Circularity indicators and their relation with nutrient use efficiency in agriculture and food systems

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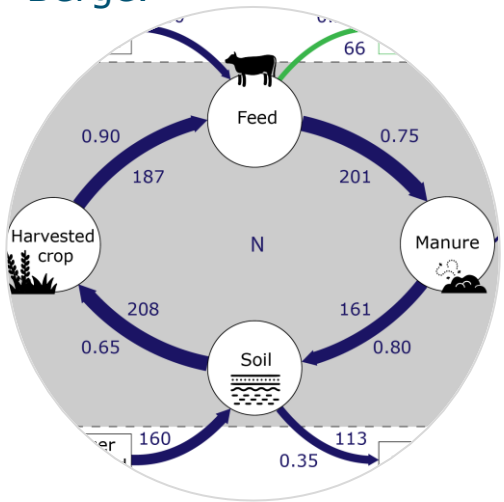

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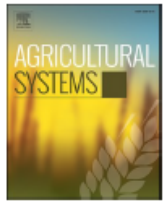

Circularity indicators and their relation with nutrient use efficiency in agriculture and food systems

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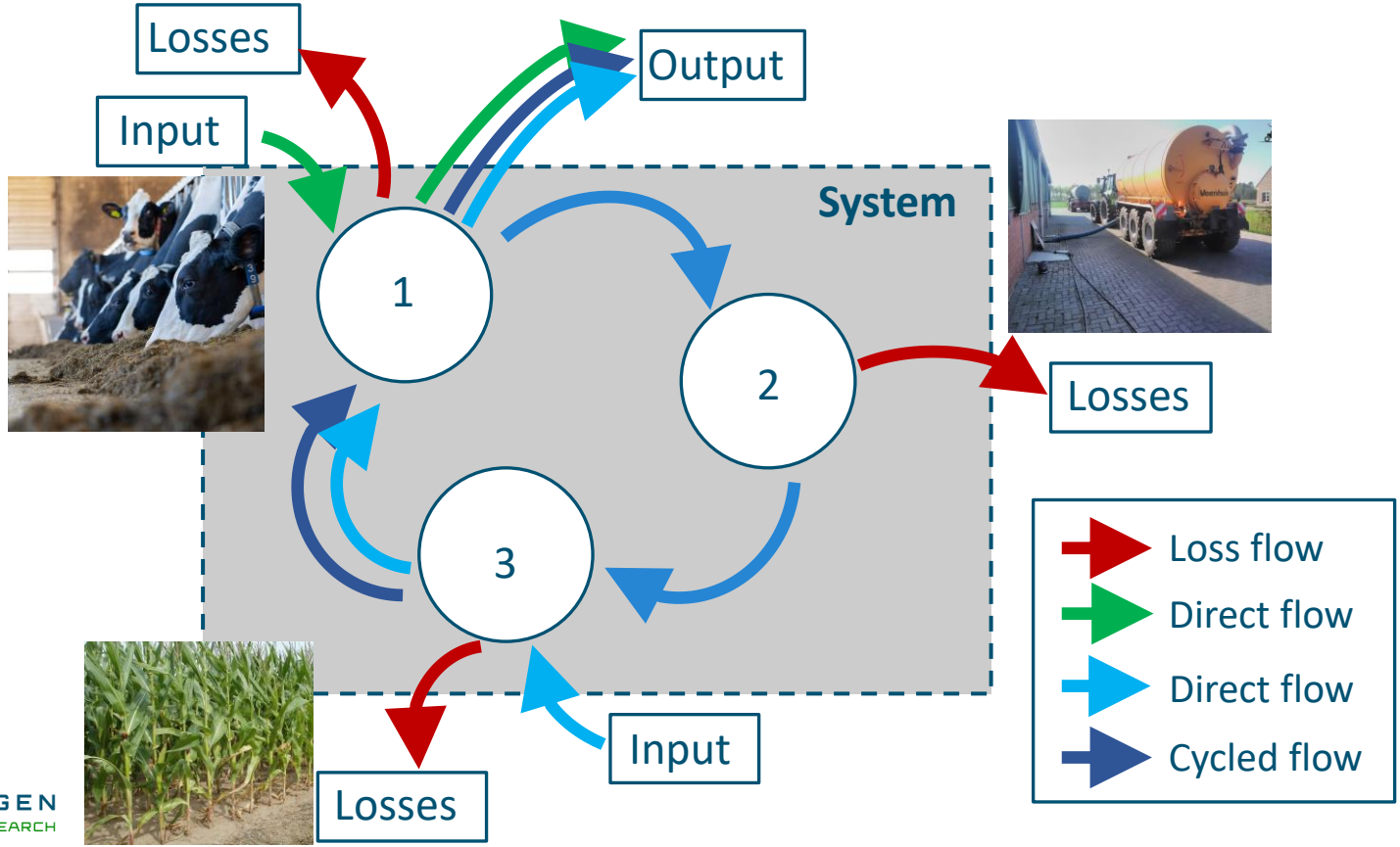
Introduction

- Efficient production is key for sustainable agri-food systems in a increasingly populated world
- Increased circularity proposed as primary solution in Europe
- Nutrient cycling receives large attention in recent years, but its relationship with nutrient use efficiency (O/I) is often ignored
- Robust circularity indicators are needed to monitor progress and benchmark management practices of agro-food systems

How often does it go round?

Example circular agricultural production system



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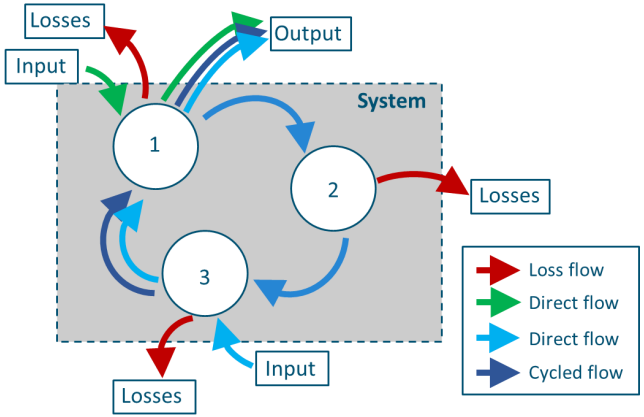
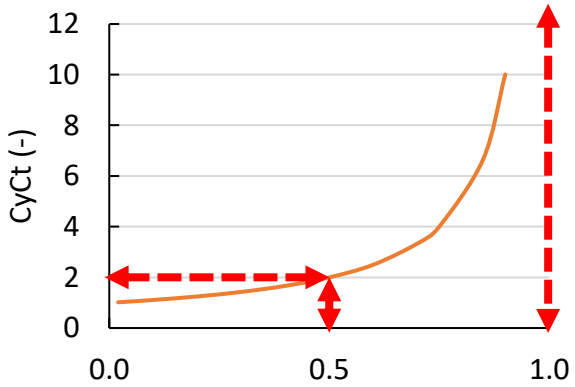
Cycle Count, *CyCt*

- Cycle count, *CyCt*, how many times will a single cohort of input, pass through a full cycle before being dissipated

$$CyCt \equiv \sum_{m=1}^{\infty}(1-A)^m = (1-A)/A$$

(A = Fraction nutrients removed from the system per cycle)



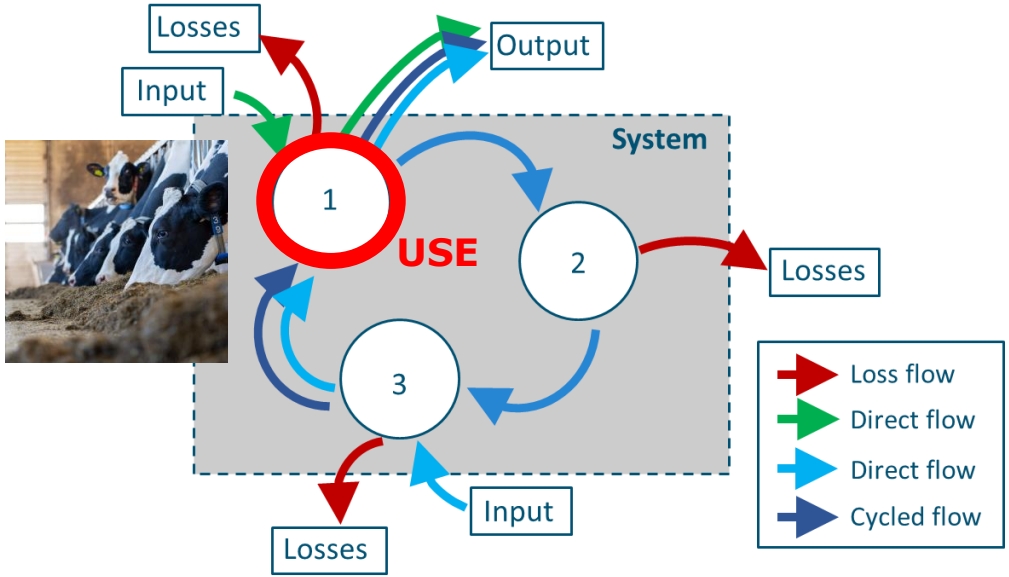


Cycle Count, *CyCt*

- At first: What is the relevance of CyCt?
- Circularity indicators used in ecology -> Stability of ecosystems
- *A* does not distinguish between system's product output *O* from nutrient losses, therefore:
- No direct relation with agricultural output, which is the main purpose of an agricultural system (i.e. field, farm, region)

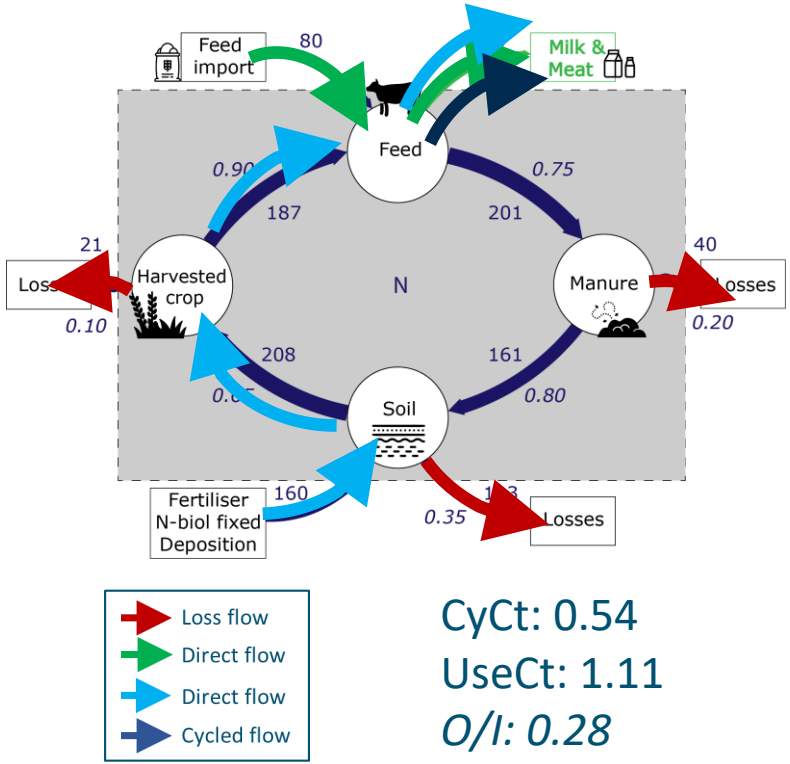
Use Count, *UseCt*

- How many times a unit of fresh nutrient input passes, on average, through the 'use compartment'

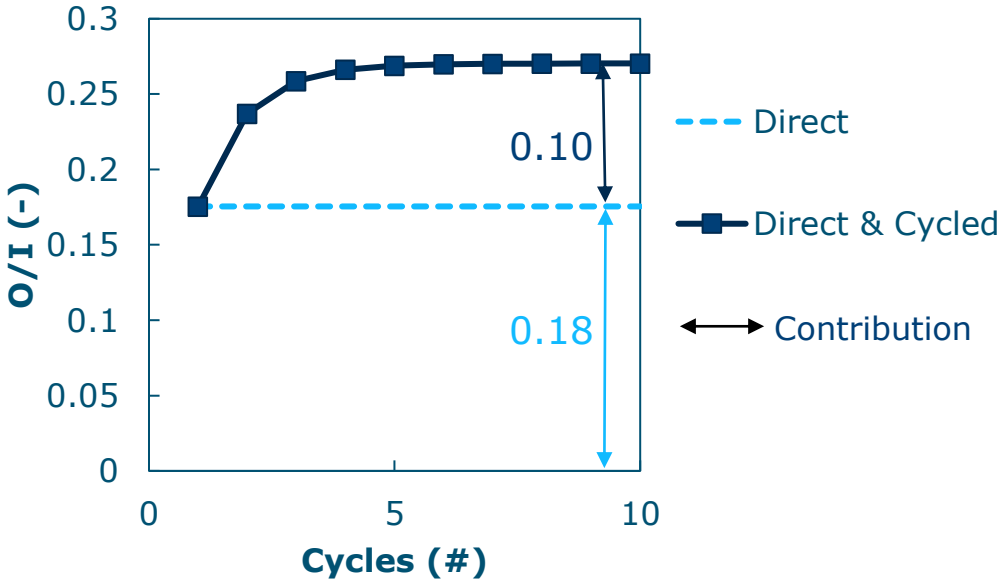


- What does this add to the already widely implemented O/I ratio?

Contribution of direct and cycled flow to *O/I*



CyCt: 0.54
UseCt: 1.11
O/I: 0.28



The ratio between *O/I* contributions from direct and cycled flows is 1:*CyCt*

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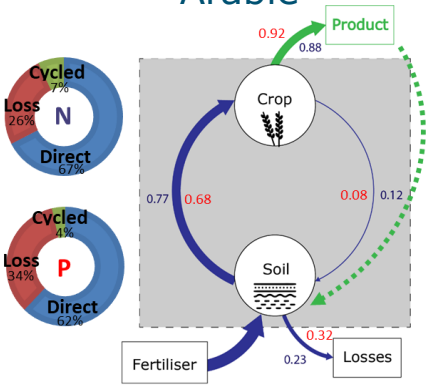
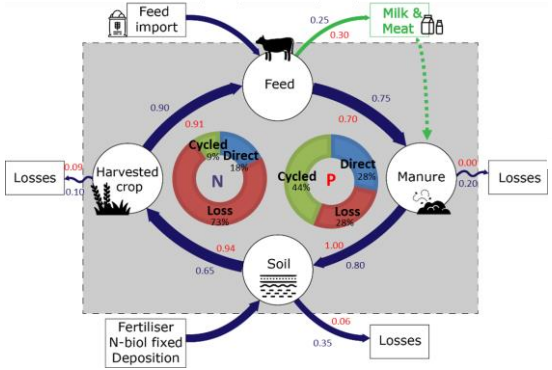
Test studies

Arable



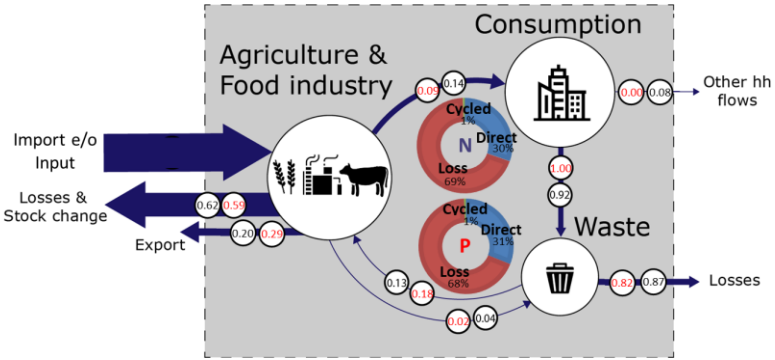
Broadbalk, UK: winter wheat. Data source: Rothamsted Research, 2022

Dairy



De Marke experimental dairy farm Hengelo, the Netherlands. Data source: Oenema (2013) and Aarts (2000)

Agro-food

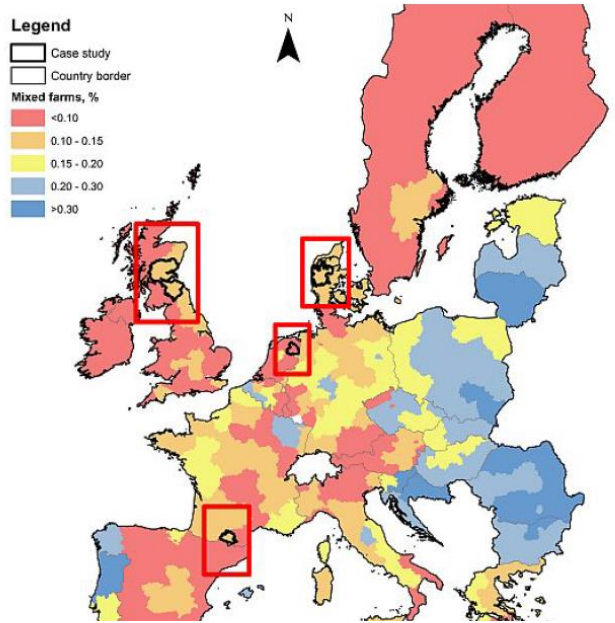


Flanders, Belgium. Data source: Papangelou & Mathijs, 2021

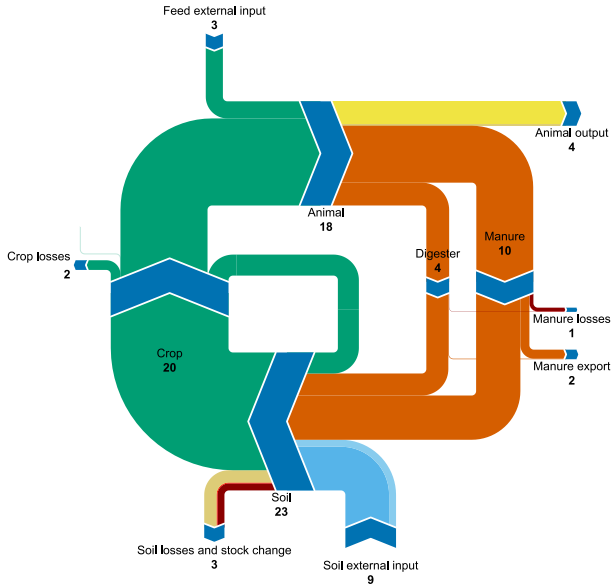
Conclusions and questions remaining

- *CyCt* can be used to predict how *O*/*I* will respond to changes in system properties. More cycling vs more direct efficiency.
- *UseCt* can replace *O*/*I* as measure of nutrient use efficiency in food systems with human consumer as top trophic level (there is no *O* here).
- Cycling in current agricultural systems is limited
    - Can it be improved? What is the current variation that exists?

Implementation of indicators in the Mi Bicycle project



Modelled N flows of a typical Dairy farm in Drenthe (NL)



Cycle count: 0.52;
O/I ratio: 0.34.

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BENCHMARKING NUTRIENT CIRCULARITY AT DIFFERENT SCALES: USING A FOOD SYSTEMS PERSPECTIVE

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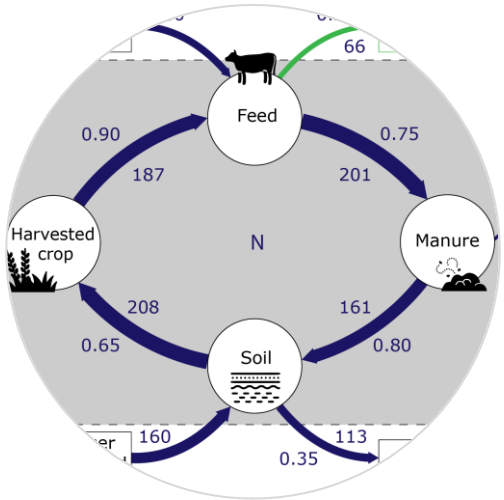

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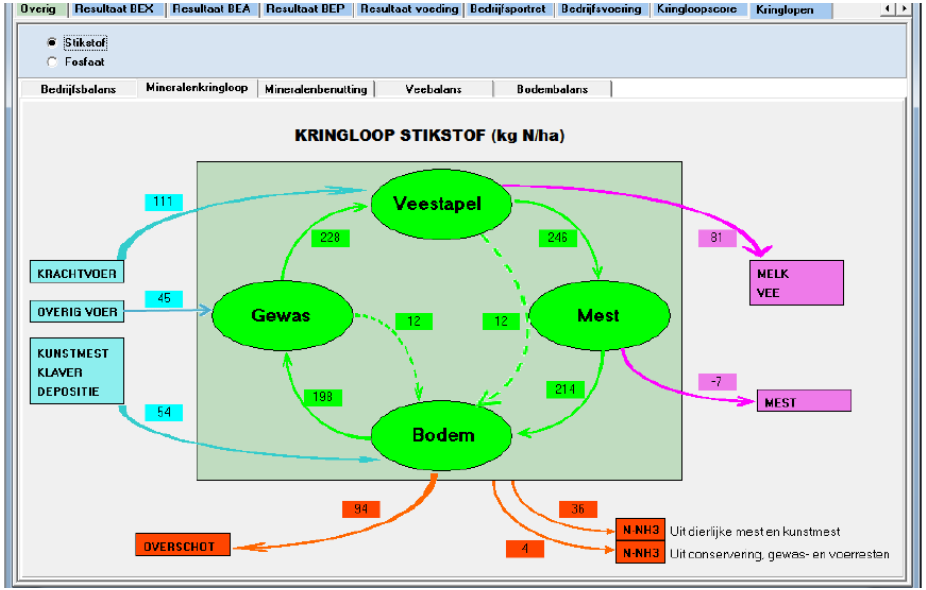
University of Antwerp

Project objectives

- What are the implications of different management practices, technologies and farm configuration interventions on nutrient (N, P) cycling at both farm and agri-food level?
- How can improvements in system circularity be realized without compromising on food production at both farm and agri-food level?
- Which management practices, technologies and farm configurations related to circularity are most promising for progress towards the objectives of the Farm-to-Fork strategy to reduce inputs and nutrient and GHG emissions while maintaining production?

Dairy farms, the Netherlands

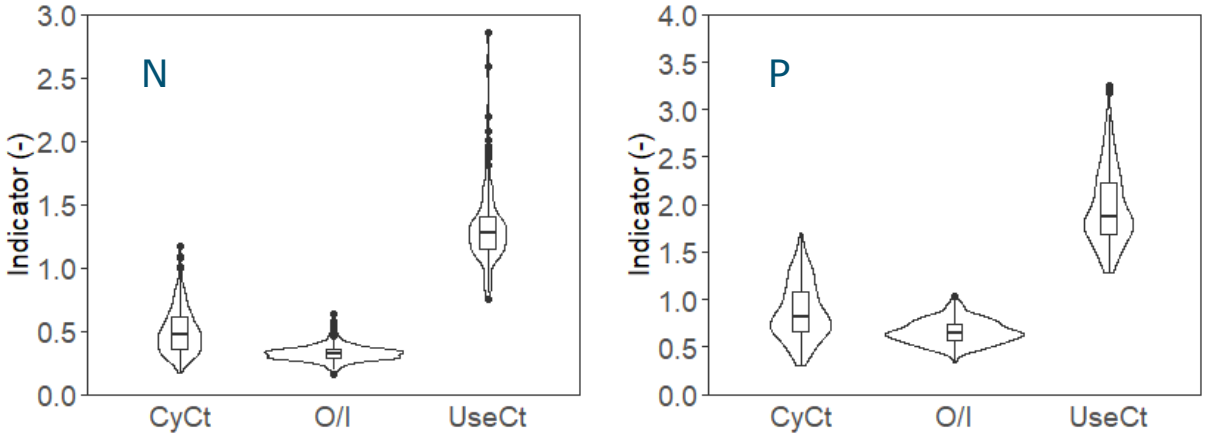
- Data on nutrient flows obtained from Kringloopwijzer of the Cows and Opportunity farms (Koeien en Kansen)



Example output of Kringloopwijzer

Nutrient cycling Dutch dairy farms

- 27 farms across the Netherlands
- Years 2006 – 2022, some farms have 2 years of data up to 17 years
- In total 284 unique year and farm combinations



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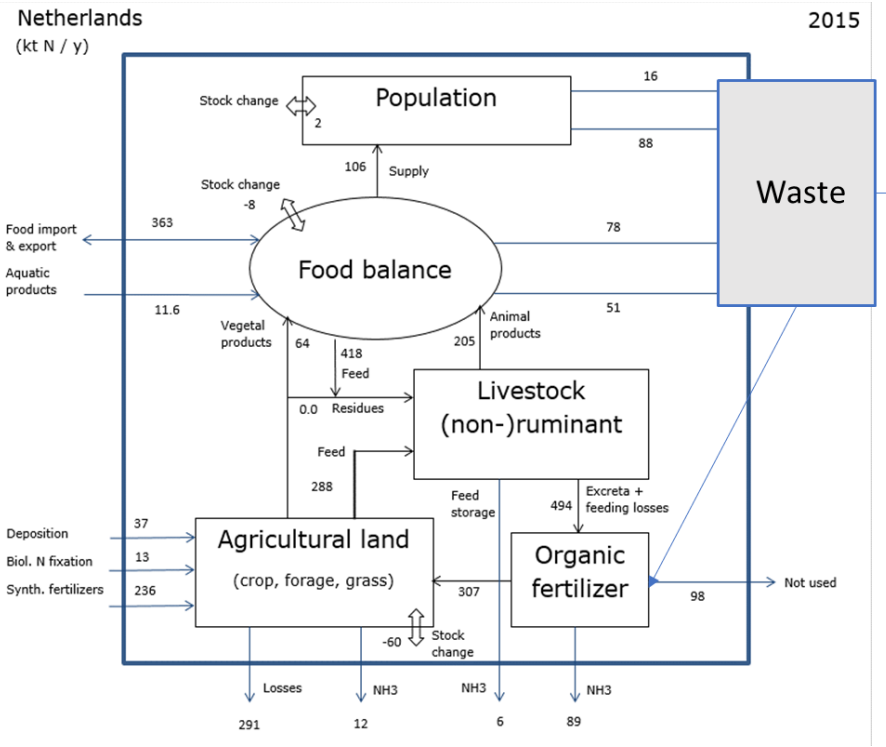
Agri-food level the Netherlands & Flanders

- Alligning the 2 systems:
  In terms of e.g. system boundaries, compartments, scenario's, coefficients



Conijn, BioSpacs

Next steps

- Assess nutrient cycling, food production and greenhouse gas emissions on farm and agri-food level and the implications of different management practices, technologies and farm configuration interventions
    - Quantify impact of manure processing and feed import on nutrient circularity and GHG emissions at food systems level

Questions?

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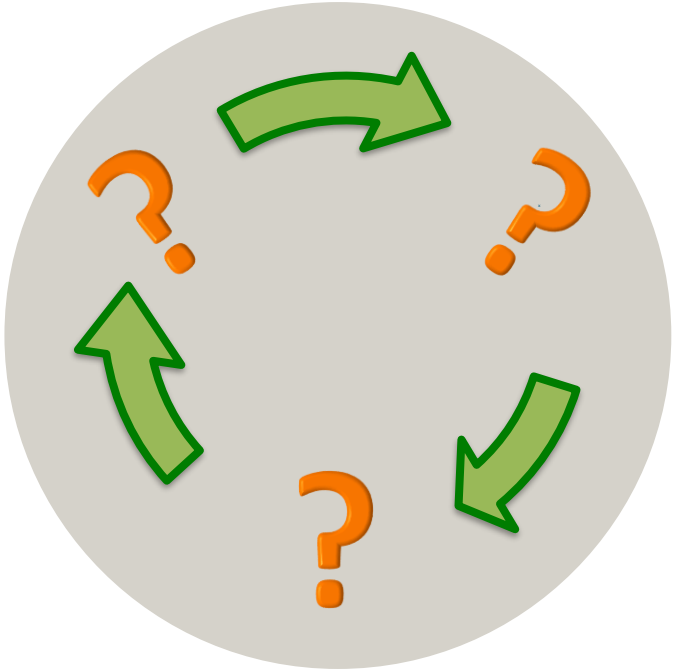

Discussion

- Do you use indicators for circularity in your project? What aim do you have?
- What should be the characteristics of a good indicator for circularity?
- Is a higher degree of circularity always beneficial? And if not, when?
- What extra information do we need from circularity indicators, besides already existing indicators for losses and productivity?
- What are other import aspects of circularity not covered by looking at nutrient cycling?