Visualizing the mitigation effect of nitrogen load and chemical fertilizer use, and resource recycling using the food nitrogen footprint concept

The recent price hikes in fertilizers, feeds, and food threaten the global food system, people's livelihoods, and food security. This unstable global situation seriously affects small islands because they heavily rely on importing food and chemical fertilizers to sustain food supply and production. Chemical fertilizer is essential for crop production. However, inefficient use of fertilizers causes considerable loss of reactive nitrogen (Nr) to the environment through volatilization, leaching, and run-off. This phenomenon pollutes the atmosphere, groundwater, and surface water bodies, damaging the environment. To reduce the release of Nr into the environment, we should minimize the use of chemical fertilizers and promote the efficient reuse of regional resources, such as livestock manure. Farmers alone cannot improve nitrogen flow in the food system. The cooperation of consumers, the main driving force of nitrogen flow in the food system, is also essential. The nitrogen footprint is a simple quantitative indicator of the reality and problems of the nitrogen cycle and is useful for sharing results among stakeholders, including consumers. In this study, we aimed to evaluate the present nitrogen flow in the food system of Ishigaki Island, located in the subtropical zone of Japan, and propose a measure to improve it based on the nitrogen footprint concept.

We calculated Nr loss under the present condition of Ishigaki Island using statistical data. It aimed to assess the nitrogen load of the island's entire food system, including imported food and feed and exported food. The study also explored scenarios for achieving a 30% reduction in chemical fertilizer use, a goal of the Sustainable Food Systems Strategy, MIDORI, by maximizing the use of livestock manure on farmland. The results showed that by utilizing 70% of cattle manure on farmland, Nr inputs to crop production could be maintained even with a 30% reduction in chemical fertilizer use, ultimately reducing total Nr loss on Ishigaki Island by 18%.

The food nitrogen footprint applied in this study holds promise for similar tropical and subtropical island regions. It aligns with the United Nations Sustainable Development Goals (SDGs) and the Sustainable Food Systems Strategy, MIDORI. It is expected to aid in the development of strategies to address the recent volatility in chemical fertilizer prices.

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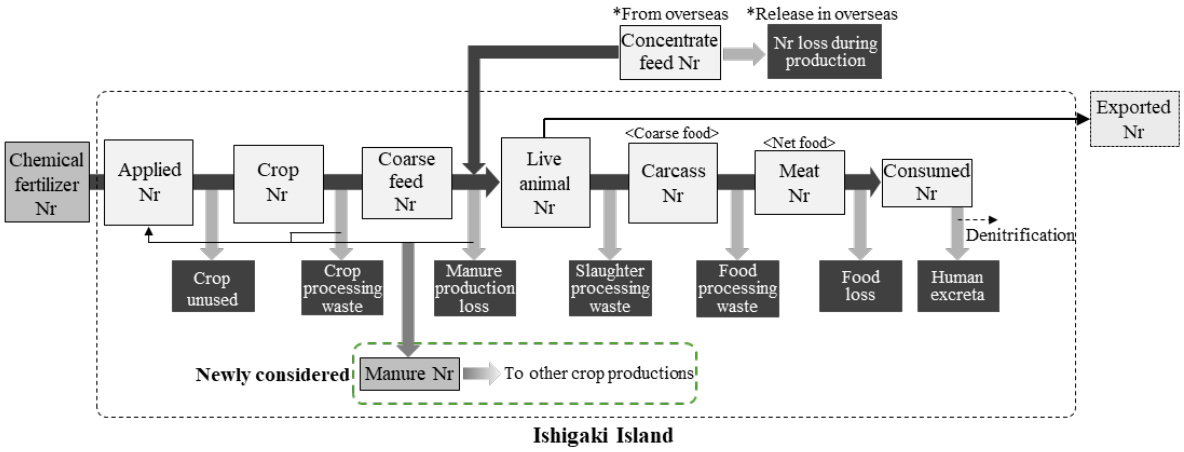

Fig. 1. Schematic for calculating nitrogen flow in livestock production

Nr represents reactive nitrogen. The present study newly considered manure distribution to other crop production.

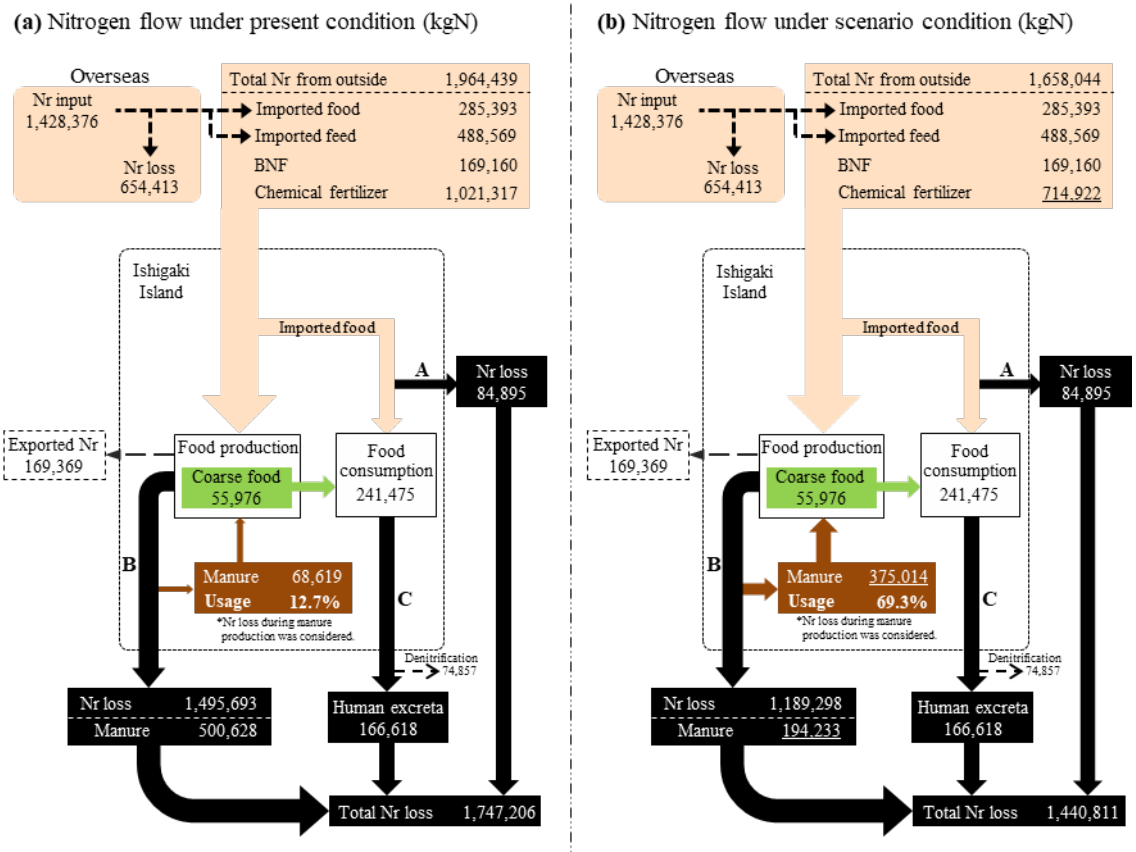

Fig. 2. Nitrogen flow under the (a) present and (b) scenario conditions

Nr is reactive nitrogen, BNF is biological nitrogen fixation, and 'denitrification' is the removed Nr by denitrification from human excreta during sewage treatment. The underlined values indicate differences between the present and scenario conditions. Arrows A–C represent food processing waste and food loss of imported coarse food (A), all Nr losses excluding human excreta in the food system (B), and human excreta after food consumption (C).

Reference: Hamada et al. (2023) *Environmental Research Letters* 18: 075010.