Nitrogen and the Sustainable Development Goals

David R. Kanter, Xin Zhang, Clare M. Howard[3]

[1] Department of Environmental Studies, New York University, 285 Mercer Street, New York, NY, 10003, USA, david.kanter@nyu.edu
[2] University of Maryland Center for Environmental Science, 301 Braddock Rd., Frostburg, MD, 21532, USA, xin.zhang@umces.edu
[3]Centre for Ecology and Hydrology, Bush Estate, Scotland, EH26 OQB, UK, inms@ceh.ac.uk, www.inms.international

Abstract

The United Nations' new Sustainable Development Goals (SDGs) aim to maximize social, economic and environmental wellbeing, from ending hunger and poverty, to enhancing access to education and healthcare, to protecting biodiversity. The inevitable overlap between these broad goals call for implementation strategies that can exploit potential co-benefits. Improving nitrogen management provides a key opportunity for strengthening the three pillars of sustainable development, given nitrogen's widespread uses and impacts. For example, nitrogen inputs are fundamental to modern food production and rural livelihoods, with Haber-Bosch nitrogen responsible for the existence of almost half the world's current population. And yet nitrogen pollution is also one of the most important environmental issues of the 21st century, contributing to air and water pollution, biodiversity loss, climate change and stratospheric ozone depletion. Consequently, improving humanity's complex relationship with nitrogen could be a key component of implementing the SDGs from local to global scales, as well as measuring progress towards them. This study examines the links between nitrogen management and the SDGs. We identify 16 of the 17 goals as relevant to nitrogen management, and group them into three categories: those that require more nitrogen, those that require less nitrogen, and those that could help improve nitrogen management. The "Towards an International Nitrogen Management System" project has taken the first steps to create a science support system for the emerging nitrogen policy community, which could be used to better integrate nitrogen management into implementation strategies for the Sustainable Development Goals.

Keywords
Sustainable Development Goals; Nitrogen; International Nitrogen Management System

Introduction

In September 2015, all member countries of the United Nations agreed to a suite of new targets for the international community: the Sustainable Development Goals (SDGs). These 17 objectives (and the 169 more specific targets therein), to be achieved by 2030, tie together the three pillars of sustainable development with the aim of maximizing social, economic and environmental wellbeing. The goals range from ending poverty and hunger (Goals 1 and 2) to promoting gender equality (Goal 5) and responsible production and consumption, to protecting life above and below land. With such broad goals there is inevitable overlap – measures that could be implemented to achieve one target can also positively or negatively impact another.

Indeed, the monumental effort that will be required to achieve the SDGs, it is important to find implementation strategies that can take advantage of the synergies that exist between the goals. Improving nitrogen management provides a unique opportunity to maximize the likelihood of meeting several of the outcomes embedded in the SDGs. Nitrogen inputs are both crucial to the global food system while also being a major source of pollution. The Haber-Bosch process – the industrial synthesis of ammonia – was one of the most important inventions of the 20th century and

is now responsible for growing food that feeds half the world and supports rural livelihoods (Erisman et al., 2008). However, this massive increase of nitrogen inputs into the global food system has made nitrogen pollution one of the most important environmental issues of the 21st century, contributing to air and water pollution, biodiversity loss, soil quality deterioration, climate change and stratospheric ozone depletion. Consequently, improving our management of the nitrogen cycle would be a key contribution to meeting many of the SDGs. Moreover, several nitrogen-related metrics such as nitrogen use, nitrogen losses and nitrogen use efficiency could be very helpful in measuring progress towards the SDGs (Zhang et al., 2015). In fact, nitrogen use efficiency has been proposed as an indicator for measuring countries' progress towards the SDGs by several experts and NGOs (e.g. EU nitrogen expert panel, UN Global Partnership for Nutrient Management Zhang et al., 2015), and it was originally included in the indicator solicitation process led by the United Nations. However, all direct measurements of nitrogen management were dropped from the final list of possible SDG indicators.

Given the importance of nitrogen management, coupled with its lack of visibility in international policy circles, this study aims to highlight the connections between nitrogen management and the SDGs. We also demonstrate how the 'Towards an International Nitrogen Management System' (INMS) project could help integrate nitrogen management into implementation strategies for the Sustainable Development Goals.

The Sustainable Development Goals and Nitrogen

N management is relevant to 16 of the 17 SDGs (Figure 1). However, the role of N varies significantly depending on the goal, with three broad groups of SDGs emerging: those that require more N, those that require less, and those that could help improve N management.

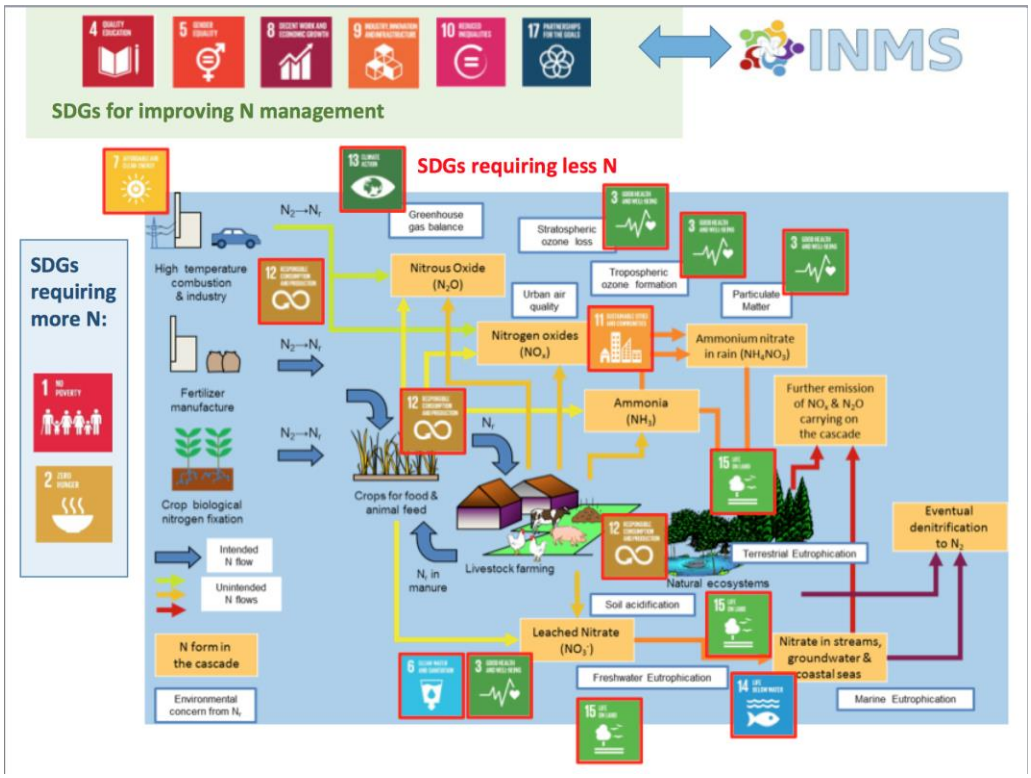

Figure 1 The nitrogen cascade and its links to the Sustainable Development Goals, classified as follows; blue, more nitrogen is required (or greater efficiency in use of that currently available), red, less nitrogen is required (or better management of that to avoid losses to the environment), green, N management may be improved (through education on better use of resources to maximize yields/avoid losses, decrease consumption, etc). Adapted from Sutton et al. 2011

SDGs requiring more nitrogen

Access to nitrogen is a critical component to ending poverty and hunger (SDGs 1 and 2). A central reason why hunger is still an issue in many parts of the world is inadequate access to nitrogen and other nutrients. Of the regions of the world that have yet to reach 75% of their attainable yields, 73% of them could close the yield gap by solely focusing on nutrient inputs (Mueller et al. 2012). Indeed, Mueller et al. (2012) estimate that if nitrogen imbalances and inefficiencies were largely resolved, global nitrogen consumption would only have to increase by 9% (along with other nutrient inputs) to increase cereal production by approximately 30%. In addition, an increase in crop yields, particularly in the poorest countries of the world, would positively impact economic livelihoods. Consequently, a focus on better access to nitrogen is crucial to success for SDGs 1 and 2.

SDGs requiring less nitrogen

Despite its centrality in modern food production, nitrogen can also pollute because it is a notoriously difficult resource to use efficiently – more than 50% of the nitrogen applied to agricultural land is lost as some form of environmental pollution (Smil, 2001). Moreover, nitrogen's chemical behavior means that it can easily change form once converted from atmospheric dinitrogen (N_2), enabling it to contribute to several environmental problems relevant to the SDGs (SDG 3, 6,11-15). This dynamic is referred to as the nitrogen cascade (Galloway et al., 2003). For example, a nitrogen atom added as urea fertilizer to a field can first be volatilized as ammonia (NH_3), an important component of air pollution. This same nitrogen atom can subsequently precipitate out and oxidize to nitrate (NO_3^-), a major cause of eutrophication, which can negatively impact water quality. NO_3^- can then be denitrifed to nitrous oxide (N_2O) and emitted to the atmosphere, where it contributes to climate change and stratospheric ozone depletion. This suite of environmental impacts has a considerable economic impact on society. A recent report estimated the global social cost of nitrogen pollution to be $200-$2000 billion USD, which is approximately 0.3-3% of global gross domestic product (Sutton et al. 2013). In fact it is possible to break down this estimate and calculate the contribution of N pollution to the social costs of several environmental problems. And yet technologies and best management practices exist that could reduce nitrogen losses significantly. Indeed, in many parts of the world, N consumption could be reduced significantly without impacting yields (Sutton et al. 2013).

SDGs for improving nitrogen management

There are also SDGs whose implementation would improve nitrogen management and thus increase the likelihood of meeting the other SDGs requiring more nitrogen inputs and/or less nitrogen lost to the environment. For example, SDG 9.1 focuses on improving infrastructure such as roads and railways, which is currently one of the major impediments to improved and more affordable nitrogen access in the world's poorest countries. SDG 5a focuses on equal access to economic resources for women, including land – if women had the same access to resources as men, yields on their farms could increase by 20-30% (Dobermann et al. 2013). The emphasis of SDG 17.6-17.7 on knowledge and technology transfer is key to the dissemination of N use efficiency-improving technologies and best management practices.

SDGs and INMS

The INMS project is intended as the first step towards a science-support process for nitrogen, an 'International Nitrogen Management System'. Within the project a number of activities will help to deliver the SDGs (Figure 2). Selected examples include the development of nitrogen use efficiency (NUE) indicators at a range of scales, from farm to the full food supply chain, which act as proxies for both improved yields (SDG 2.4) and lead to a decrease in air and water pollution (SDG 6.6, 14.1). NUE indicators for combustion vehicles and power plants could also provide valuable insights into attainment of consumption (SDG 12.a) and air pollution (SDG 11.6) targets.

Five demonstrations of the INMS concept will also take place in developing countries, providing opportunities for direct interaction in improving national plans and priorities (SDG 15.9) and direct NUE improvement trials at the field scale (SDG 2.4).

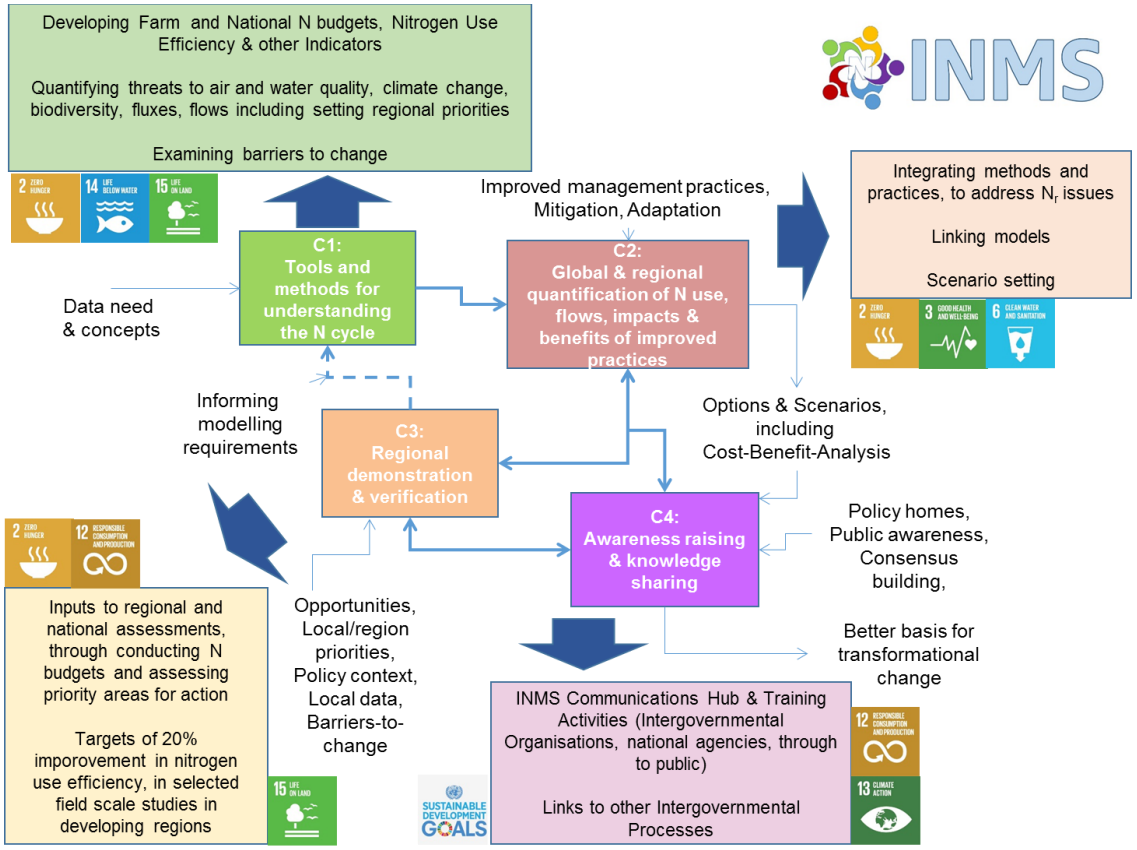

Figure 2 The four components of the INMS project and selected examples of how they can help deliver the SDGs and associated targets.

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