Evidence-based Nitrogen Indexes for Sustainable Agriculture

Xia Liang[1], Shu Kee Lam[1], Hans J.M. van Grinsven[2], Xin Zhang[3] and Deli Chen[1]

[1] School of Agriculture and Food, The University of Melbourne, Victoria 3010, Australia
[2] Netherlands Environmental Assessment Agency (PBL), Postbus 30314, The Netherlands
[3] University of Maryland Center for Environmental Science, Frostburg, Maryland 21532, USA.

E-mail: liang.xia@unimelb.edu.au

Abstract

Reactive nitrogen (Nr) is essential for agricultural production and human nutrition, but also leads to Nr pollution. Nr pollution induced by food are created by millions of diverse producers/products worldwide with vastly different climates, soils and agronomic management. To identify effective solutions under this heterogeneity, we presented a methodological framework to build the evidence-based nitrogen (N) indexes for global food at varying levels of detail and complexity. It would provide a comprehensive assessment of Nr loss for individual food items, a robust prediction of associated environmental and socioeconomic impacts to make global agriculture more sustainable, less polluting and more profitable.

Keywords: Reactive nitrogen, agroecosystems, evidence-based indexes

1. A three-tiered approach to estimate reactive nitrogen loss across the global food supply chains

To identify effective solutions under millions of diverse producers and products worldwide, we presented a three-tiered approach at varying levels of detail and complexity to build the evidence-based nitrogen (N) indexes for 155 major crop commodities and 11 major livestock commodities in 184 countries, covering different reactive nitrogen (Nr) loss pathways along entire food supply chains. Tier 1: internationally available statistics (e.g. FAOSTAT), default values (e.g. IPCC) and data from global model assessments (e.g. IMAGE); Tier 2: nationally and sub-nationally specific emission factors, as well as process-based models attuned to local climate, soil characteristics and land-management practices based on the common practices; Tier 3: detailed datasets based on the implementation of different management practice.

2. Reducing food's reactive nitrogen loss through production and consumption

Our results confirm that there is high variation in Nr loss among both food products and producers/countries. Within almost all the major animal and crop products, 90th-percentile impacts are more than three times greater than 10th-percentile impacts on all Nr loss pathways, creating substantial mitigation opportunities for food's Nr loss through production. Most remarkably, Nr loss of the lowest emission intensity animal products typically exceed those of vegetable substitutes, providing new evidence for the importance of dietary change for reducing food's Nr loss through consumption.

3. An integrated mitigation framework for sustainable agriculture

We illustrated a potential methodological framework to build evidence-based N indexes for global food that can adequately capture the environmental impacts of Nr associated with production and can serve as effective tools to communicate to consumers, producers and policymakers (Fig. 1).

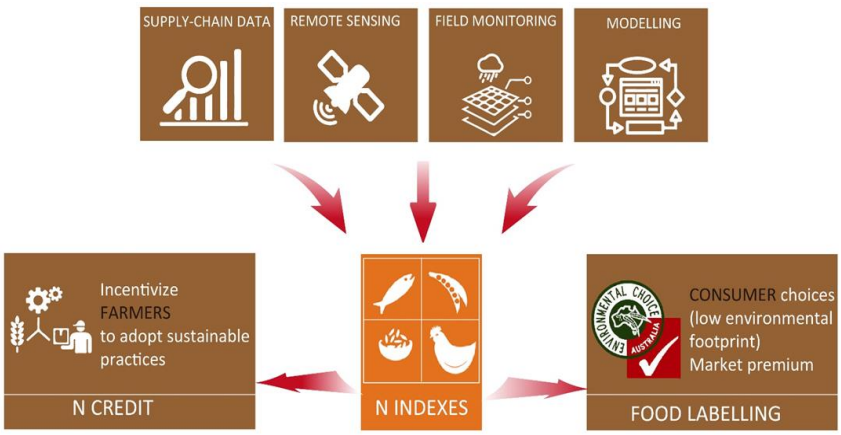

Fig. 1: Graphical representation of the integrated mitigation framework for sustainable agriculture.

We demonstrate potential options and tools of how our N indexes can be used to, firstly, highlight regions, management practices, and agricultural products as potential foci for mitigation; secondly, estimate the societal cost of N pollution and establish N credit, labelling and rating to guide consumers' selection of food products with lower Nr loss and to incentivize farmers to adopt more sustainable N management practices; and ultimately, to make global agriculture more sustainable, less polluting and more profitable.