Circularity and smallholder systems

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Sustainability Day 10 October 2018
Circularity in smallholder farming systems?

- A system view: comparing past, present and future?
- Importance of nutrients for productivity of systems
“Centripetal” nutrient concentration
(numbers in kg N/ha/y)

7 ha farm, **1.0 pers./ha**, NL~1800

- People: 5.7 (faeces, urine), 1.3 (meet, milk)
- Livestock: 47.3 (feed, hay + grass sods), 40.7 (manure)
- Crop / grass land: 13.9 (Heith cuts), 23.9 (N deposition)
- Org fert.: 6.1

1.751 Mha, **9.7 pers./ha**, NL 2010

- People: 6.9 (meet, milk), (faeces, urine) 59
- Livestock: 151 (net feed + food), 60 (food)
- Crop / grass land: 29 (N deposition), 129
- Org fert.: 38

Source data: S. Conijn, pers. comm.
Conijn et al., 2018. Agric. Ecosyst. Environm. 251, 244-256
F. Aarts. "Boeren in Peel en Kempen omstreeks 1800"
Optimised and combined organic systems in NL
(numbers in kg N/ha/y)

<table>
<thead>
<tr>
<th>People</th>
<th>4.4 ha crop + 3 ha grass-clover, 3.4 pers./ha</th>
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<tbody>
<tr>
<td></td>
<td>(faeces, urine) 34</td>
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<tr>
<td>Crop / grass land</td>
<td>4.4 (meet, milk) 18</td>
</tr>
<tr>
<td>Org fert.</td>
<td>16 (food) 53</td>
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<tr>
<td>Livestock</td>
<td>50 (manure) 50 (N deposition) 53 (feed, hay)</td>
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<td></td>
<td>42 (N2-fixation) 44.5</td>
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<tr>
<td></td>
<td>30 (N deposition) 30</td>
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<td></td>
<td>48 (Den.+NO$_3^-$) 48</td>
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<tr>
<td></td>
<td>8 (NH$_3$) 8</td>
</tr>
</tbody>
</table>

| Source data: Current menu: 6.14 kg N/pp/y, 7.08 kg N/pp/y milk/meat |
| Van der Burgt et al. 2016 Planty organic 5 year evaluation. LBI report. |
| Schröder et al 2006. De stikstofstromen bij Oosterhof nader bekeken. WUR report |
## Systems compared

<table>
<thead>
<tr>
<th></th>
<th>Historical</th>
<th>NL Current(^2)</th>
<th>NL Organic(^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(^1)N-input</td>
<td>14</td>
<td>296</td>
<td>0-18.5</td>
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<tr>
<td>N-yield</td>
<td>52</td>
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<tr>
<td>Losses</td>
<td>33.6</td>
<td>261</td>
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<tr>
<td>Persons / ha</td>
<td>1.0</td>
<td>9.7</td>
<td>2.5-3.4</td>
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<td>27-33</td>
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\(^1\)Input excludes \(\text{N}_2\)-fixation and deposition

\(^2\)Current menu: 6.14 + 7.08 kg N/pp/y plant- and animal products
Smallholder systems in Kenia and Ethiopia

2.4 ha farm, 0.48 pers./ha

- People
  - 0.7 (Food)
  - 2.6 (Feed)
  - 36 (N2-fixation)
  - 4.3 (Fert)
  - 5 (N deposition)

- Crop / grass land
  - 24

- Livestock
  - 11.8 (manure)

- Org fert.
  - 8

- Waste
  - 8.1

1.15 ha farm, ~5.6 pers./ha

- People
  - 9.2 (Food)
  - 0.2 (Feed)
  - 4 (N2-fixation)

- Crop / grass land
  - 5

- Livestock
  - 20.5 (feed)

- Org fert.
  - 26

- Waste
  - 13.7


Systems compared

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<th>Historical</th>
<th>NL Current&lt;sup&gt;2&lt;/sup&gt;</th>
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<sup>1</sup>Input excludes N<sub>2</sub>-fixation and deposition

<sup>2</sup>Current menu: 6.14 + 7.08 kg N/pp/y plant- and animal products
Trade offs: need for long-term vision with targets

- Optimal current food system
  - Minimising losses per ha or per person?
  - How much “meat” do we need?
  - Less fertiliser or less import of feed?
  - Spatial farm re-allocation: minimising GHG, losses + max biodiversity?
  - Re-wetting peatlands (CO₂ loss eq. to ~1 M cars)
    - “wetland” dairy or convert to biodiverse C-sink?

- Smallholders: compensating farm nutrient exports
  - Restoring soil fertility by better fertilising crops
Increasing protein yield...but at a cost

Remainder is accumulated in the soil or lost
- Eutrophication of water bodies ($\text{NO}_3^-$)
- Greenhouse gases (incl. $\text{N}_2\text{O}$)

Lassaletta et al., 2014. Env. Res. Letters
Study area of the Geodatics project

- W-Kenya:
  - 4.3 M people,
  - >80% farmers
  - Abundant rainfall
  - 2 crops/year
  - Kenya is net importer of maize
The need for balanced NPK fertilizer supply

Njoroge et al., 2018 (under review) EJA
The need for tailored fertilizer advice

Siaya (W. Kenya)
Nutrient omission trials
150 kg N
40 kg P
60 kg K

Including 23 farms.

NP: Mining of K, difference between fields increased over time.

NPK: stable yields. Best advice...but on some farms not needed.

Njoroge et al., 2017 FCR; 2018 (under review) EJA
The Geodatics approach

- Agronomic training
- Profiling interview (mobile phone)
- NPK kg/ha + bags/field
- Delivery of inputs (on credit)
Crop growth model

NASA-Power TRMM SOILGRIDS

MODIS-NDVI

Farmer
Home fields
Middle fields
Outfields

Soil fertility gradient

Exch. K
P-Olsen
SOC
pH
PAW
Study area in W-Kenia
Measuring impact of the new service

- Stratified selection of M&E farmers
  - Villages in 5 regions, representative soil types
  - 3 Geodatics and 3 control farmers per village ("similar" farmers)

- Measurements
  - Extensive interviews
  - Soil samples + inputs applied
  - crop cuts
Comparisons between Control and Geodatics

Kenya, long rains 2017

Grain yield, t/ha

Kenya long rains 2018 (prelim. results)
The 2017 season: Fall army worms

Control farmers without insecticide use had 1.2 t/ha less grain.

Fall army worm had **a major impact** in 2017.
Conclusions / discussion points

- Clear trade-offs identified in circular systems
  - Re-using waste streams a “no-regret”
  - How organic can we go?
  - Artificial fertilizer, feed or food import?
- GHG emissions needs to be included in food system optimisation
- External inputs are required for sustainable production
  - Focus on RUE in practice: good agronomy crucial
  - Variability on farms needs local knowledge input
A food systems approach with open boundaries?

Van Zanten et al. (2018b)
Global Food Security
Thank you!

Gerrie van de Ven
Sjaak Conijn

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