INMS Component 2: Global & regional quantification of N use, flows, impacts & benefits of practices

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First e-briefing for the Nitrogen Working Group of the United Nations Environment Programme

Contents

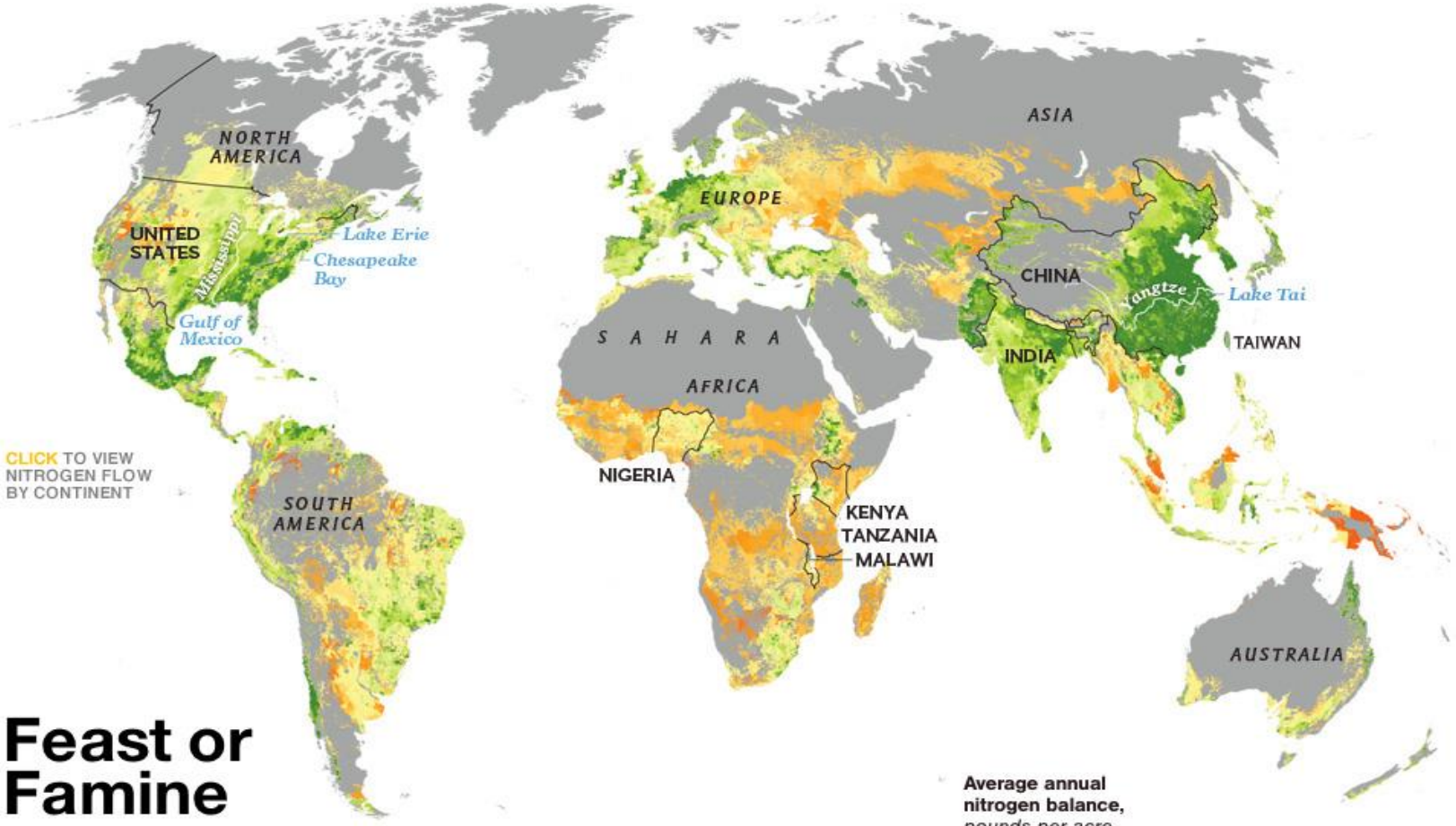
Global scale integrated N assessment modelling

- The rationale: need for cost-benefit quantification of N policies
- The challenge: modelling interactions in the N cascade

INA part C: Global integrated assessment across the N cycle

- Outline and links to INMS modelling
- Examples of model results
  - Present (and past) N impacts
  - Future N impacts in response to scenarios and measures

Benefits: food and feed production



Threats of N use in agriculture: Impacts on air, soil and water quality: health, climate and biodiversity

Biodiversity impacts

Climate change impacts

N outputs: harvested crops

Atmosphere

NH_3 N_2O NO_X N_2

Atmosphere

NH_3 N_2O NO_X N_2

N inputs:
N fertilizer
N fixation
N deposition

Crop production

feed

manure

Animal production

N outputs: milk, meat, eggs

NH_4^+ $\mathbf{NO_3^-}$ DON N_{part}

NH_4^+ NO_3^- DON N_{part}

Ground water & surface water

In addition: Impacts of (industrial) N emissions on air quality and human health

Global scale integrated N assessment modelling in view of benefits and threats

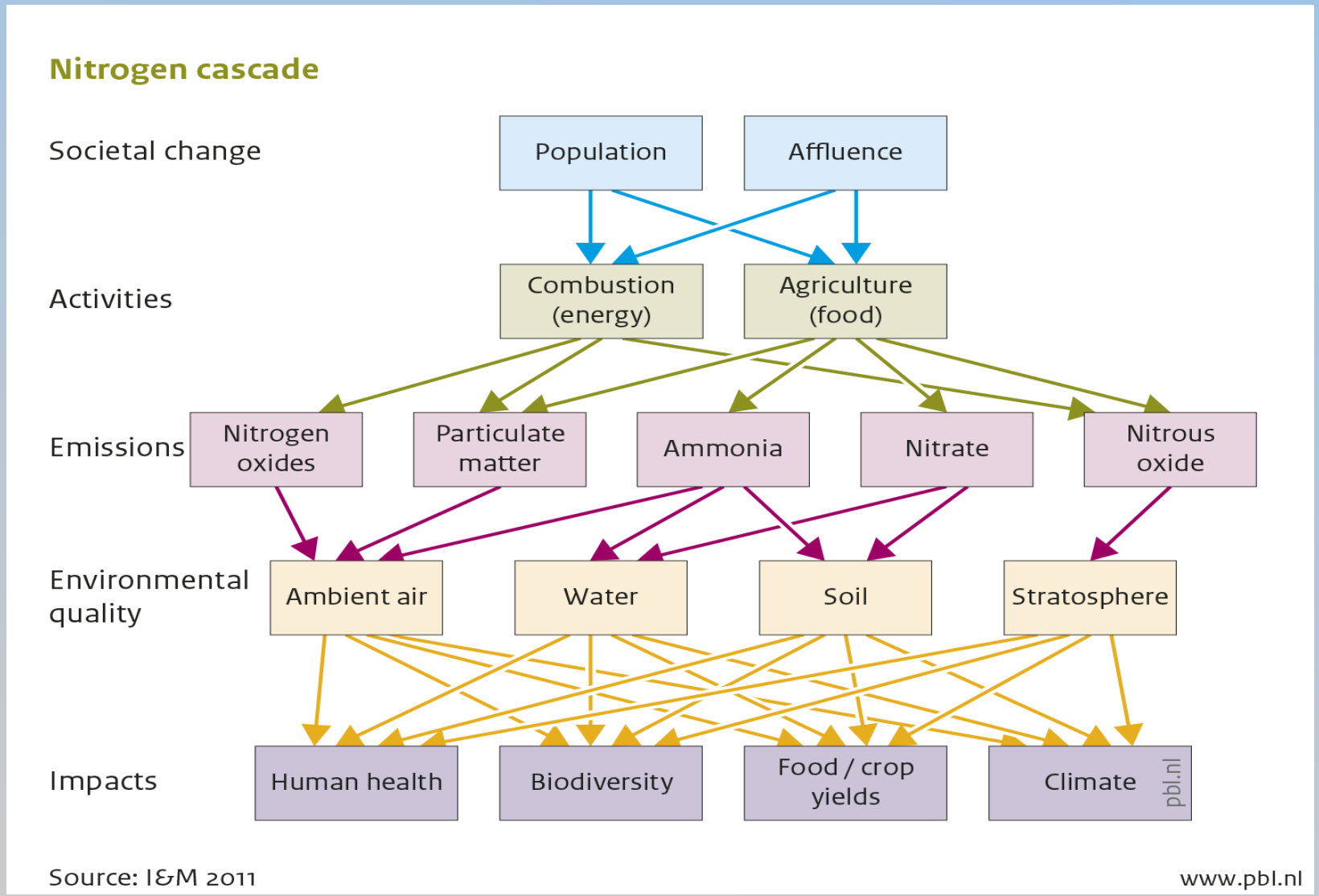
A global integrated nitrogen assessment model needs to quantify effects of N management (N policies) on:

- food, feed and fiber production (benefits)
- quality of air, soil and water, and related human health, climate and biodiversity impacts (threats)

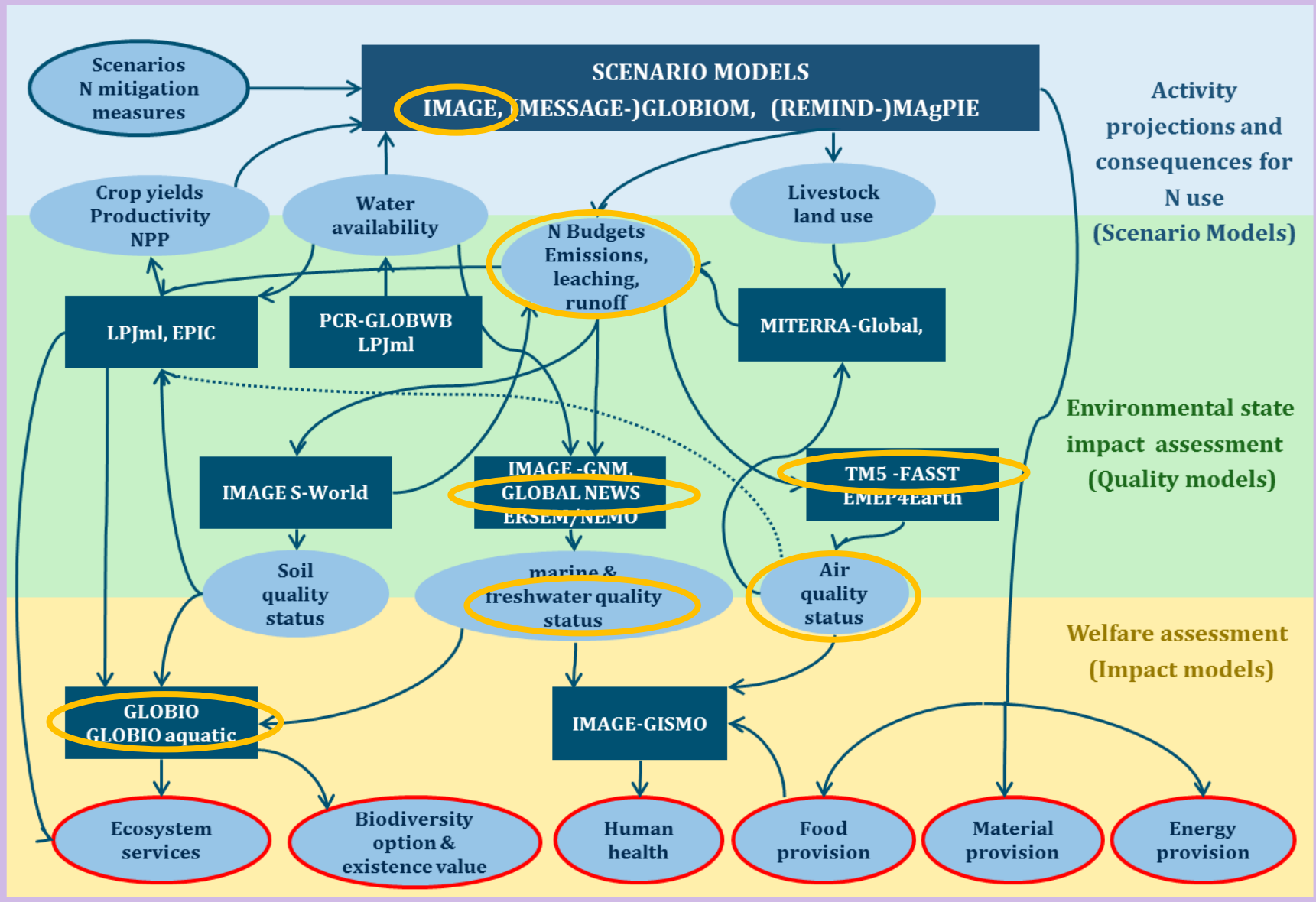
while

- being linked to socio-economic drivers (scenarios)
- accounting for variations in climate, soils, crops.

Global scale integrated N assessment: challenge to model the N cascade



Multi model approach: involved models and linkages



How will this be included in the INA part C

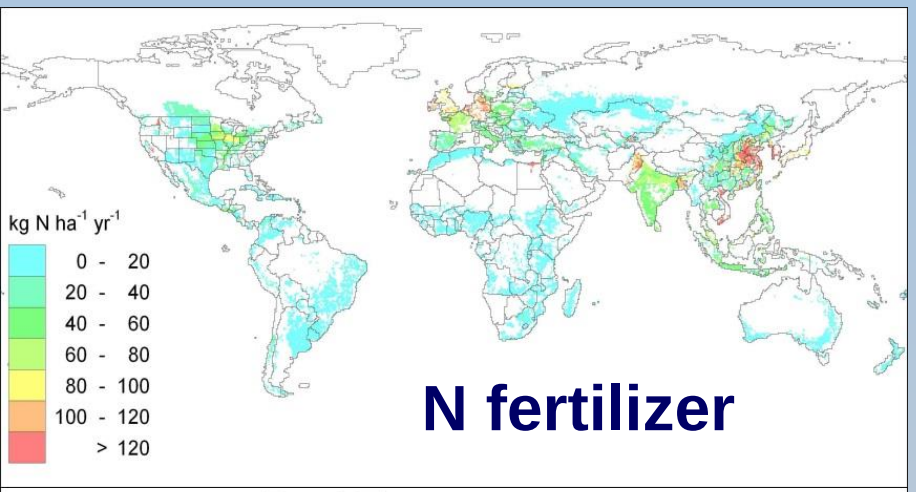
Impacts will be described by presenting current status and predictions up to 2050 (2010) based on WAGES

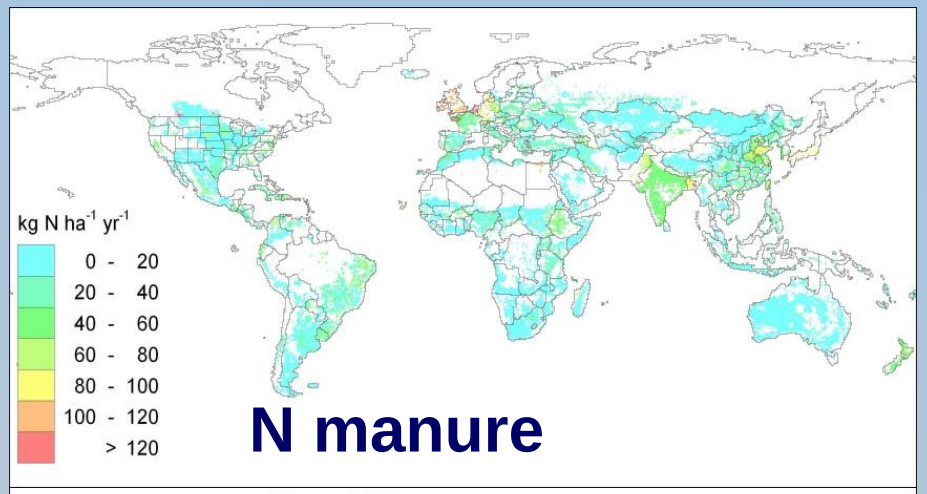
- Starting with *total N budgets*. C10

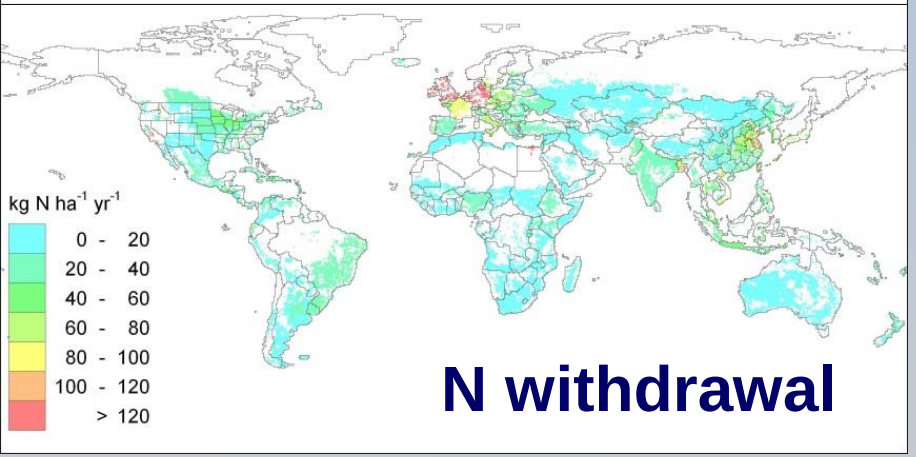
- **W**ater quality: linked to aquatic (marine) eutrophication C11
- **A**ir quality: linked to health C12
- **G**reenhouse gas emissions: linked to climate C13
- **E**cosystems: linked to terrestrial and aquatic biodiversity C14
- **S**oil: linked to soil N budgets (input, uptake, losses to air and water) and related soil acidification C15

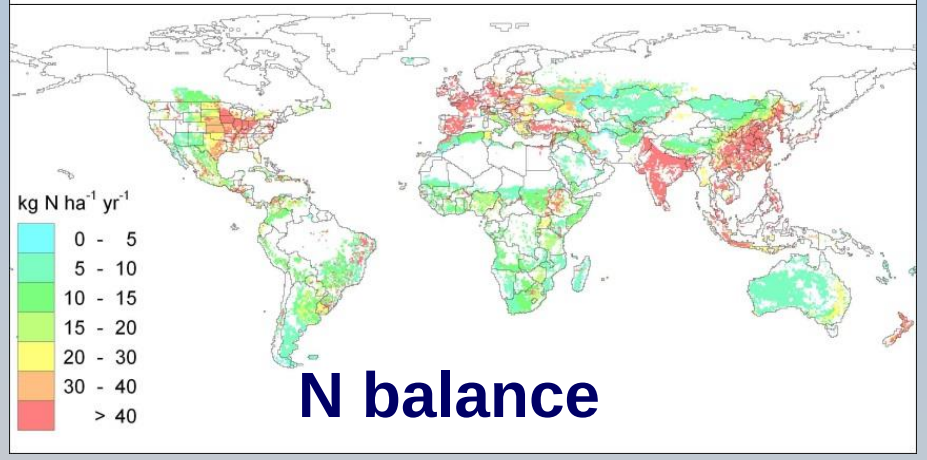
- Finalizing with *cost-benefit analysis* C16

Example Chapter 10-15: Soil N budget results with IMAGE



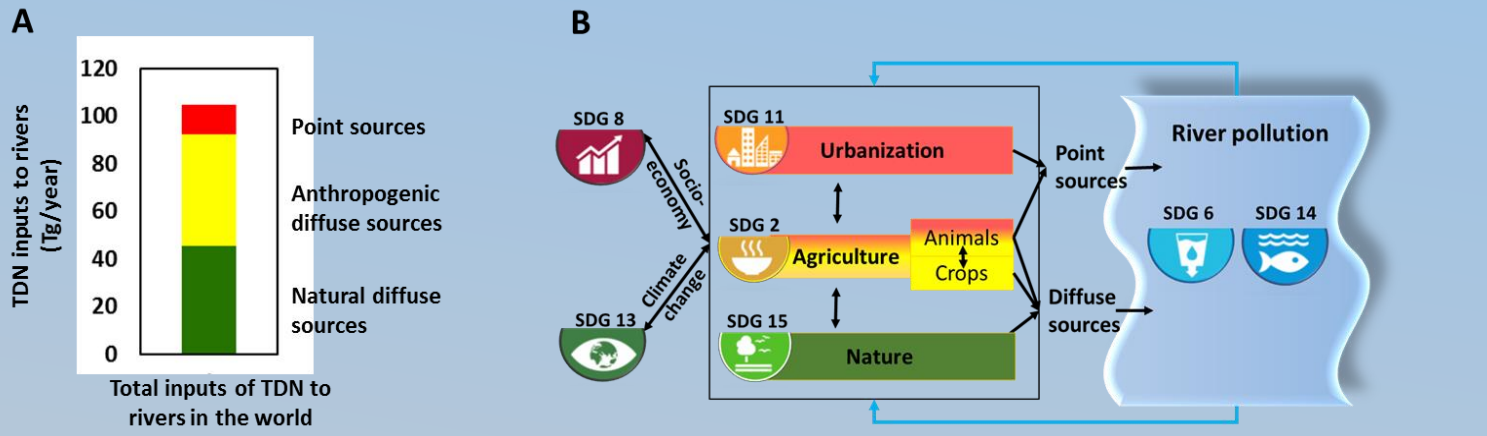






Bouwman et al. (2019)

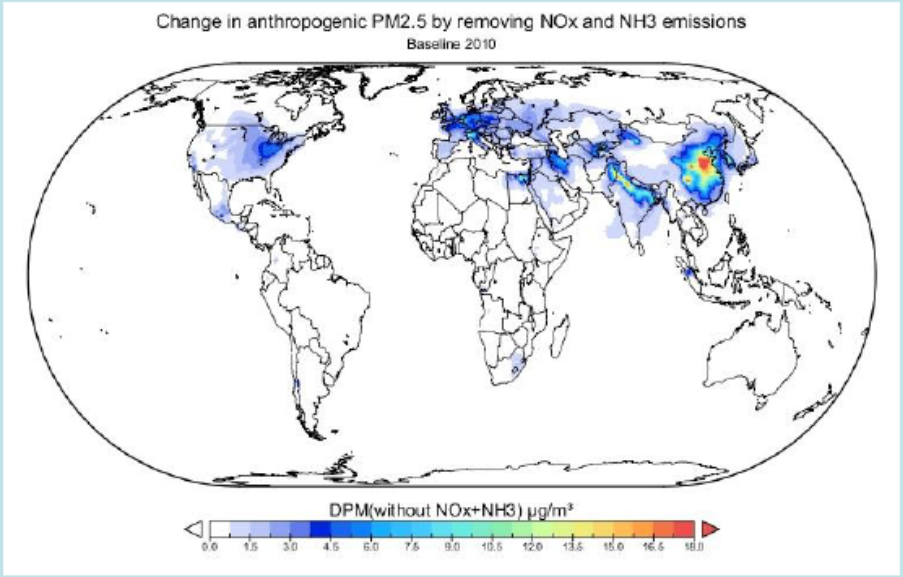
Example Chapter 11: Water quality assessment with Global NEWS



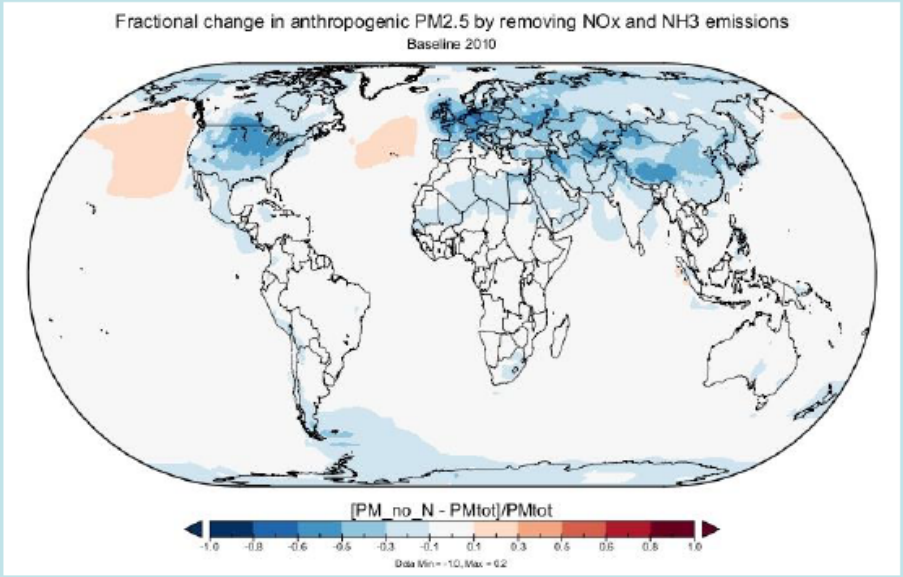
Strokal et al. (2020; INI Berlin proceedings)

Example Chapter 12: Air quality assessment with TM5-FASST

Absolute change in PM2.5 by removing NO_x and NH_3 emissions



Fractional change in **anthropogenic** PM2.5 by removing NO_x and NH_3 emissions



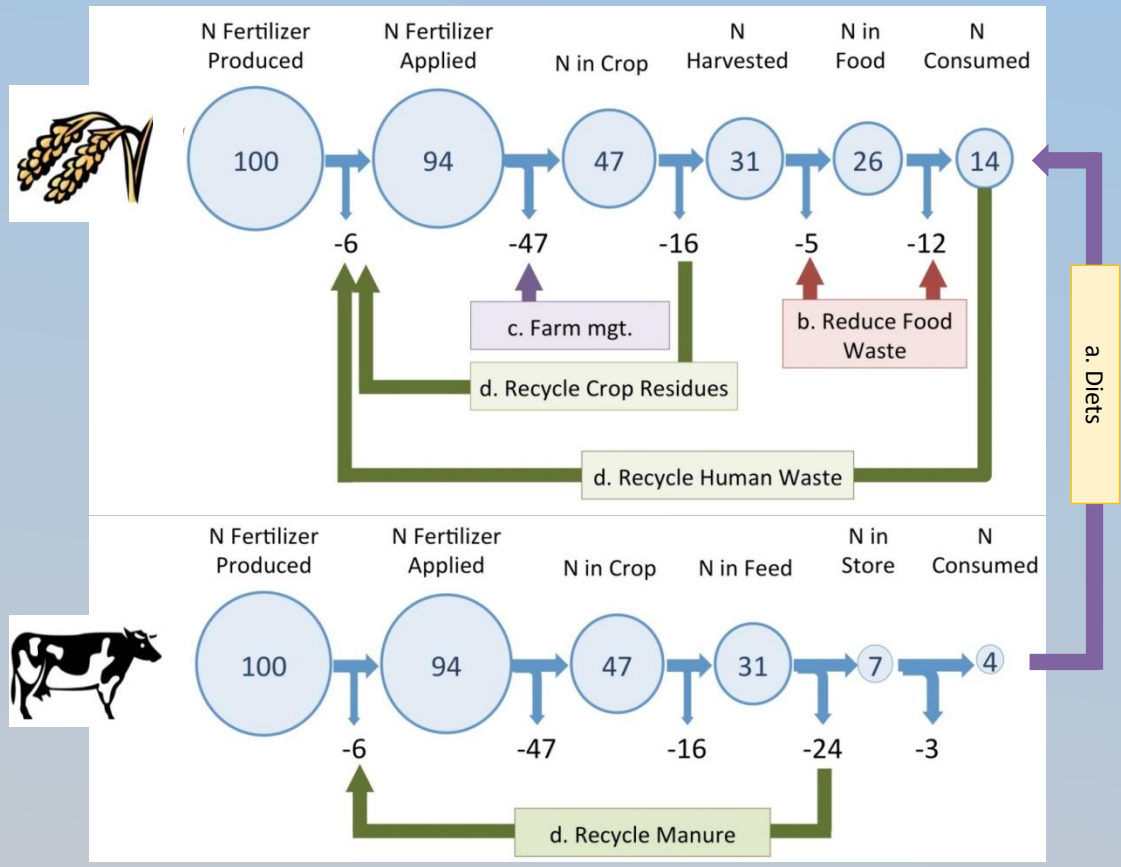
Impacts of NO_x and NH_3 emissions on $PM_{2.5}$ affecting health: Van Dingenen et al. (2019)

Challenge ahead: systematic evaluation of scenarios and N mitigation measures

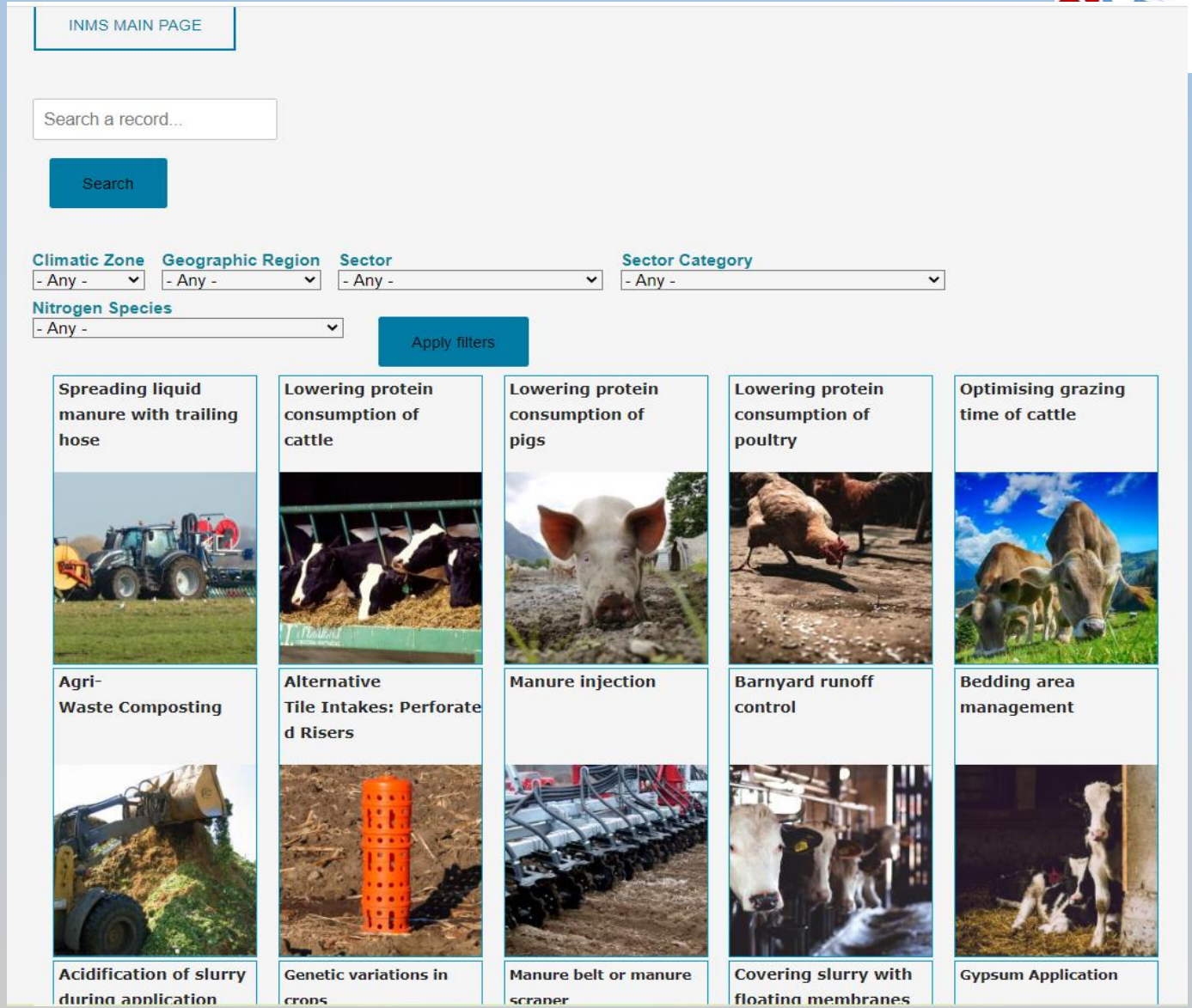
We use existing global scenario's, i.e. SSPs and RCPs, including dietary change propositions.

We assess separate N mitigation policies related to

- enhanced (animal, plant, human) waste recycling
- improved nutrient management.



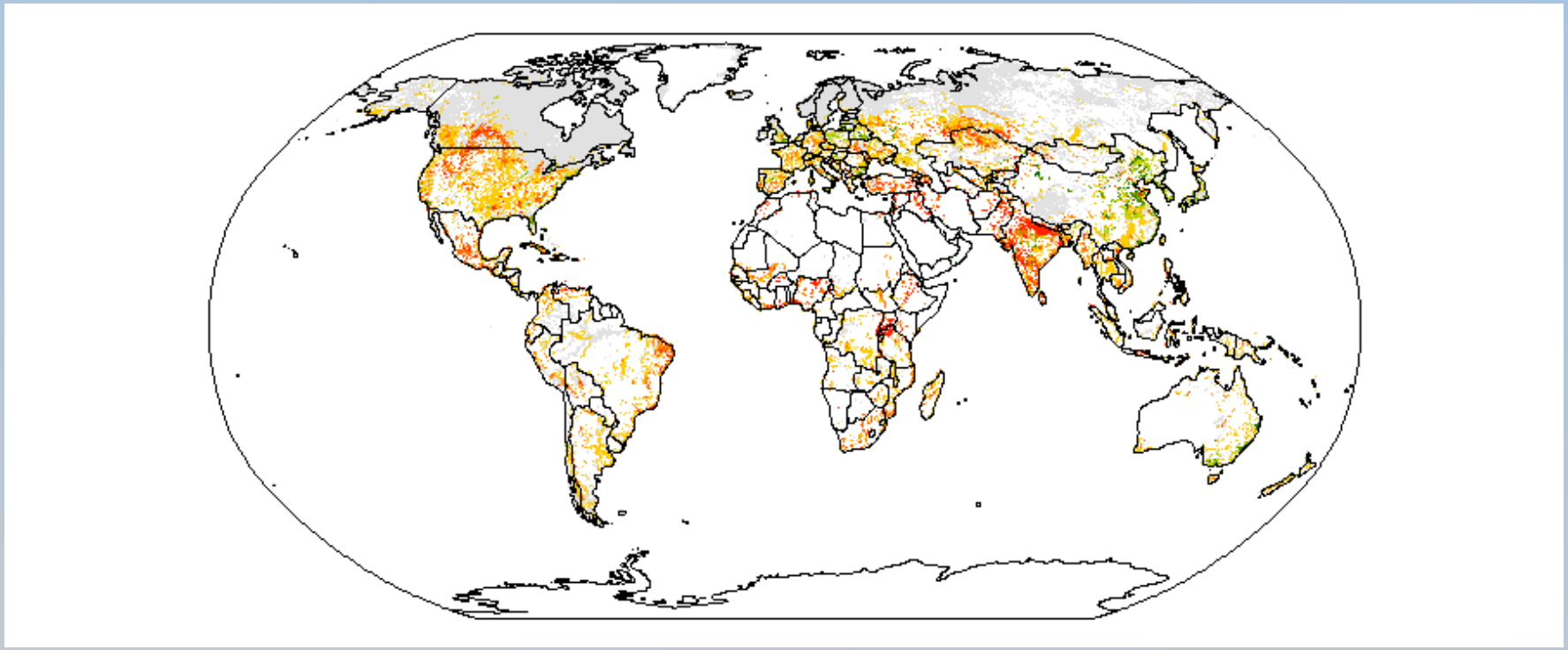
Examples of good N management practices



- Developing selection criteria, and methodology to select top ten measures, which may extend to regional top tens for each UN global region.

Examples of scenario results

Change in harmful algal blooms in lakes (2010 -> 2050) in response to SSP2 scenario



Deterioration in many regions due to increased N and P loading as well as temperature rise.

Janse et al (in prep)

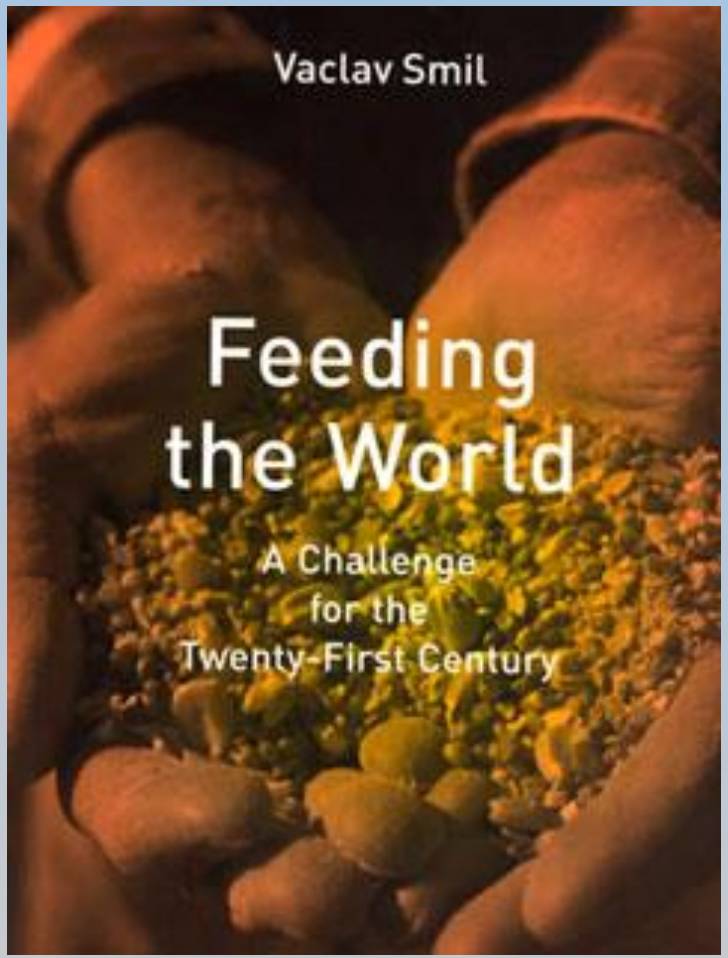
So what is the main contents of part C INA

- Current status of N uses on soil, air and water quality and thus on biodiversity, human health and climate

- Evaluate impacts (costs and benefits) of scenarios and N related N policies/measures (management) on air, soil and water quality for:
  - food/feed supply
  - Biodiversity, human health and climate

Basis is result of coupled models evaluating scenarios (population growth, dietary patterns, bioenergy use) and N policies/measures

Questions?


Vaclav Smil
Feeding the World
A Challenge for the Twenty-First Century