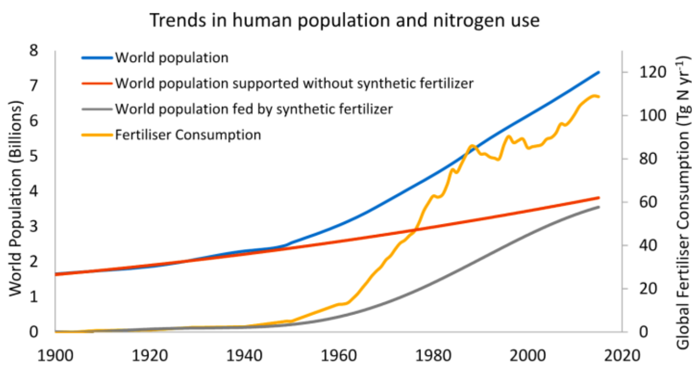
Addressing nitrous oxide: An often ignored climate and ozone threat

Policy Brief of the workshop on "Climate change, reactive nitrogen, food security and sustainable agriculture" 15-16 April, 2019 Garmisch-Partenkirchen, Germany

- Anthropogenic emissions of N_2O, of which two thirds are emitted from agricultural soils, currently contribute 6% to the anthropogenic greenhouse effect.
- Atmospheric concentrations of N_2O have increased 20% since pre-industrial times. Every year, natural processes only remove two thirds of the emitted quantities, leading to continuous and increasing accumulation. With a half-life of 130 years, emissions now will continue to have direct climate impacts for future generations.
- Recent climate mitigation policies, including the Paris Agreement, are increasingly focusing on the agricultural sector, with direct implications for N_2O. Furthermore, N_2O is now the most abundant ozone-depleting substance and is the greatest threat to the stratospheric ozone layer; destroying ozone at a level comparable to CFC compounds when they were phased out by the Montreal protocol (signed in 1987).
- The global average nitrogen use efficiency (NUE - the ratio of the N applied to the crop to the N removed during harvest) of fertilized crops is 40%, implying that 60% is lost to the environment. The situation for OECD states is better (NUE is around 60%), but still the potential for further improvements remains.
- Given the importance of N in food production, phasing out N fertilizers is not an option. Careful consideration of crop N requirements to prevent excess use is central to any approach to reduce N-related environmental problems; particularly the increasing atmospheric N_2O concentrations.

What is the issue?

Nitrogen (N) is an essential element for all forms of life. However, most nitrogen on Earth is not readily available. To make N available for agricultural production, we rely on two processes: biological N fixation by leguminous crops and (since 1910) industrial N fixation via the Haber-Bosch process. The latter has been essential to boost crop production and food security for an increasing world population. In practice, N application is inefficient (most of the developed world), lacking (most of the developing world), or both. This unbalanced use of N causes severe environmental problems, exceeding safe thresholds for human and ecosystem health. As a

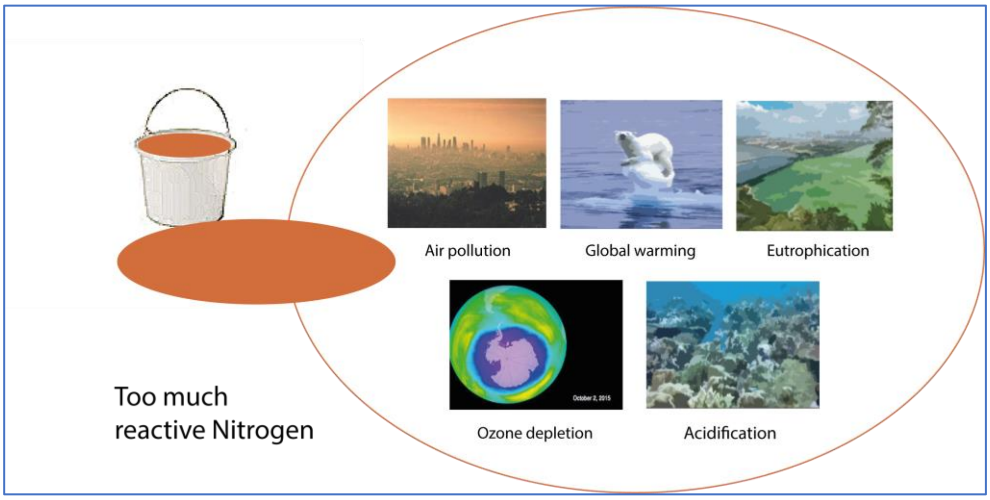


Estimates of the global population reliant on synthetic N fertilisers for food production. (Source: OurWorldInData.org) consequence, in most of the developed world, food production is associated with the release of reactive N compounds to the environment that exacerbate a range of impacts, from air and water pollution to biodiversity loss and climate change. To date, agriculture is the largest source of nitrous oxide (N_2O), which is – after carbon dioxide and methane – the third most important greenhouse gas and the largest remaining threat to the stratospheric ozone layer. Lead scientists from around the globe recently came together for a meeting in Garmisch-Partenkirchen, Germany supported by the OECD Co-operative Research Programme: Biological Resource Management for Sustainable Agricultural Systems. They exchanged and assessed the latest knowledge and agreed that, despite uncertainties and the need for additional research on processes driving N_2O emissions, there is sufficient knowledge available to implement immediate action towards reducing N pollution, specifically N_2O emissions. The actions listed below demand a more efficient use of fixed and reactive nitrogen in order to reduce greenhouse gas emissions and other forms of N pollution from agricultural systems.

What should policy makers do?

The Nationally Determined Contributions (NDCs) are central components of the Paris Agreement. Given the key role of N_2O as a leading agricultural GHG, specific consideration of this gas in the 2020 NDC updates is essential.

Implement targeted mitigation options for N_2O. These must avoid the risk for "pollution swapping" – where one N compound is reduced at the expense of another. This can provide significant improvements (co-benefits) to water and air quality, biodiversity, acidification and eutrophication of soils and water bodies.



Environmental impacts of reactive nitrogen compounds

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Mitigation Options

Strongly discourage use of N in excess of crop requirement. There is a clear non-linear relationship between fertilizer application and N_2O emissions, with emissions increasing exponentially when application rates exceed plant N requirements.

Enhance NUE of mineral and organic fertilizers. Technologies and practices to apply fertilizer at the right time, the right place, the right type and the right quantity are available (e.g. variable rate technologies, or enhanced efficiency fertilizers).

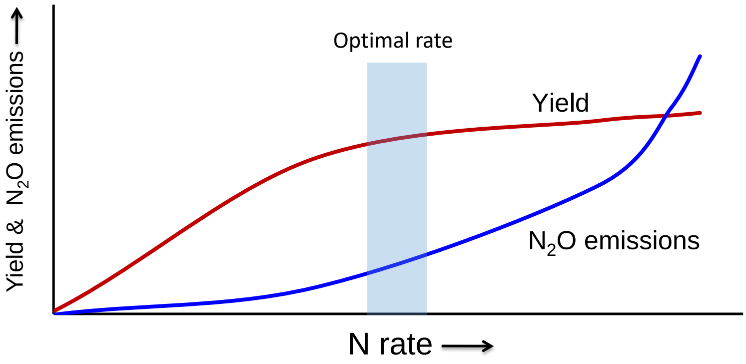
Encourage the increased use of cover crops and perennial forages in crop rotations as this helps retaining N within the agro-ecosystem, thus improving NUE.

Promote novel technologies, such as the development of **new crop varieties** that reduce N losses through **biological nitrification inhibition (BNI)** by plant root exudates. New microbiological research shows the potential to cultivate **N_2O-reducing bacteria** that may significantly reduce N_2O emissions upon application to soil.

Improve recycling of N-containing agricultural products typically considered as waste (circular economy). This includes optimizing animal manure management and reducing food waste (at both the industrial and household level).

Incentivize reduced human consumption of animal-sourced protein (meat, milk, eggs). NUE of animal-sourced protein is approximately one tenth of that for plant protein. The trend in some OECD countries of reduced consumption of animal-sourced proteins not only benefits the environment, but is also favorable to human health.

Promote the increased use of biological or microbial derived N (e.g. legumes) in the agri-food chain as this benefits soil health and can reduce the use of synthetic fertilizers without jeopardizing yields.



Due to the non-linear relationship between fertilizer application and N_2O emissions and yields, optimal N rates avoid excessive losses with minor impacts on yields

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Scheer C, Pelster D, Butterbach-Bahl K, Van Cleemput O, Kanter D, Winiwarter W, Ogle S, Boeckx P, Fuchs K, Baggs E, Bakken L, Barton L, Cardenas L, Clough T, DelGrosso S, Dorich C, Friedl J, Hu C, Leitner S, Massad R, Peterson SO, Skiba U, Smith W, Subbarao GV, Vogeler I and Wagner-Riddle C. (2019) Addressing nitrous oxide: An often ignored climate and ozone threat. *Policy Brief of the workshop on "Climate change, reactive nitrogen, food security and sustainable agriculture" Garmisch-Partenkirchen, Germany.*