Japan’s National Action Plan on Sustainable Nitrogen Management

September 2024

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Chapter 1. Introduction

Section 1. Background

Reactive nitrogen (e.g., nitrogen compounds in chemical forms other than nitrogen gas or molecular nitrogen (N2) such as nitric oxide (NO), nitrogen dioxide (NO2), dinitrogen monoxide (N2O), nitric acid (HNO3), nitrous acid (HNO2) and ammonia (NH3)) is mainly used as raw materials for chemical fertilizers and chemical products, but it may deteriorate various environmental media, in the form of air pollution, water eutrophication and groundwater contamination.

Commercialization of the Haber-Bosch process in the early 20th century has contributed to the rapid increase in the consumption of chemical nitrogen fertilizers made from ammonia since about 1960, followed by a corresponding increase in grain and meat production (Figure 1). Also, nitrogen compounds chemically synthesized from ammonia are utilized in various applications in manufacturing industries as materials including polymers and ceramics, which supports the current rich lifestyle. Additionally, combustion of ammonia does not emit carbon dioxide (CO2); therefore, ammonia applications are expected to expand in the future, especially in the power generation and marine transportation sectors, contributing to decarbonization.

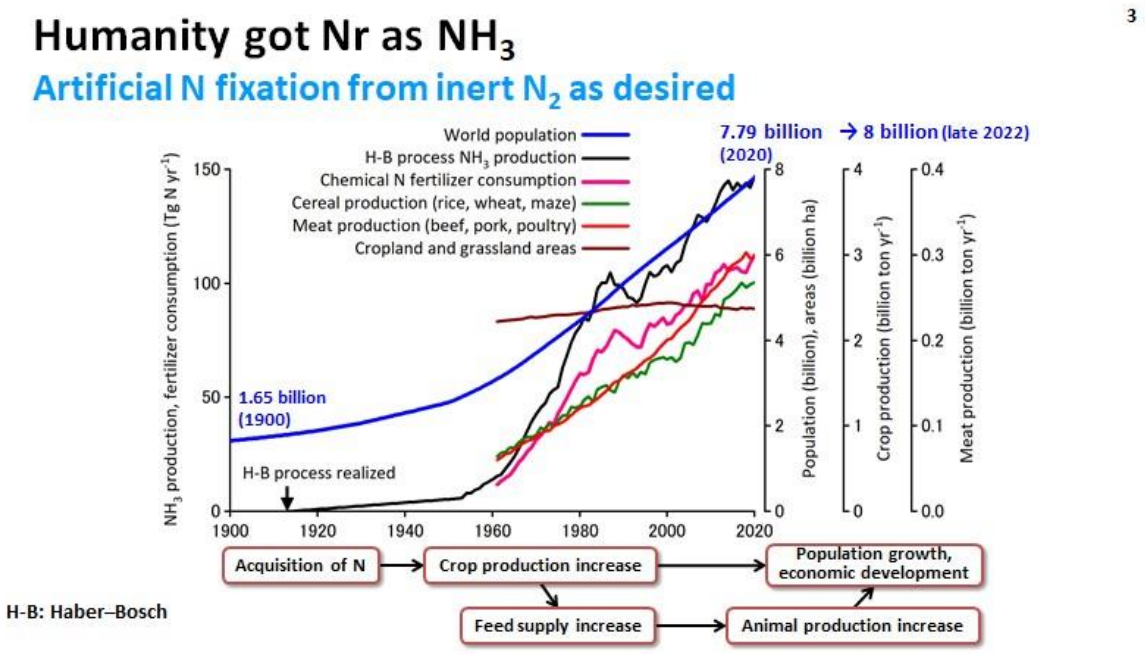


Figure 1 Transitions in ammonia production, chemical nitrogen fertilizer consumption and food production

Modified from source: Hayashi et al. (2021) 'Illustrated Book of Nitrogen and the Environment'.

On the other hand, according to the research on "Planetary Boundaries" (Figure 2)[1], an example of methods for objectively assessing the various impacts of human activities on the Earth system, the "Biogeochemical Flow of Nitrogen", which indicates the effects of nitrogen (mainly HNO3, HNO2, and ammonia) generated from anthropogenic activities such as agriculture and industry on oceans and soils, far exceed the Planetary Boundaries. In addition, nitrogen in the form of N2O is a type of greenhouse gas and an ozone-depleting substance that contributes to "Climate Change" and "Stratospheric Ozone Depletion". Nitrogen in the form of NOx (an umbrella term for NO and NO2) and ammonia contribute to "Atmospheric Aerosol Loading". Although nitrogen is an important nutrient together with phosphorus, it is involved in "Biosphere Integrity" because both eutrophication (too much nitrogen) and oligotrophication (too little nitrogen) affect biodiversity. "Land System Change" refers to the effects of deforestation and soil loss and is discussed in the context of organic carbon; the soil organic matter and trees obviously contain carbon as well as nitrogen. In this way, "Nitrogen" influences a wide range of fields of the Earth system.

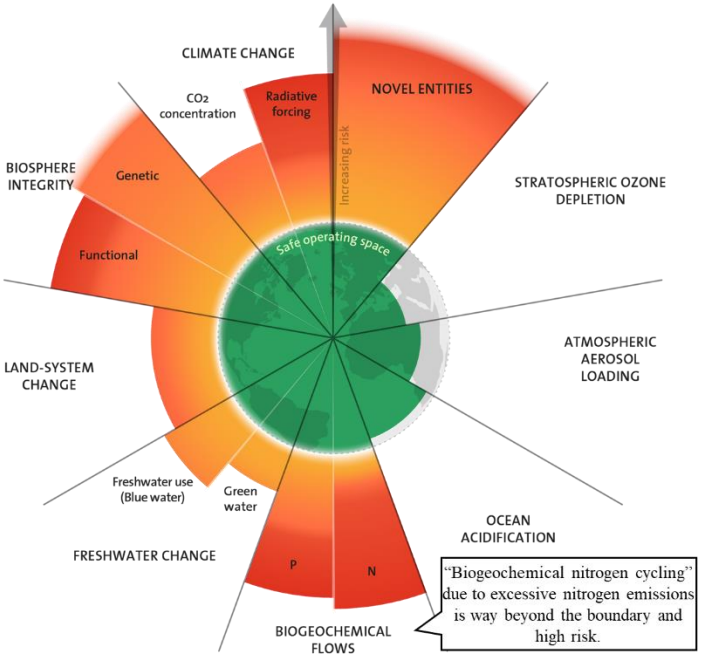


Figure 2 Planetary Boundaries (updated in 2023)

Source: Azote for Stockholm Resilience Centre, based on analysis in Richardson et al 2023

The United Nations Environment Assembly (UNEA) adopted a resolution on sustainable nitrogen management (Resolution 4/14) in 2019 to consider the options for facilitating improved coordination of policies across the global nitrogen cycle. The UNEA resolution (Resolution 5/2) also noted with concerns that excessive levels of nutrients, in particular

[1] Stockholm Resilience centre. (2023). https://www.stockholmresilience.org/research/planetary-boundaries.html (Accessed in Jan. 2024)

nitrogen and phosphorus, have significant impacts on water, soil, air, biodiversity and ecosystem functioning, and encouraged Member States to accelerate actions to significantly reduce nitrogen waste (e.g., reactive nitrogen discharged to the environment through nitrogen production and consumption, inert N2 that returns to the atmosphere without being used as a resource) globally by 2030 and beyond, and to share information on national action plans. Additionally, a working group, the UNEP Working Group on Nitrogen (hereinafter referred to as "WG on Nitrogen") was established under the United Nations Environment Programme (UNEP) to implement these resolutions, and discussions were facilitated. From Japan, the Ministry of the Environment (MOE), the Ministry of Agriculture, Forestry and Fisheries (MAFF) and experts participated in the WG on Nitrogen to share information on Japan's actions, and to contribute to the discussions on the preparation of a template for the national action plans.

In this context, the Government of Japan has held the Liaison Conference of the Relevant Ministries and Agencies and review meetings by experts and has proceeded with the discussion/consideration for the development of the national action plan for sustainable nitrogen management as encouraged by the UNEA resolution. In addition, public comment on the draft action plan was requested. Also, the national action plan was reported to the Water Environment and Soil Pesticide Subcommittee and the Air and Noise Vibration Subcommittee of the Central Environment Council.

Based on the 6th Basic Environmental Plan (approved by the Cabinet in May 2024), the government formulated this national action plan for sustainable nitrogen management.

Section 2. Significance of developing the national action plan

It is required to establish systems and implement actions for comprehensive management of nitrogen material flow with the balance of its inputs and outputs as reactive nitrogen exists across various media such as water, soil, and air. Nitrogen is an essential substance for food production and industrial production; however, it may deteriorate various environmental media in the form of air pollution, eutrophication of water bodies and groundwater contamination. Moreover, Japan imports almost all the raw materials for major chemical fertilizers, facing challenges not only to the stable supply of fertilizers, but also to its economic and food security.

Therefore, Japan will promote sustainable nitrogen and phosphorus management which contributes to societies and regions by taking an integrated approach with conservation and management of the water and atmospheric environment, decarbonization, resource circulation and symbiosis with nature. Specifically, Japan will take measures to address nitrate nitrogen and nitrite nitrogen in groundwater, which continue to exceed environmental standards, and eutrophication in lakes, which also serve as sources of drinking water, through proper fertilizer application, expansion of the use of compost and fertilizer made from sewage sludge resources, energy use of livestock manure and sewage sludge resources. In addition, in the

development/use of ammonia for fuel, hydrogen carriers, and other applications that are expected to expand in the future, Japan will facilitate the avoidance of NOx and N2O emissions by utilizing technologies that do not increase NOx emissions. Furthermore, Japan will promote proper nutrients management to achieve "Clean and Rich Sea".

Japan will also continue to elaborate the nitrogen inventory and consolidate scientific knowledge while contributing to international nitrogen management by sharing Japan's experience with Asian developing countries, where nitrogen consumption is increasing rapidly.

From the domestic perspective, the preparation of the national action plan for sustainable nitrogen management, in response to the UNEA resolution and international discussions at UNEP, would provide an opportunity for relevant ministries to unify their recognitions by reorganizing their existing initiatives with "nitrogen" as a starting point, which will create synergy for new collaborative projects among the ministries. Projects that bring benefits to our countries and regions will be implemented through an "Integrated Approach" with conservation and management of the water and atmospheric environment, carbon neutrality, circular economy, and nature positivity.

From the international perspective, to contribute to promoting nitrogen management in Asian countries, Japan will facilitate information dissemination on our knowledge and experience, capacity building and technology transfer through our international cooperation frameworks including the Acid Deposition Monitoring Network in East Asia (EANET), the projects for promoting a co-benefit approach applied to measures to improve air quality and to take measures against climate change (hereinafter referred to as "the Co-benefit Promotion Projects"), the Water Environment Partnership in Asia (WEPA), and the Asia Water Environment Improvement Model Project. The national action plan encouraged by the UNEA resolution is an effective tool for disseminating information on the water and atmospheric environment improvements resulting from our past nitrogen emission reductions. It is effective that Japan leads the national action plan preparation and inter-ministerial collaborative projects, accumulates good practices of coordination among relevant ministries/agencies, and shares our experiences that may be useful to other countries.

Chapter 2. Nitrogen management in Japan

Section 1. Profile of Japan

1. Population

The total population of Japan is about 126 million, which is 1.5 % of the world population (about 7,841 million[2]).

[2] The Statistic Bureau of Japan, World Statistics 2023.

Table 1 Total population and age structure of Japan.

Year	Population(thousand)				Percentage composition (%)		
	Total	Age: 0 - 14	15 - 64	65 -	Age: 0 - 14	15 - 64	65 -~
2020	126,146	15,031	75,087	36,026	11.9	59.5	28.6

Source: Statistics Bureau, Ministry of Internal Affairs and Communications. 2020 Population Census. Basic Complete Tabulation on Population and Households. Summary of results.

2. Climate

Japan is located in the eastern part of the Asian Pacific Region. As its territory stretches from south to north with many mountainous areas and therefore be divided into various climatic zones; the north is subarctic, and the south is subtropical. The climate along the side of the Sea of Japan differs from that of the Pacific Ocean. Such differences in climate resulted in different tree species of forest components and major agricultural/livestock products, which influences nitrogen dynamics.

Japan has greater annual changes in precipitation and total precipitation than Paris (France) and New York (USA) in the same northern hemisphere and Sydney (Australia) in the southern hemisphere. Therefore, it is expected that reactive nitrogen entering terrestrial ecosystems such as soil is likely to flow to other systems such as water bodies.

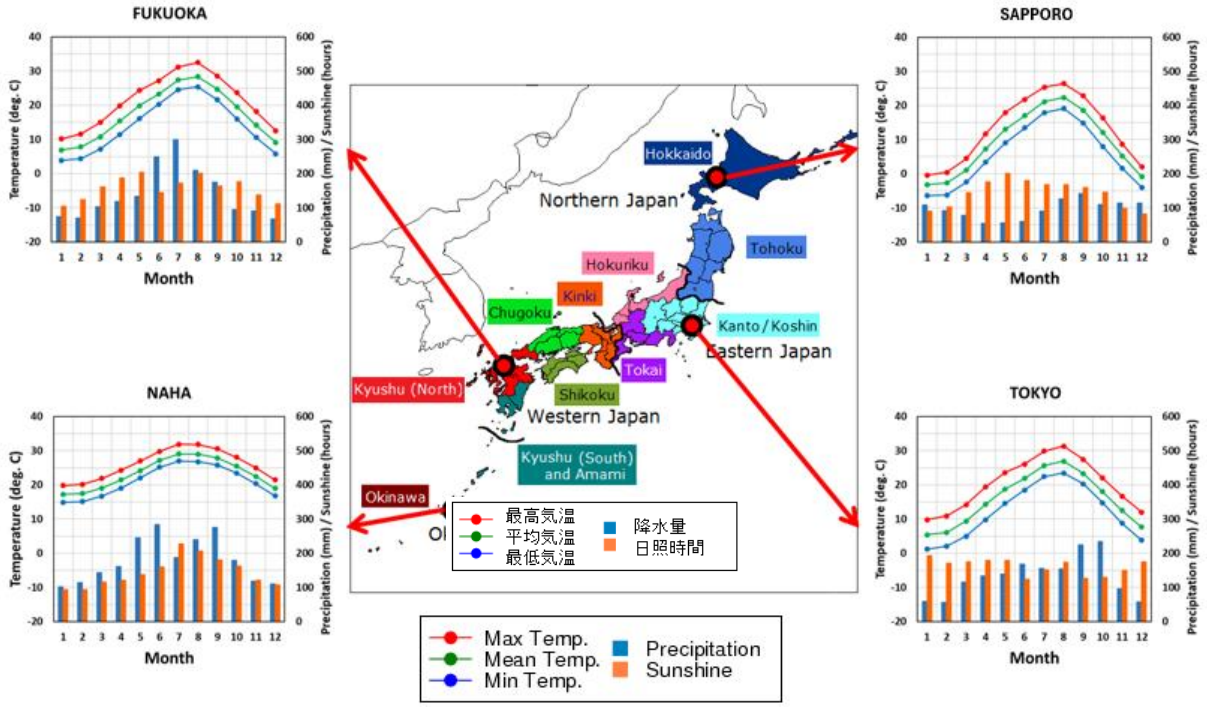


Figure 3 Seasonal changes in temperature, precipitation, and hours of sunlight in Japan (Sapporo, Tokyo, Fukuoka, Naha)

Source: Japan Meteorological Agency. Overview of Japan's climate (https://www.data.jma.go.jp/gmd/cpd/longfcst/en/tourist_japan.html)

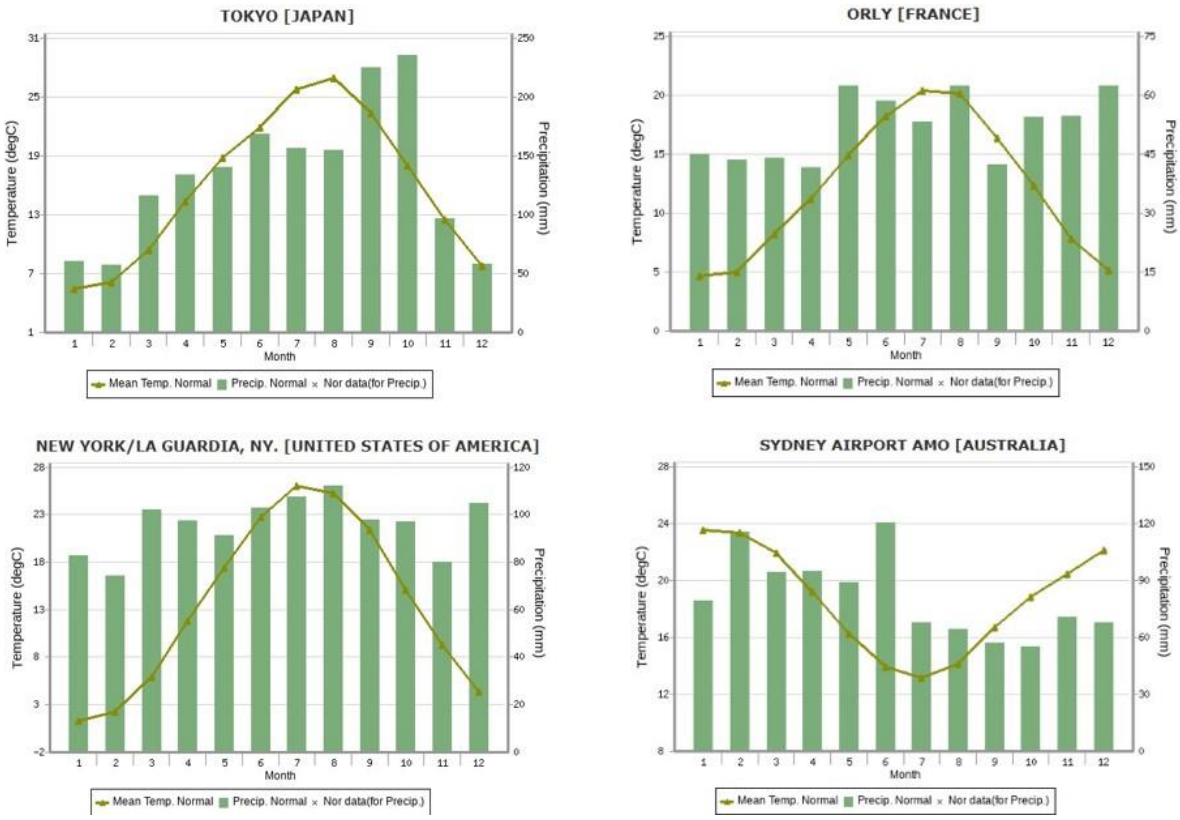


Figure 4 Seasonal changes in temperature and precipitation in countries around the world (Tokyo, Paris, New York, Sydney)

Source: Japan Meteorological Agency. The global location-specific normal values. (https://www.data.jma.go.jp/cpd/monitor/normal/about_normal.html)

3. Manufacturing and agricultural sectors

Among Japan's industries, agriculture, forestry and fisheries account for small shares (1% or less) in each of the following: (nominal) gross domestic product, the number of business establishments, and the number of employees. On the other hand, manufacturing accounts for a relatively large share of gross domestic product (about 19%) and the number of employees (about 14%). Therefore, of the amount of nitrogen artificially fixed by the Haber-Bosch process and other methods, about 80% and about 40-50% are used in chemical fertilizers worldwide and in Japan respectively. It is also characterized that the percentage of nitrogen artificially fixed used in other industrial products is relatively large in Japan[3].

Table 2 Japan's GDP, number of business establishments, and number of employees

[3] Hayashi et al. (2021) Nitrogen budgets in Japan from 2000 to 2015: Decreasing trend of nitrogen loss to the environment and the challenge to further reduce nitrogen waste. Environmental Pollution, 286, 117559. https://doi.org/10.1016/j.envpol.2021.117559

Sector	(1) (Nominal) GDP (billion) (2022)	(2) Number of business establishments (2021)	(3) Number of employees (thousand) (2021))
Manufacturing	107,617.8 (19.2%)	412,682 (7.8%)	8,804 (14.1%)
Agriculture, Forestry and Fisheries	5,695.6 (1.0%)	43,623 (0.8%)	461 (0.7%)
Total	113,313 (20.2%)	456,305 (8.6%)	9,265 (14.8%)

Source:

(1) Annual Report of the National Accounts, Cabinet Office, Government of Japan

(2) (3) "2021 Economic Census - Activity Survey" by the Ministry of Internal Affairs and Communications.

Note: The definitions of the manufacturing and agricultural sectors by each statistic are not identical.

Section 2. Reactive nitrogen uses in Japan

1. Amount of ammonia produced in/imported to Japan

In 2019, global ammonia production was about 200 million tons, of which about 32 % was produced in the East Asia. Japan's ammonia consumption was about 1.08 million tons in 2019, accounting for about 0.5 % of the global production. About 80 % of the ammonia consumption in Japan was produced domestically, and about 20 % was imported from Indonesia and Malaysia.

It is to be noted that the amount of domestic production and net imports of reactive nitrogen were about 5.88 million tons in 2015, and fuel-derived nitrogen and nitrogen in forms other than ammonia, such as raw materials for chemical fertilizers, are also produced/imported (see section 2.3 of this chapter 2).

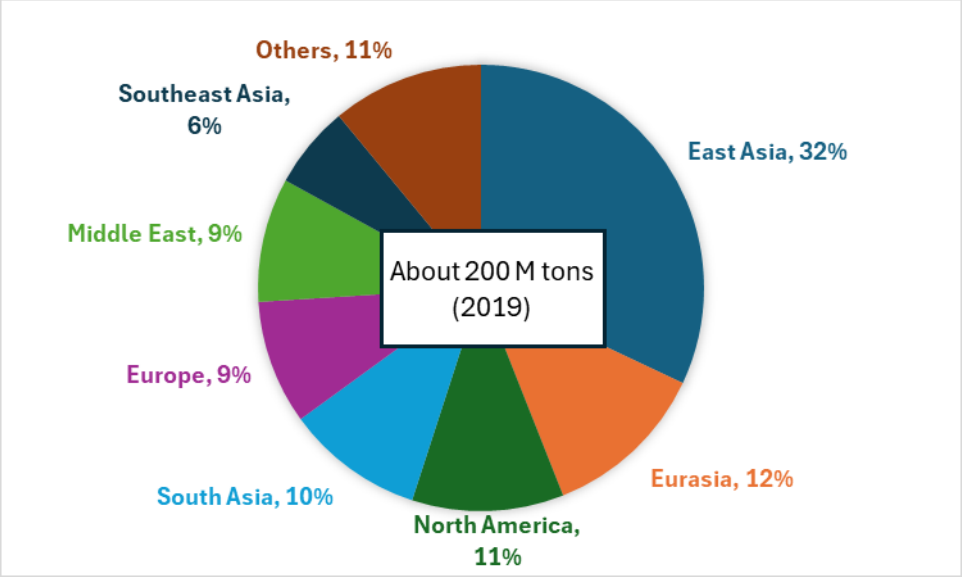


Figure 5 Breakdown of global ammonia production (2019)

Source: Agency for Natural Resources and Energy.

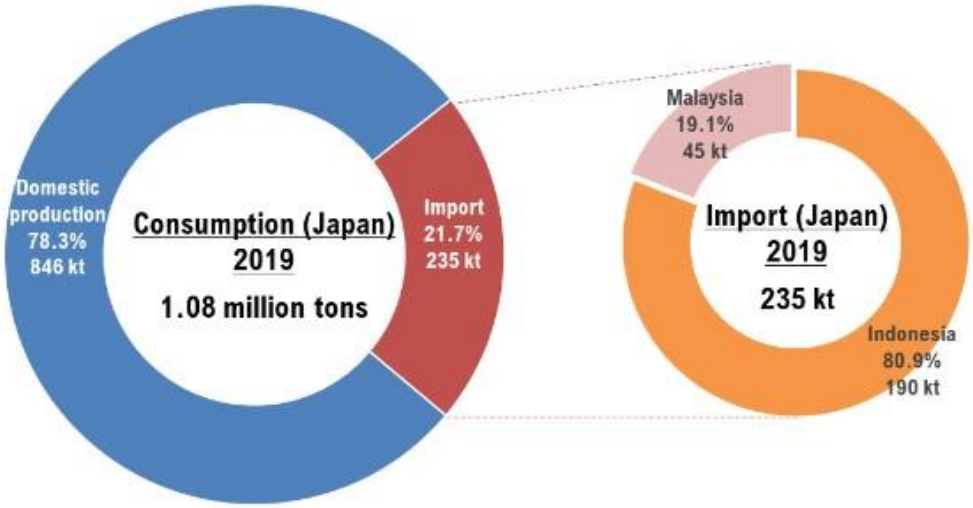


Figure 6 Breakdown of Ammonia Consumption and Production and Imports in Japan (2019)

Source: Ammonia can be used as fuel! Part 1: Ammonia is commonly used in our daily life, but its potential is not widely known, Ministry of Economy, Trade and Industry.

2. Nitrogen applications in Japan

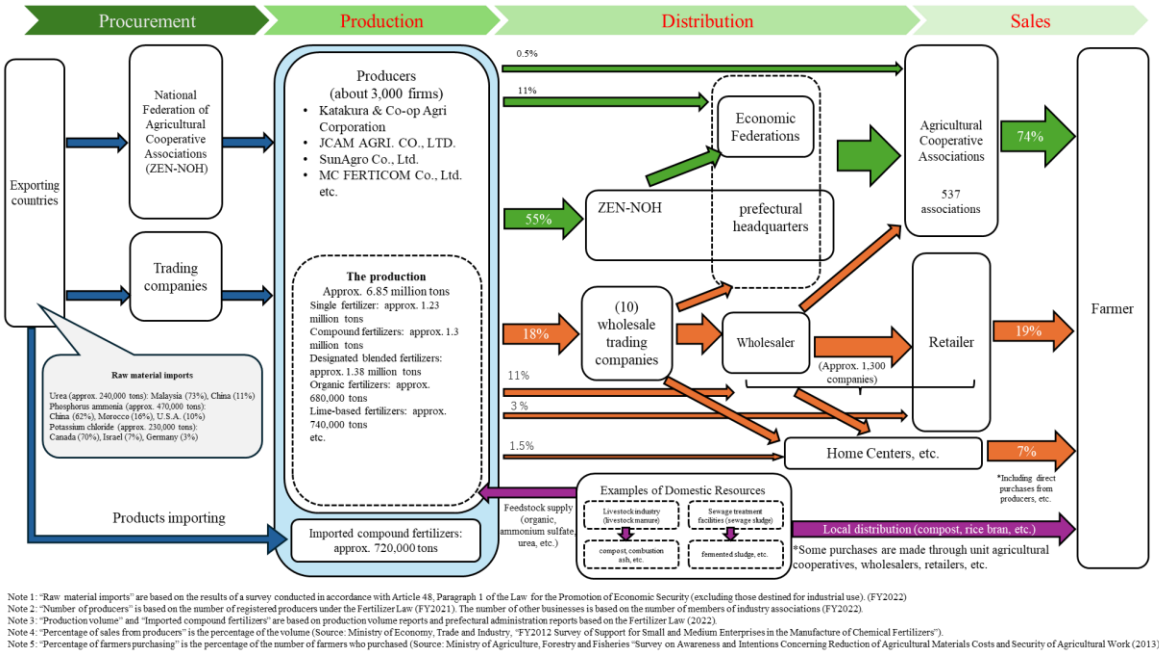
Globally, reactive nitrogen is mainly utilized for chemical fertilizers with about 20 % accounting for industrial applications while it is characterized that over 50 % of ammonia production accounts for industrial applications in Japan[4]. In Japan, almost all of urea and ammonium phosphate dibasic used mainly as raw materials of chemical nitrogen fertilizers are imported. Fertilizers made by fertilizer producers are sold to farmers through various sales routes (mainly agricultural cooperatives) (Figure 7). About 81 % (in FY2022) of livestock manure is used for agricultural purposes such as composting. Raw materials used in chemical industry, such as urea, and acrylonitrile, are also important applications.

The "Green Growth Strategy Through Achieving Carbon Neutrality in 2050" (developed in June 2021) identifies the fuel ammonia industry as one of the 14 important fields that are expected to grow, based on both industrial/energy policies. The strategy aims to introduce/expand the use of 20 % co-firing nitrogen in power generation by 2030 (short-term target) and to increase the co-firing rate (50%) and commercialize the single-fuel firing technology by 2050 (long-term target); domestic demand is expected to be up to 3 million tons per year in 2030, and about 30 million tons per year in 2050 (both in weight of ammonia).

The "Strategy for Promoting the Transition to a Decarbonized Growth-Oriented Economic Structure (GX Promotion Strategy)" (approved by the Cabinet in July 2023) states that

[4] KATAGIRI, K., MIZOGUCHI, S., MATSUBAE, K., NAGASAKA, T. (2018). "Changes in nitrogen flows in Japan from 2005 to 2015, mainly in industries" Journal of the Japanese Society for LCA, 2018, Vol. 14 No. 4 pp. 319-331.

hydrogen/ammonia are expected to play important roles in various fields including power generation/transportation/industry. Under the national strategy to proceed with the transition to clean hydrogen/ammonia, a large-scale and resilient supply chain will be established inside and outside Japan. Similarly, hydrogen/ammonia will be promoted for co-firing/single-firing to ensure the ability to coordinate decarbonization.



Note 1: "Raw material imports" are based on the results of a survey conducted in accordance with Article 48, Paragraph 1 of the Law for the Promotion of Economic Security (excluding those destined for industrial use). (FY2022)
Note 2: "Number of producers" is based on the number of registered producers under the Fertilizer Law (FY2021). The number of other businesses is based on the number of members of industry associations (FY2022).
Note 3: "Production volume" and "Imported compound fertilizers" are based on production volume reports and prefectural administration reports based on the Fertilizer Law (2022).
Note 4: "Percentage of sales from producers" is the percentage of the volume (Source: Ministry of Economy, Trade and Industry, "FY2012 Survey of Support for Small and Medium Enterprises in the Manufacture of Chemical Fertilizers").
Note 5: "Percentage of farmers purchasing" is the percentage of the number of farmers who purchased (Source: Ministry of Agriculture, Forestry and Fisheries "Survey on Awareness and Intentions Concerning Reduction of Agricultural Materials Costs and Security of Agricultural Work (2013)").

Figure 7 Domestic Distribution Structure of Fertilizer in 2022

Source: Ministry of Agriculture, Forestry and Fisheries.

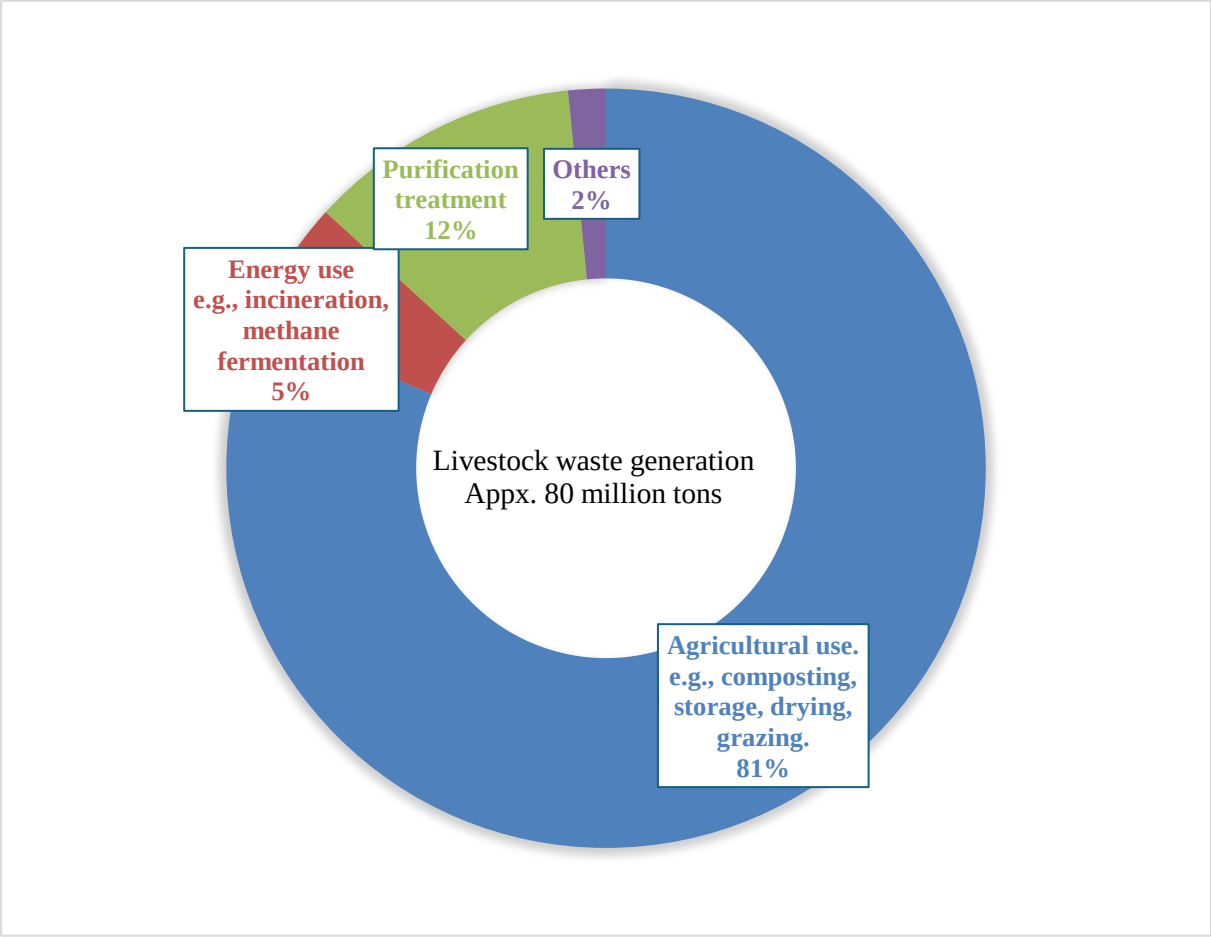


Figure 8 Utilization of Livestock Wastes in 2022

Source: Ministry of Agriculture, Forestry and Fisheries. Due to rounding, the breakdown and totals do not match.

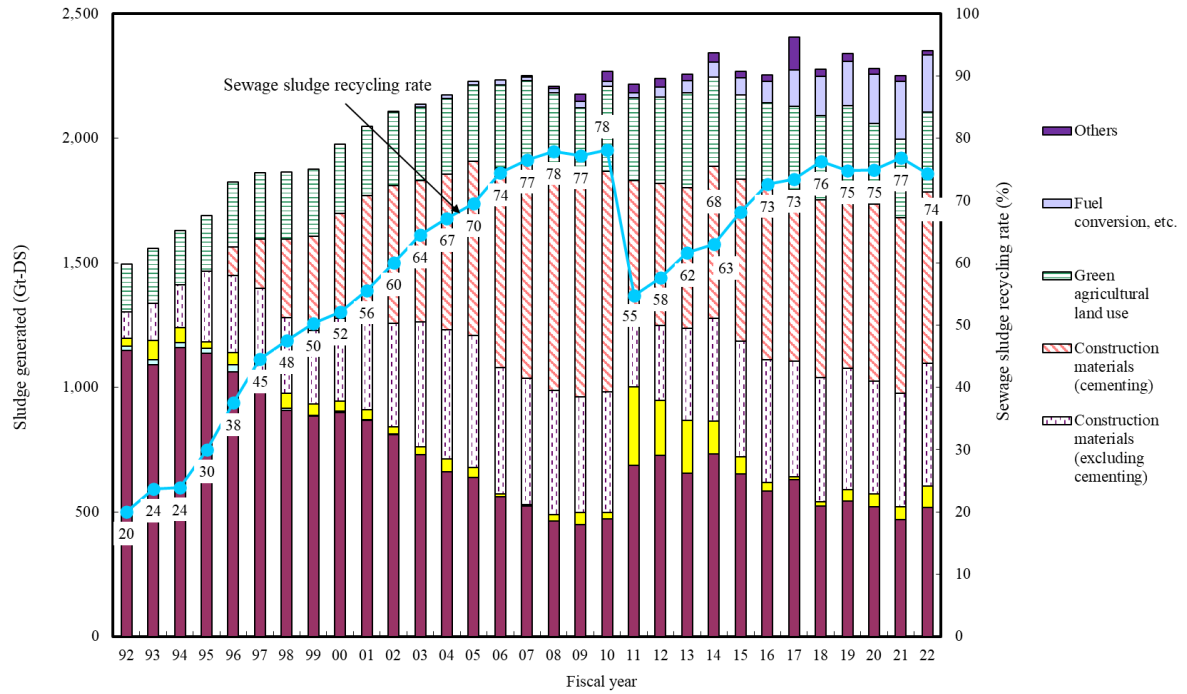


Figure 9 Sewage Sludge Generation and Recycling in Japan

Source: Ministry of Land, Infrastructure, Transport and Tourism.

3. Nitrogen budget in Japan

Not only ammonia but also reactive nitrogen with various forms enters and leaves various media, including the domestic atmosphere, water bodies, human society, and farmlands. Some of which are nitrogen contained in food, fertilizers, and products. According to the latest research on the nitrogen budget in Japan, the net input of nitrogen amount in 2010 was about 4.79 million tons. Most of the amount is derived from fossil fuels (about 3.67 million tons of nitrogen).

Nitrogen for industrial purposes was composed of about 5.5 million tons of imported nitrogen, about 990,000 tons of nitrogen fixed from N2 in the atmosphere, and about 290,000 tons of recycled nitrogen at the waste disposal stage. Nitrogen transferred from industry to energy was 3.7 million tons. About 780,000 tons of the nitrogen was emitted to the atmosphere as reactive nitrogen (2.93 million tons as N2 for air emissions).

Nitrogen contained in fertilizers applied to crop production/grassland was about 790,000 tons, of which about 140,000 tons of nitrogen was emitted to the atmosphere (about 140,000 tons as N2) and about 360,000 tons of nitrogen was discharged to terrestrial waters. Nitrogen in feed used for livestock production was about 870,000 tons, of which about 310,000 tons was composted, about 170,000 tons was returned to industry as products, and about 180,000 tons was emitted to the atmosphere as reactive nitrogen.

About 1.1 million tons of nitrogen were supplied to consumers; of that amount, roughly 660,000 tons were transferred into sewage and garbage. Roughly 10,000 tons were emitted into the atmosphere as reactive nitrogen. Approximately 370,000 tons were released to terrestrial waterways.

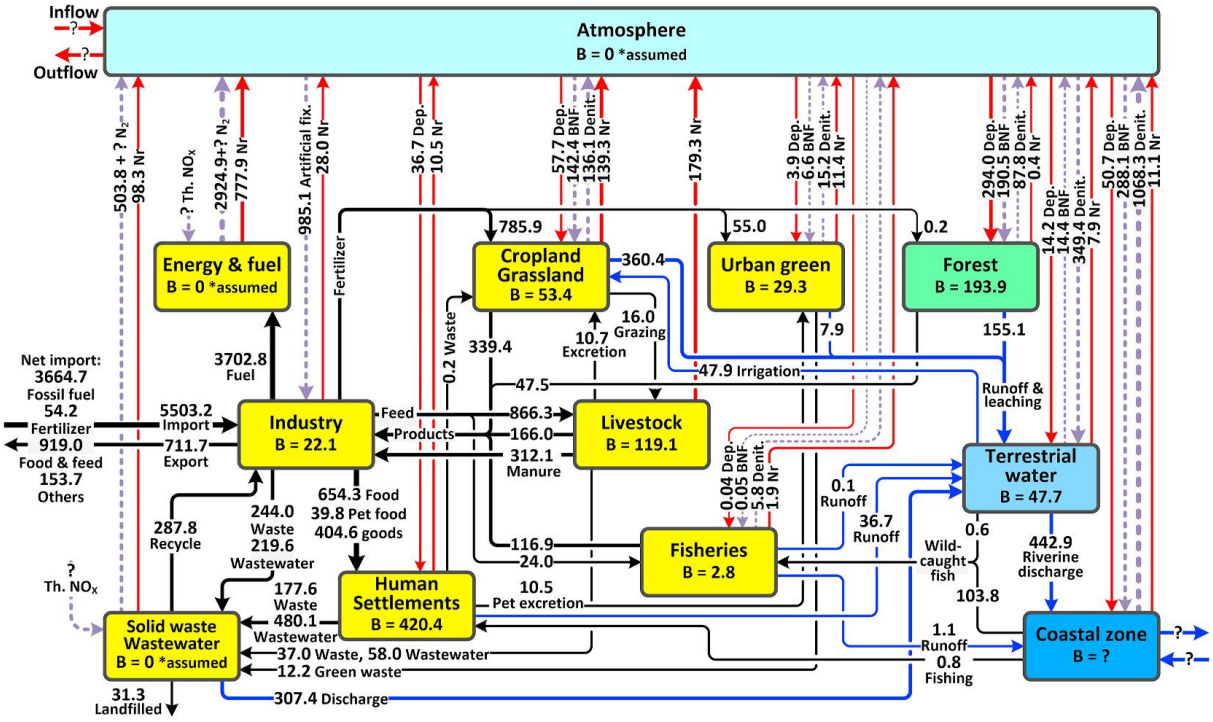


Figure 10 Nitrogen flows in 2010 (unit: Gg nitrogen/year)*1 Gg is 1,000 tons

Solid black arrows: Reactive nitrogen flows related to human society
Solid red arrows: Reactive nitrogen flows via the atmosphere
Purple dotted arrow: Denitrification (N2) flow to the atmosphere
Blue solid arrow: Reactive nitrogen flow related to water
B: Difference between inflow and outflow

Source: Hayashi et al. (2021), p.6

In terms of the change over time, the annual amount of reactive nitrogen loss to the environment in Japan from 2000 to 2015 was 1.86 to 2.29 million tons, and these amounts have been decreasing over time. The annual reactive nitrogen loss from the energy/manufacturing industry was 740,000 to 940,000 tons, accounting for around 40 % of the total loss. The annual reactive nitrogen loss from agriculture (crops/livestock/grassland) was 660,000 to 810,000 tons, accounting for around 35 % of the total loss. It is to be noted that some of the reactive nitrogen from agriculture was included in the reactive nitrogen from waste/sewage. Within the reactive nitrogen loss, 62 - 64 % was emitted to the atmosphere as NOx, ammonia and N2O. The rest was mainly discharged to terrestrial waters as nitrate nitrogen and other forms of nitrogen.

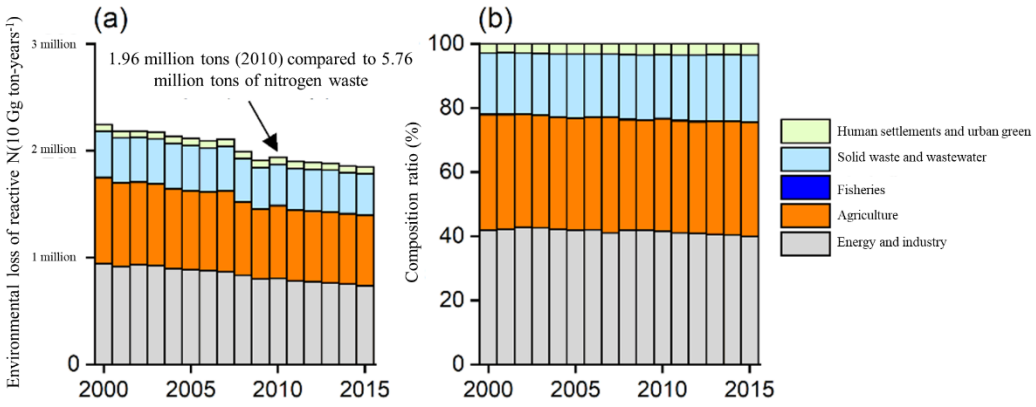


Figure 11 Reactive nitrogen loss to the environment due to human activities (by source, 2000-2015)

Source: National Institute of Agro-Environmental Sciences. (Research Results) Nitrogen budgets in Japan from 2000 to 2015.

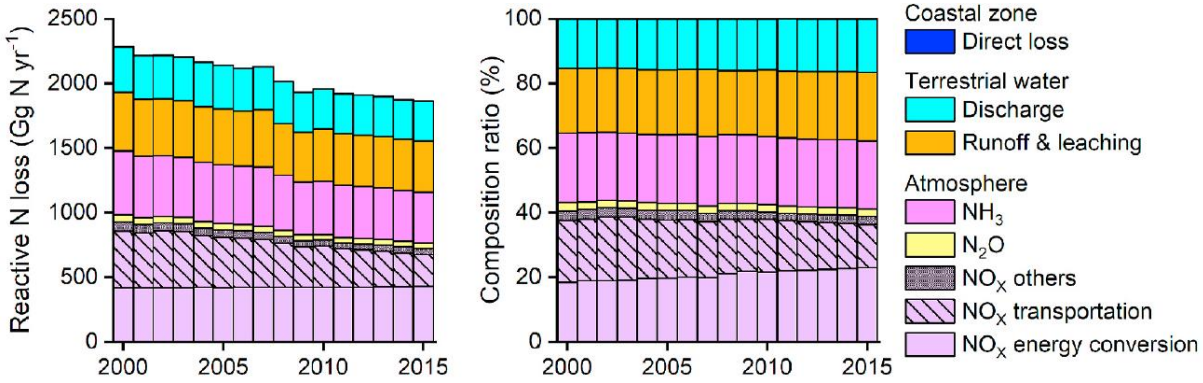


Figure 12 Reactive nitrogen loss to the environment due to human activities (by chemical species, 2000-2015)

Source: National Institute of Agro-Environmental Sciences. (Research Results) Nitrogen budgets in Japan from 2000 to 2015.

Section 3. Measures taken to manage nitrogen in Japan

1. Management of atmospheric environment

Regarding nitrogen management in the atmospheric environment, the Basic Environment Law (Law No. 91 of 1993) establishes an environmental standard for NO2 related to air pollution. In Japan, to achieve the environmental standard, the Air Pollution Control Act (Act No. 97 of 1968) provides emission standards for NOx discharged or dispersed from stationary sources such as plants and workplaces, and permissible limits for NOx from mobile sources such as automobile exhaust gas, and local governments have implemented emission regulations such as total emission limits for each designated region and specified factory or place of business based on a plan for reducing the total quantity. For areas where pollutions from automobile emission are significant, the Law Concerning Special Measures for Total Emission Reduction of Nitrogen Oxides and Particulate Matter from Automobiles in Specified Areas (Law No. 70 of 1992) (hereinafter referred to as the Automobile NOx/PM Law) has regulated vehicle types and promoted low-emission vehicles and other measures. The Offensive Odor Control Act (Act No. 91 of 1971) also, designates ammonia as a "Specified Offensive Odor Substance" and has regulated offensive odors generated from business activities at factories/workplaces in regulated areas.

As a result of these measures, Japan's air pollution due to reactive nitrogen has been reduced dramatically; NO2 concentrations have been steadily decreasing at both Ambient Air Pollution Monitoring Stations (APMSs) and Roadside Air Pollution Monitoring Stations (RAPMSs), and all APMSs and RAPMSs achieved 100% of the environmental standard in FY2021. The atmospheric concentration of fine particulate matter (PM2.5), including salts composed of nitrate ions (NO3-) and ammonium ions (NH4+) is also greatly reduced from FY 2010 to FY 2021 at both APMSs and RAPMSs. They achieved 100% of the environmental standards in FY2021. In addition, as for the Automobile NOx/PM Law, the report of the Central Environmental Council on the "Future Policy for Comprehensive Automobile Emission Control" published in April 2022 evaluated that the targets to secure the environmental standards for NO2 and Suspended Particulate Matter (SPM) have been almost achieved.

Moreover, annual NOx emissions were reduced from about 1.7 million tons in FY2015 to 1.42 million tons in FY2018, and emissions generated from mobile sources such as ships and motor vehicles were reduced. Besides, the annual emissions of ammonia were about 450,000 tons in FY2015 and FY2018.

On the other hand, the achievement rate of environmental standards for photochemical oxidants (Ox), in which NOx is involved in their formation and degradation, remains low. As for the Automobile NOx/PM Law, it was also recommended that the system should be reviewed after about five years of the publication of the report of the Central Environmental Council, with continuous implementation of existing various measures, based on the fact that some of

the pollution monitoring stations achieved the NO2 environmental standard but did not reach concentration levels not to potentially exceed the environmental standard.

As ammonia is expected to be widely used in the future as a fuel and hydrogen carrier, it is necessary to promote efforts that are compatible with the control of emissions to the atmospheric environment.

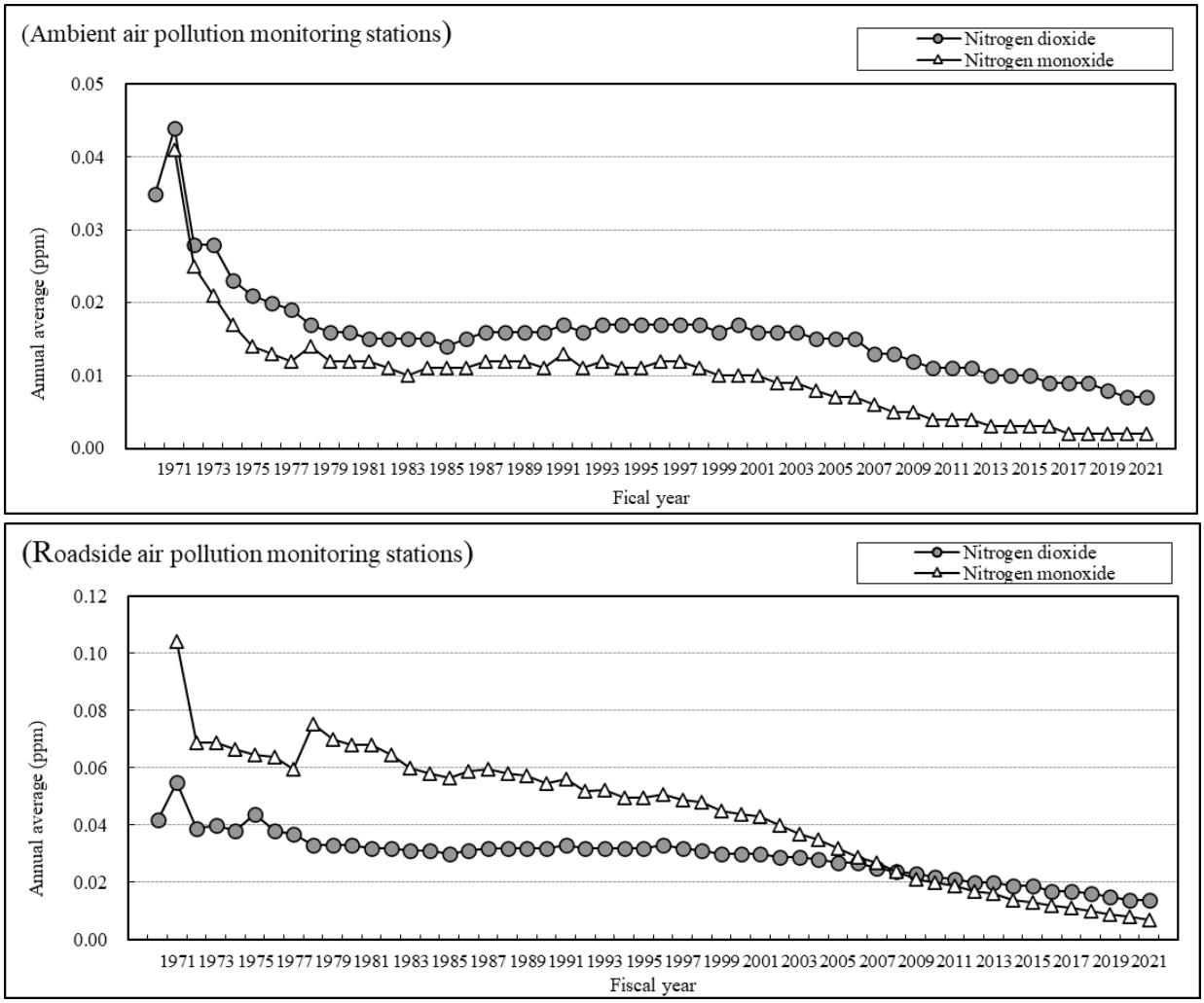


Figure 13 Transitions in annual average of NO2 and NO concentrations

Source: Ministry of the Environment. FY2021 Results of Constant Monitoring and Measurement of Air Pollutants.

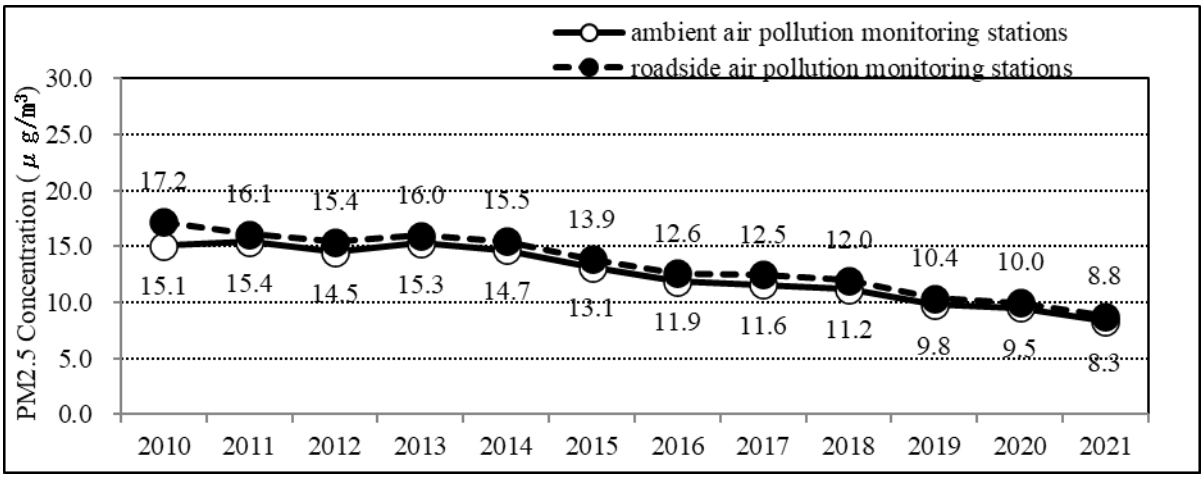


Figure 14 Transitions in Annual average of PM2.5 concentrations

Source: Ministry of the Environment. FY2021 Results of Constant Monitoring and Measurement of Air Pollutants.

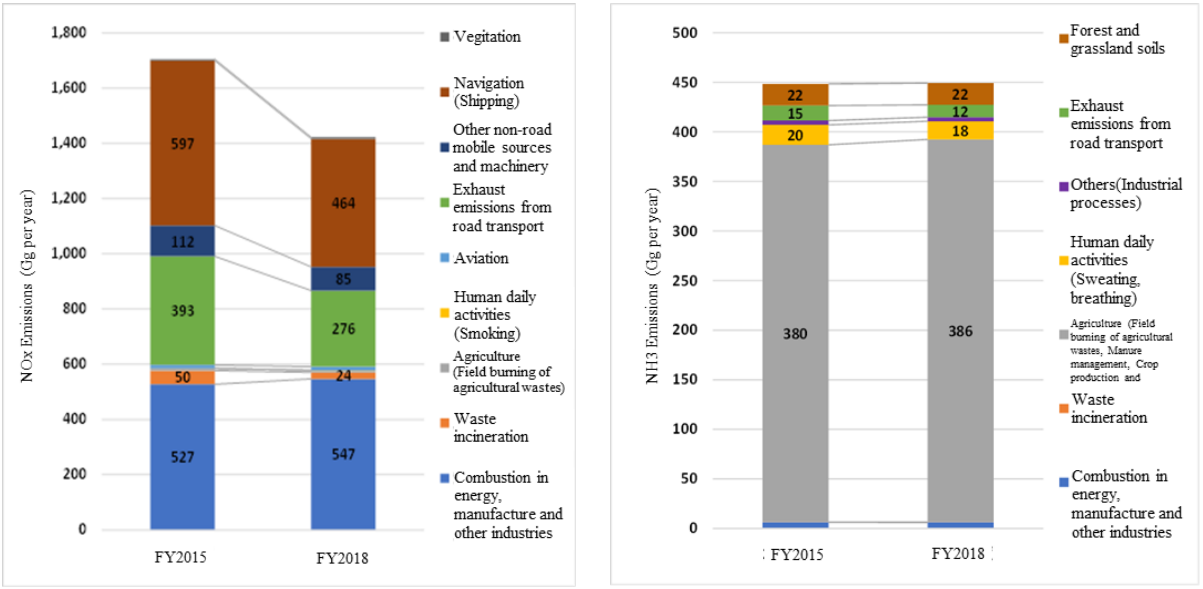


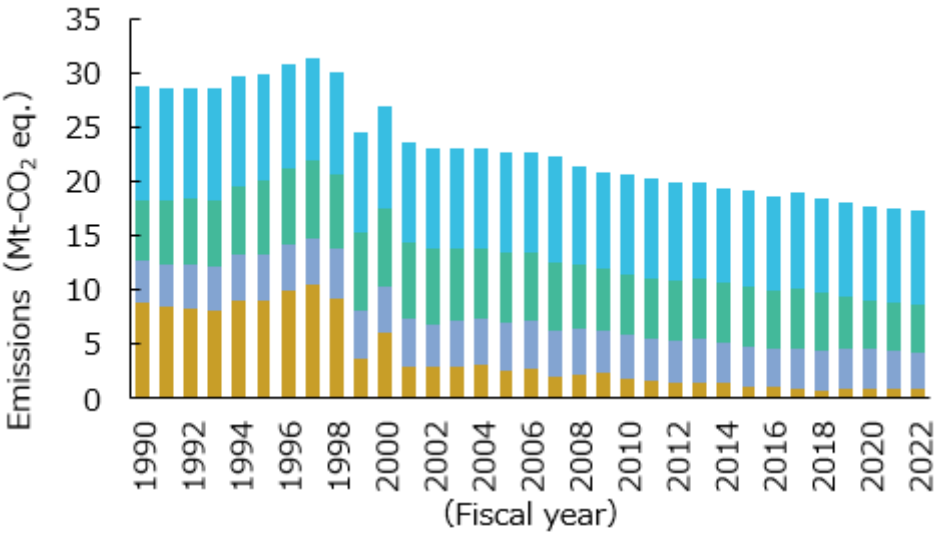
Figure 15 NOx and ammonia emissions (FY2015 and FY2018)

Source: Ministry of the Environment. Emission Inventory of PM2.5 and Other Air Pollutants.
Note that the FY2015 values are at the trial calculation stage and are not final values.

In terms of climate change measures, based on the Act on Promotion of Global Warming Countermeasures (Act No. 117 of 1998), to target N2O, one of the greenhouse gases, parties that produce considerably high greenhouse gas emissions (specified emitters) are required to calculate their greenhouse gas emissions and report to the relevant minister. For N2O management measures in the Plan for Global Warming Countermeasures (Cabinet Decision on October 22, 2021), Japan has also made progress in implementing measures to reduce N2O emissions, including measures to address emissions form industrial processes and to advance combustion system in incineration facilities of waste/sewage sludge through introducing fully continuous combustion furnaces.

As a result of these measures, N2O emissions were reduced by 40.3 % in FY 2022 compared to FY 1990. This is because of the reduction of emissions from industrial processes and product applications (e.g., emissions from adipic acid production in the chemical industry). The emissions in FY 2022 were reduced by 13.3 % compared to FY2013. These emission reductions were effective in the following order: fuel combustion/leakage, industrial processes, and product applications.

It should be noted that aerosols comprising NO3- and NH4+, as well as the precursors NOx and ammonia, are classified as short-lived climate forcing factors (SLCF) that have an impact on the climate because they are extremely reactive both chemically and physically in the atmosphere. The Inter-governmental Panel on Climate Change adopted in its 60th session a decision on the terms of reference for the Task Group on a methodology report on SLCFs to be completed by 2027.



	FY2022 emissions (Mt-CO2 eq.)	Share	Amount of change	
			Compared to FY2013	Compared to FY2021
Agriculture	8.6	50.0%	−3.1%	−0.7%
Energy	4.3	25.0%	−22.2%	−2.9%
Waste	3.5	20.1%	−13.5%	−2.1%
Industrial Processes and Product Use	0.8	4.9%	−41.6%	−8.1%
Total	17.3	100%	−13.3%	−1.9%

Figure 16 Trends in N2O emissions

Source: Ministry of the Environment. Japan's National Greenhouse Gas Emissions and Removals in Fiscal Year 2022 (April, 2024).

2. Management of Water Environment

For nitrogen management in the water environment, the Basic Environment Law has established environmental standards for water pollutants in public waters and groundwater: an environmental quality standard for nitrate nitrogen and nitrite nitrogen for the protecting human health (hereinafter referred to as health items), and environmental quality standards for total nitrogen for conserving living environments (hereinafter referred to as living environment items). In Japan, the Water Pollution Prevention Act (Act No. 138 of 1970) has established effluent standards for factories or workplaces (specified workplaces) that have facilities to discharge polluted water or wastewater (specified facilities). Japan has implemented projects that contribute to the conservation of water quality such as the effluent regulations for water discharged from specified workplaces into public waters, and the development of wastewater treatment facilities including sewage systems/septic tanks. Besides, for certain specified workplaces in some industrial and livestock sectors that have a difficulty meeting the uniform effluent standard, a tentative effluent standard is applied with a specified time limit. Under the Waterworks Law (Law No. 177 of 1957), nitrate nitrogen and nitrite nitrogen are also set as drinking water quality standard items in terms of effects on human health. However, these substances cannot be reduced by ordinary water purification treatments (coagulation sedimentation sand filtration). If they are required to be reduced, it puts a heavy burden on water supply businesses to introduce advanced treatment systems and other responsive measures. Therefore, it is important to manage nitrogen in the water environment also from the perspective of avoiding or reducing the impact on water supply businesses.

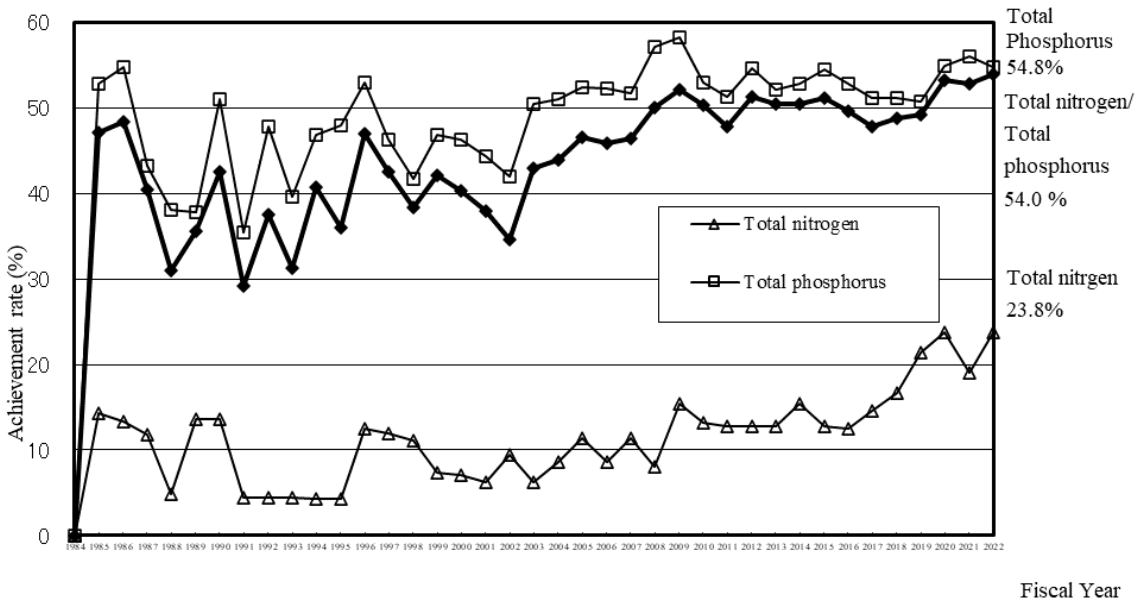
In addition, for lakes where the environmental standards for water pollutants need to be urgently achieved, Japan has implemented pollution load control measures and lakeside environmental conservation measures such as the conservation of vegetation/aquatic organisms through a Lake Water Quality Conservation Plan according to the Law Concerning Special Measures for the Preservation of Lake Water Quality (Law No. 61 of 1984). Furthermore, focusing on wide and enclosed coastal areas where population/industry is concentrated (Tokyo Bay, Ise Bay and the Seto Inland Sea), based on the Water Pollution Prevention Act and the Law Concerning Special Measures for Conservation of the Environment of the Seto Inland Sea (Law No. 110 of 1973), Japan has been reducing the total nitrogen by setting goals for the total pollutant load of nitrogen and other designated items, and enforcing regulations for target factories or workplaces. Other initiatives have been undertaken to preserve, restore and create healthy ecosystems, such as improving the bottom sediment environment with sand cover.

As a result of these measures, water pollution by reactive nitrogen in Japan has been drastically reduced; the exceeding rate of the environmental standard in FY2022 was 0.05 % for nitrate nitrogen and nitrite nitrogen of a health item in rivers/lakes/sea areas. In addition, the

exceeding rate of the environmental standards for the total nitrogen of a living environment item in sea areas has been greatly reduced since FY 1995, and the rate was 0.7 % in FY2022. The exceeding rate of the environmental standard for nitrate nitrogen and nitrite nitrogen in groundwater has also reduced with a peak in FY 2003, and the rate was 2.7 % in FY 2022.

On the other hand, the achievement rate of the environmental standards for total nitrogen of a living environment item in lakes is continuously low. It is unlikely to show a significant increasing trend. Although the achievement rate of the environmental standard for nitrate nitrogen and nitrite nitrogen also tends to increase, the concentration of nitrate nitrogen and nitrite nitrogen remains at a high level over long periods, especially among the groundwater environmental standard items.

In contrast, it has been pointed out that in the Seto Inland Sea, Ise Bay, and other sea areas, there are problems affecting marine resources such as the fading of the color of nori seaweed due to a lack of nutrients. Therefore, it is necessary to maintain/restore healthy water cycles and material circulation.



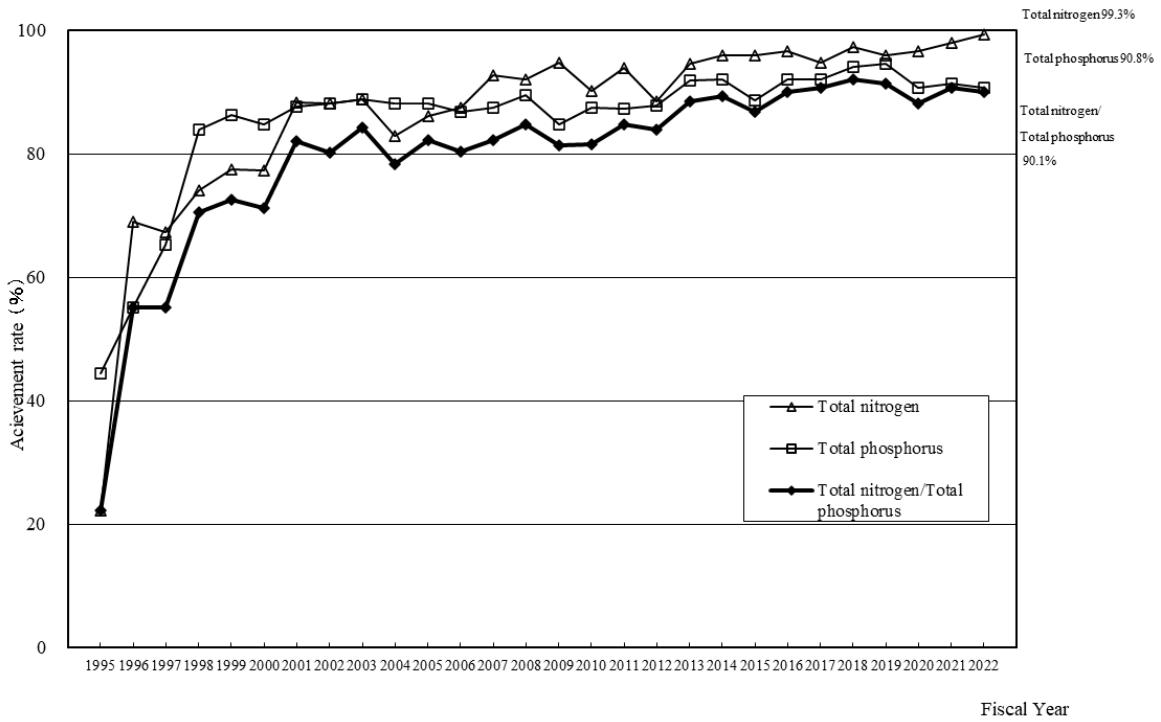


Figure 17 Percentage of lakes (above) and sea areas (below) achieving environmental standards for total nitrogen and total phosphorus

Source: Ministry of the Environment. Results of Water Quality Measurements of Public Water Bodies in FY 2023 (January 2023).

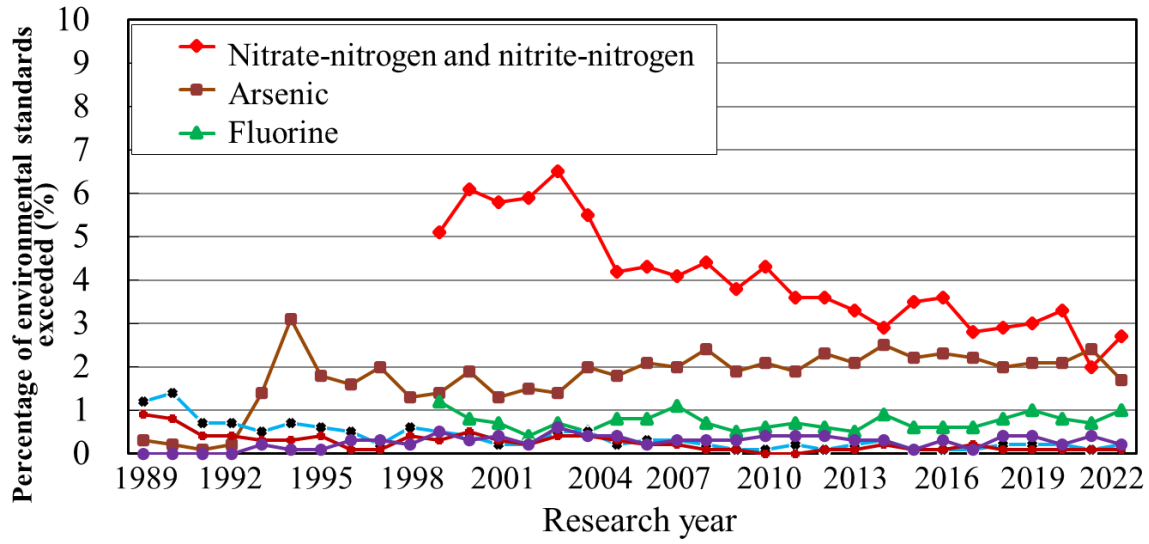


Figure 18 Trends in percentages of groundwater exceeding environmental standards in the groundwater overview research

Source: Ministry of the Environment. Results of Underground Water Quality Measurements in Fiscal 2021 (January 2023).

3． Agriculture/livestock industry

In Japan, one of the nitrogen applications is agricultural fertilizer, and excessive application

of fertilizer causes a portion of the nitrogen to be discharged to the atmospheric and water environment.

There is ammonia nitrogen or nitrate nitrogen used for agriculture, and fertilizers containing them have been used since around 1900. Under the Act on the Quality Control of Fertilizer (Act No. 127 of 1950), to secure the quality of fertilizers, any person who intends to manufacture fertilizers must register or notify the national or prefectural government, and only fertilizers that meet the official specifications are allowed to be distributed. The Act was amended in 2020 to reduce chemical fertilizers and to facilitate utilization of organic materials such as compost, and the relevant regulation on fertilizer formulation was reviewed.

To reduce the use of chemical fertilizer, each prefectural government has compiled and published "fertilizer application standards", "soil diagnosis standard value", and "fertilizer reduction standards" based on the soil quality and crops in its jurisdiction, with basic knowledge and information on efficient fertilizer application techniques.

Additionally, the MIDORI Strategy for Sustainable Food Systems (developed in May 2021) sets targets to reduce the use of chemical fertilizer made from imported raw materials and fossil fuels by 20 % (compared to the 2016 fertilizer year) and 30 %, by 2030 and 2050 respectively, and the Act to Promote Low Environmental Impact Business Activities for the Establishment of Environmentally Harmonized Food Systems (Act No. 37 of 2022) (hereinafter referred to as the "MDORI Act") certifies implementation plans prepared by agricultural producers and businesses supporting them that aim to reduce environmental impact by reducing the use of chemical fertilizers and encourages such activities described in the plans. In addition, the Ministry of Agriculture, Forestry and Fisheries (MAFF) has been promoting proper fertilizer application on a trial basis since FY2024 by implementing a “cross-compliance” system that makes it mandatory for all subsidized projects and other initiatives to reduce environmental impact, such as recording and storing fertilizer use and preparing soil through the proper application of organic matter, as a minimum.

The use of chemical fertilizers has been reduced by about 6 % (compared to the 2016 fertilizer year) in FY2021 due to the progress in effective fertilizer application through soil diagnosis, but it is still necessary to promote the reduction of excessive fertilizer use in agriculture.

The "Policy Outline to Strengthen Food Security" (decided in December 2022) aims to make double the use of compost/sewage sludge resources and to increase the ratio of national resources to 40 % of the total amount of fertilizers used (based on phosphorus) by 2030. At present, Japan imports almost all of the main chemical fertilizer raw materials. For a stable supply of fertilizers, and economic and food security, it is vital to improve the resilience of food production by reducing dependence on fertilizer imports through appropriate fertilizer application and increased fertilizer use of domestic resources such as compost and sewage sludge resources. It is also essential to promote appropriate nitrogen management domestically.

In addition, compost is effective in accumulating carbon in soils and helping to absorb CO2 through farmland and pasture management activities. However, as the amount of livestock manure generated is likely to be unevenly distributed across regions, it is necessary to further promote resource circulation by expanding the distribution of compost and energy use.

4. Waste/resource circulation

Nitrogen is used for industrial activities, enters human societies as food products, and is transferred to the environment through waste and sewage discharged from these activities. To manage nitrogen sustainably, it is necessary to address the proper management of waste containing nitrogen and the resource circulation/effective utilization.

Wastes containing nitrogen are food waste of municipal waste, sludge of industrial waste, animal residues and animal manure, and the Act on Waste Management and Public Cleaning (Act No. 137 of 1970) (hereinafter referred to as the Waste Management Act) requires the reduction in discharge of wastes and their management in an environmentally sound manner.

Especially, the Act on Promotion of Recycling and Related Activities for Treatment of Cyclical Food Resources (Act No. 116 of 2000) (hereinafter referred to as the Food Recycling Act) requires food-related businesses to conduct generation reduction, recycling, thermal recovery, and volume reduction). In addition, the Act on Promotion of Food Loss and Waste Reduction (Act No. 19 of 2019) (hereinafter referred to as the Food Loss and Waste Reduction Promotion Act) implements public awareness and other measures to deepen the understanding of the importance of reducing food loss and waste (discarded but still edible food) with cooperation/collaboration between consumers and businesses who could contribute to food loss and waste reduction.

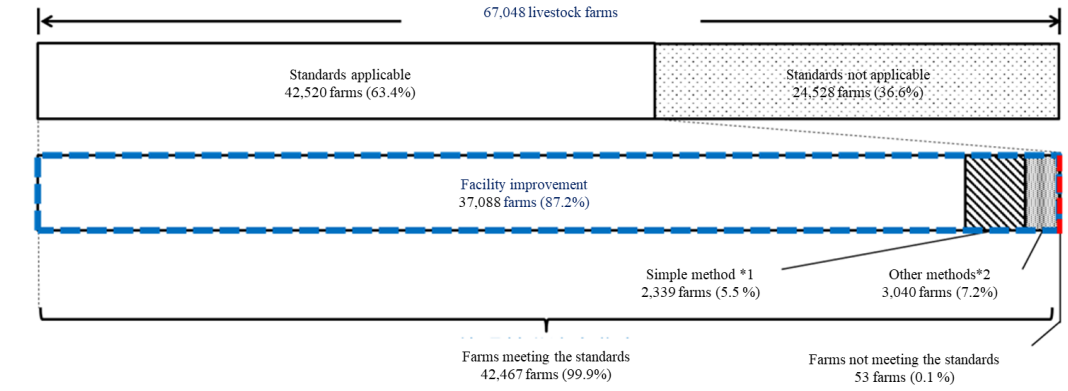
Regarding animal manure (manure from cattle, pigs, chickens, and horses), the Waste Management Act requires livestock farmers to properly dispose of manure as industrial waste on their own responsibility. The Act on the Proper Management and Promotion of Use of Livestock Manure (Act No. 112 of 1999) (hereinafter referred to as the Livestock Manure Management Act) also facilitates the utilization of livestock manure while eliminating field piles and unlined pits to ensure the proper management (treatment and storage) of livestock manure.

For sewage sludge, the Waste Management Act stipulates that sewage sludge should be properly treated as industrial waste. In addition, under the Sewerage Act (Act No. 79 of 1958), a public sewerage system administrator is required to endeavor to reduce the volume of generated sludge and to have it recycled as fuel or fertilizers.

As a result of these measures, the recycling rate of cyclical food resources has increased every year, and the amount of food loss and waste was reduced by about 47 % in FY2021 compared with FY 2000. For livestock manure, 99.6 % of the farmers subject to the

Livestock Manure Management Act complied with the structural equipment standards, and about 81 % of livestock manure was recycled for agricultural purposes in 2022. The sewage sludge recycling rate has also increased in recent years, and about 77 % was recycled in FY2021, but only 14 % of that was used for agriculture and landscaping.

However, livestock manure is generated unevenly in the regions where the livestock industry is popular, and it is important to facilitate wide-area distribution according to regional conditions to further promote recycling. Furthermore, about 1,000 wastewater treatment plants utilize sewage sludge for fertilizers, but most of them employ fertilizer utilization as one of the several recycling/disposal methods; therefore, it is necessary to increase the ratio of fertilizer utilization to the total amount of sludge generated.



*1 These include applications that would not fall under the category of permanent facilities (e.g., covering with tarps, etc.).
*2 These include applications of waste to farmland, year-round grazing, commissioning of others to process waste and use of sewers.

Figure 19 Number of farmers subject to the Livestock Manure Management Act

Source: Ministry of Agriculture, Forestry and Fisheries.
Survey on the Enforcement Status of the Livestock Manure Management Act (as of December 1, 2021)

Table 2 Laws and regulations on each medium related to nitrogen [5]

Medium	Act/law	Type	Target	Target substance	Environmental standard/ Emission standard	Note
Atmospheric Environment	Basic Act on the Environment	Environmental standard (health item)	Atmosphere	NO2	Daily average of 1 hour value is within the range of 0.04 - 0.06 ppm or less	
	Offensive Odor Control Act	Regulation standard	Atmosphere	Ammonia	Regulation standard set for each prefecture and each zone classification	
	Air Pollution Control Act	Emission standards	Fixed sources	NOx	Set by facility and scale	
		Permissible limits (emission standard)	Mobile sources	NOx	Set by vehicle type and gross vehicle weight	
	Act on Prevention of Marine Pollution and Maritime Disaster	Emission standards	Vessels	NOx	Set by type of engine, capacity, and use of the vessel	There are also regulations for sewage discharge.
	Civil Aeronautics Act	Emission standards	Aircrafts	NOx	Set by rated thrust of engine and date of manufacture	
	Act on Regulation, Etc. of Emissions from Non-road Special Motor Vehicles	Emission standards	Non-road special motor vehicles	NOx	Set by rated output	
	Law Concerning Special Measures for Total Emission Reduction of Nitrogen Oxides and Particulate Matters	Emission standards	Automobiles	NOx	Set by vehicle type and gross vehicle weight	
	Act on Promotion of Global Warming Countermeasures	Emission Reporting Obligation	Specified Business Operator	N2O		
Aquatic environment	Basic Act on the Environment	Environmental standards (health items)	Public water bodies, groundwater (environmental standards and purification standards)	NO3-N + NO2-N	10 mg L-1* or less	Same as in the water quality standards for tap water. *Total amount of nitrate ion concentration multiplied by 0.2259 and nitrite ion concentration multiplied by 0.3045
				Total cyanogen	Not to be detected	
		Environmental	Lakes	Total	0.1 -1.0 mg L-1 or	5 categories (I - V)

[5] Cited and modified from the source: Hayashi et al. (2021). "Illustrated Science of Nitrogen and the Environment - Linkage between Human, Nature and Sustainable Nitrogen Use", Asakura Shoten.

Medium	Act/law	Type	Target	Target substance	Environmental standard/ Emission standard	Note
		standards (living environment items)		nitrogen	less	
			Marine areas	Total nitrogen	0.2 - 1.0 mg L-1 or less	4 categories (I - IV)
	Water Pollution Prevention Act	Effluent standards	Factories and workplaces	NH4-N + NO3-N + NO2-N	100 mg L-1 *	Discharged into public waters. *Ammonia nitrogen multiplied by 0.4, total amount of nitrite nitrogen and nitrate nitrogen *Tentative effluent standards exist for some industries.
				Cyanide	1 mg CN L-1	Discharged into public waters
				Total nitrogen	120 mg L-1 (daily average 60 mg/L)	Set for closed sea areas, lakes designated by the Ministry of the Environment Factories or workplaces with a daily wastewater discharge of 50 m3 or more Provisional effluent standards exist for some industries.
		Underground permeation standard		NH4-N NO3-N NO2-N	0.7 mg L-1 0.2 mg L-1 0.2 mg L-1	Underground permeation is not allowed when the concentration of target substance is equal to or higher than the standard
		Standards for controlling total emissions	Factories and workplaces	Total nitrogen	Set by industry and facility in each prefecture	Tokyo Bay, Ise Bay, Seto Inland Sea
	Law Concerning Special Measures for Conservation of Lake Water Quality	Regulations and promotion of measures	Factories and workplaces	Total nitrogen	Set by industry and facility in each prefecture	
	Sewerage Act	Sewage removal (from factories) standards	Specific factories	NH4-N + NO3-N + NO2-N	380 mg L-1 (If there is an additional standard in the ordinance based on the Water Pollution Prevention Act, it is less than 3.8 times the additional standard)	125 mg L-1 (or less than 1.25 times the additional standard) when sewage from manufacturing or gas supply industry is more than 1/4 of the treated sewage.
	Purification Tank Act	Promotion of measures	Citizens	Organic nitrogen, NH4-N NO3-N NO2-N		Advanced purification tank
	Water Supply Law	Environmental standards (health items)	Tap water	NO2-N	0.04 mg L-1or less	
				NO3-N + NO2-N	10 mg L-1 or less	

Medium	Act/law	Type	Target	Target substance	Environmental standard/ Emission standard	Note
				Cyanide ions and cyanogen chloride	Cyanide ions have to be 0.01 mg/L or less in terms of cyanogen content	
Agriculture and Livestock Industry	Act on the Quality Control of Fertilizer	Regulations	Business operators	Fertilizer		
	Economic Security Promotion Act	Promotion of measures	Farmers	Fertilizer		
	Law Concerning the Promotion of Business Activities to Reduce Environmental Impacts for the Establishment of a Food System in Harmony with the Environment	Promotion of measures	Business operators and Farmers	Chemical fertilizer		30 % reduction in chemical fertilizer use by 2050, 20 % reduction by 2030 (both compared to 2016 fertilizer year)
	Food Sanitation Act	Standards	Business operators	NO2-N	0.04 mg L-1 or less	Soft drinks
				NO3-N + NO2-N	10 mg L-1 or less	
				Cyanogen (cyanogen ion and cyanogen chloride)	0.01 mg L-1 or less	
				Food additives such as KNO3 and NaNO3	0.2 g L-1 0.1 g L-1	Cheese, Sake, etc.
	Basic Act on Shokuiku (Food and Nutrition Education)	Promotion of measures	Citizens and business operators	Organic nitrogen		
Waste and Resource Circulation	Waste Management Act	Regulations and promotion of measures	Municipal waste and industrial waste	Organic nitrogen		
	Act on Promotion of Recycling and Related Activities for Treatment of Cyclical Food Resources	Promotion of measures	Business operators and farmers	Organic nitrogen		
	Food Loss and Waste Reduction Promotion Act	Promotion of measures	Business operators	Organic nitrogen		
	Act on the Proper Management and Promotion of Use of Livestock Manure	Regulations and Promotion of measures	Livestock farmers	Organic nitrogen NO3-N		
	Water Pollution Prevention Act	Effluent standards	Business operators (livestock)	NH4-N + NO3-N + NO2-N	-General effluent standards Values indicated in the above "Aquatic Environment/Water Pollution Prevention	Provisional effluent standards apply to the following specified facilities. -Pig pens with a total area of 50 m2

Medium	Act/law	Type	Target	Target substance	Environmental standard/ Emission standard	Note
					Act /effluent standards. -Provisional effluent standards 300 mg L-1 * (cattle pen) 400 mg L-1 * (pig pen)	or more -Cattle pens with a total area of 200 m2 or more -Horse stalls with a total area of 500 m2 or more *Total of ammoniacal nitrogen multiplied by 0.4, nitrite-nitrogen and nitrate-nitrogen n
				Total nitrogen	-General effluent standards Values indicated in the above "Aquatic Environment/ Water Pollution Prevention Act/ effluent standards -Provisional effluent standard 130 mg L-1 (daily average 110 mg/L)	Provisional effluent standards apply to pig farming places with a daily effluent volume of 50 m3 or more discharging into closed sea areas and lakes designated by the Ministry of the Environment's public notice.
	Offensive Odor Control Act	Standards	Business operators	Ammonia	Varies by region	
	Sewerage Act	Promotion of measures	Business operators Firms	Organic nitrogen		Recycling sewage sludge

Chapter 3. The National Action plan on sustainable nitrogen management

As a result of implementation of the measures to present, air and water pollution caused by nitrogen compounds has been drastically reduced in Japan. However, some areas still do not meet the environmental standards for nitrate nitrogen and nitrite nitrogen in groundwater and for total nitrogen in lakes. On the other hand, in some enclosed coastal areas, it has been noted that biodiversity/biological productivity has been affected by nutrients deficiencies. In addition, it is expected that ammonia fuel will be widely used to achieve carbon neutrality, which will be compatible with reducing nitrogen emissions to the atmospheric environment.

In this respect, each region in Japan has different problems. Therefore, a healthy nitrogen cycle is required with considerable correspondences such as promoting the reduction and recovery/recycling of nitrogen waste according to the region’s conditions.

For this reason, as an integrated approach to conservation/management of the water and atmosphere environment with carbon neutral, circular economy and nature positive, collaborative projects among relevant ministries and agencies will be developed to bring benefits to societies and regions through nitrogen management.

Japan will also contribute to nitrogen management in Asian countries by sharing Japan’s

knowledge and experience, facilitating capacity building and technology transfer.

Section 1. Conservation and management of the water and atmospheric environment

It is vital to consider actions for sustainable nitrogen management after understanding the comprehensive nitrogen material flow with the balance of its inputs and outputs as reactive nitrogen is found in different media such as water, soil, and air.

1. Environmental monitoring

To understand the reactive nitrogen concentration in the water and atmospheric environment, national/prefectural governments will conduct continuous monitoring. The government will also consider whether additional monitoring for ammonia and other substances is necessary and feasible to ensure the sustainable nitrogen management.

In addition, Japan will accumulate detailed data on the presence of reactive nitrogen in the environment and promote understanding of the cross-media behavior of reactive nitrogen in water, air, and soil, by collaborating with EANET and other research institutions. The EANET has been continuously monitoring dry and wet deposition of nitrogen-containing substances for a long time to identify the status of acid rain and its influence in the East Asian region.

2. Wastewater effluent/air emission control

To control and properly manage the discharge of reactive nitrogen into the water and atmospheric environment, Japan will make efforts to prevent water and air pollution by enforcing effluent and emission standards and promoting advanced treatment such as denitrification at necessary workplaces, and other initiatives based on the Water Pollution Prevention Act, the Law Concerning Special Measures for the Preservation of Lake Water Quality, the Air Pollution Control Act, the Automobile NOx/PM Law. Moreover, based on the Water Pollution Prevention Act, the government will identify the status of wastewater treatment improvement at workplaces where provisional effluent standards are applied such as those in livestock and agriculture sectors and continue to encourage them to improve water quality of effluent.

As for lakes, considering the impact of climate change and changes in biodiversity, the national government will shift its policy to conserve both aquatic resources and water quality and consider evaluation indicators for the health and material cycle of the lakes by promoting material circulation in addition to reducing the traditional nitrogen loading from input.

In enclosed coastal seas, to achieve “Clean and Rich Seas,” approaches to water environment management that are tailored to the specific conditions of each sea area will be considered,

including reviewing the Total Pollutant Load Control System and the environmental standards for preserving living environments that meet regional needs, etc. Furthermore, the follow-up on legislative changes, including the nutrients management system will be conducted five years after the amendment of the Law Concerning Special Measures for Conservation of the Environment of the Seto Inland Sea. For the follow-up, the government will promote information collection/study/research on the effectiveness of nutrients management to ensure biodiversity/biological productivity and reflect the results of such activities on more appropriate improvement measures in the future.

For groundwater, the government will comprehend the current situation and clarify issues with countermeasure guidelines and analysis models, etc. to continuously promote consensus building among local stakeholders and initiatives to reduce nitrogen loads. In addition, issues in the comprehensive regional measures for nitrate-nitrogen, etc. that have been implemented so far will be sorted. Similarly, methods to promote voluntary initiatives by municipalities, etc. will be examined. Simultaneously, examples of advanced initiatives will be horizontally deployed.

For the atmospheric environment, through the implementation of the "Comprehensive Measures against Photochemical Oxidants (Ox) to Combat Climate Change and Improve the Atmospheric Environment (the Working Plan on Ox Measures)" (developed in January 2022) for the reduction of Ox for which achievement rate of the environmental standard is low, the government will promote various policy measures, including the measures against the precursors NOx and volatile organic compounds, based on scientific knowledge.

Section 2. Integrated approaches of water and atmospheric management with carbon neutral

In closed coastal areas where nutrients deficiency are identified, the government will take measures to provide nutrients from wastewater treatment facilities for the creation of the "Clean and Rich Sea", examining effectiveness of active operation management of wastewater treatment facilities for energy conservation.

It is crucial to improve the quality of rivers, lakes and groundwater, which can be a source of water supply. Therefore, the use of fertilizers and appropriate treatment of fermentation residues generated as by-products of methane fermentation of livestock waste etc. should be considered. Meanwhile, the government will promote energy use through biogasification and reducing excess nitrogen discharge into soil, groundwater etc. and measures to control excessive nitrogen emissions into soil, groundwater, etc.

Developing and utilizing ammonia and other substances for applications such as thermal power generation, fuel in industrial furnaces and ships, and hydrogen carriers, are expected to expand in the future. Accordingly, the use, development and introduction of technologies, etc.

that do not increase NOx and N2O emissions should be promoted. In addition, the government will promote the expansion of ammonia use and other substances that contribute to decarbonization, in harmony with the local atmospheric environment. It will be conducted by promoting measures against unburnt ammonia and conducting ambient environment monitoring, including of ammonia.

The government will also promote alternatives to cleaner vehicles such as electrified vehicles.

To reduce emissions of the greenhouse gas N2O, the agricultural sector will work on reducing the use of nitrogen fertilizers, developing and disseminating fertilizer technologies that match the growth stage of crops, controlling nitrification for efficient fertilizer use, promoting denitrification reactions and N2O control technologies. In addition, regarding emissions from sewage and wastewater treatment and incineration of waste and other materials, the practical implementation and dissemination of N2O emission control technologies, such as the collection of knowledge through fact-finding surveys and the upgrading of combustion, will be promoted.

Besides, the government will verify the energy-saving and N2O emission reduction effects and promote the use of the J-credit system, which brings benefits to the region.

Section 3. Integrated approaches of water and atmospheric management with circular economy

Based on the MIDORI Strategy for Sustainable Food Systems, to achieve the reduction target of the use of chemical fertilizers, the government will facilitate the proper fertilizer application, incubate collaboration among suppliers of raw materials for fertilizer and manufacturers and users of fertilizer, and promote the establishment of necessary facilities/infrastructure with sewerage system administrators. In addition, in terms of compliance with prefectural fertilizer application standards, especially in the areas where pollution load from agriculture and livestock industry is significant, the government will control excess nitrogen emissions into the air, water bodies and other environmental media by applying the correct amount of fertilizer according to the nature of the land through promoting soil diagnosis and fertilizer application plans based on the diagnosis.

In lakes facing the eutrophication problem, the government will consider initiatives for effective use of bottom sediment resources.

While promoting the technology development for recovering ammonia, nitric acid and other substances from ammonia nitrogen and nitrate nitrogen in the wastewater treatment process to increase the amount of nitrogen recovery, the government will consider the establishment of nitrogen supply chains including securing users for the recovered substances. The government will also consider measures to control ammonia volatilization during compost production processes (identifying the status of ammonia emissions, expanding the use of deodorization

technology, developing ammonia recovery technologies and marketing potential users of recovered ammonia), toward expanding the use of manure and sewage sludge resources as fertilizer and energy sources.

To reduce excess nitrogen emissions from the disposal of food products, food-related businesses will address food loss and waste in accordance with the Act on Promotion of Recycling and Related Activities for Treatment of Cyclical Food Resources and the Act on Promotion of Food Loss and Waste Reduction, and prioritize and promote producing animal feed and fertilizer, which can be the most effective use of rich nutrient value for recyclable food resources.

To ensure that businesses have an advantage in working on reducing nitrogen loading and to create consumer demand for products with reduced nitrogen loading, the government will consider a system to visualize the achievements of businesses that have reduced nitrogen loading in food production and inform consumers about these achievements.

Moreover, the government will consider providing incentives and developing programs to encourage the following businesses to choose products with reduced nitrogen loading: businesses involved in food preparation/supply and sales (restaurants, hotels, convenience stores and supermarkets) and businesses that host MICE[6] such as international conferences (municipal convention centers, municipal officials, and travel agencies). The government will facilitate ethical consumption by raising public awareness about the usefulness of products with reduced nitrogen loading and promote the dissemination of these products.

Section 4. Integrated approaches of water and atmospheric management with nature positive

Nitrogen, phosphorus, and other nutrients are essential for life and are vital to a bio-rich ocean. On the other hand, excessive nitrogen could cause eutrophication in lakes and oceans. The Kunming-Montreal Global Biodiversity Framework, adopted at the 15th meeting of the Conference of the Parties to the Convention on Biological Diversity in December 2022, included Target 7, which aims to reduce excess nutrients lost to the environment. It is also essential to consider the balance between nutrients such as nitrogen and phosphorus, and carbon for the conservation of ecosystems such as watersheds. For this reason, the government needs to diagnose the natural ecosystem including aspects of the material balance such as the nitrogen cycle and strive to achieve the sustainable use of natural environment and

[6] MICE is acronym of the followings: Meeting for companies, etc. (Meeting), Incentive and study travels conducted by companies, etc. (Incentive Travel), International conventions conducted by international organizations/associations and academic societies (Convention), Exhibitions/trade fairs and event (Exhibition/Event), and general term for business events that are expected a large number of visitors and interactions. (cited from Japan Tourism Agency, the Ministry of Land, Infrastructure, Transport and Tourism)

resources from an international perspective.

In enclosed coastal areas lacking nutrients, the government will promote active operation management for nutrients in wastewater treatment facilities under regional agreements, as well as realizing the "Clean and Rich Sea" by implementing initiatives such as the conservation/restoration of seaweed beds and tidal flats, which are also expected to function as blue carbon in coastal areas.

In addition, the Global Core Disclosure Indicators of the TNFD, which establishes a framework for private companies and financial institutions to appropriately assess and disclose risks and opportunities related to natural capital and biodiversity, include the global core disclosure indicators for total air pollutants other than greenhouse gases (GHG), NOx and ammonia. Considering these trends and others, necessary measures should be considered to ensure that information disclosure by private companies engaged in appropriate nitrogen management, including LCA (Life Cycle Assessment), leads to improved corporate value and business continuity.

Section 5. Awareness-raising on nitrogen management

To promote the understanding of stakeholders on the importance of chemical fertilizer reduction toward sustainable agricultural production and of using fertilizer made from national resources in Japan, which possesses few natural resources as raw materials for fertilizers, the government will provide information on advanced practices using domestic resources for fertilizer and hold forums for exchanging information and building partnerships among stakeholders.

To expand business initiatives that contribute to the reduction of nitrogen loading and promote ethical consumption to select products with reduced nitrogen loading, the government will consider approaches including seminars/symposiums and food education activities and facilitate initiatives to raise awareness among consumers and businesses, in collaboration with research institutions.

Section 6. Capacity building on nitrogen management

To utilize existing international cooperation frameworks and contribute to nitrogen management in Asian countries, Japan will promote the international sharing of our knowledge and experience in nitrogen management and capacity building for administrative officials through the activities of EANET and WEPA. EANET has members from 13 Asian countries and promotes regional cooperation in monitoring acid rain and air pollutants, while WEPA has members from 13 Asian countries and promotes each country’s water management governance by improving water-related legal systems and strengthening operation and wastewater management.

While collaborating with relevant international organizations, Japan will also promote its technologies for improving the water and atmospheric environment internationally, through the following projects that Japan has implemented in the Asian region: Co-benefit promotion projects to improve the atmospheric environment and mitigate climate change, and Asian Water Environment Improvement Model Projects to conduct on-site demonstrations of Japanese companies' technologies to improve the water environment.

Section 7. Public investment in nitrogen management

The government will allocate the necessary budget to implement activities mentioned in this national action plan to promote sustainable nitrogen management.

In addition, to reduce excessive nitrogen waste, the government will develop and introduce technologies to reduce the amount of fertilizer applied, develop/install hard infrastructure such as composting facilities, and promote demonstrations/experiments of the technologies.

Section 8. Progress in science and technology on nitrogen management

To further advance efforts for sustainable nitrogen management, relevant research institutions are expected to advance technological development with a view to accumulating scientific knowledge of recovery and effective utilization of reactive nitrogen before it is discharged into the environment, research on visualization of nitrogen loading and circulation of nitrogen discharged into the environment, refining nitrogen inventories and their continuous updating methods, and developing LCA methods that enable businesses to understand and assess their nitrogen loading, and establishing a nitrogen supply chain. The government will collect and analyze the data that will serve as the basis for considering and reviewing measures by promoting information sharing between research institutions and government agencies, including the accumulation of knowledge and technologies on reductions of reactive nitrogen losses. The government will also promote human resource development for young researchers and others, who are involved in nitrogen management, and technology development/succession, through measures such as proposing administrative needs in the Environment Research and Technology Development Fund, considering mechanisms to promote discussions/developments on new measurement methods, technologies to respond by private companies and research institutions.

In addition, since EANET has been monitoring wet deposition, dry deposition, soil, vegetation, terrestrial water, and watersheds for a long time in East Asia and has gained knowledge and experience for a lot of monitoring data on reactive nitrogen, Japan will contribute to elaborating the nitrogen inventory by utilizing such data and proceed with nitrogen deposition assessment and source analysis that will benefit formulating measures.

Furthermore, the government will enrich the scientific knowledge by conducting

studies/research on the relationship between nitrogen management and biodiversity conservation including the material balance perspective such as the nitrogen cycle in inner bays and hinterland watersheds or terrestrial areas and promote policy measures related to the conservation/restoration of seaweed bed/tidal flats and blue carbon initiatives.

Chapter 4. Follow-up of the national action plan

Relevant ministries and agencies will cooperate in following up on the implementation status of the national action plan, as appropriate. They will also understand the current situation of national nitrogen management by updating the national nitrogen budget and emission inventory as appropriate.

The government will review the national action plan as needed based on discussions among the relevant ministries and agencies, considering trends in international discussions on sustainable nitrogen management, the progress of relevant initiatives in Japan, other environmental conditions, and changes in society/economy.

Members of the Liaison Conference of the Relevant Ministries and Agencies on Sustainable Nitrogen Management

Ministry of Health, Labour, and Welfare	Director, Water Supply Division, Health and Consumer Affairs Bureau * Participated as a member until March 2024 due to transfer to a different organization.
Ministry of Agriculture, Forestry and Fisheries	Director, Environmental Biomass Policy Division, Minister's Secretariat
Ministry of Economy, Trade and Industry	Director, Hydrogen and Ammonia Division, Energy Conservation and New Energy Department, Agency for Natural Resources and Energy
Ministry of Land, Infrastructure, Transport and Tourism	Director, Environmental Policy Division, Policy Planning Bureau
Ministry of the Environment	Director, Environmental Management Division, Environmental Management Bureau (Chair)

Secretariat: Environmental Management Division, Environmental Management Bureau, Ministry of the Environment

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Kentaro Hayashi	Professor (Chairperson), Research Department, Research Institute for Humanity and Nature, National Institute for Global Environmental Studies
Masaaki Hirohata	Director, Kumamoto Prefectural Institute of Public Health and Environmental Science
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