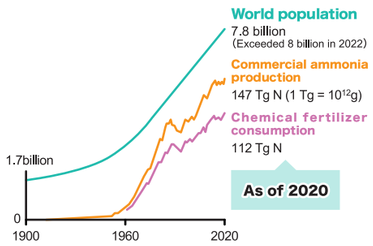
Human Nr Production Changed the World

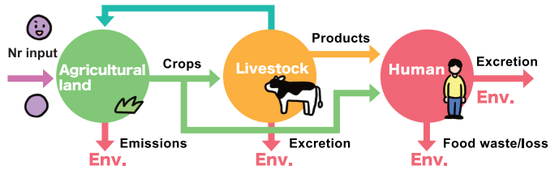
How much Nr has humanity used? Commercial production of ammonia by the Haber-Bosch process began in 1913. Since the 1960s, ammonia production and chemical fertilizer consumption have grown rapidly and continue to this day. Nitrogen fertilizers have improved food production and thereby supported the growing world population.



Nitrogen fertilizers have also increased crop yields, part of which is used for animal feed, increasing livestock production.

However, much of the Nr input for food production leaks into the environment. The world's nitrogen use efficiency, the ratio of N in harvested crops to the total input N, is approximately 50% for crops and only 5%–20% for livestock products. The rest is lost to the environment unless we circulate it properly.

If you take in the same amount of protein, livestock products tend to result in a higher Nr loss to the environment than crops. Food loss and waste not only waste the food that is thrown away but also the Nr input to produce the food.



Nr leaks into the atmosphere, soil, water, and oceans. Once lost in the environment, Nr travels around, changing its forms, and exhibits different impacts depending on species.

Agriculture is not the only source of Nr loss. The combustion of fossil fuels to generate energy for more comfortable life living and waste incineration also emit Nr, typically nitrogen oxides, to the atmosphere.

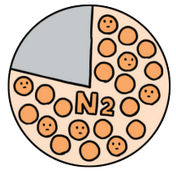
Nr in exhaust gas and wastewater can be converted back to an unharmful form, N_2 through treatment, but it is expensive. It is, therefore, important to use Nr more efficiently.

What problems can the Nr loss to the environment cause?

What is "Nitrogen?"

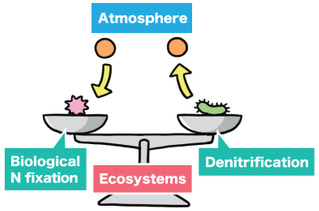
Nitrogen is the fifth most abundant element in the solar system with the symbol "N."

Earth's atmosphere is composed of 78 % molecular nitrogen (dinitrogen: N_2).



Nitrogen is crucially important to living things as an essential component to form proteins and DNAs. Nitrogen makes up about 3% of the human body weight.

However, N_2 abundant in the atmosphere is inert and does no harm nor good. What is needed is reactive nitrogen (Nr), a form usable to living organisms. Nr has diverse chemical species.

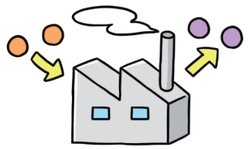


Some microbes produce Nr from N_2 in ecosystems. Plants absorb Nr to grow. Herbivores eat plants and carnivores eat herbivores to deliver Nr into their bodies. Microbes also decompose Nr in organic matter and eventually convert it back to N_2.

Humanity has also been living by circulating Nr. In the past, agriculture fully depended on Nr in various organic matter such as manure and waste.

Shortage of Reactive Nitrogen (Nr)

The world population has increased gradually. More food was required for us to survive. How were we able to yield more food? The answer lay in "fertilizers." We needed Nr as fertilizers for crops.



In the early 20th century, the Haber-Bosch process was developed to artificially synthesize ammonia (a species of Nr) from N_2. This method allows us to produce chemical fertilizers as desired.

Nr has various uses other than fertilizers, e.g., industrial materials such as polymers and explosives, and an alternative energy source as fuel ammonia.

What is the outcome of artificially synthesizing Nr?

Sustai-N-able Project

Towards Sustainable Nitrogen Use
Connecting Human Society and Nature

FY2020 Incubation Study
FY2021 Feasibility Study
FY2022 Pre-Research
FY2023–FY2027 Full Research

Project Leader : Kentaro Hayashi (RIHN)
Natural Cycling Unit Leader : Keisuke Koba (Kyoto University)
Human Society Unit Leader : Kazuyo Matsubae (Tohoku University)
Economic Evaluation Unit Leader : Koichi Kuriyama (Kyoto University)
Future Planning Unit Leader : Kentaro Hayashi (RIHN)

Please visit the Sustai-N-able website for further information on the project and nitrogen issue.

https://www.chikyu.ac.jp/Sustai-N-able/index.html

457-4 Motoyama, Kamigamo, Kita-ku, Kyoto 603-8047 Japan
Tel : 075-707-2315
Mail : rihn.susn@chikyu.ac.jp

Research Institute for Humanity and Nature
大学共同利用機関法人 人間文化研究機構 総合地球環境学研究所

Production : Maki Asano, Yu Umezawa, Ayako Kimura, Makoto Saiki, Ryunosuke Tateno, Kentaro Hayashi, Tamaki Bito, Kanako Minaki

Illustration : Madoka Nakabayashi

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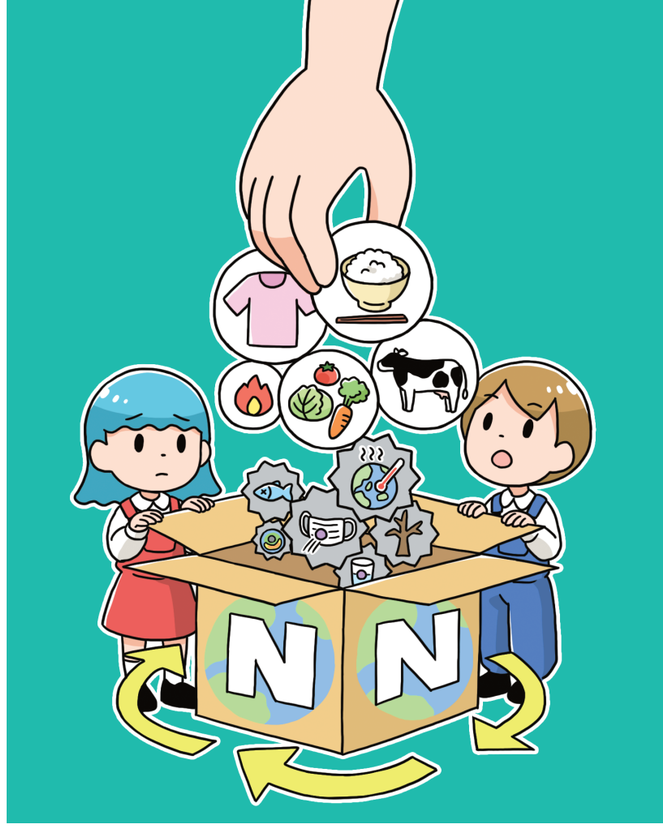

Research Program, Research Institute for Humanity and Nature

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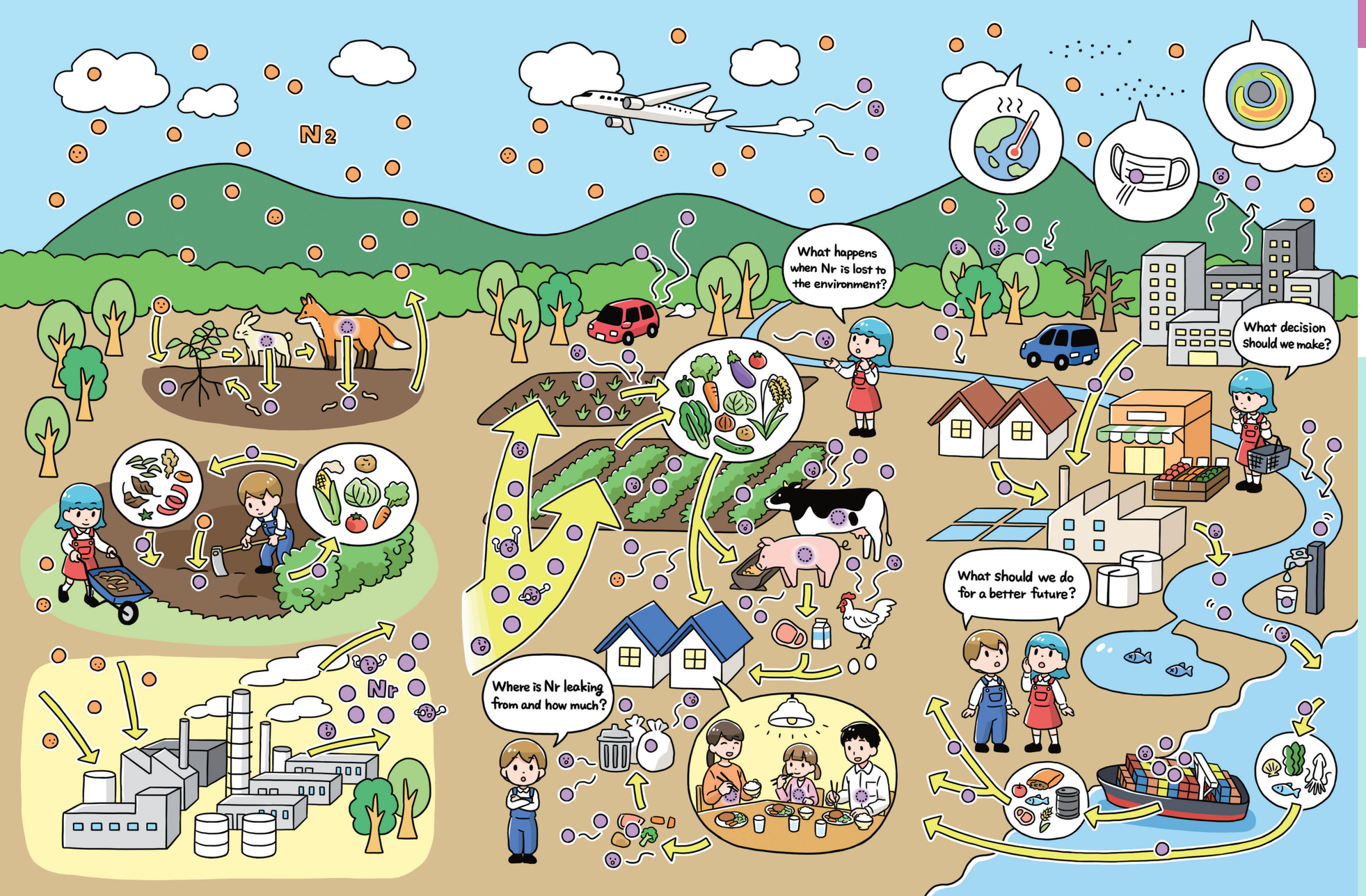

Impacts of Reactive Nitrogen (Nr) in the Environment

Global Warming

Nitrous oxide (N_2O) is a powerful greenhouse gas nearly 300 times as potent as carbon dioxide.

Stratospheric Ozone Depletion

N_2O is also an ozone depleting substance that increases ultraviolet radiation reaching the ground surface.

Air Pollution

Nitrogen oxides and PM2.5 (fine particulate matter) including the Nr-containing compounds are harmful to respiratory tract.

Water Pollution

Nitrates and nitrites in drinking water can cause health problems such as cyanosis and mutagenicity.

Eutrophication

Too much Nr can lead to eutrophication and change biodiversity and ecological functions, even causing death of living organisms.

Acidification

Nitric acid and nitrous acid acidify soils and land water, with some negative impacts on living things.

What We Do – the Sustai-N-able Project

Natural Cycling Unit

Q1 What happens when Nr is lost to the environment?

This unit aims to demonstrate the effects of Nr losses on the atmosphere, water, and soil, their impacts on human and natural health as well as nature's ability to convert Nr back to N_2.

Human Society Unit

Q2 Where is Nr leaking from and how much?

This unit will elucidate nitrogen flows and Nr losses to the environment from production and consumption of food, goods, and energy, and develop nitrogen footprint and future scenarios of nitrogen use.

Economic Evaluation Unit

Q3 What decision should we make?

This unit will identify how much emphasis is placed on measures to address the Nr-induced environmental impacts in consumers' food choice and farmers' food production, and explore sustainable food and agriculture.

Future Planning Unit

Q4 What should we do for a better future?

This unit will inform the public that our nitrogen use not only supports our life but also unintendedly induces nitrogen pollution, and work toward coproducing a system to explore sustainable nitrogen use for future generations.