How should different compartments of the nitrogen cycle be linked when formulating global nitrogen integrated assessment models

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Contents

Questions global scale integrated N assessment modelling.

- What is the aim?
- Which models are needed (in view of relevant nitrogen threats and benefits) at different scales?.
- Which model linkages (integration vs soft linkage) are needed?.
- Which model approaches (empirical versus process based) to use?.
- Which models are available?

Needed models in view of nitrogen threats and benefits at various scales

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

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

while

- being linked to socio-economic and natural factors
- including interactions of N cycling with other element cycles (macro- and micronutrients and water availability)

Biodiversity impacts

N outputs: harvested crops

Climate change impacts

N inputs:
N fertilizer
N fixation
N deposition

NH_3 N_2O NO_X N_2

Crop production:
- *Crop type*
- *Crop area*
- *Management*

feed

manure

NH_3 N_2O NO_X N_2

Animal production:
- *Animal species*
- *Animal number*
- *Management*

N outputs: milk, meat, eggs

NH_4^+ NO_3^- DON N_{part}

NH_4^+ NO_3^- DON N_{part}

Ground water & surface water

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P surpluses and P shortage

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Source : Mc Donald et al. (2011)

Needed models in view of nitrogen benefits

Integrated N management models should enable an:

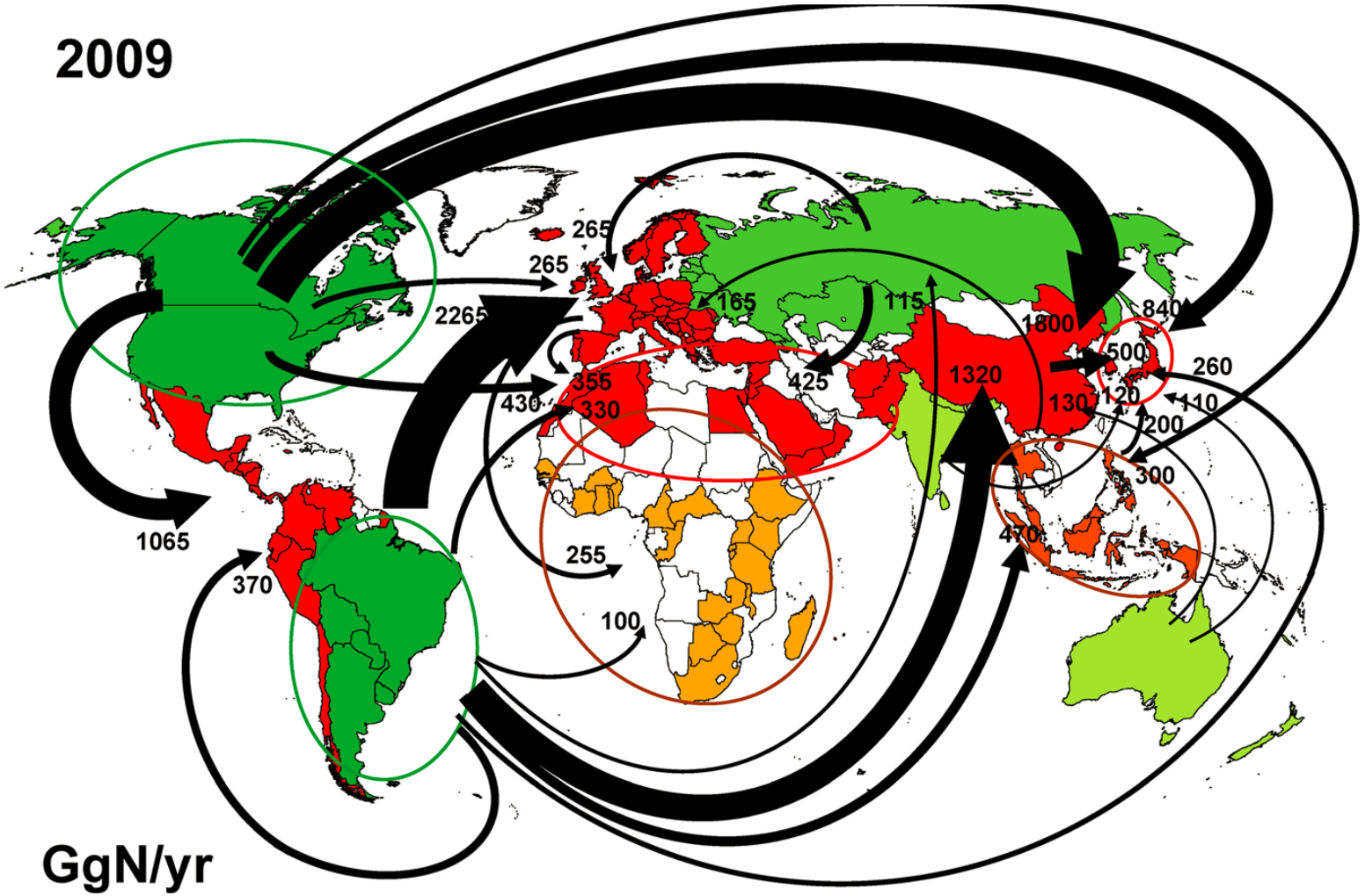
- Assessment of food and feed demand in response to population growth, dietary patterns and bioenergy use
- Assessment of goods and energy demand from required industrial N uses
- Comparison of demand with the current food and feed production
- Evaluation of possibilities to alleviate difference in food and feed supply and demand by changing nitrogen management, including interactions with water and other nutrients

Needed models in view of nitrogen benefits

In relation to food and feed production, an integrated N assessment model needs to :

- make the link to livestock nitrogen flows,
- include the link to bioenergy production
- distinguish relevant subscales (watersheds/landscapes, country/regions)
- connect top-down and bottom-up approaches.
- evaluate the effect of *global trade*, and the intensification or extensification the international exchanges

Needed models in view of nitrogen benefits



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Source : Lassaletta et al. (2014)

Needed models in view of nitrogen benefits

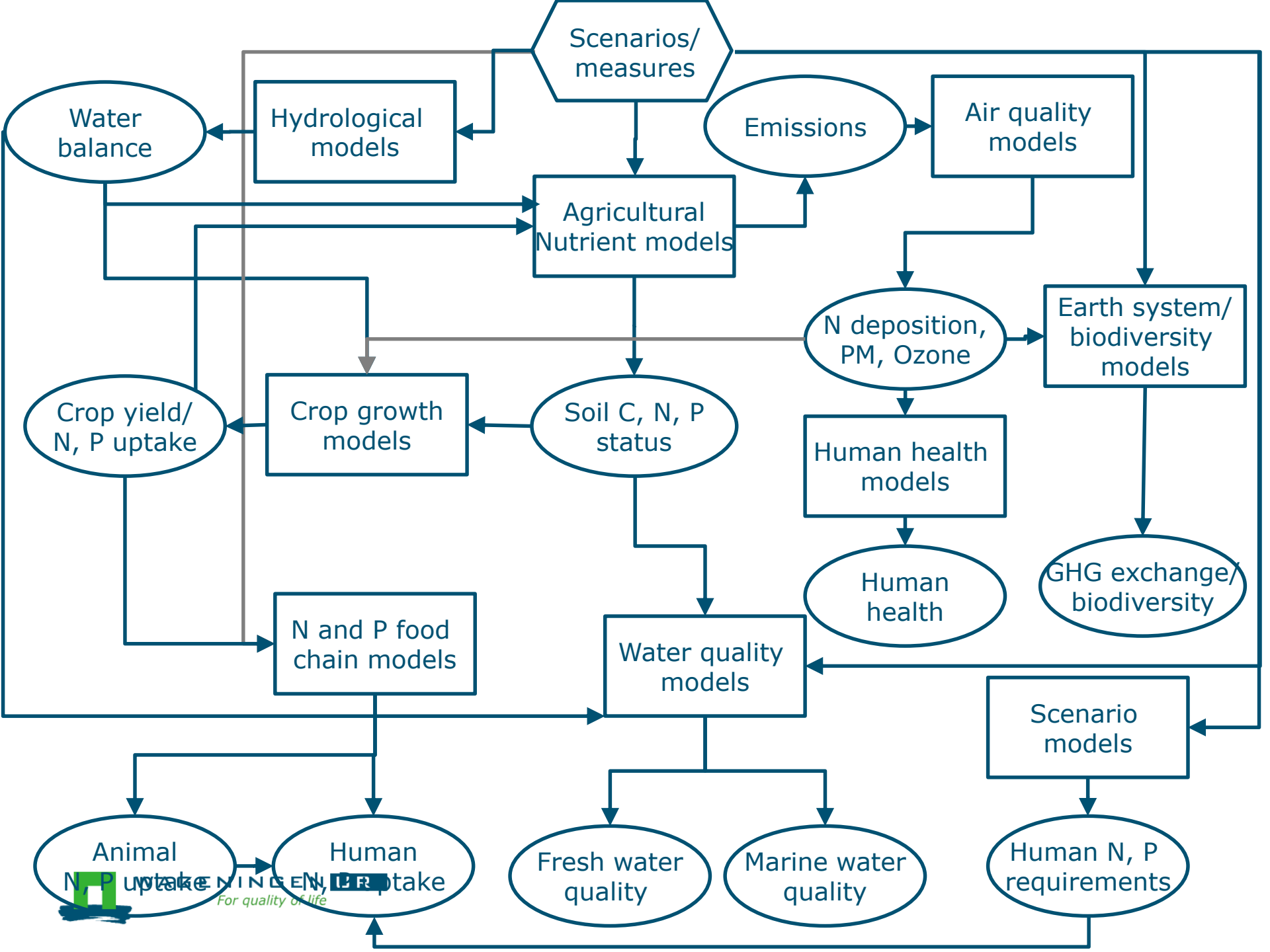
An integrated nitrogen assessment model needs to include:

- *Hydrological models:* water availability and water balances.
- *Agricultural soil quality models:* soil quality/soil fertility (C, N and P status, acidity status, micronutrient) in response to management.
- *Crop and grass growth models:* crop and grass production (food, feed and bioenergy) in response to soil quality and water availability.
- *Livestock models:* livestock production in relation to different management strategies
-

Needed models in view of nitrogen threats

An integrated nitrogen assessment model needs to include:

- *Emission models:* N emissions (NH_3, NO_x and N_2O).
- *Air quality models:* air quality (NH_3, NO_x, O_3, $PM_{2.5}$/PM_{10} and N deposition)
- *Human health models*: detailed impact modeling vs comparing exposure with critical levels and critical loads
- *Earth System models:* carbon uptake and N_2O emissions, in interaction with climate and air quality.
- *Water quality models:* N and P concentrations in surface waters, coastal and marine systems


Scenarios/ measures
Water balance
Hydrological models
Emissions
Air quality models
Agricultural Nutrient models
N deposition, PM, Ozone
Earth system/ biodiversity models
Crop yield/ N, P uptake
Crop growth models
Soil C, N, P status
Human health models
Human health
GHG exchange/ biodiversity
N and P food chain models
Water quality models
Scenario models
Animal N, P uptake
Human N, P uptake
Fresh water quality
Marine water quality
Human N, P requirements
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Needed model linkages to enable a consistent modeling approach

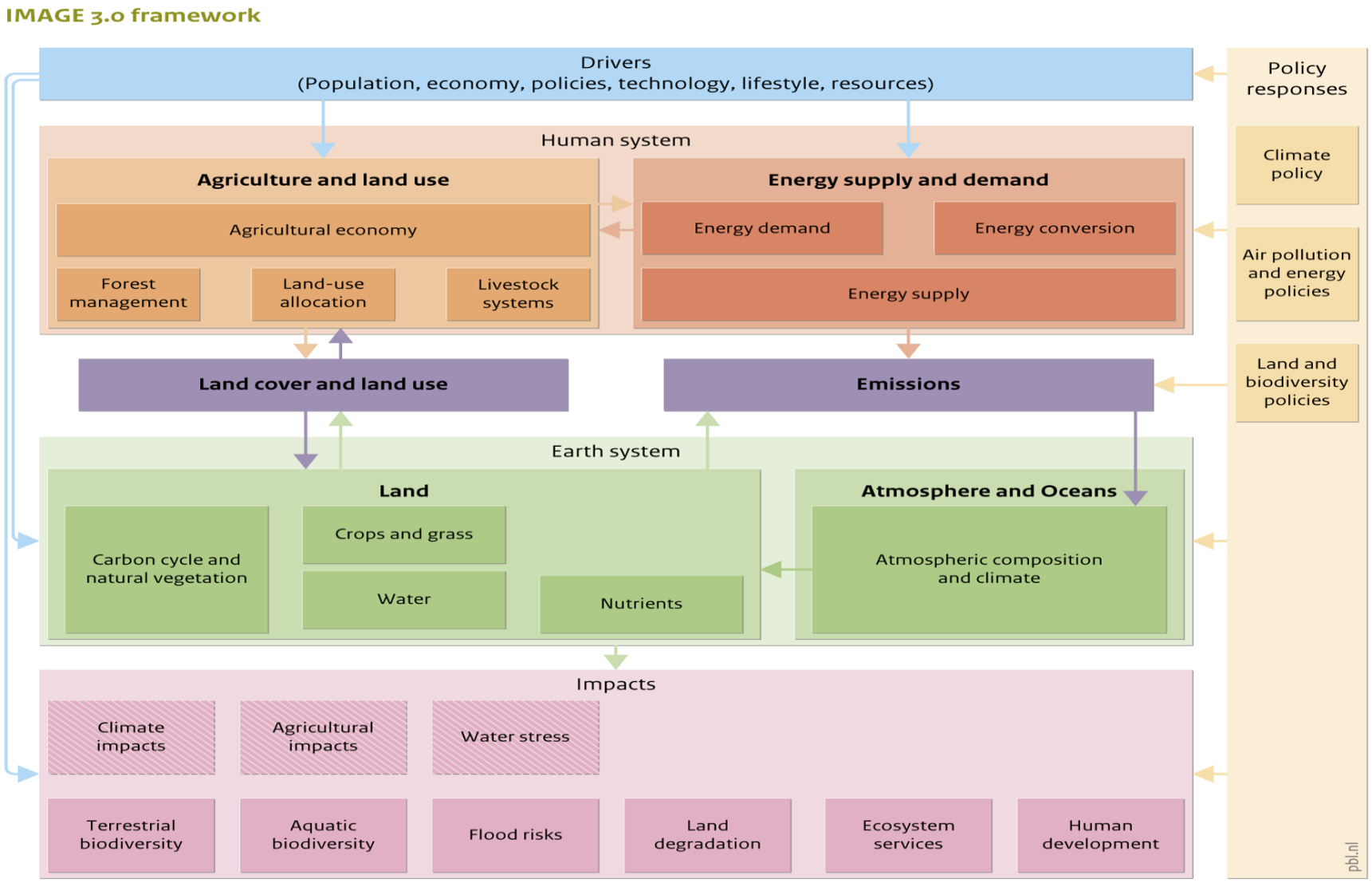
In assessing a consistent modeling approach, we need to evaluate whether we :

- need an integrated model approach
- Can soft link models (output of model 1 is input of model 2)

Example of

- integrated approach is IMAGE3.
- Model linkage is IMAGE-N to Global NEWS

IMAGE3.0



Source: PBL 2014

What are relevant model approaches?

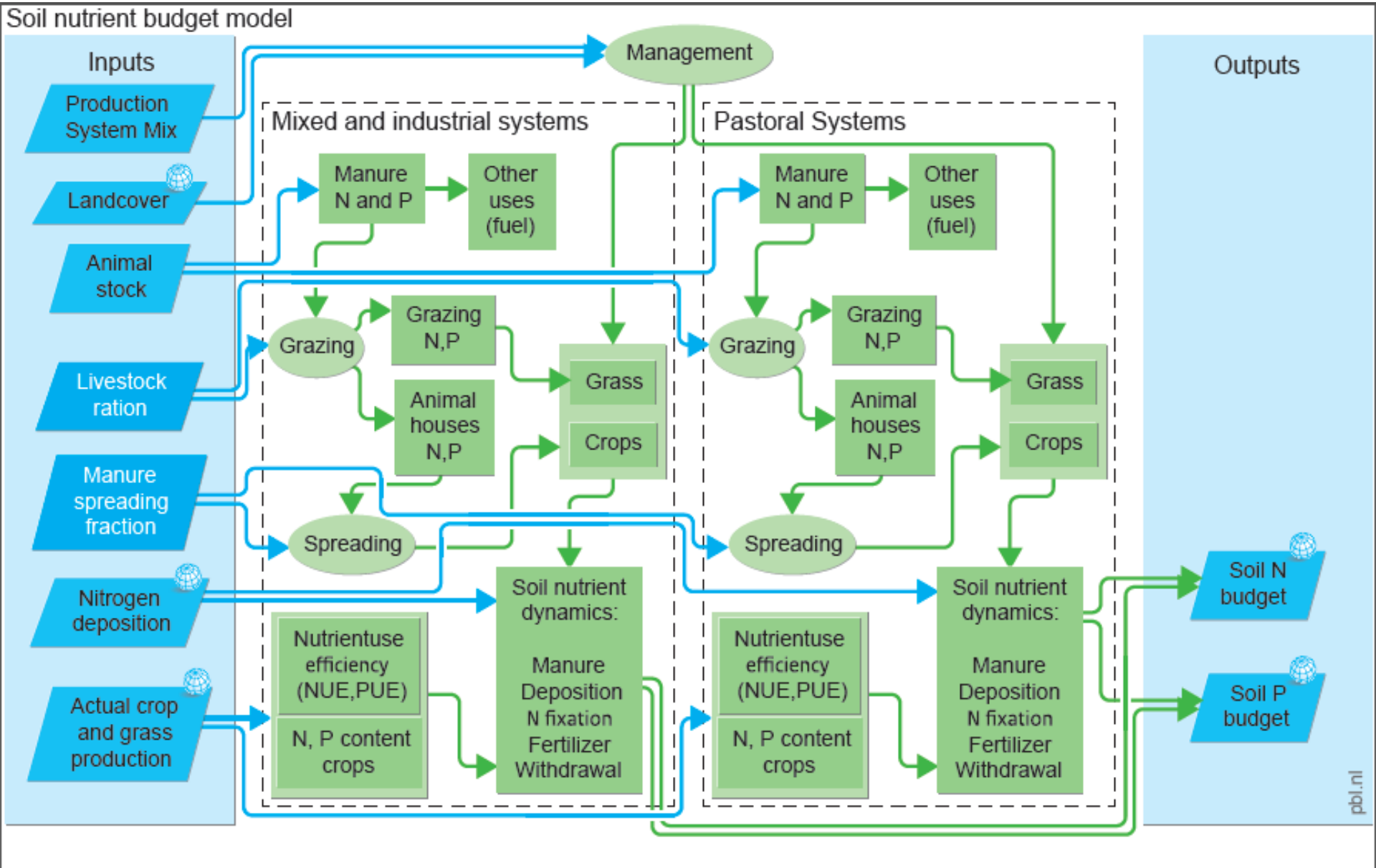
There is a need to balance between

- the needed model complexity and inherent needed data
- versus available data.

We may use

- relatively simple empirical approaches, based on experimental results and detailed model approaches.
- more complex models to include key interactions across the nitrogen cycle .

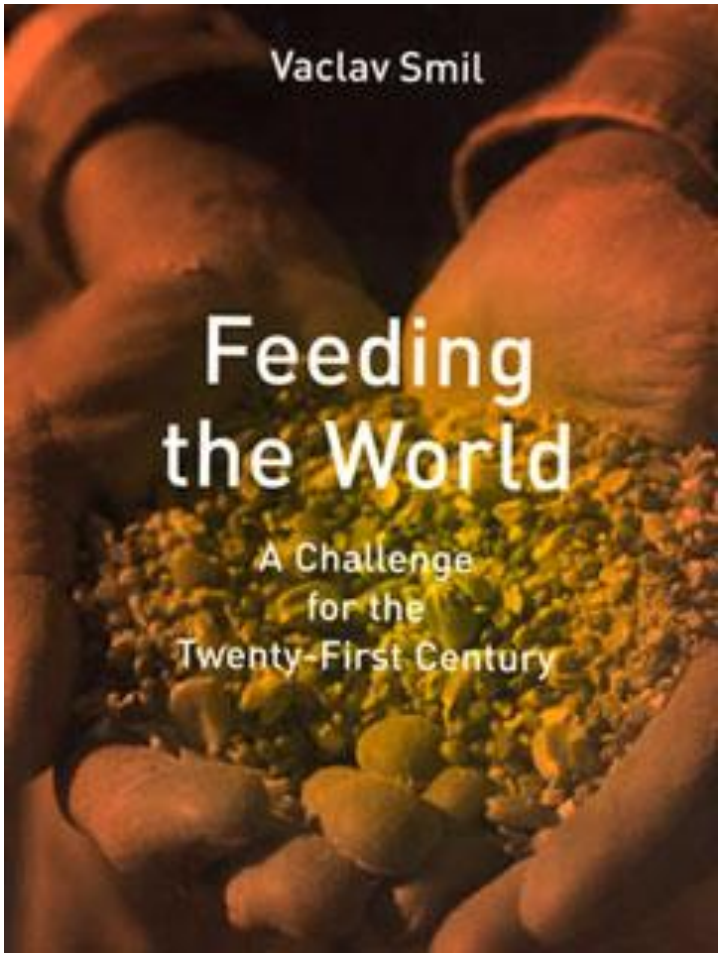
Soil nutrient budget model in IMAGE3.0



Relevant global scale models

- Scenario (Driver-pressure) models: GAINS, *IMAGE 3.0*, MAgPIE, MAGNET, CAPRI
- Emission models: EDGAR, *IMAGE-N*, MITERRA Global
- Hydrological models: *LPJml*, PCR-GLOBWB, WBM
- Air quality models: TM5, EMEPglobal
- Soil quality models: Forest/LandscapeDNDC, (VSD+).
- Water quality models: NEWS, *IMAGE spiralling, RIVE*
- Crop growth models: (LPJml, WOFOST, SIMPLACE)
- Earth system models: *LPJ guess,* CLM, OCN, Jules
- Biodiversity models: *GLOBIO, GLOBIO aquatic*.

Questions?



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