The Global Nitrogen Challenge:
a case of too much and too little nutrients

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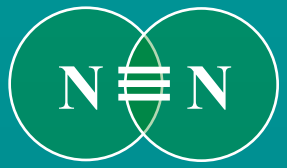
What is nitrogen?

- An element. 7 protons; mostly 7 neutrons. Atomic mass 14, "Unreactive Nitrogen"
  - Two N together: N_2. Really stable. Contains a huge amount of energy.
  - But many other N forms, ammonia, nitrate, nitric acid, nitrous oxide. Etc. = "Reactive Nitrogen"

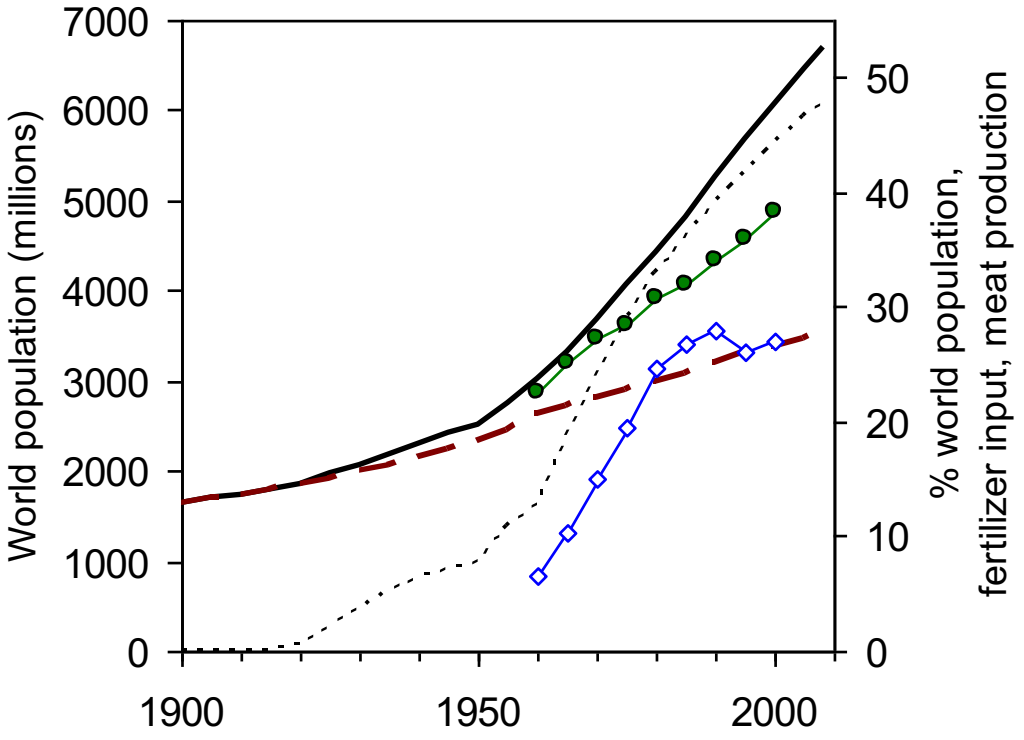


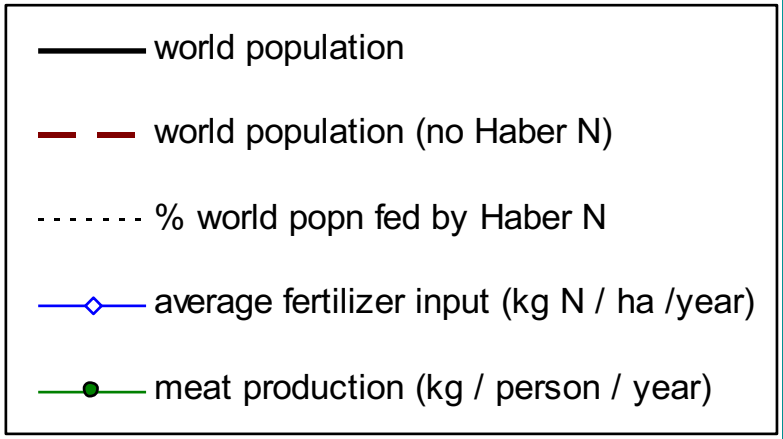
- Economy, Health & Environment
  A coherent nitrogen policy focus is missing and would have big triple wins

Nitrogen Form	Structure	Typical concentrations	Main Sources	Main Effects	
Di-nitrogen (N_2)		78% of air	Conversion from NO_3^- & NH_4^+ in soil & waters	Natural chemical inertness in the world's atmosphere	
Ammonia (NH_3)		0.1 to 100 ppb of air	Manure, urine, fertilizers, biomass burning, cars	Forms ammonium (NH_4^+) containing Particulate Matter (PM) in air affecting health (heart disease, respiratory illness); Causes eutrophication of ecosystems, affecting biodiversity	
Nitric oxide (NO)		0.1 to 100 ppb of air	Combustion from transport & energy sources	Direct health risks, and forms NO_2 in air affecting health (heart disease, respiratory illness).	**Sum = NO_x**
Nitrogen dioxide (NO_2)		0.1 to 100 ppb of air	Formed by rapid oxidation of NO	Direct health risks; Forms Particulate Matter (NH_4NO_3) in air contributing to heart disease, respiratory illness. Also causes ground-level ozone air pollution (O_3)	
Nitrates (NO_3^-)		Air: 0.1-10 μg m^{-3} Water: 1-500 mg per litre	Air: Oxidation of NO_x Water: Agriculture, waste water. Formed by oxidation of NH_4^+	As Particulate Matter (e.g. NH_4NO_3) in air it affects health (heart disease, respiratory illness) As a water contaminant, it affects health (e.g. bowel cancer) & causes eutrophication of ecosystems threatening biodiversity	
Nitrous Oxide (N_2O)		330 ppb in air	Agriculture, industry, combustion; Formed by conversion from NH_4^+ & NO_3^- in soil and waters	A powerful greenhouse gas contributing to climate change. Now the main cause of stratospheric ozone depletion	

PPB = parts per billion

Benefit No 1: Ammonia feeds the world





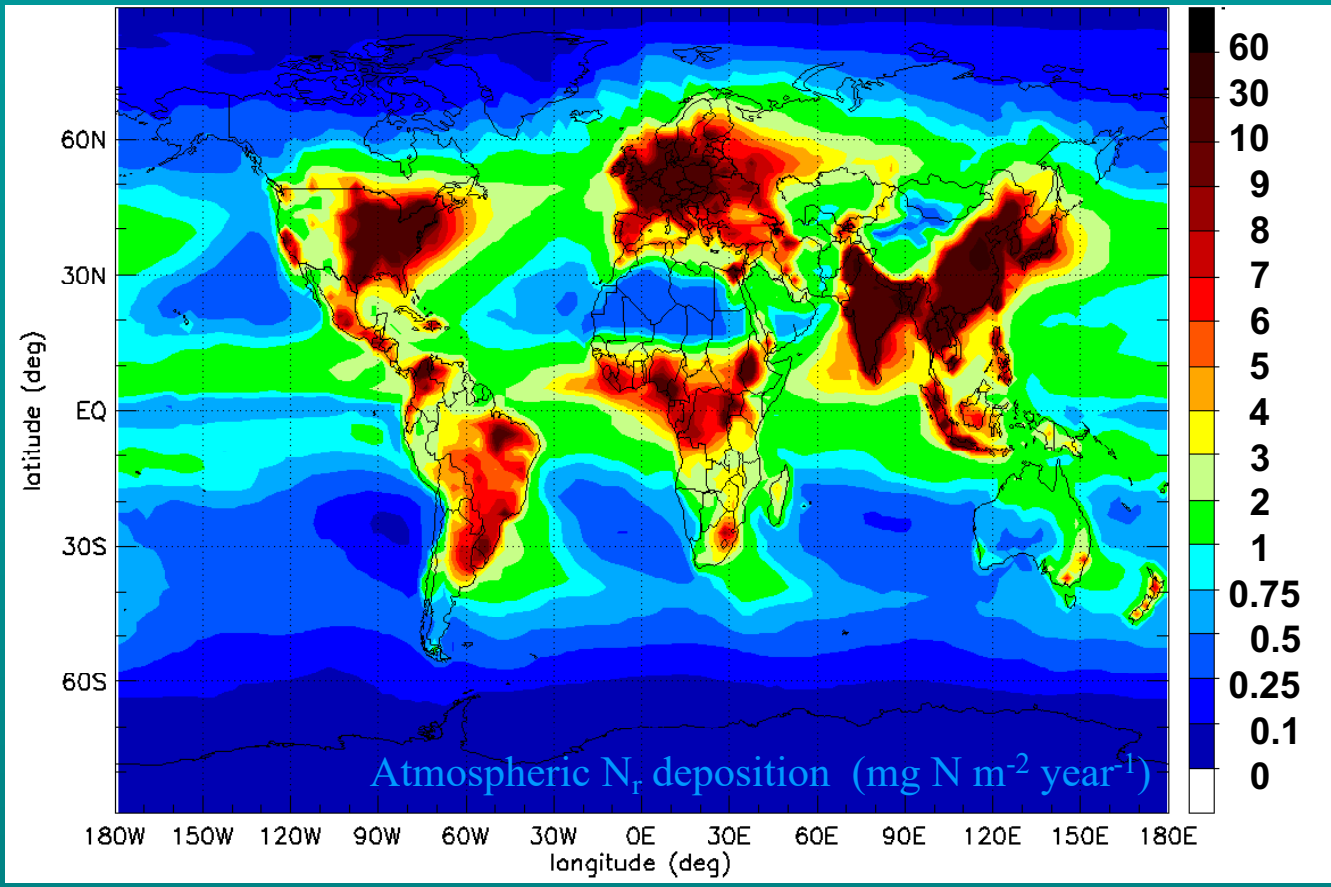
Erisman et al.
Nature Geoscience 2008

- Nitrogen provided food for 3.5 billion people
- Nitrogen responsible for 100 million war deaths

Global N_r production & dispersion

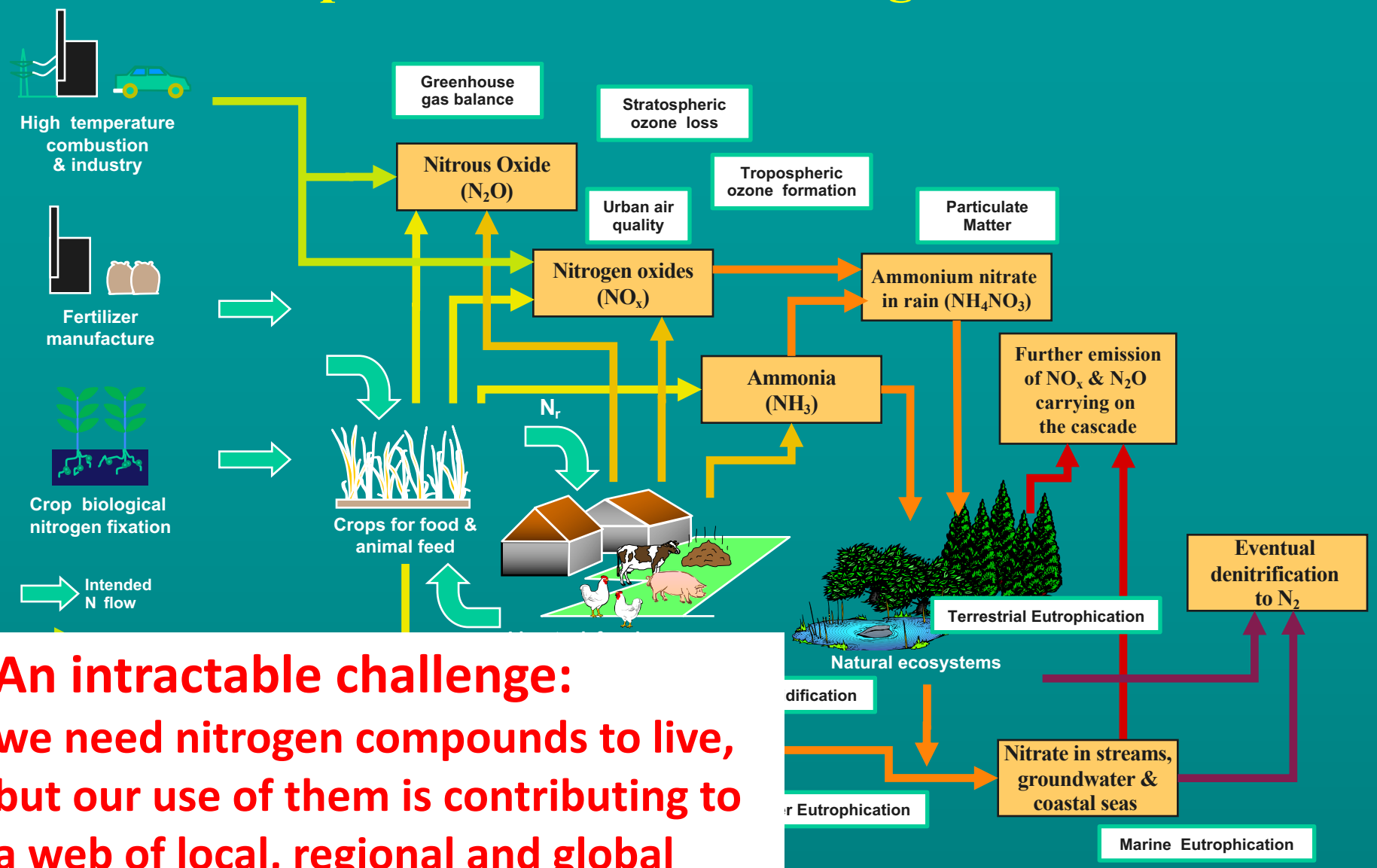
Human N_r Production:
(Tg yr^{-1})
1860: 15
1995: 156
2005: 191

2005 sources:
Haber Bosch: 130
Biol N fixn: 50
NO_x emission: 50



Galloway et al. *Science* (15 May 2008)

Simplified view of the Nitrogen Cascade



An intractable challenge:

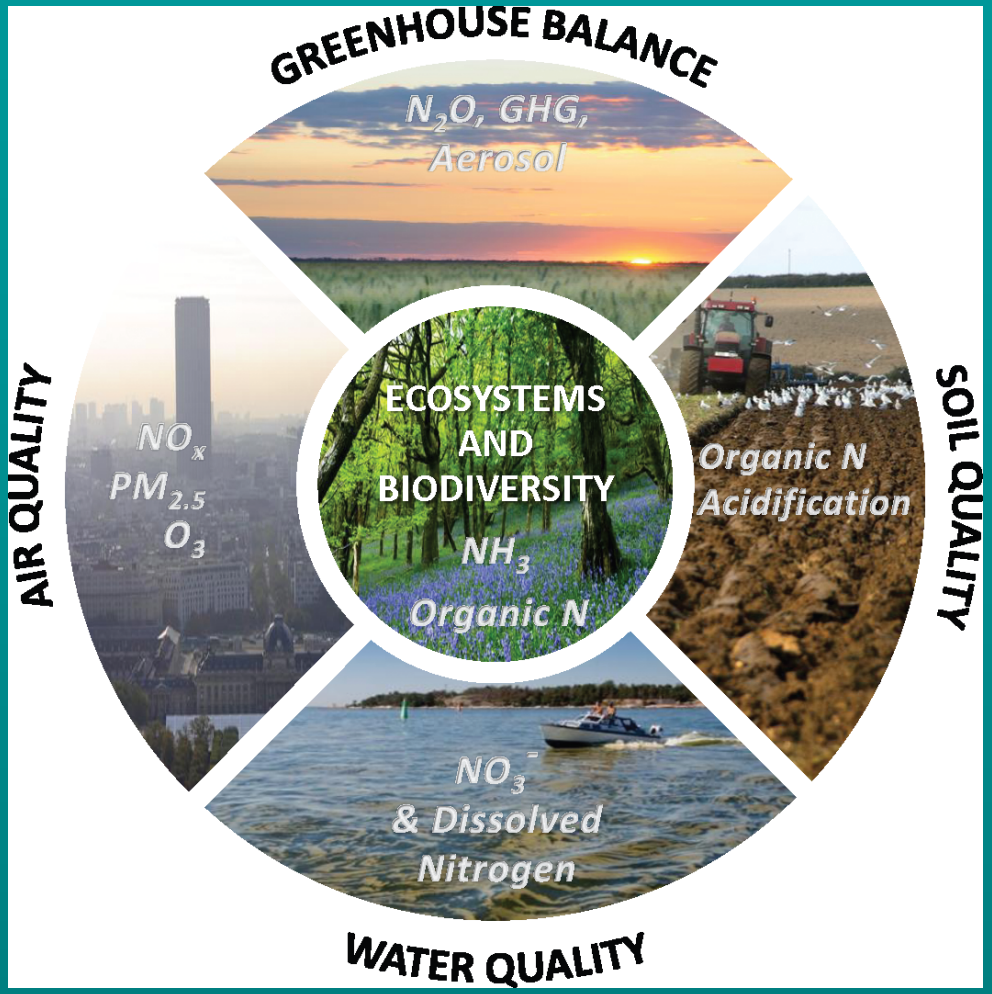
we need nitrogen compounds to live, but our use of them is contributing to a web of local, regional and global environmental problems.

European Nitrogen Assessment, 2011

The five key threats of excess Nitrogen

The WAGES of too much nitrogen

Water quality
Air quality
Greenhouse balance
Ecosystems
Soil quality

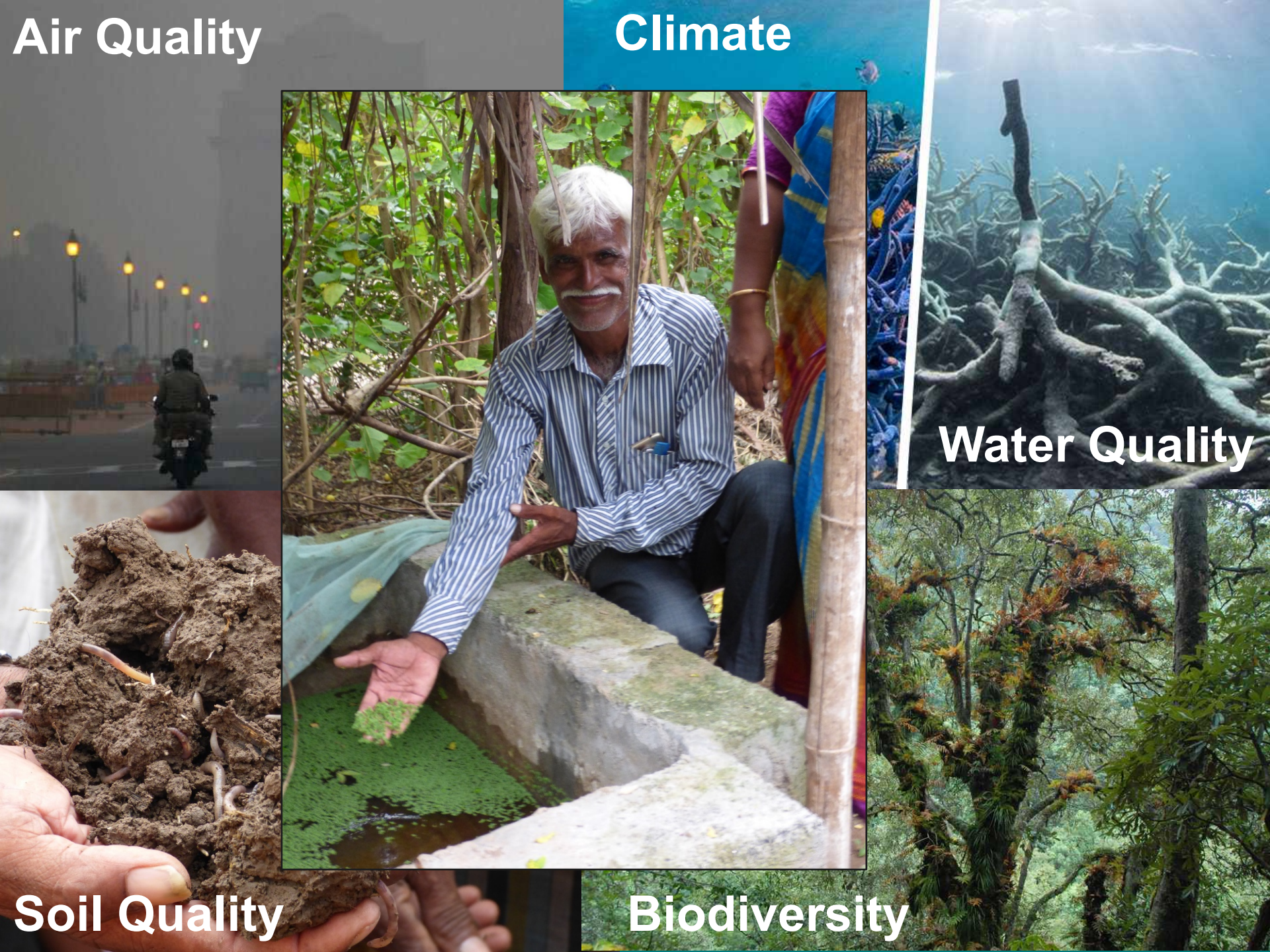


European Nitrogen Assessment, 2011

Photos *Nature* April 2011


2017


2017


Air Quality
Climate
Water Quality
Soil Quality
Biodiversity

- INMS brings scientific evidence together to inform policies and the public on the multiple benefits and threats of reactive nitrogen
- UNEP and INI launched the process in December 2016 with funding from the Global Environment Facility (GEF)
- $6M cash + $54M partner contributions

Scope and Approach

Data need & concepts

Improved management practices, Mitigation, Adaptation

C1: Tools and methods for understanding the N cycle

C2: Global & regional quantification of N use, flows, impacts & benefits of improved practices

Informing modelling requirements

Options & Scenarios, including Cost-Benefit-Analysis

C3: Regional demonstration & verification

C4: Awareness raising & knowledge sharing

Policy homes, Public awareness, Consensus building,

Opportunities, Local/region priorities, Policy context, Local data, Barriers-to-change

Better basis for transformational change

What will INMS deliver?

- **A global assessment** of the threats and benefits of human alteration of the nitrogen cycle and the opportunities for improvement.
- **A forward look** of what may happen if the problem is ignored.
- **Guidance on joining up** mitigation and adaptation options and strategies, linked to circular and green economy thinking – including the *Nitrogen Top 10*
- **A platform for better cooperation** helping to overcome the barriers.

Where are we with nitrogen policy?

- Single issue focus of policy departments
- General fragmentation between issues (water, air, ghg, biodiversity, food etc)
- Major barriers to change Cars struggle to go further in reducing NO_x; Agricultural lobbies prevent adoption of N policies.

Addressing fragmentation of Nitrogen-related Targets

across Multilateral Environmental Agreements

UNECE Air Convention

Gothenburg Protocol 1999 & 2012

"7. Taking into account the scientific knowledge about the hemispheric transport of air pollution, the influence of the nitrogen cycle and the potential synergies with and trade-offs between air pollution and climate change" establishes national "emission reduction commitments" for NO_x and NH_3 by 2020 critical loads and critical levels for 2020, and "minimum control measures" for NO_x and NH_3.

No global framework

GPA

Manila Declaration 2012

"4. *Decide* actively to engage ourselves and step up our efforts to develop guidance, strategies or policies on the sustainable use of nutrients so as to improve nutrient use efficiency with attendant economic benefits for all stakeholders, including farmers, and to mitigate negative environmental impacts through the development and implementation of national goals and plans over the period 2012–2016, as necessary;"

UNFCCC

Kyoto Protocol 1997 "3.1 The Parties… shall, individually or jointly, ensure that their aggregate anthropogenic carbon dioxide equivalent emissions of the greenhouse gases listed in Annex A [inc. N_2O] do not exceed their assigned amounts… with a view to reducing their overall emissions of such gases by at least 5 per cent below 1990 levels in the commitment period 2008 to 2012"

Paris Agreement 2015 "2.1. aims to strengthen the global response…including by… b) Increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development [inc. N_2O], in a manner that does not threaten food production."

Policy Arena for Nitrogen UNEA

Overarching Goals including *Economy Wide Nitrogen Use Efficiency*

More food and energy with less pollution

INMS

International Nitrogen Management System

Convention on Biological Diversity

Aichi Targets 2010

Target 8: "By 2020, pollution, including from excess nutrients, has been brought to levels that are not detrimental to ecosystem function and biodiversity."

Key focus on nitrogen. Each country free to set its own indicators and goals.

Montreal Protocol

1987 No N_2O commitment

Recognized by the Vienna Convention. UNEP (2013): "Global anthropogenic N_2O emissions … expected to almost double by 2050 unless mitigation action is accelerated. The continued build-up of N_2O in the atmosphere will continue to deplete the stratospheric ozone layer and in so doing will to a degree undermine the achievements of the Montreal Protocol."

SDGs & Nitrogen

In development – a joined up system needed

Towards the INMS
International Nitrogen Management System
www.inms.international

Options for future Nitrogen Policy Coordination

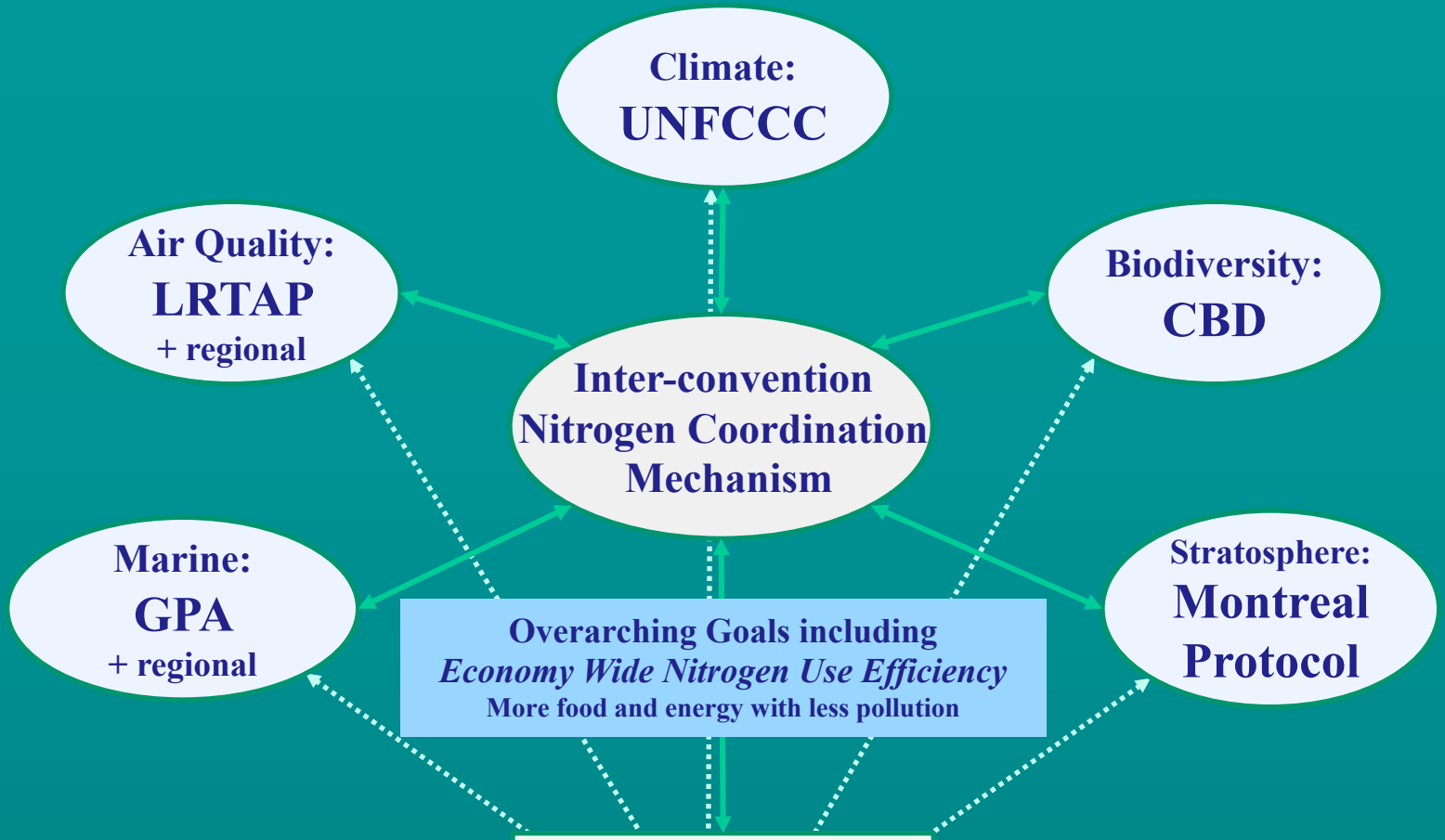
Option 1 Nitrogen fragmentation across policy frameworks – *the status quo*

Option 2 Nitrogen leadership under one existing policy framework – *challenge of mandate*

Option 3 A new international convention to address the nitrogen challenge – *little readiness*

Option 4 A nitrogen coordination mechanism, e.g., under the mandate of UNEA – *preferred option?*

Developing the Policy Arena for Nitrogen



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Role of United Nations Environment Assembly

Nitrogen relevant for multiple UNEA Resolutions

2/6 (Paris Agreement), 2/7 (Chem & Waste), 2/8 (SCP), 2/9 (Food Waste), 2/10 (Oceans), 2/12 (Coral Reefs), 2/24 (Land degradation), 3/4 (Env & Health), 3/6 (Soil), 3/8 (Air Quality), 3/10 (Water Pollution)

Res 3/8 " 4. Further encourages governments to pursue synergies and co-benefits between national clean air policies… and **to take advantage of synergistic effects of efficient nitrogen management on reducing air, marine and water pollution.** "

Draft Nitrogen Resolution for UNEA-4

Led by South Asia (SACEP meetings Sept. 2017 and March 2018) in preparation for UNEA-4: **"Calls on UN Environment to support development of a coherent evidence-based policy approach for sustainable nitrogen management."**

Should the UN agree a goal to "Halve Nitrogen Waste" by 2030?

- Challenge to more than double economy-wide NUE using all available options (crop, animal, food choice, food waste, sewage, combustion etc)
- Roughly halve the amount of N fertilizers produced from N_2 fixation (global saving ~€100 billion / year)
- Massive economic and environmental benefits for air, water, climate, health, biodiversity etc.
- Huge business opportunities for circular economy innovation and business goals (*e.g. 20% of EU fertilizer made from recycled sources by 2030*)

UN environment

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INI Commitment for *Our Oceans Conference 2018*

- "INI commits to support a global goal to halve nitrogen waste by 2030, offering a resource-saving of $100 billion per year globally, by reducing pollution by 100 million tonnes per year, as a key to protecting Our Oceans with quantified co-benefits for water quality, air quality, biodiversity, climate resilience, food and livelihoods."

- "INI cannot work alone, but must join with governments, business and citizens globally to achieve this goal, spearheading a holistic approach for nitrogen across the Sustainable Development Goals."
- "INI makes this commitment by providing a global science-policy support process for better nitrogen management, the International Nitrogen Management System (INMS), working 2018-2022 in partnership with UN Environment and a global network of over 80 partners from science, governments, agencies and civil society. Over this period, the INMS partnership commits a US$ 60M effort, including $6M through the Global Environment Facility (GEF)."

Questions for Discussion

Immediate (Now)

- Do we agree that the multi-dimensional nature of nitrogen make it a special challenge?
- What are the key things to be considered for a UNEA-4 Nitrogen Resolution?

Medium Term (2-3 years)

- How might we address fragmentation across the nitrogen policies?
- What are the pros and cons of the four options for International Nitrogen Policy Coordination?
- Should we have a goal to "*Halve Nitrogen Waste*"?