



ELSEVIER

Contents lists available at SciVerse ScienceDirect

Environmental Development

journal homepage: [www.elsevier.com/locate/envdev](http://www.elsevier.com/locate/envdev)

# The global nutrient challenge: From science to public engagement

Mark A. Sutton<sup>a,\*</sup>, Clare M. Howard<sup>a</sup>, Albert Bleeker<sup>b</sup>, Anjan Datta<sup>c</sup>

<sup>a</sup> NERC Centre for Ecology & Hydrology, Edinburgh, UK

<sup>b</sup> Energy research Centre of the Netherlands, Petten, The Netherlands

<sup>c</sup> United Nations Environment Programme, Nairobi, Kenya

## 1. Introduction

Among the many environment and development challenges facing humanity, it is fair to say that nutrients do not currently feature so regularly in the newspapers, radio and television. The media tends to prefer easy single issues which affect our daily lives in a clear-cut way.

The role of carbon in climate change is a good example. We all depend on climate. Burning fossil fuels makes more carbon dioxide, tending to change temperature and rainfall patterns, to which we can easily relate. The science is complex, but it is a simple message for the public to understand. It does not take long to think of several other easily grasped threats, like urban air pollution, poor drinking water, or even the occurrence of horsemeat in food chains.

It is perhaps for these reasons that the role of nutrients in environmental change has received much less public attention. After all, nutrients – including nitrogen, phosphorus and many micronutrients – play multiple roles in our world; they affect many biogeochemical processes and they lead to a plethora of interacting threats. If we are not careful, we can quickly get buried in the complexity of the different ways in which our lives are affected by these elements. The outcome is that it can become hard to convey the science of global nutrient cycles in a way that the public can understand.

These are points about which we have given substantial thought as we contributed to a recently launched report *Our Nutrient World: The challenge to produce more food and energy with less pollution* (Sutton et al., 2013). The report was commissioned by the United Nations Environment Programme (UNEP) and conducted by the Global Partnership on Nutrient Management in cooperation with the International Nitrogen Initiative. The commission was not to provide a full scientific assessment, but rather to develop a global overview of the challenges associated with nutrient management. Drawing on existing knowledge, the aim was to distill the nature of the nutrient challenge answering clearly: why should anyone care, how has the problem got worse, what is already being done, and what still needs to be done?

\* Corresponding author.

E-mail address: [ms@ceh.ac.uk](mailto:ms@ceh.ac.uk) (M.A. Sutton).

In scientific terms we realised that 'nutrient management' is a good descriptor. Humans manage nitrogen and phosphorus for the benefit of society, and through better management can find ways to reduce the unintended threats.

But we also recognized that 'nutrient management' does not reflect the power language that makes for an easy sell to a wider public. In developing the global overview, we therefore needed to think carefully about how to package and communicate our messages. This was particularly important for nutrients because of one of the conclusions of the overview: that a lack of public awareness of the global nutrient challenge represents one of the major barriers to change. In short, if the world is going to learn to manage its nutrients better, then the world's citizens need to be motivated to make it happen.

## 2. Clarifying the threats

One of the first tasks in this developing agenda was therefore to simplify the message to its essence. We needed hooks to which people could relate. Much of the ground-work here was already done in the European Nitrogen Assessment (Sutton et al., 2011), which distilled down 21 reasons to be worried about too much nitrogen. We first reduced the list to 9 major concerns, and then into just five key threats. These were easily extended in *Our Nutrient World* to cover the challenges in different parts of the world, including from too much nitrogen and phosphorus in places like Europe, North America and South East and South Asia, and from too little of these nutrients in sub-Saharan Africa and parts of Latin America.

The five threats deliberately make an acronym: the WAGES of too much or too little nutrients, clearly explaining why anyone should worry. These threats also highlight ways in which nutrients join up many well-known themes: Water quality, Air quality, Greenhouse gas balance, Ecosystems and biodiversity, and Soil quality (together spelling out WAGES). The essence is that nutrients link multiple global change threats, and by managing nutrients better, humans can make a contribution to addressing all the environmental problems we know so well.

## 3. Crystalizing the challenge

This takes us swiftly to the core nutrient challenge: to produce more food and energy with less pollution. In a world with rapidly expanding human population and increasing per capita consumption patterns, there are significant risks for future world food and energy security combined with degrading environmental conditions. For example, based on scenarios emphasizing economic growth, a 70% increase in global nitrogen pollution would be anticipated by 2050, if no action were taken (Sutton and Bleeker, 2013).

We need nutrients in fertilizers and manures to grow the crops to feed the increasing human population. In a world with growing renewable energy needs, a significant fraction of these nutrients may also be diverted in future to bioenergy production. Into this we should also roll the nitrogen oxides produced unintentionally by high-temperature combustion processes. These add an extra 40 million tonnes worth of nitrogen every year, but its wide dispersion in the atmosphere means that this nitrogen is very poorly targeted to productive use.

And so in our developing societal dialog we hold a tension. Humanity needs nutrients for global food and energy production, but we live in a world where nutrients are often used inefficiently, leading to substantial environmental pollution. This inefficiency can be highlighted by key numbers extracted from the global budgets: of new nitrogen added to agriculture (e.g. in fertilizers and biological nitrogen fixation), 80% is lost to the environment rather than reaching intended products (Sutton et al., 2013).

## 4. Indicators of progress

The next question is how can we measure the improvements expected from taking action to manage nutrients better. The world is highly diverse, with some regions using too much nutrients and others not having enough. We recognize the wide diversity of possible indicators, many of them with complex and expensive long-term measurement requirements.

In a global context we therefore need an approach that is simple enough to report progress for all countries in the world. Based on these criteria, *Our Nutrient World* selected “nutrient use efficiency” (NUE) as a common indicator around which all could build consensus. In regions of too much nutrients, improving NUE reduces pollution and contributes to the Green Economy by saving on the cost of nutrient inputs or by increasing production for the same input. In regions of too little nutrients, improving NUE makes a scarce resource go further emphasizing the production benefits.

It should be noted however, that the report added a particular twist to the term NUE. Whereas particular sectors often talk about crop NUE or livestock NUE, *Our Nutrient World* extends this to ‘full-chain NUE’. This means the ratio of nutrients in final products used by society (food crops eaten by people, animal products eaten by people, other durable nutrient products, etc.) to the original nutrient inputs (e.g. mineral fertilizers, biological nitrogen fixation, etc.). This approach gives countries the maximum flexibility to see how they can improve. In many cases this will be by improving technical efficiency, but could equally be by considering choices between societal consumption patterns of different efficiency.

## 5. Taking action

With the 5 key threats in mind, *Our Nutrient World* then identified a list of 10 key actions for change (Fig. 1). Based centrally around the idea of improving NUE, these include technical measures in crop and livestock agriculture and for better use of animal manures (Actions 1–3). They cover measures for the transport and industry sectors (Actions 4–5) and in waste water treatment sector (Actions 6–7), in both cases emphasizing the need to improve recycling of existing nitrogen and phosphorus sources (including from nitrogen oxide emissions and from wastewaters). Each of these actions focus on challenges for different production sectors in society.

As regards citizens choices, humans can improve NUE and reduce emissions substantially by energy and transport saving – both aligning well with air pollution and climate policies – and by reducing our consumption of animal protein (Actions 8–9).

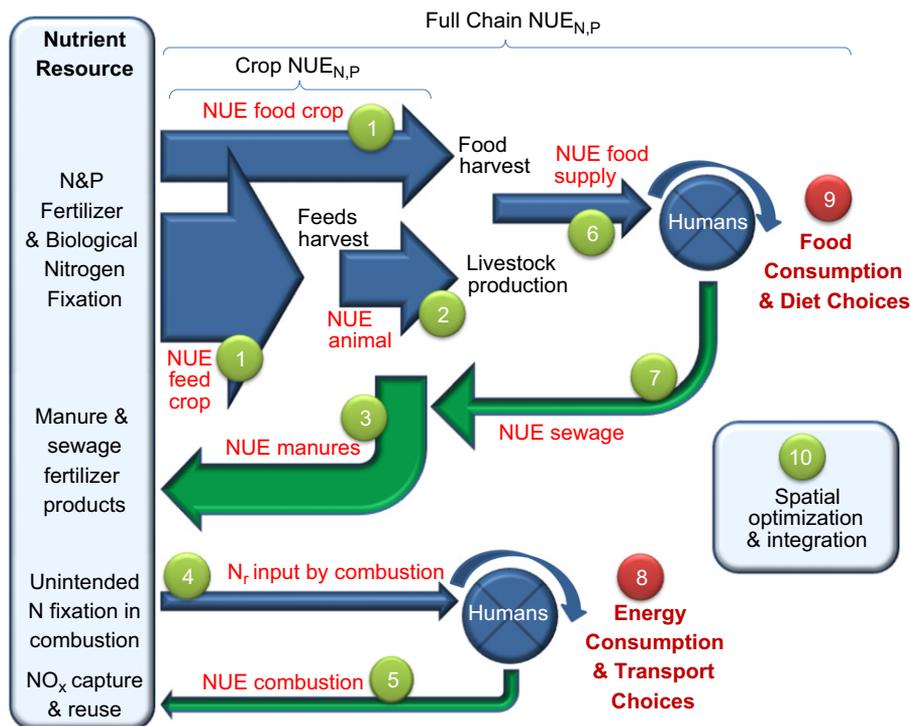
This last point is particularly central for the nutrient challenge. Amazingly, 80% of nitrogen harvested globally (agricultural biomass harvested, including grazing) goes to feed livestock rather than people. Only 20% goes to feed people directly (Sutton et al., 2013). If we combine this with a finding from the European Nitrogen Assessment, that the average European citizen consumes 70% more protein than is needed for a healthy diet (Reay et al., 2011), then a clear picture emerges. In many developed countries, society's high use of nutrients is not really a matter of “food security”, but is instead is a matter of “food luxury”, as we use nutrients to sustain unnecessarily high rates of livestock consumption.

In fact, we can even coin a new word and talk about “food luxury”, which is the real issue faced by developed societies, and may be defined as “the security of our food luxury”. If people in the developed world were to reduce their rates of consumption of animal products, this would lead to a substantial improvement in full-chain NUE, reducing levels of pollution, while substantially increasing the amounts of food production available to meet food security concerns in world regions that really do not have enough.

Finally, the tenth key action considers the opportunities for integration and optimization leading to overall improvements in NUE. This includes both temporal and spatial aspects, such as more closely linking crop and livestock farming systems, so as to make better use of manures (Billen et al., 2013). Contrary to the drive to scale-up crop and livestock agriculture in different regions, there is thus substantial potential for localization to improve nutrient use efficiency and reduce pollution levels.

## 6. Policies and barriers to change

Of course, much is already being done to improve nutrient management. Several of these actions are already being addressed, and *Our Nutrient World* considers how progress is being made through policies in six case study regions of the world, including the current extreme levels of nitrogen pollution in China (Liu et al., 2013). A clear picture emerges that more could and should be



**Fig. 1.** Summary of major global nutrient flows highlighting the potential to improve nutrient use efficiency (NUE) for nitrogen (N) and phosphorus (P) through 10 numbered key actions (for details see text).

done, and that there are substantial barriers to further action. These include the challenges of working with diverse sectors and finding ways for sectors to pass on any costs of measures to downstream markets.

Even more of a barrier is the multi-faceted nature of the nutrient challenge, as we see how nutrients play a role in many different policy arenas, but are rarely linked up to show the combined benefits of taking action. At the hub there is the challenge for governments to take the nutrient challenge seriously, and to realize how nutrient management can address multiple concerns simultaneously.

Recognizing these points, *Our Nutrient World* highlights how there is currently no global intergovernmental framework that links the different benefits and threats of too much and too little nutrients. It considers the possible indicators to measure improvement, emphasizing the role of NUE, and explores the possible tasks and institutional arrangements for such a future inter-governmental framework.

One option outlined is to strengthen and extend the mandate of an existing intergovernmental framework: the "Global Programme of Action for the protection of the marine environment from land-based activities" (GPA). The report outlines the arguments, the pros and cons of different institutional options—encouraging disagreement and debate as a basis to develop consensus!

## 7. The motivating role of public awareness

As we have identified, however, the ultimate barrier to change is that the public are not sufficiently aware of the nutrient challenge.

Parts of the story are surely being addressed under other headings, such as reducing car use or food waste to meet climate objectives. But if society follows such a piecemeal approach, there will be substantial policy gaps, while key synergies will be missed. If the world is to meet the “challenge to produce more food and energy with less pollution”, it is therefore vital that governments and the public learn to see how understanding *Our Nutrient World* can help them. To do this we will need hooks to continue building and reinforcing public awareness.

In the last weeks we have used just a few of these. A brief search of the recent media on and after 18 February 2013 will show that the launch of *Our Nutrient World* attracted substantial press interest around the globe. We put particular effort into targeting the media and reaching the public. We needed to simplify and pick out the key issues.

An excellent help here is the proposal outlined in *Our Nutrient World* for governments to work to a common global goal to improve NUE by 20%, saving 20 million tonnes of nitrogen annually by the year 2020. We call it the ‘20:20 for 2020’ goal, estimating that meeting it would contribute a net saving including environment and health benefits worth around 170 (50–400) billion US dollars per year.

In our approach to the media, we highlighted the need for a future intergovernmental framework to work towards the 20:20 goal. And we highlighted the contribution that could be made through addressing the 10 key actions to improve NUE.

It is here that some sensitivity to public interest becomes important. Because, while actions like improved manure spreading techniques are important, we realize that these do not top the charts of public interest. By contrast, the recommendation of *Our Nutrient World* to reduce consumption of animal products could not have come at a better time. As the journalists quickly realized, this recommendation from an environmental perspective could easily be aligned with responses to the horsemeat scandal. Both our message and the emerging message of ‘horsegate’ point to citizens thinking hard about their food choices.

From an environmental perspective, we also flagged that it is not a question of being vegetarian, but a question of how much meat (and dairy) each person consumes. This opened the door for a “medium ambition” option, in the form of a ‘demitarian’ diet—consuming half the normal local amount of animal products for developed countries.

Suddenly, the media was interested (e.g. Harvey, 2013; McCarthy, 2013; Sutton et al., 2013). They wanted to know what demitarian meant. They wanted to know whether the lead author was a demitarian, and they wanted to see how the issues could be linked up to effect change—environment, food traceability and human health.

In the process, the global nutrient challenge found an outlet to be heard more loudly than would otherwise have been the case, and a platform gained to talk about the environmental threats and the benefits of better nutrient management... including manure spreading.

It is a dialog that needs to continue. And in the process, we learnt something about the press. It became much clearer to us how the press is not about “news”, but about “selling newspapers”. It is about building brand recognition on your issue: the more that nitrogen, phosphorus and nutrients are talked about in the news, the more they are welcome to be talked about in the news. As the public learn to understand why they should care about nutrients, the more they want to read about it, and the more newspaper editors will be willing to run an article.

It is an interesting angle. It means that, as nitrogen and phosphorus scientists, we should not be satisfied with only publishing in scientific journals. We need to keep bringing our reports and papers to the wider media, educating and informing about why nutrients matter.

It is just as we emphasized in *Our Nutrient World*:

“Only once the world's citizens begin realize how nutrients represent a nexus that unites all our concerns, will many governments become sufficiently empowered to support society as a whole in taking the actions needed.”

*Our Nutrient World* is published (18 February 2013) by the Centre for Ecology and Hydrology on behalf of the Global Partnership on Nutrient Management (GPNM) and the International Nitrogen Initiative (INI). It can be downloaded from the GPNM, INI, SCOPE and IGBP websites. Hard copies may be purchased at <http://www.earthprint.com> (US\$40) and <http://www.word-power.co.uk> (GB £25).

## References

- Billen, G., Garnier, J., Lassaletta, L. The nitrogen cascade from agricultural soils to the sea: modelling N transfers at regional watershed and global scales. *Philosophical Transactions of the Royal Society B*, in press.
- Harvey, F., 2013. Halve meat consumption, scientists urge rich world. *The Guardian* (<http://www.guardian.co.uk/environment/2013/feb/18/halve-meat-consumption-scientists>).
- Liu, X., Zhang, Y., Han, W., Tang, A., Shen, J., Cui, Z., Vitousek, P., Erisman, J.W., Goulding, K., Christie, P., Fangmeier, A., Zhang, F., 2013. Enhanced nitrogen deposition over China. *Nature* 494, 459–462.
- McCarthy, M., 2013. UN says fertiliser crisis is damaging the planet. *The Independent* (<http://www.independent.co.uk/environment/nature/un-says-fertiliser-crisis-is-damaging-the-planet-8498777.html>).
- Reay, D.S., Howard, C.M., Bleeker, A., Higgins, P., Smith, K., Westhoek, H., Rood, T., Theobald, M.R., Sanz Cobeña, A., Rees, R.M., Moran, D., Reis, S., 2011. Societal choice and communicating the European nitrogen challenge. In: Sutton, M.A., Howard, C. M., Erisman, J.W., Billen, G., Bleeker, A., Grennfelt, P., van Grinsven, H., Grizzetti, B. (Eds.), *The European Nitrogen Assessment*. Cambridge University Press. (Chapter 26).
- Smith, B.P., Burns, P. & Reading, S. 2013 Communicating 'Our Nutrient World' – a report for UNEP (Published 18 February 2013). March 2013. Centre for Ecology & Hydrology 12 pp. <[http://www.ceh.ac.uk/news/news\\_archive/CommunicatingOurNutrientWorld.html](http://www.ceh.ac.uk/news/news_archive/CommunicatingOurNutrientWorld.html)>.
- Sutton, M.A., Bleeker, A., 2013. The shape of nitrogen to come. *Nature* 494, 435–437.
- Sutton, M.A., Howard, C.M., Erisman, J.W., Bealey, W.J., Billen, G., Bleeker, A., Bouwan, A.F., Grennfelt, P., van Grinsven, H., Grizzetti, B., 2011. The challenge to integrate nitrogen science and policies: the European Nitrogen Assessment approach. In: Sutton, M.A., Howard, C.M., Erisman, J.W., Billen, G., Bleeker, A., Grennfelt, P., van Grinsven, H., Grizzetti, B. (Eds.), *The European Nitrogen Assessment*. Cambridge University Press, pp. 82–96. (Chapter 5).
- Sutton, M.A., Bleeker, A., Howard, C.M., Bekunda, M., Grizzetti, B., de Vries, W., van Grinsven, H.J.M., Abrol, Y.P., Adhya, T.K., Billen, G., Davidson, E.A, Datta, A., Diaz, R., Erisman, J.W., Liu, X.J., Oenema, O., Palm, C., Raghuram, N., Reis, S., Scholz, R.W., Sims, T., Westhoek, H., Zhang, F.S., 2013. Our Nutrient World: The challenge to produce more food and energy with less pollution. *Global Overview of Nutrient Management*. Centre for Ecology and Hydrology, Edinburgh on behalf of the Global Partnership on Nutrient Management and the International Nitrogen Initiative114 (<http://initrogen.org/index.php/publications/our-nutrient-world/>).