Needed improvements in nitrogen use efficiency to achieve environmental quality objectives: the EU case

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The problem:

‘Planetary boundaries’ related to human N fixation have been exceeded... ... but nitrogen is both a matter of ‘too much’ and ‘too little’.

→ Can we derive spatially explicit ‘nitrogen boundaries’?
Three core questions of our research:

1. At which nitrogen input do we exceed environmental thresholds? ("Critical N input")

2. How much nitrogen input is required for crop production? ("Required N input")

3. How can environmental and crop production targets be reconciled? ("Necessary improvements in nitrogen use efficiency")

1. At which nitrogen input do we exceed environmental thresholds? ("Critical N inputs")

- Critical N inputs:
- Critical loads
- Critical N deposition on terrestrial ecosystems
- Critical N deposition on agriculture
- Critical N runoff
- Critical N leaching
- Critical NO\textsubscript{3} emissions
- Critical Soil N surplus
- Critical N fertilizers, manure, BNF

- Critical NO\textsubscript{3} concentration in groundwater: 50 mg NO\textsubscript{3} l\textsuperscript{-1}
- Critical N concentration in surface water: 2.5 mg N l\textsuperscript{-1}
Necessary **decrease** in N inputs to protect **surface water**

### Actual N inputs

- **145 kg N ha\(^{-1}\)** as **kg N ha\(^{-1}\) yr\(^{-1}\)**

### Critical N inputs (surface water)

- **83 kg N ha\(^{-1}\)** as **kg N ha\(^{-1}\) yr\(^{-1}\)**

### Actual - Critical N inputs

- **-62 kg N ha\(^{-1}\)** (-43%)

**Source:** De Vries et al. 2019 (in prep)

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2. **How much nitrogen input is required for crop production? (“**Required N inputs**”)**

1. **Current yield**
2. **Target yield:** 80% of yield potential

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## Required increase in N inputs to obtain target yield

<table>
<thead>
<tr>
<th>Actual N inputs</th>
<th>Required N inputs</th>
<th>Required - Actual N inputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>kg N ha(^{-1}) yr(^{-1})</td>
<td>kg N ha(^{-1}) yr(^{-1})</td>
<td>kg N ha(^{-1}) yr(^{-1})</td>
</tr>
<tr>
<td>145</td>
<td>185 (+27%)</td>
<td>+40 (+27%)</td>
</tr>
</tbody>
</table>

Source: Schulte-Jebbing et al. 2019 (in prep)

### 3. How can environmental and crop production targets be reconciled? (**“Necessary improvements in nitrogen use efficiency”**)

- **Crop N uptake**
- **Critical N inputs (fertilizer, manure, BNF)**
- **N deposition on agriculture**
- **Critical N deposition on terrestrial ecosystems**
- **Critical NH\(_3\) emissions**
- **Critical Soil N surplus**
- **Critical N runoff**
- **Critical N leaching**
- **Critical NO\(_3\) concentration in groundwater**
- **Critical NO\(_3\) concentration in surface water**
- **2.5 mg N l\(^{-1}\)**
- **50 mg NO\(_3\) l\(^{-1}\)**

Critical loads
Necessary increase in NUE to protect surface water

Necessary NUE surface water

Can current yields be reconciled with critical runoff by increasing NUE?

No, required NUE is > 90%

Yes, if NUE is increased to...

- ...70–80%
- ...max. 70%

Yes, even at current NUE

Source: Schulte-Uebbing et al. 2019 (in prep)

Summary & Outlook

1. Critical N inputs

2. Required N inputs

3. Necessary NUE

Summary: Actual, critical and required N inputs for EU27

Future work: from European scale to global scale...

Sum of critical N inputs for all grid cells can be considered a ‘planetary boundary’ for nitrogen

Source: Steffen et al. 2015
The Dutch “stikstofcrisis” (“nitrogen crisis”)

Last 40 days: nitrogen front page news 16 times!

A ‘social’ or ‘juridical’ boundary rather than a natural one?

Thank you

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