness Tokyo App.
- Promote utilization of the Tokyo Disaster Readiness Guide.
- Reconstruct the disaster information system.
- Distribute flood risk maps.
- Create and distribute VR videos of storms and flooding.
- Promote experience-based training at the Life Safety Learning Centers and on the VR Disaster Simulator Truck.
- Revise flood inundation area maps assuming the heaviest possible rainfall.
- Raise public awareness of disaster preparedness through "plain Japanese."
- Create a pocket manual for use in case of an emergency or disaster.
- Train volunteer coordinators for disasters.

Non-structural measures (during a disaster)

- Ensure an emergency water supply system to protect the lives of Tokyo residents in the event of a natural disaster.
- Provide information to protect Tokyo residents from storm surges.
- Improve collection and distribution of information on river water levels.
- Enhance Tokyo Amesh (multilingualization).
- Deploy "HQR (TFD Head Quarters Rescue Operation Forces)"responding to abnormal weather-caused catastrophic disaster for immediate fact-finding and rescue activities.
- Dispatch TMG disaster language volunteers.

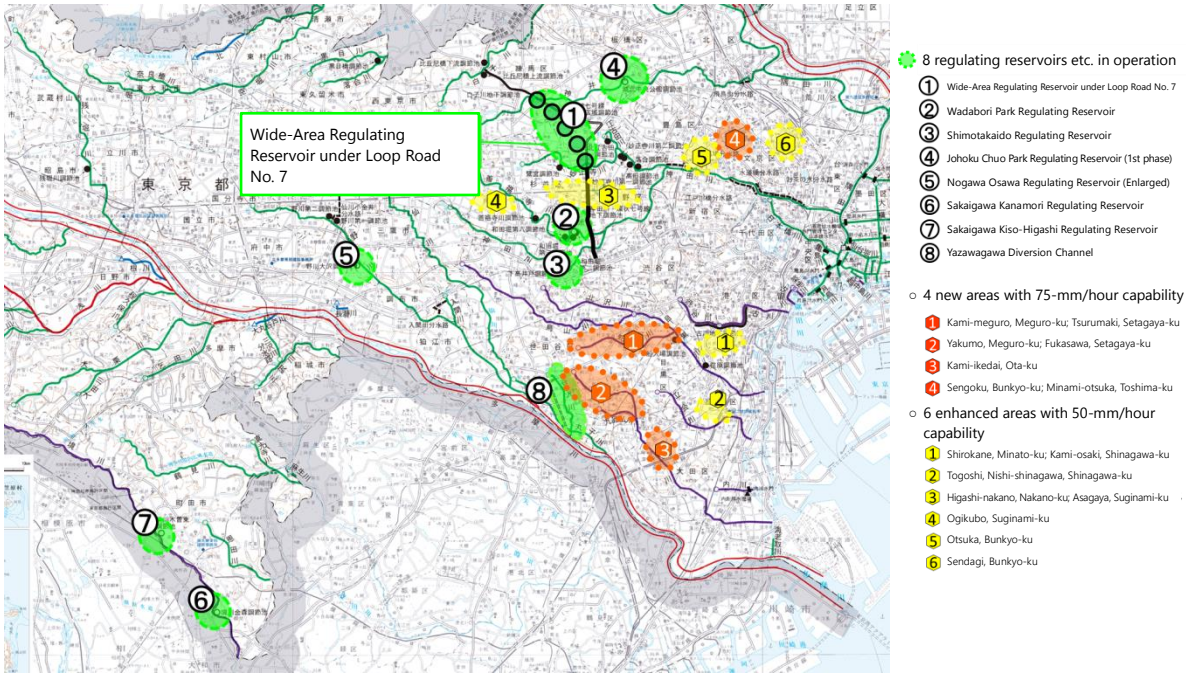
Typical examples of initiatives:

Maintain and expand regulating reservoirs to achieve the capability to deal with rainfall of 65 or 75 mm/hour.

Develop stormwater storage facilities to enhance stormwater drainage capacity of sewerage systems.

- Promote the maintenance of regulating reservoirs in operation, the study to operationalize new regulating reservoirs, and the study and early operationalization of the extension of the wide-area regulating reservoir under Loop Road No. 7.
- Examine the addition of new areas to sewerage systems with the capability to cope with rainfall of 75 mm/hour, to and steadily promote the development of facilities with the capability to cope with rainfall of 50 mm/hour.

8 regulating reservoirs in operation and areas emphasized in measures under the Sewerage Emergency Plan for Heavy Rains



Typical examples of initiatives:

Promote the removal of utility poles to be better prepared for natural disasters, such as increasingly larger typhoons.

- Promote the removal of utility poles from Tokyo metropolitan roads, municipal roads, and private development projects to avoid their collapse during earthquakes, storms and flooding, and prevent them from hindering response to disasters.
- Continue financial and technical support to promote the removal of utility poles from municipal roads and share know-how related to banning the construction of new utility poles.

Before

After

Typical examples of initiatives:

Ensure broader spread of “Tokyo My Timeline.”

- Create Tokyo My Timeline, which puts together materials for thinking about evacuation from floods on a daily basis so that each Tokyo resident can properly understand the disaster preparedness information required for evacuation and evacuate in a manner suitable for their environment and regional characteristics.
- Make effective use of the Tokyo My Timeline to further raise Tokyo residents’ awareness of storms and flooding.

Tokyo My Timeline set

Guidebook

My Timeline Sheets

Stickers

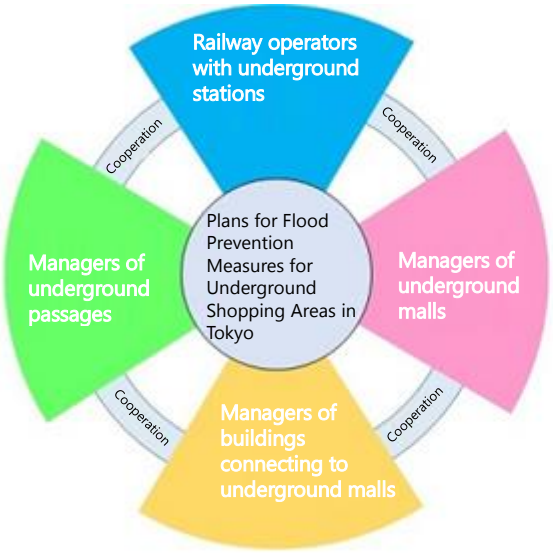
Guidebook for Elementary Students

Typical examples of initiatives:

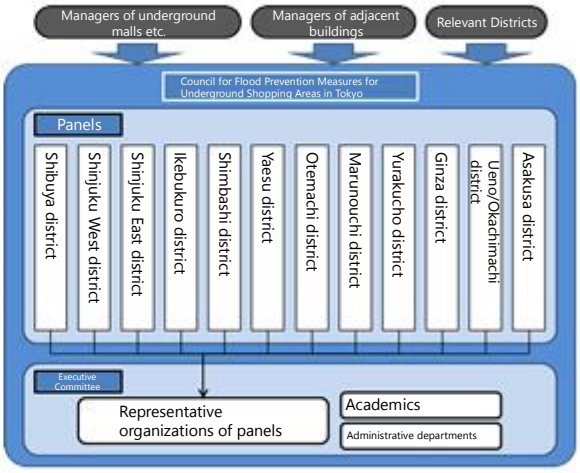
Expand measures against inundation in large underground malls and subways.

- Promote further enhancement of measures against inundation in underground spaces, including closer cooperation among managers of underground malls, subways, and adjacent buildings, by helping relevant private managers and the administration work together through examination of countermeasures by the Council for Flood Prevention Measures for Underground Shopping Areas in Tokyo and formulation of countermeasure plans by each district.

Positioning of the plan



Structure of the council



- Strengthen measures against inundation for the Toei Subway by taking necessary additional measures in light of the announcement of new expected inundation areas that may assume the heaviest possible rainfall. Furthermore, examine more effective measures for early restoration from large-scale floods, such as overflowing of the Arakawa River.

Watertight door

Typical examples of initiatives:

Raise public awareness of disaster preparedness through "plain Japanese."

- Provide opportunities for foreigners to learn about and experience disaster preparedness and mitigation by offering disaster preparedness drills for foreigners using plain Japanese.
- Create a leaflet on disaster preparedness in plain Japanese to raise foreigners' awareness of disaster preparedness.
- Offer training for TMG disaster language volunteers to learn how to communicate using plain Japanese.

Disaster preparedness drill flyer

4.2 Health

4.2.1 Climate Change Impacts

(1) Heat

The more sweltering days and extremely hot days, the more deaths from heatstroke. The number of deaths from heatstroke continues to rise, and an increase in the number of sweltering days and extremely hot days will result in more deaths from the illness.

(2) Infectious diseases

Temperature rise and changes in the spatio-temporal distribution of precipitation due to climate change may change the distributional range of arthropods, such as mosquitoes, which transmit infectious diseases, and the rate of invasion or settlement of alien organisms which cause human damage. This may lead to a higher risk of arthropod-borne infectious diseases.

4.2.2 Policies for Response and Main Measures

○ TMG will further strengthen appropriate preventive and ex-post measures to minimize cases of heatstroke and infectious disease and adverse health effects due to temperature rise.

Heat countermeasures

- Promote urban greening to ensure shade in living spaces and mitigate heat.
- Develop cool spots to protect the health of Tokyo residents from extreme heat.
- Leverage knowledge and expertise of heat countermeasures as a legacy of the Tokyo 2020 games.
- Maintain heat blocking pavements, particularly in central Tokyo.
- Increase the number of residential buildings with improved thermal insulation.
- Install air conditioning equipment in indoor sports facilities at public schools.

Countermeasures for infectious diseases

- Reduce the risk of infectious disease outbreak by providing information on the occurrence of mosquito-borne infectious diseases, infection prevention measures, and appropriate measures to control mosquito sources.
- Conduct surveillance of mosquitoes, which transmit infectious diseases, and ensure an inspection system for pathogens.
- Promote measures against alien species, which cause human damage.

Typical examples of initiatives:

Promote urban greening to mitigate heat.

- Ensure the shade of trees block the blaze of the sun in summer by properly maintaining roadside trees, including planned pruning.
- Promote strategic and meticulous management and maintenance through the use of ICT and other methods to allow roadside trees to exercise various functions as green infrastructure.

Maintaining large tree crowns

After pruning in 2017 summer

After pruning in 2018 summer

Typical examples of initiatives:

Leverage knowledge and expertise of heat countermeasures at the Tokyo 2020 Games as a legacy.

- Taking the Tokyo 2020 Games as an opportunity, help TMG bureaus collaborate to implement measures, such as maintaining solar heat blocking pavement and utilizing misting devices to create cool areas.
- Encourage the Tokyo Metropolitan Research Institute for Environmental Protection, which has been engaged in research on countermeasures for the urban heat island effect, to collect and accumulate knowledge of heat countermeasures obtained at the Tokyo 2020 Games and provide relevant information.
- Comprehensively promote urban heat countermeasures as a legacy of the Games.

4.3 Agriculture, Forestry, and Fisheries

4.3.1 Climate Change Impacts

(1) Horticultural crops (flowers and vegetables)

For open-field vegetables, leaf vegetables, such as komatsuna (brassica vegetable), and root vegetables, such as radish, are harvested earlier due to higher temperatures. Poor growth at early stages of development has been increasing under high temperatures and dry conditions. In addition, fruit and vegetables also suffer from poor fruit set due to high temperatures, which appears prominently in tomato cultivation at facilities[1].

(2) Fruit

As for fruit in general, such as pears, germination and flowering have been accelerated because of warmer winter and spring seasons. This has resulted in damage, such as the death of flower buds and young shoots due to frost damage afterward. High temperatures in summer have caused problems, including poor coloration of grapes and sunburn on pears, kiwis, and other fruits. High temperatures and low rainfall following the fruit growth phase have brought about physiological disorders, including water core and cracking[1].

(3) Stockbreeding

For dairy cows and laying hens, measures such as ventilation and watering can be taken to reduce impacts. However, it is predicted that global warming will cause a decrease in milk production, declined egg production rates, and more soft shell eggs. Depending on breeding conditions, it is expected that global warming will expand areas where the growth of hogs and poultry will slow down, as well as increase the levels of the slowdown.

(4) Diseases and pests

Pests that prefer high temperatures, such as spider mites, codling moths, and thrips, have been occurring frequently and their periods of occurrence have been prolonged. There has been no increase in diseases clearly caused by climate change. However, damage to agricultural crops may be expanded due to the increased occurrence of pests or expansion of their distributional ranges.

(5) Agricultural production bases

An increase in extreme phenomena, such as abundant rainfall and droughts, and temperature rise, are expected to affect agricultural production bases across Japan. In addition, it is predicted that more frequent heavy rains and higher rainfall intensity will increase the risk of flooding in agricultural areas.

[1] Ministry of Agriculture, Forestry and Fisheries. *Global Warming Impact Investigation Report 2017,* October 2018.

(6) Forestry

Temperature rise and changes in precipitation patterns may increase water stress due to a dry atmosphere, leading to a decline in planted cedar forests.

(7) Fisheries

Catches of migratory fish may decrease due to sea temperature rising. For coastal and sessile species, it is predicted that catches of lefteye flounder, red sea bream, and black abalone will decrease in the long term. Seaweeds that make up seagrass beds are expected to be affected in the short term as well, depending on their species[1].

4.3.2 Policies for Response and Main Measures

○ TMG will realize a robust agriculture, forestry and fisheries industry by disseminating heat resistant breeds, switching to breeds that utilize the temperature rise, developing agricultural facilities, and researching the impacts of changes in the marine environment in response to concern about changes in suitable cultivation areas and deterioration in quality due to temperature rise and damage caused by typhoons.

Measures for agriculture, forestry, and fisheries

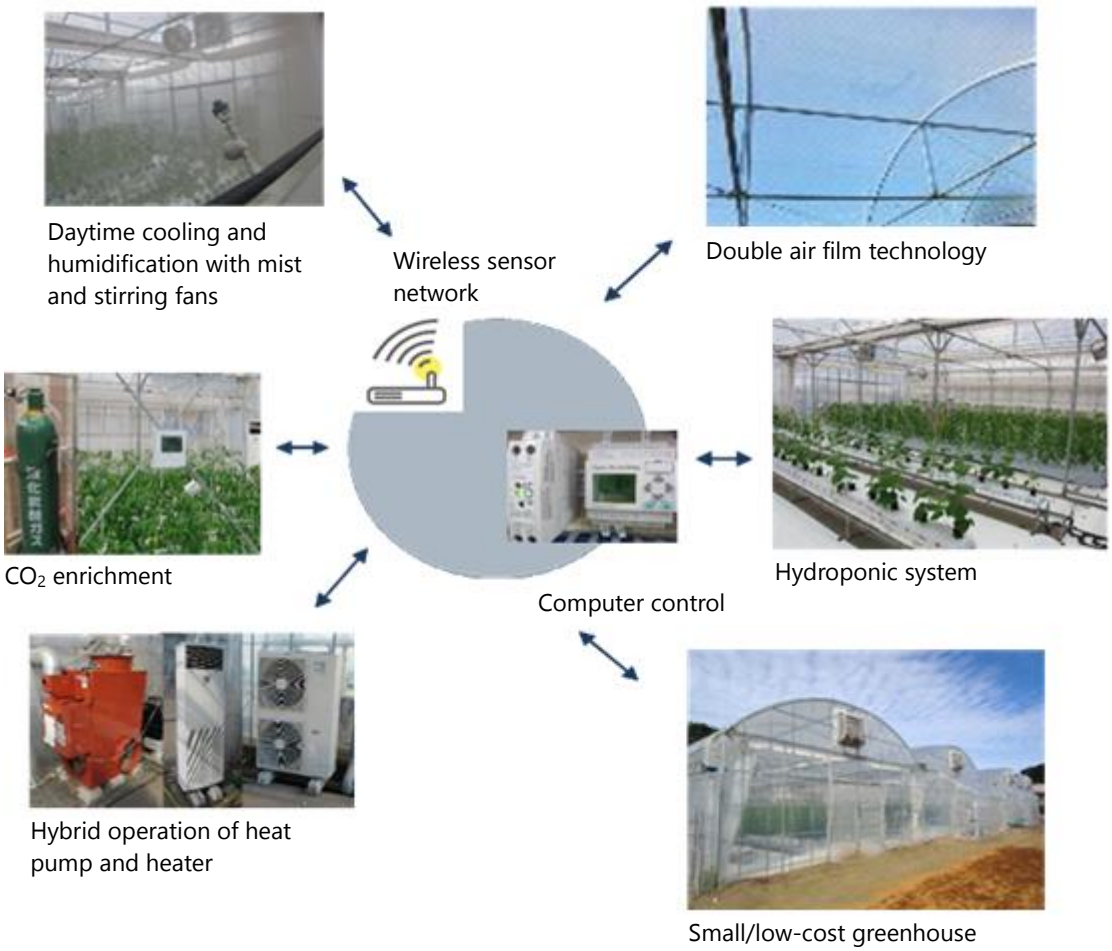
- Provide technical guidance for and promote the spread of switching to items and varieties compatible with temperature rise.
- Develop robust agricultural facilities that can withstand increasingly larger typhoons and better cope with extreme heat.
- Implement forest circulation through appropriate management and develop forests resistant to mountain disasters.
- Identify sea conditions, including water temperature and ocean currents, and conduct research and provide information concerning inhabitation of rocky shore resources, including shellfish and seaweeds.

[1] Hisami Kuwahara, Sadamitsu Aketa, Satoshi Kobayashi, Akira Takeshita, Hiroshi Yamashita, Katsutoshi Kido. *Prediction of changes in the distributional ranges of aquatic organisms in Japan due to global warming.* Global Environment Vol. 11 No. 1, 2006 (Japanese).

Typical examples of initiatives:

Develop robust agricultural facilities that can withstand increasingly larger typhoons and better cope with extreme heat.

- Develop Tokyo Future Agrisystem, an agricultural facility which realizes profitable agricultural management on small lots of agricultural land.
- Enable labor-saving control of temperature, humidity, and CO2 concentration during extremely hot seasons by using thick pipes in greenhouses for more wind resistance and introducing an ICT-based integrated environmental control system.
- Rapidly expand the use of this type of system to promote the development of Tokyo-style agriculture adapting to climate change.



4.4 Water Resources and Water Environment

4.4.1 Climate Change Impacts

(1) Water resources

Nine droughts have occurred in summer and winter since 1989 along the Tone River system, a major water source for Tokyo.

The available amount of water resources is expected to decrease due to larger fluctuations in annual and seasonal precipitation, more frequent light rainfall, changes in seasonal precipitation patterns, decrease in the amount of snow, and earlier snow melting[1].

(2) Water environment

Climate change is expected to cause changes in water temperature, water quality, and outflow characteristics of nutrient salts from the basin.

Predictions for rivers include: the possibility of more frequent heavy rains and torrential rains to cause worsening turbidity through more outflow of earth and sand, less dissolved oxygen due to higher water temperature, promotion of organic matter decomposition by microorganisms, and increased algae.

For enclosed sea areas, an increase in surface seawater temperature has been reported. In addition, it is expected that saltwater will run up to broader coastal areas as the sea level rises.

4.4.2 Policies for Response and Main Measures

○ TMG will reduce the risks posed by severe droughts and deterioration of raw water quality as much as possible to ensure stable supply of high-quality tap water.

○ TMG will create a comfortable water environment through improvements in water quality by enhancing the combined sewer system and developing advanced treatment facilities as well as through maintenance and improvement of the water quality of rivers and canals.

Stable supply of high-quality tap water

- Ensure mutual supply between river systems utilizing a raw water connecting pipe and the proper management of water conservation forests.
- Introduce purification technologies capable of correctly responding to changes in raw water quality and ensure thorough water quality management.

Measures for preservation of water quality of public water bodies

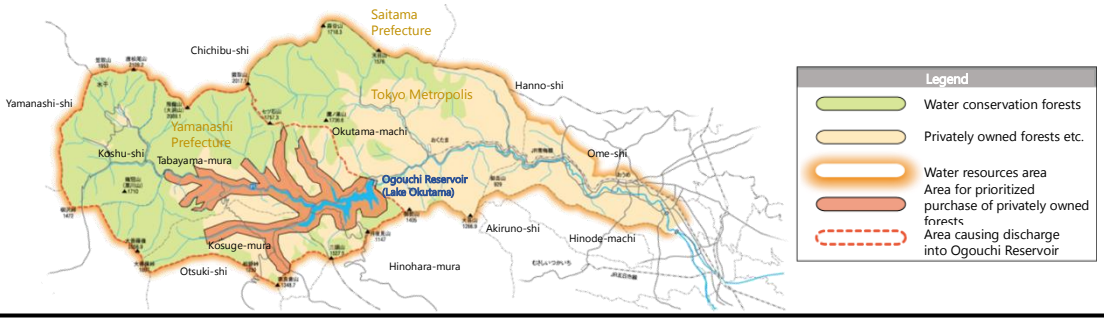
- Promote the development of facilities to capture initial stormwater mixed with sanitary sewage, which is particularly contaminated during a rain event, as well as the development of advanced treatment facilities.
- Dredge sludge from rivers and canals systematically.
- Promote monitoring of water quality of lakes and reservoirs, rivers, and sea areas as well as research and study of the aquatic organisms living there.

[1] Watanabe. *Global Warming and Water Issues in the World and Japan.* Water Resources and Environmental Studies Vol. 21 pp. 15-24, 2008.

Typical examples of initiatives:

Properly manage water conservation forests.

- Properly manage water conservation forests in the upper basin of the Tama River to improve the functions of the forests.
- To restore the privately owned forests, actively purchase privately owned forests which may discharge earth and sand into the Ogouchi Reservoir or conserve them by the Tama River Water Resources Forest Team.
- Cooperate with various actors to develop and manage forests including privately owned forests in the upper basin of the Tama River, and ensure a stable flow rate of the river and conserve the Ogouchi Reservoir.

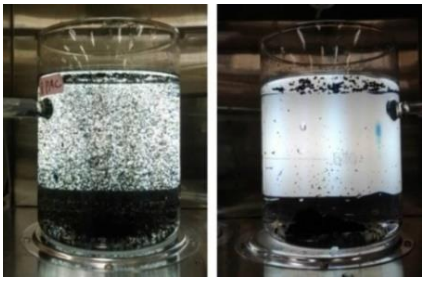


Typical examples of initiatives:

Introduce purification technologies capable of correctly responding to changes in raw water quality.

- Introduce high basicity polyaluminum chloride (PAC) which can use in a wider range of pH than PAC currently in use as a coagulant, in order to cope with an increase in raw water pH due to more days with no precipitation and decreased amount of snow.
- Examine the introduction of an organic polymer to aid coagulation with PAC and accelerate the sedimentation of suspended substances, in order to respond to more frequent increases in turbidity caused by outflow of earth and sand caused by more heavy rains and torrential rains.
- Consider the introduction of super powdered activated carbon along with the renewal or development of facilities as there is a concern about more frequent musty odors in high concentrations due to more algae being caused by higher water temperature.

Sedimentation facilitated by organic polymer coagulant



PAC only | PAC with organic polymer

4.5 Natural Environment

4.5.1 Climate Change Impacts

(1) Terrestrial ecosystem

Regarding natural and secondary forests, the suitable habitat of many component species of cool-temperate forests is expected to shrink as it moves to higher latitudes and higher elevations while the suitable habitat of many component species of warm-temperate forests is expected to expand as it moves to high latitudes and high elevations.

It is predicted that the population of wild animals and birds, such as Cervus nippon, will increase and their habitat will expand due to temperature rise and shorter periods of snow cover.

(2) Freshwater ecosystem[1]

In lakes, reservoirs and rivers, the algae production rate will increase due to temperature rise and an increase in CO_2. However, in a freshwater ecosystem with poor supply of nutrient salts, high trophic level production is predicted to decrease because the ecosystem's quality as feed degrades as algae increases.

(3) Coastal and marine ecosystems

In subtropical areas, coral bleaching has already occurred due to sea temperature rising. It is predicted that sea areas suitable for the growth of reef-building corals may disappear by 2040 due to higher water temperature and ocean acidification.

In Tokyo Bay, wintering of southern hemisphere green mussels native to Southeast Asia has been confirmed. In addition, there have been changes, such as southern hemisphere butterfly fish, which used to be seen only in summer, now being seen after autumn.

(4) Biological seasons

Impacts on various species are predicted, including earlier flowering dates of Somei-Yoshino cherry trees. It is expected that there will be impacts on not only individual species but also various interactions between species.

(5) Changes in distribution and populations

A study mentions the possibility that there will be changes in distributional ranges and life cycles, changes in species interactions due to the migration or local extinction of species will cause further adverse effects, and habitat fragmentation will prevent species migration following climate change, resulting in the extinction of species.

It is predicted that climate change will lead to changes in the invasion and settlement rates of alien species.

[1] Urabe J., J. Togari, and J. J. Elser. *Stoichiometric impacts of increased carbon dioxide on a planktonic herbivore*. Global Change Biology, 9, 818-825, 2003.

4.5.2 Policies for Response and Main Measures

○ TMG will minimize impacts on biodiversity, such as changes in the distribution of organisms, resulting from the impacts of climate change.

○ In order to improve resilience, TMG will strive to enhance efforts to utilize and restore the functions of the natural environment.

Biodiversity conservation

- Formulate a local biodiversity strategy that considers climate change impacts.
- Restore public benefits of forests through the reforestation project in the Tama area and pruning projects to increase water penetration.
- Expand conservation areas to protect valuable biodiversity.
- Operate the Greenery Program and Development Permit System.
- Promote the conservation of rare species and measures for alien species.
- Promote appropriate management of Cervus nippon.
- Conserve the natural environment by regulating behavior and developing facilities in vast natural parks.

Typical examples of initiatives:

Formulate a local biodiversity strategy that considers climate change impacts.

- Promote efforts to formulate a local biodiversity strategy, a plan for the conservation and sustainable use of biodiversity.
- Strive to conserve and restore biodiversity by promoting the conservation of the natural environment and strengthening water and green networks.
- Promote the enhancement and utilization of ecosystem functions related to adaptation to climate change and disaster preparedness and mitigation.

Satoyama (open light-filled woodland near populated areas) in Tokyo (Yokosawairi satoyama conservation area)

Urban greening (Mitsui Sumitomo Insurance Surugadai Building and Surugadai New Building)

5. Promotion of Adaptation Measures

5.1 Implementation System

As mentioned in Section 4, climate change affects various fields. Therefore, we need to consider and implement adaptation measures for the impacts of climate change for each sector and in a cross-sectoral manner. TMG will formulate a Local Climate Change Adaptation Plan based on Article 12 of the Climate Change Adaptation Act by the end of FY 2020, and make sure that adaptation measures are promoted by collaborative efforts throughout TMG.

From now on, TMG will coordinate with relevant organizations to establish the Local Climate Change Adaptation Center based on Article 13 of the Climate Change Adaptation Act in the Tokyo Metropolitan Research Institute for Environmental Protection which has been engaged in research on countermeasures for the urban heat island effect.

We will collaborate with the center to collect, organize, analyze, and provide information on climate change impacts and adaptation to climate change.

5.2 Role of Each Actor

5.2.1 Role of TMG

To encourage efforts for adaptation by Tokyo residents and businesses, TMG will actively provide information on climate change impacts and adaptation measures in cooperation with the national government, National Institute for Environmental Studies, and Local Climate Change Adaptation Center. TMG will address present and future climate change impacts by incorporating the perspective of adaptation into all of our initiatives.

At the same time, we will support efforts of municipalities developing community-based initiatives by strengthening cooperation with them.

5.2.2 Role of Municipalities

Municipalities are required to formulate a local climate change adaptation plan, ensure cooperation among related departments to actively incorporate climate change adaptation into relevant initiatives according to the natural, economic, and social circumstances of their local area, and promote policies regarding climate change adaptation in each field.

5.2.3 Role of Tokyo Residents

Tokyo residents are required to deepen their understanding of climate change impacts by utilizing information provided by the national government and TMG, and promote efforts to address climate change impacts by collecting information on the impacts by themselves.

5.2.4 Role of Businesses

Businesses are required to deepen their understanding of adaptation measures for climate change and climate change impacts on their business activities by utilizing information provided by the national government and TMG, and develop operations with the perspective of climate change adaptation embedded, keeping future climate change firmly in mind.

Reference

1. [Excerpt] Climate Change Adaptation Act (Act No. 50 of 2018)

Article 12 Local Climate Change Adaptation Plan

In view of the Climate Change Adaptation Plan, prefectures and municipalities shall, either independently or in coordination with each other, endeavor to formulate a local climate change adaptation plan (meaning a plan for adapting to climate change suitable to the natural, economic and social circumstances in their region) in order to promote policies regarding Climate Change Adaptation, in accordance with the natural, economic and social circumstances of their local area.

Article 13 Local Climate Change Adaptation Centers

(1) Prefectures and municipalities shall, either independently or in coordination with each other, endeavor to establish systems that will function as centers (referred to as "Local Climate Change Adaptation Centers" in the following paragraph and in paragraph (1) of the following Article), to collect, organize, analyze, and provide information regarding the Climate Change Impact and Climate Change Adaptation, and also to give technical advice in order to promote Climate Change Adaptation in their local area.

(2) Local Climate Change Adaptation Centers shall work to share gathered information and the results of organizing and analyzing this information with the National Institute for Environmental Studies.

2. Characteristics of Tokyo

This section summarizes natural conditions, such as terrain, and social conditions, such as population, in order to facilitate understanding of the Tokyo's characteristics toward the formulation of the Climate Change Adaptation Plan.

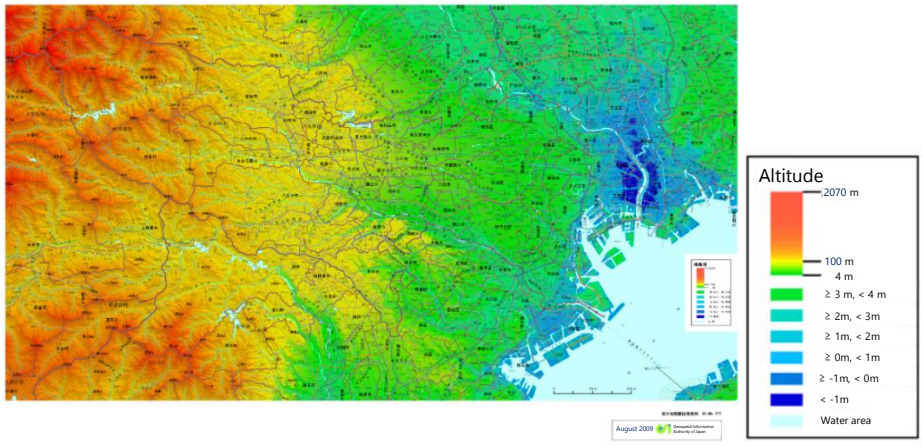
(1) Terrain

Tokyo is located in the Kanto Plain and faces Tokyo Bay. It consists of the 23 wards adjoining Tokyo Bay, the Tama area in the central western region, and the Izu and Ogasawara Islands. Having an area of 2,194 km^2, Tokyo is the third smallest prefecture in Japan after Kagawa (the smallest) and Osaka.

Excluding the islands, Tokyo is divided into mountain terrain in the west, hilly terrain in the central part, and plateaus and lowlands in the east. The western mountain terrain is the Kanto Mountains at an altitude of 1,500 to 2,000m, extending from the Chichibu Mountains in the north to the Tanzawa Mountains in the south. The central part consists of the Sayama Hills which extends into Saitama Prefecture and the rugged Tama Hills that reach the base of the Miura Peninsula in Kanagawa Prefecture. The eastern plateau is the Musashino Plateau covered by the Kanto Loam Formation. The Yamanote District in the ward area is located at the eastern end of the plateau, forming a rugged topography with a mix of plateaus and lowlands.

Rivers, including the Tama, Arakawa, and Edogawa Rivers, flow into Tokyo Bay. In their downstream basins, the Tama River and Edogawa River flow near the borders between Tokyo and Kanagawa and between Tokyo and Chiba, respectively.

The volcanic Izu and Ogasawara islands are scattered north and south on the Pacific Ocean.



Referential figure 2.1: Topographic map of Tokyo

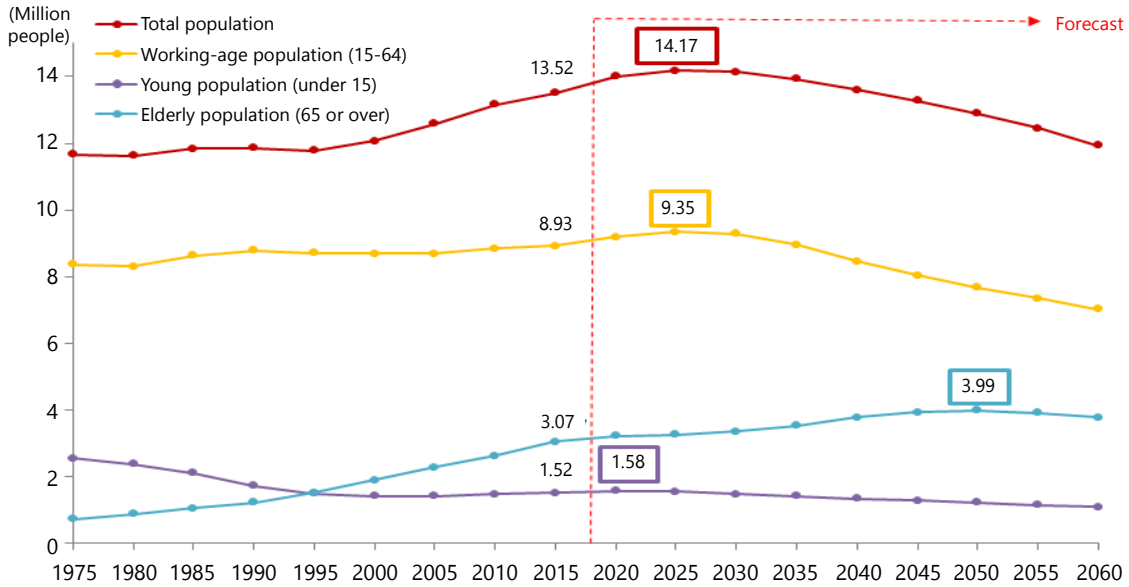
Source: Technical Data (D1-No. 777) of Geospatial Information Authority of Japan (Japanese).

(2) Climate

The climate of Tokyo, except the islands, is classified as being a humid subtropical climate. That is characterized by high temperature and humidity in summer and low rainfall and humidity in winter. The islands in the Pacific Ocean under the strong influence of the Kuroshio Current have a mild marine climate even in winter and a subtropical climate in the south. They are also often affected by typhoons.

(3) Population

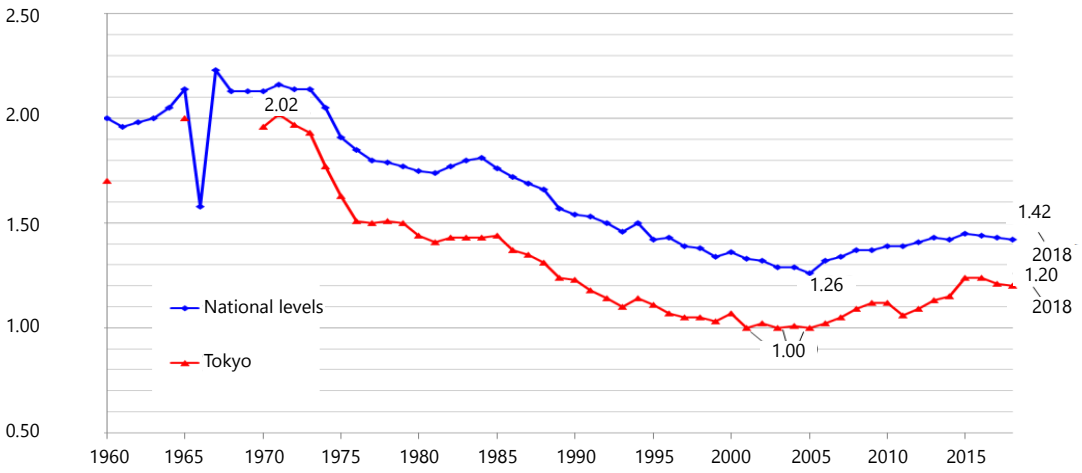
Being almost flat from 1975 to 1995, the population of Tokyo then started to increase, reaching 13.52 million in 2015. It is expected to start decreasing after peaking at 14.17 million in 2025. The ratio of the elderly population was 22.7% in 2015 and is anticipated to increase in parallel with the national aging trends.



Referential figure 2.2: Changes in three population segments by age in Tokyo

Source: Issues of Tokyo in the Future--Investment for the Future, August, 2019 (Japanese).

The total fertility rate (hereinafter referred to as "fertility rate") of Tokyo peaked at 2.02 in 1971, falling to 1.00 in 2001, 2003, and 2005. The fertility rate recovered until 2016, but remained at 1.20 in 2018, still at the lowest level among prefectures in Japan.



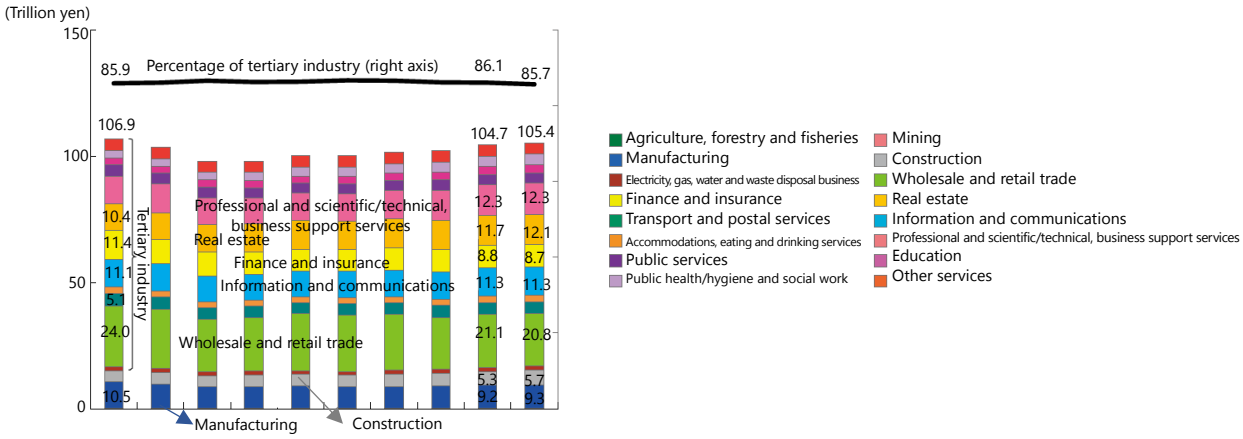
Referential figure 2.3: Changes in fertility rate of Japan and Tokyo

Source: Ministry of Health, Labour and Welfare. *Vital Statistics*.

(4) Industry structure

Tokyo has an economic scale comparable to that of a nation. The nominal gross product output in Tokyo in FY 2016 was approximately 105,400 billion yen, and is sustaining a gradual increase.

Tertiary industry accounts for about 90% of gross prefectural domestic product. Wholesale and retail has the largest share in terms of industry classification.

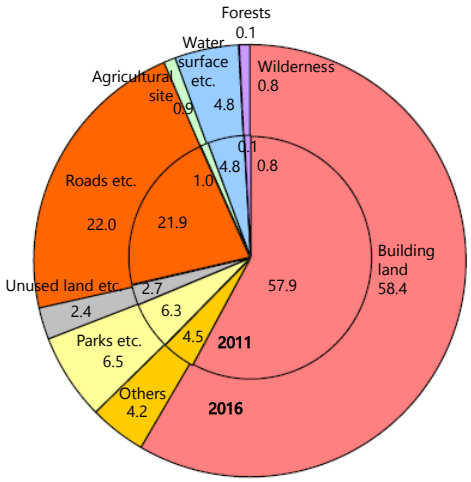


Referential figure 2.4: Gross prefectural domestic product (nominal) by economic activity (Tokyo)
Percentage of the tertiary industry (Tokyo)

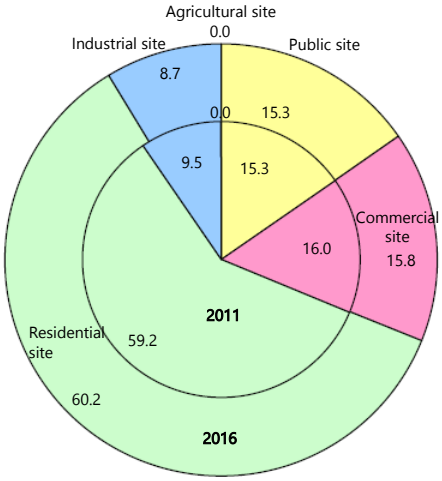
Source: Industry and Employment in Tokyo.

(5) Land use

The land use in the 23 wards is mainly composed of building land and roads. In building land, residential sites account for approximately 60%, followed by commercial sites, public sites, industrial sites, and agricultural sites in this order.

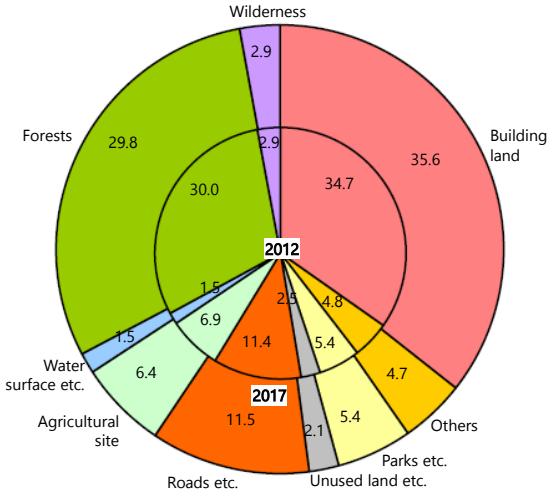


Referential figure 2.5:
Land use share (23 wards)

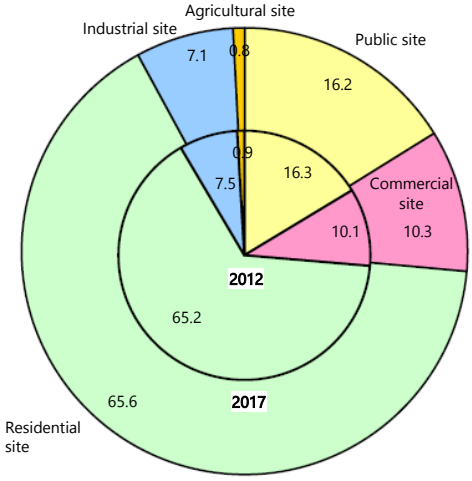


Referential figure 2.6:
Building land use share (23 wards)

In the Tama urban area (26 cities and 2 towns excluding Okutama-machi and Hinohara-mura), urban districts (building land, parks, unused land, roads, etc.) account for approximately 59%, with agricultural sites making up approximately 6% and natural land (water surface, forests, and wilderness) approximately 34%. Approximately 36% of the urban area is covered by building land, in which residential sites account for approximately 66% and public sites approximately 16%.

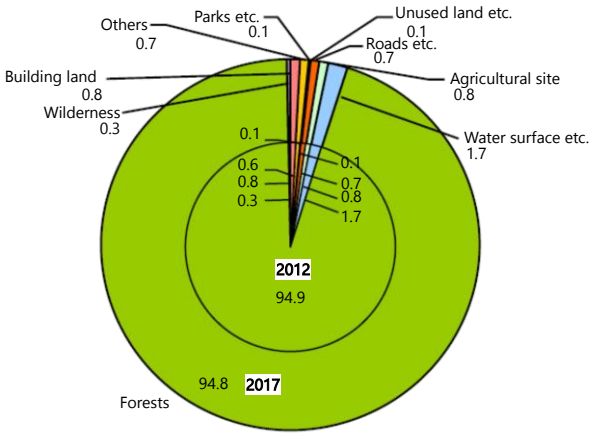


Referential figure 2.7:
Land use share (Tama urban area)

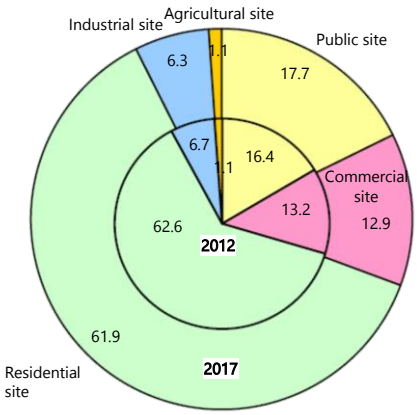


Referential figure 2.8:
Building land use share (Tama urban area)

In the Tama mountain villages (Okutama-machi and Hinohara-mura), natural land accounts for approximately 97%, urban districts approximately 2% (approximately half of which is building land) and agricultural sites approximately 1%. In building land, residential sites account for approximately 62%.

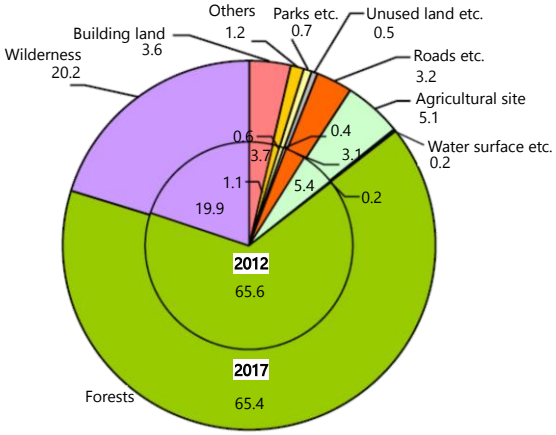


Referential figure 2.9:
Land use share
(Tama mountain villages)

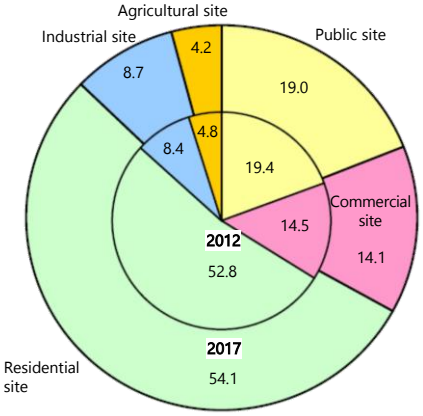


Referential figure 2.10:
Building land use share
(Tama mountain villages)

In the islands, natural land (water surface, forests, and wilderness) accounts for approximately 86%, urban districts approximately 8%, and agricultural sites approximately 5%. In building land, residential sites account for approximately 54%.



Referential figure 2.11:
Land use share (islands)



Referential figure 2.12:
Building land use share (islands)

Source: Land Use in 23 Wards of Tokyo 2016 for the 23 wards, Land Use in Tama Area and Islands of Tokyo 2017 for the Tama area and the islands (Japanese).

(6) Agriculture

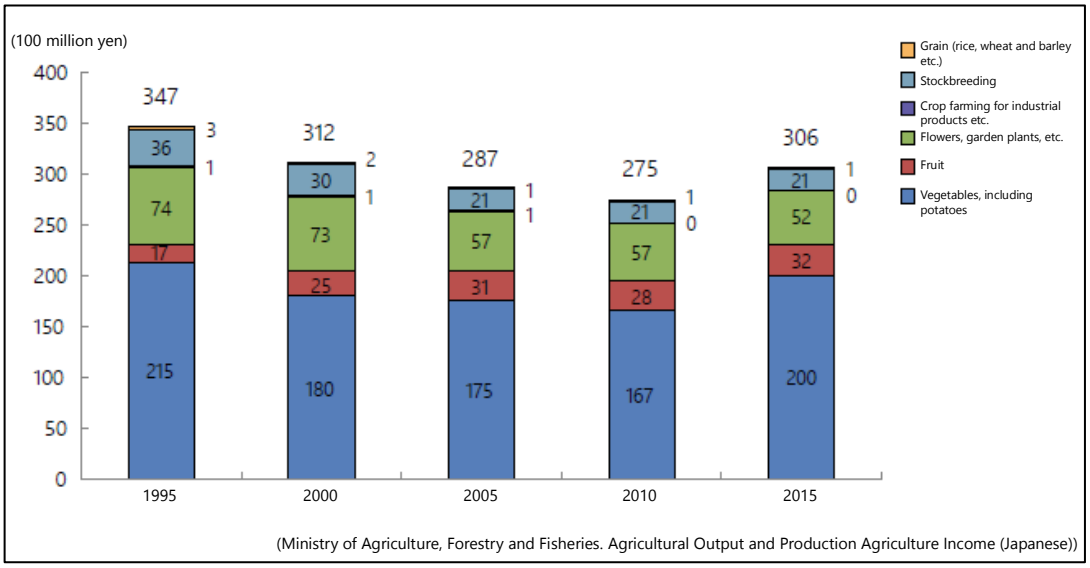
In the islands, specialties are produced making use of the characteristics of each island, such as cut leaves and tropical fruit which take advantage of the warm climate.

In the mountains of the hilly and mountainous areas, specialty vegetables, such as Japanese horseradish and potatoes, are cultivated.

In surrounding areas of the city, open-field vegetables, such as sweet corn and cabbage, agricultural products, such as tea and fruit, and livestock products are produced in relatively large agricultural lots, which include agricultural promotion areas.

In urban areas, komatsuna (brassica vegetable) and tomatoes are cultivated in facilities that make the most of small agricultural lots, helping the development of highly profitable agriculture.

As for production items, vegetables account for approximately 65% of the agricultural output of Tokyo, or 30.6 billion yen (as of 2015). Fruit, flowers, garden plants, and livestock products are widely produced in addition to vegetables, bringing forth a rich diversity which characterizes agriculture in Tokyo. Taking advantage of being part of a major place of consumption, agricultural management is being developed in a variety of manners, including multifaceted operations covering processing, direct sales, and tourism.



Referential figure 2.13: Changes in agricultural output in Tokyo

Source: Tokyo Agriculture Promotion Plan, May 2017.

(7) Fisheries

Fisheries around the Izu Islands include diving fisheries of shellfish and seaweeds, such as turban shells and tengusa seaweed, as well as pole-and-line fisheries of demersal fish, trawl fisheries, and gill net fisheries targeting alfonsin. In addition to the production of kusaya, a traditional processed fishery product, efforts have been started recently to create new processed products utilizing unused or underused fishery resources.

Fisheries in the Ogasawara Islands include pole-and-line fisheries of demersal fish, such as ruby snapper, and vertical longline swordfish fisheries.

Fisheries in the inner bay of Tokyo include gill net fisheries of sea bass and righteye flounder, clam fisheries, and fisheries using burrows for conger eels.

On the inland waters of Tokyo, such as the Tama River, fishery associations release sweetfish and yamame (a kind of trout), and sell tickets for recreational fishing to anglers. Trout, including yamame and rainbow trout, are farmed in the upper basin and fishing of freshwater clam and eel is carried out in the lower basin.

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