Nitrogen footprint updates in Japan: *Significance of global trades and food culture*

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What's the updates of N footprint in Japan?

Introduction

- Nitrogen (N) is an essential nutrient for all biota, but reactive N (all forms of N except N_2) becomes a source of pollutant for water, air, and soil when the amount and/or concentration of N exceed the demand of ecosystems and the thresholds of certain environment capacity.
- Nitrogen footprint analysis has been developed to estimate direct and indirect loss of reactive N to the environment through the use of food, energy, goods and services, and transportation. Those include reactive N loss through food production, processing and consumption for each food category.
- Japan, which was previously an agricultural and fishery country, currently relies on much imported food and feed from foreign countries and is being further impacted under the global trades with the third largest gross domestic product (GDP) following the U.S.A and China. Those characteristics would affect the national and per capita N footprint in Japan. Recent studies provided several important insights in the N footprint in Japan.

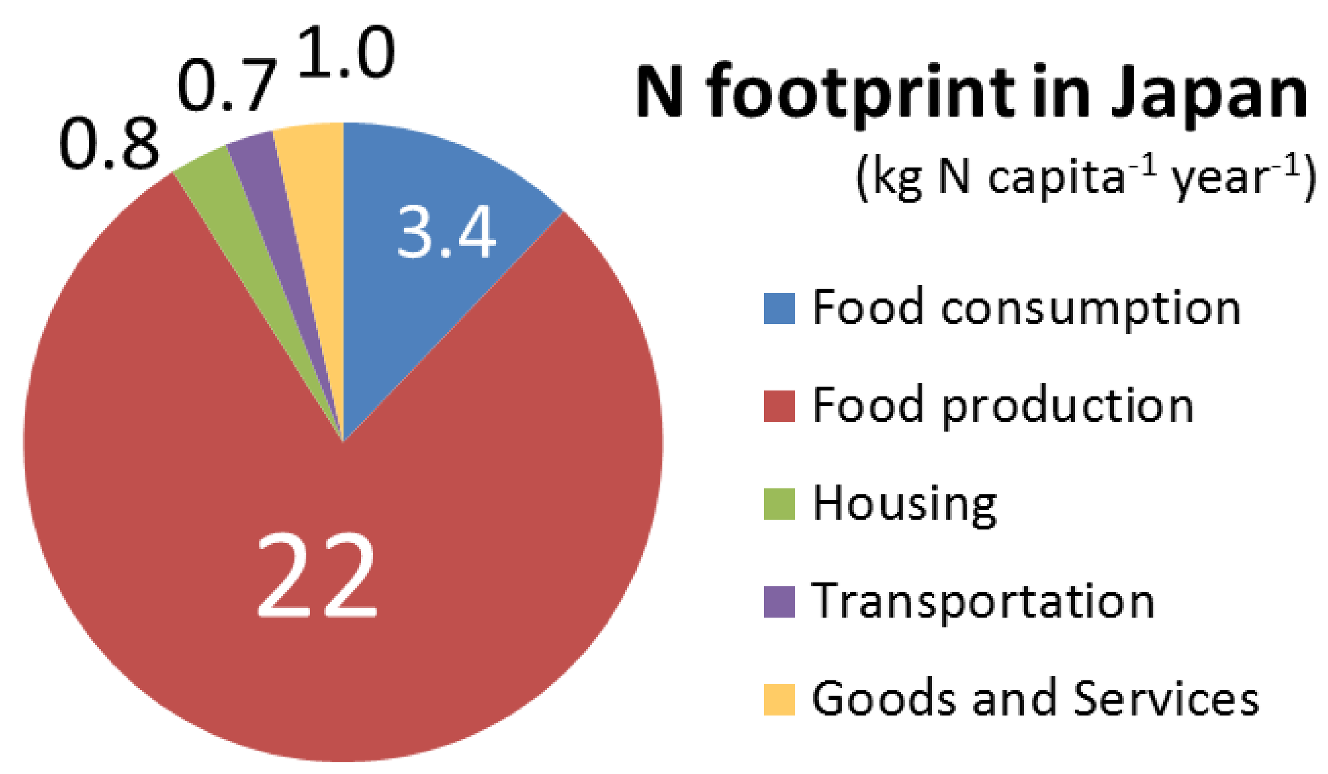

Figure 1. **The per capita N footprint (kgN capita^{-1} year^{-1}) in Japan**, predicted using N-Calculator (created from Shibata et al. 2014.) Food production and consumption are significant source of N footprint

Global comparison: impact of global trade

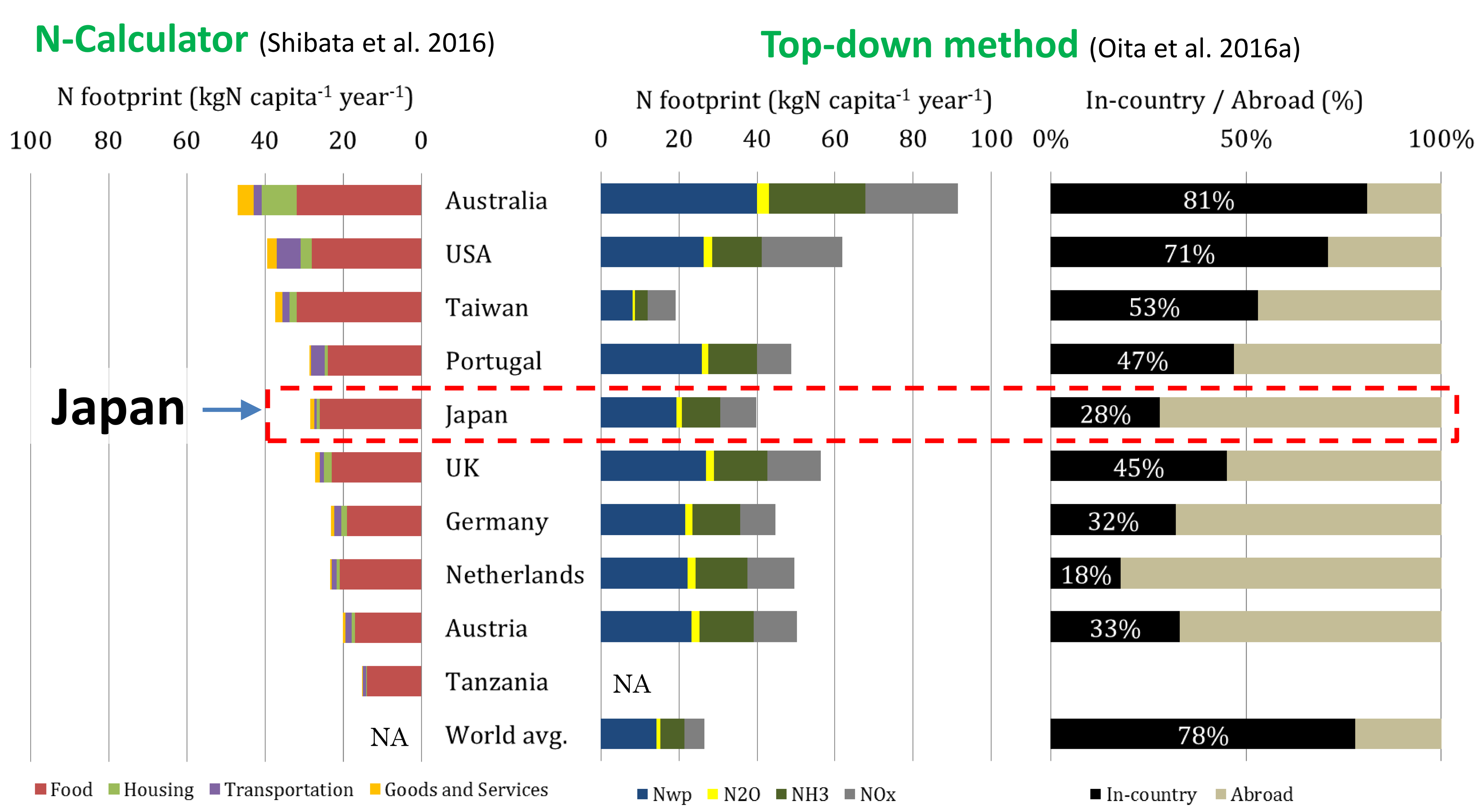

Figure 2. **Per capita N footprints** using the N-Calculator (Shibata et al. 2016) and top-down method (Oita et al. 2016a) in various countries and the world average (kg N capita^{-1} yr^{-1}), and the relative ratios of in-country and abroad for the N footprint (Oita et al. 2016a). Nwp: nitrogen potentially exportable to water bodies, mostly nitrate .

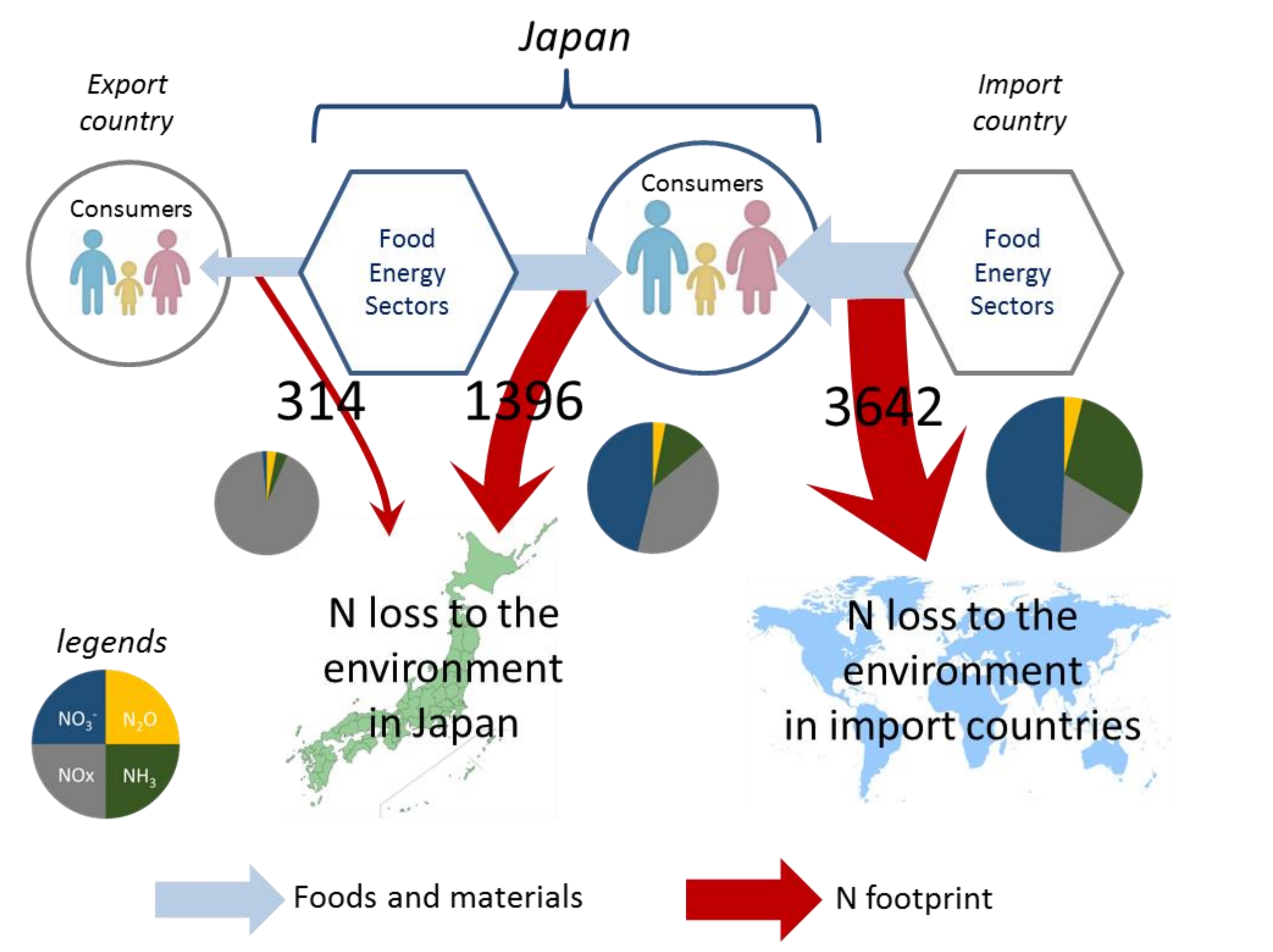

Figure 3. Total N footprint flow (Gg year^{-1}) caused by Japanese consumers inside and outside of Japan, and the N footprint flow in Japan caused by consumers in the export country. The NO_3^- means the N potentially exportable to water bodies, mostly nitrate (= Nwp in Figure 2). Created from Oita et al. (2016a).

Virtual N factors (VNFs) = Ratio of reactive N released to the environment during food production per unit of reactive N consumed

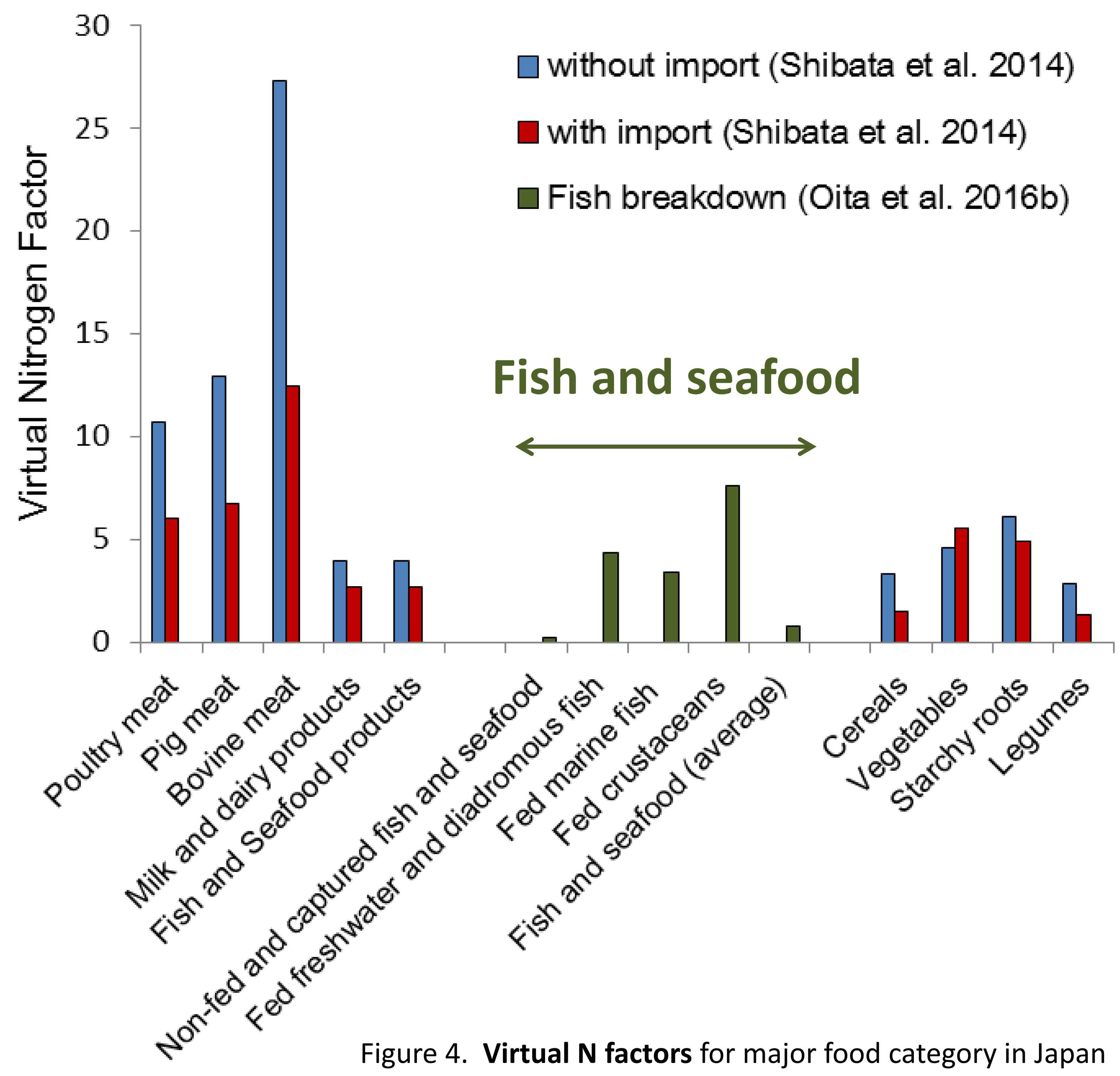

Figure 4. **Virtual N factors** for major food category in Japan (created from Shibata et al. 2014 and Oita et al. 2016b)

Table 1. **Virtual Nitrogen Factors (VNFs)** in various countries and region (Shibata et al. 2016; in *italic*, Oita et al. 2016b). The VNFs of animal products in Japan is relatively higher than those in US and Europe. The VNFs of fish is smaller when non-fed aquaculture fish and seafood is distinguished from fed aquaculture fish (Figure 4).

Food category	USA	Europe	Austria	Tanzania	Japan	Taiwan	Australia
Pork	4.4	4.4	3.6	3.3	6.7	8.6	5.5
Chicken	3.2	3.2	2.5	0.8	6.0	9.3	4.0
Beef	7.9	7.9	5.4	7.0	12.4	23.9	13.4
Milk	4.3	3.9	3.7	8.3	2.7	6.4	5.0
Mutton	5.2	5.2	3.8	3.3	5.6	11.9	9.3
Fish and seafood	4.1	2.9	N/A	0.2	2.9 *0.8*	1.8	1.9
Vegetables	9.6	8.2	4.3	4.1	5.5	4.7	8.0
Starchy roots	1.5	1.1	2	1.8	4.9	8.5	4.9
Legumes	0.5	0.5	0.4	0.3	1.3	7.4	1.2
Fruits	9.6	8.2	4.3	4.1	5.5	12.4	9.4
Cereals	1.4	1.3	1.2	6.2	1.5	1.4	1.8

Conclusions and suggestions:

- ✓ Demand by Japanese consumers is associated with much reactive N loss both within Japan and in imported countries as the top net N footprint importer. Further understanding for future trends of N footprint with aging and shrinking population in Japan is needed to develop a sustainable society under limited recourses.
- ✓ Spatial gaps of consumers and producers of reactive N derived from N footprint and their environmental consequence should also be addressed locally, regionally and globally.
- ✓ More public awareness for adequate dietary choices from the aspects of human health, economy and environment is critical to reduce the loss of reactive N to the environment as well as technical innovation to increase the N use efficiency in various food and energy sectors, especially in agricultural and aquaculture practices.

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Key publications:

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- Oita A, Nagano I and Matsuda H (2016b) An improved methodology for calculating the nitrogen footprint of seafood. Ecol Indicators 60, 1091-1103.
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- Shibata H, Branquinho C, McDowell WH, Mitchell MJ, Monteith DT, Tang J, Arvola L, Cruz C, Cusack D, Halada L, Kopáček J, Máguas C, Sajidu S, Schubert H, Tokuchi N, Záhora J (2015) Consequence of altered nitrogen cycles in the coupled human and ecological system under changing climate: The need for long-term and site-based research. Ambio 44, 178-193.
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