Options to decrease N losses from our global food system

7th International Nitrogen Initiative congress (INI2016)
4-8 Dec. 2016, Melbourne, Australia

Sjaak Conijn, Prem Bindraban & Jaap Schröder

WAGENINGEN
UNIVERSITY & RESEARCH

Content of this presentation

- Goals
- Methods
- Results
- Conclusions

WAGENINGEN
UNIVERSITY & RESEARCH

Goals

- Analysis of the food system for current and future scenarios in the context of planetary boundaries[1,2]

- Exploration of effective interventions in the food system for guidance towards a safe operating space[1,2]

- Comprehensive understanding of the trade-offs and synergies when combining multiple measures to multiple targets

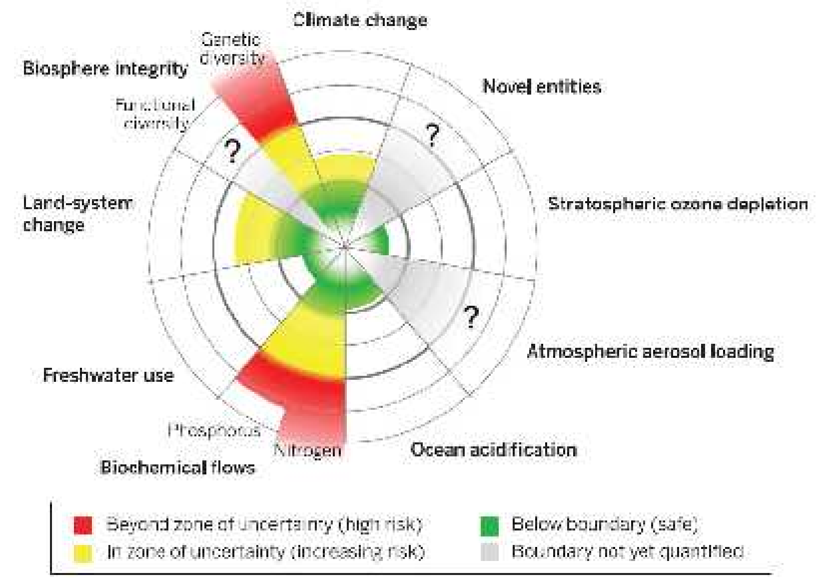
1) Rockström et al., 2009. Planetary Boundaries: Exploring the Safe Operating Space for Humanity. Ecol Soc 14.

2) Steffen et al., 2015. Planetary boundaries: Guiding human development on a changing planet. Science 347.

Planetary boundaries?

- PB framework defines a safe operating space for humanity
  - Earth system processes (nine) and
  - Control variables (1 or 2 for each Esp) and
  - Limits = PB

Steffen et al., 2015. Science 347



- In our food system study:
  - Climate change
  - Land-system change
  - Biochemical flows of N and P

- This presentation: N loss

WAGENINGEN UNIVERSITY & RESEARCH

Methods 1/3

- We developed a quantitative model to calculate
    - input requirements (land, N and P fertilizer) and
    - associated emissions (GHG, N and P losses/wastes)

as a function of food demand (~ # people, intake/cap & diet_%)

- BIOSPACS: Balancing Inputs and Outputs for the Sustainable Production of Agricultural CommoditieS.

Methods

- We distinguish 5 major domains in BIOSPACS,

1. Agricultural land	> Grassland and cropland
2. Organic fertilizer	> Animal manure and feeding loss
3. Livestock	> Bovine, sheep/goats, pig and chickens
4. Food balance	> 20 food groups (plant, animal, aquatic)
5. Population	> Intake and waste in households

- and parameterised their main input – output relations, including their interactions

WAGENINGEN
UNIVERSITY & RESEARCH

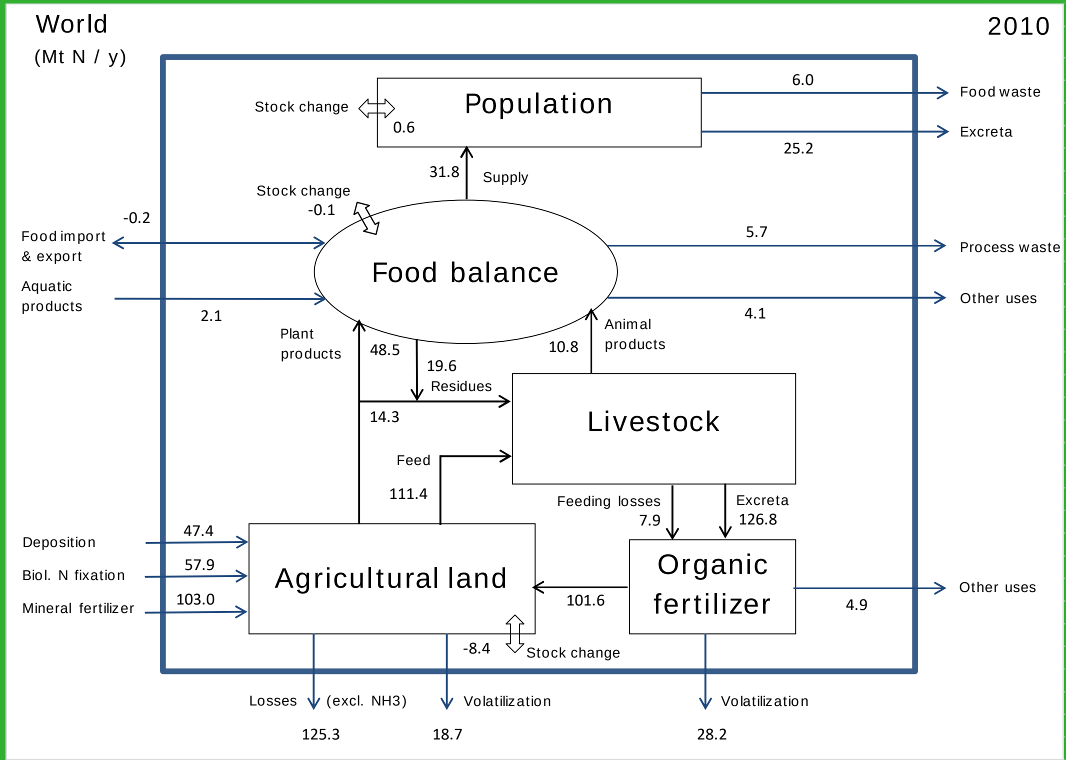
Methods 3/3

- Parameterisation is based extensively on data from FAOSTAT (global; 2010) and on additional parameters from literature
  - Land resources and crop production
  - Manure distribution and fertilizers consumption
  - Food Balance Sheets (per capita supply)
  - GHG emissions, etc.

- After parameterisation we applied the model for 2010 and verified that the results were consistent with the FAOSTAT data used for the parameterisation

WAGENINGEN
UNIVERSITY & RESEARCH

Results for 2010 1/7

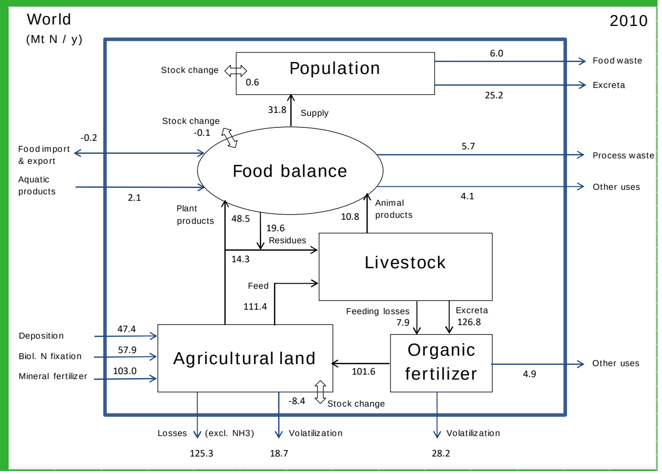


WAGENINGEN UNIVERSITY & RESEARCH

Global N flows in our food system

Results for 2010

- Some highlights
  - >80% of total harvested N from soils
    ➔ production of animal-based food items
  - 1/3 mineral fertilizer, 1/3 organic fertiliser & 1/3 (AD + BNF)
    ➔ total N input into soils (ca. 300 Mt N / y)
  - ~40% of total N input into soils
    ➔ non-NH_3 loss from soils
  - ~12% of total system N input
    ➔ actually consumed
    (210 Mt / y ➔ 26 Mt / y)



Results for 2050 (ref. scenario) 3/7

- Results for +60% food demand, due to 43% more people and 12% higher per capita consump. in 2050 (ref. scen.)
  - +45% for plant products and +75% for animal products
    → due to changed diet in 2050 (projected)
  - +78% N excretion by livestock
    → more available
  - +76% mineral N fertilizer
    → more required
  - +70% of total N loss from
    → agri. soils and NH_3 volat.

WAGENINGEN UNIVERSITY & RESEARCH

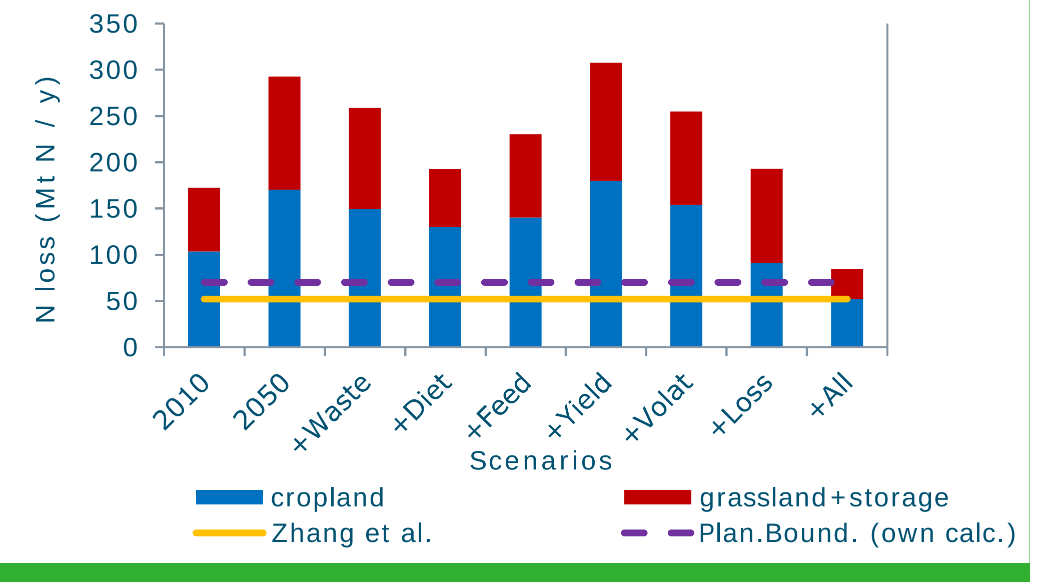
Results

- Future scenarios and measures

Code	Description
2010	The current state in 2010.
2050	Reference scenario for 2050 with +60% food demand
+Waste	50% reduction in the waste fractions
+Diet	50% reduction in supply shares of animal-based products
+Feed	25% improvement in the feed conversion ratios.
+Yield	50% increase in biomass yields of all crops and grassland
+Volat	50% reduction in NH_3 volatilization (manure and fertilizer)
+Loss	50% reduction in the soil loss fractions of N and P
+All	All above measures simultaneously.

Results for 2050 (measures)

- Focus on N loss, because
  - Lost (reactive) N in the environment = problem
  - Legislation is (often) based on environmental quality targets



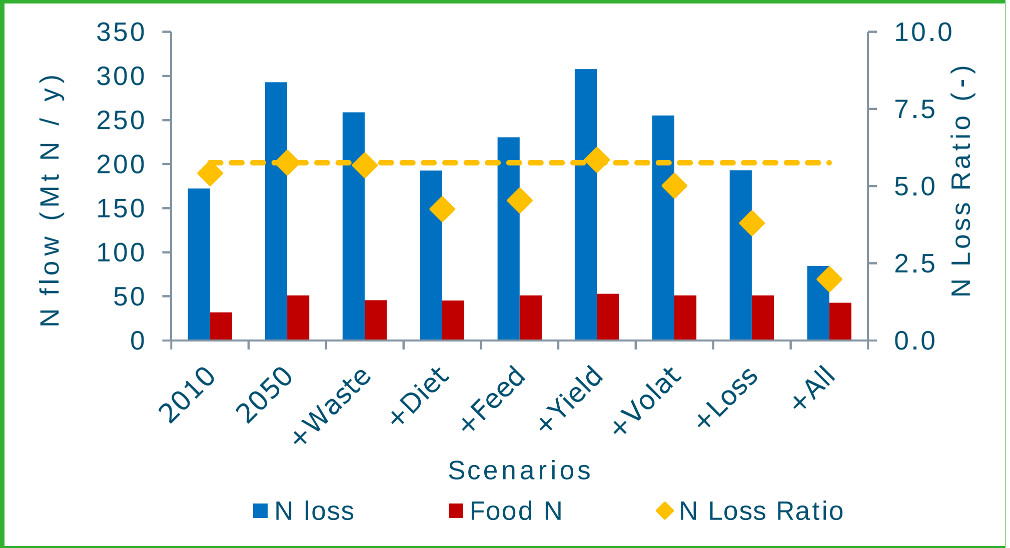
N loss from agri. soils and NH_3 volat. (83 – 307 Mt/y)

- Cro-Gra: 60–40%
- +All ~ 52 Mt/y
- +All > 70 Mt/y

WAGENINGEN UNIVERSITY & RESEARCH

Results for 2050 (measures)

- We computed the N loss ratio (N loss / Food N supply)
  - Nr footprint (kg N/kg N)
  - NLR = [1/NUE] – 1



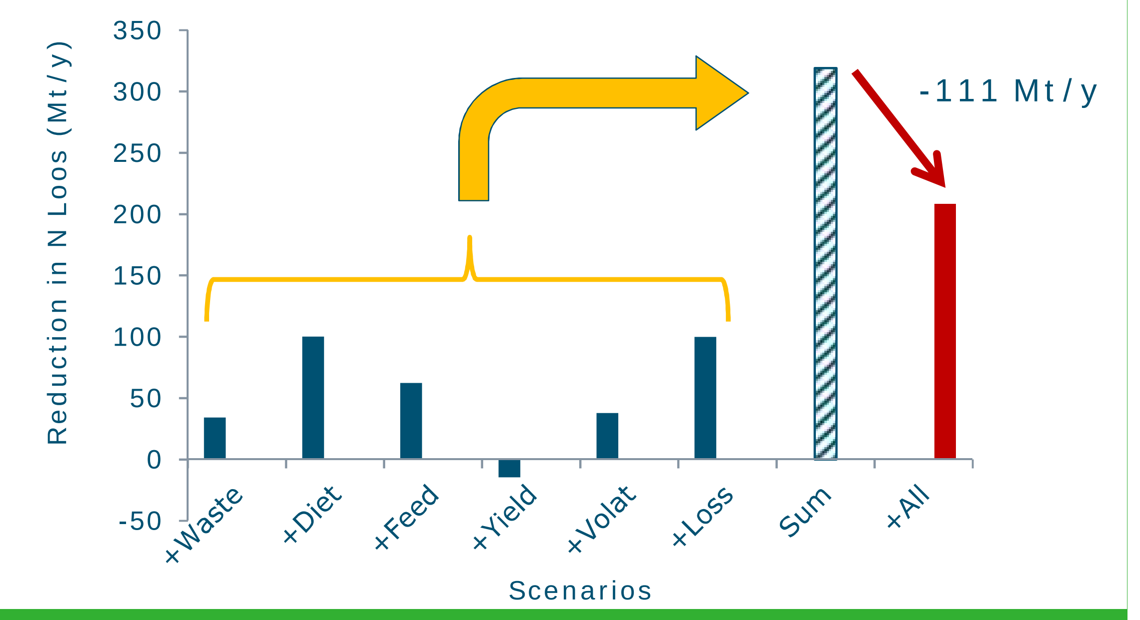
- Food N supply = available for popul. (intake + waste)
  - ➔ 2010: 32 Mt/y
  - ➔ 2050: 42 – 53 Mt/y

N Loss ratio (N Loss / Food N) varies from 2 to 6 (-)

Results for 2050 (measures) 7/7

- The sum of the effects of single measures overestimates the actual potential of combining all measures.

  - Sum = 319 Mt/y
  - +All = 208 Mt/y



WAGENINGEN UNIVERSITY & RESEARCH

Conclusions

- Single measures are insufficient and we need a combination of measures to substantially reduce N loss and NLR.
- Only a comprehensive analysis can prevent overestimation when single measures are analysed and summed.
- Improving grassland / manure management has a large potential to reduce N loss.
- NLR is a useful indicator for guidance towards environmental targets, better than NUE (?)

WAGENINGEN UNIVERSITY & RESEARCH

Thank you for your attention

More info:

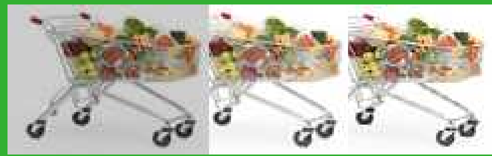
sjaak.conijn@wur.nl

Thanks to

VFRC and Dutch Min. of Economic Affairs

WAGENINGEN
UNIVERSITY & RESEARCH

Food N in 2050



Food N + N loss (All measures)

Food N + N loss (single measure)

Food N + N loss (no interventions)