

# A Credit System to Solve Agricultural Nitrogen Pollution

Baojing Gu,<sup>1,2,\*</sup> Hans J.M. van Grinsven,<sup>3</sup> Shu Kee Lam,<sup>4</sup> Oene Oenema,<sup>5</sup> Mark A. Sutton,<sup>6</sup> Arvin Mosier,<sup>4</sup> and Deli Chen<sup>4,\*</sup>

<sup>1</sup>College of Environmental and Resource Sciences, Zhejiang University, Hangzhou 310058, PR China

<sup>2</sup>Policy Simulation Laboratory, Zhejiang University, 310058 Hangzhou, China

<sup>3</sup>Netherlands Environmental Assessment Agency (PBL), Postbus 30314, The Netherlands

<sup>4</sup>School of Agriculture and Food, The University of Melbourne, Melbourne, VIC 3010 Australia

<sup>5</sup>Wageningen University & Research, P.O. Box 47, 6700 AA, Wageningen, The Netherlands

<sup>6</sup>NERC Centre for Ecology & Hydrology, Bush Estate, Penicuik, EH26 0QB, UK

\*Correspondence: [bjgu@zju.edu.cn](mailto:bjgu@zju.edu.cn) (B.G.); [delichen@unimelb.edu.au](mailto:delichen@unimelb.edu.au) (D.C.)

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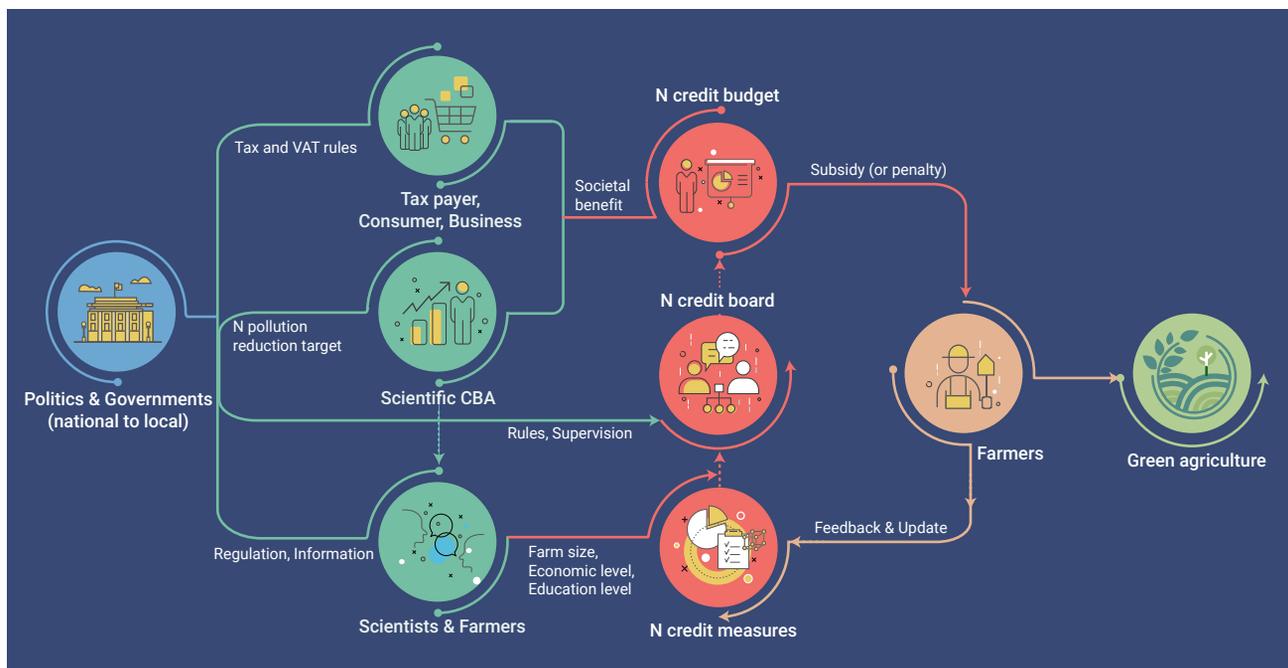
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Increasing amounts of nitrogen fertilizer have been used in agriculture during the last decades to boost food production for the increasing global human population. The marked increase in reactive nitrogen use has also contributed to severe nitrogen pollution and multiple impacts on human and ecosystems' health.<sup>1</sup> Nitrogen is an important precursor to air pollution (e.g., fine particulate matter, near-surface ozone), water pollution (algal blooms, nitrate contamination), biodiversity loss (nitrogen deposition and eutrophication), soil acidification (ammonium fertilizer use), and global warming (nitrous oxide).<sup>2</sup> Agricultural nitrogen pollution has decreased in some high-income countries, such as those in the European Union (EU), during the last decades, but the remaining nitrogen pollution still causes serious damage. The societal cost of nitrogen pollution by agriculture in the EU has been estimated to range from €35 to €230 billion per year and this cost appears to be greater than the farm profits from nitrogen fertilizer use, which range from €20 to €80 billion per year.<sup>3</sup> Socioeconomic trade-offs between farmers and society need to be introduced to decrease nitrogen pollution.

## Agricultural Nitrogen Challenges

Unlike point source pollution from industries and human settlements, nitrogen pollution from agriculture is often diffuse as it results from large numbers of independently managed farms, including both cropping and livestock production. It is a society-wide problem that requires a society-wide solution. The major obstacles to reduce agricultural nitrogen pollution are (1) biophysical (agricultural pollution varies in severity and over time due to variations in climate, soil, farming types, and practices);<sup>4</sup> (2) economic (farmers in both low- and high-income countries often lack the financial resources, incentive and knowledge to reduce nitrogen pollution); and (3) political (governments are reluctant to impose regulations or restrictions on agriculture as it is essential for local and national food security and provides income and livelihood for many communities, and society in general). Therefore, governments generally give priority to food and financial security rather than to mitigation of nitrogen pollution. As a result of reluctance or inability to manage the sources of nitrogen pollution, governments must invest substantial public resources to mitigate nitrogen pollution.



**Figure 1. Framework of a Generic Nitrogen Credit System to Mitigate Global Nitrogen pollution** VAT, value added taxes, CBA, cost and benefit analysis, N, nitrogen. Farmers pursue profit, People seek both food sufficiency and healthy food choice and a clean environment (Planet).

Currently, many farmers focus on maximizing “Profit” under prevailing markets, environmental conditions, and regulations, while avoiding economic risks. This economical focus introduces a risk of imbalance within the sustainability concept of Profit-People-Planet (3-P concept). For society, serving “People” by supplying sufficient, safe, and nutritious food, is as important as maintaining the “Planet” with a clean environment and sustainable resources.<sup>5</sup> “Profit” to retailers, processors, suppliers, and farmers for providing “People” with food is generally paid by consumers in the private agri-food supply system. However, satisfying “Profit” and “People” in many agri-food systems tends to be at the expense of “Planet” especially where serious nitrogen pollution occurs.

To tackle agricultural nitrogen pollution for the “Planet,” we propose a nitrogen credit system (NCS), for implementation in contrasting regions of the world. Our objective for the NCS is to find a generic principle for incentive-based mitigation of nitrogen pollution that acknowledges both the responsibilities and limitations of the multiple parties along the food chain, viz. consumers, farmers, suppliers, processors, retailers, and governments.

### The NCS

Our NCS is built on five principles. First, nitrogen pollution can be reduced by best management practices (BMPs) that are adopted by farmers. These BMPs will have to be defined collectively by scientists, economists, farmers, and governments. Second, mitigating nitrogen pollution beyond farm-level BMPs is the joint responsibility of the whole society, and the cost should be paid by the society as a whole since they benefit from less nitrogen pollution. Third, globally, there are hundreds of millions of farmers and there is a huge diversity in farming systems as well as in socioeconomic and environmental conditions; monitoring the performance of all these farms is impossible. Fourth, the agri-food industry and retailers are the intermediaries between farmers and consumers and should facilitate the transfer of abatement costs. Fifth, governments should secure clean air and water and healthy soil, establish pollution standards, and supervise a fair sharing of costs and benefits between farmers, suppliers, processors, retailers, consumers, and associated financial organizations.

The proposed NCS will provide economic incentives (e.g., subsidies based on the implementation cost and societal benefit) to farmers to adopt certified environmentally friendly practices to mitigate nitrogen pollution, with three components (Figure 1):

1. certified measures to abate nitrogen pollution, e.g., appropriate caps or limits for nitrogen (when farmers adopt these measures, they earn credits);
2. a budget to subsidize these credits. The subsidy ideally is in proportion to the societal benefit of reduced nitrogen pollution and higher than the abatement cost;
3. a board to administer the credit system that is responsible for granting credits and enforcing compliance. The board members ideally represent farmers, inhabitants and consumers, industry, government, and science.

Governments, farmers, agri-food businesses, and scientists need to work together to develop BMPs, including required subsidies for implementation (Figure 1). Mitigation measures can be specified by crop type, livestock type, farm size, economic capacity, climate, soil type, required farmers knowledge, etc. The system provides technical and practical information for implementation of measures, mitigation potentials, implementation costs, and nitrogen credits that can be earned.

The required financial budget depends on the targets for reducing nitrogen pollution, specified for air and waters and different nitrogen compounds (Figure 1). Ideally, the total budget in the subsidy system can be linked to the societal benefit of prevented agricultural pollution for human health and ecosystems, based on cost and benefit analysis.<sup>3</sup> The contributions to the budget should be derived from both taxing fiscal revenues of agri-food enterprises, value added taxes for consumers, or from dedicated levies or

taxes on polluting activities or products. This facilitates the transfer of cost of mitigation from farmers to those who benefit.

Governments should authorize a nitrogen credit board to manage implementation (Figure 1). Implementation would include providing general information and education on the nitrogen issues and the NCS; providing access to the NCS; evaluating submitted sets of measures and requests for nitrogen credits; signing of nitrogen credit contracts and paying out subsidies; monitoring compliance and sanctions in the case of inadequate performance; and providing reports and accountability to stakeholders. The board and authorities should also monitor the extent of pollution to evaluate the performance of mitigation under the NCS.

### Mitigating Global Nitrogen Pollution

To address regional differences, we propose a tiered approach to build NCSs according to the stages of development and relevant natural resources, which would affect the effectiveness of the NCS—adoptability, effectiveness in reducing nitrogen and unit cost of nitrogen reduction. The lowest tier is basically a top-down approach of subsidized mandatory and effective mitigation measures, the implementation of which is typically centralized or regulated by governments on regional or national scale. The highest tier represents a bottom-up approach, where farmers and other stakeholders are actively involved in selection and implementation of mitigation measures and are rewarded based on verifiable results on reduced pollution.

Chinese agriculture is characterized by small-sized farms (~0.1 ha), and poorly educated farmers. A prominent example of nitrogen mitigation is the attempt to maintain the water quality of Dianchi Lake. Over US\$ 2 billion will have been invested by Chinese governments between 2018 and 2020 to reduce agricultural nitrogen loading to the lake. Tiers 1 and 2 should be more effective than other tiers. The Chinese central government has already implemented the zero-growth in chemical fertilizer use by 2020 plan to mitigate nitrogen pollution. For instance, no livestock production should be allowed in vulnerable riverine areas with high risks of nitrogen leaching to bodies of water. Subsidies to enhance use of environmentally friendly fertilizers, such as controlled-release fertilizers, can also be adopted by smallholder farmers.

In Brazil, tier 2 should be important given that the size of its farms, the farmers' knowledge, and regulations are all at the middle level. But there are also other types of production systems from subsistence to large corporate mega-farms, which require more detailed assessment and tier choices. For instance, managing crop types to produce more soybeans while maintaining soil nutrient availability and environmental quality is more promising under the NCS with both government regulations and farmers' involvement.

In the EU, particularly the northwestern European countries, regulatory approaches such as the “Nitrate Directive” constrain farmers' behaviors and apply penalties if farmers do not follow the rules. Farms are mostly of middle size (10–30 ha) and farmers are often well educated and tier 3 or even tier 4 can be used. The NCS could be combined with current subsidy and cross-compliance schemes for environmental measures as presented in the EU Common Agricultural Policy.

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