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Furthering 4R to Verify Sustainable Emissions Reduction

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Furthering 4R to Verify Sustainable Emissions Reduction

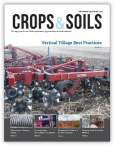
Reducing emissions from fertilizer use

1. Scope: global, USA, Canada, Africa
2. Reducing nitrogen surplus
3. Including 4R in emission reduction programs

CROPS & SOILS

4R NUTRIENT STEWARDSHIP | Full Access

What's the Scope of 4R Practices for Reducing Emissions from Fertilizer?



Volume 55, Issue 6
November–December 2022
Pages 30-36

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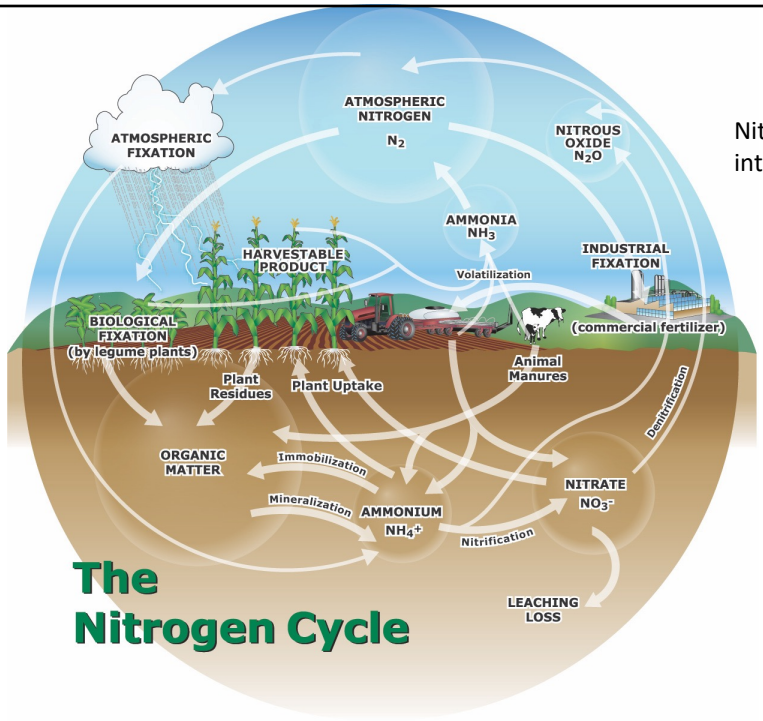

Nitrous oxide is emitted into a global pool

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Emissions from fertilizer use in context

Current (2019-2020) GHG emissions, Mt CO_2e

	World	USA	Canada
Total GHG emissions	59,000±6,600	6600	740
Total N_2O emissions	2,700±1,600	440	40
N_2O from agriculture	1,800±1,100	350	24
N_2O from fertilizer use	634	83	13
Fertilizer N use, Mt	111	11.6	2.8

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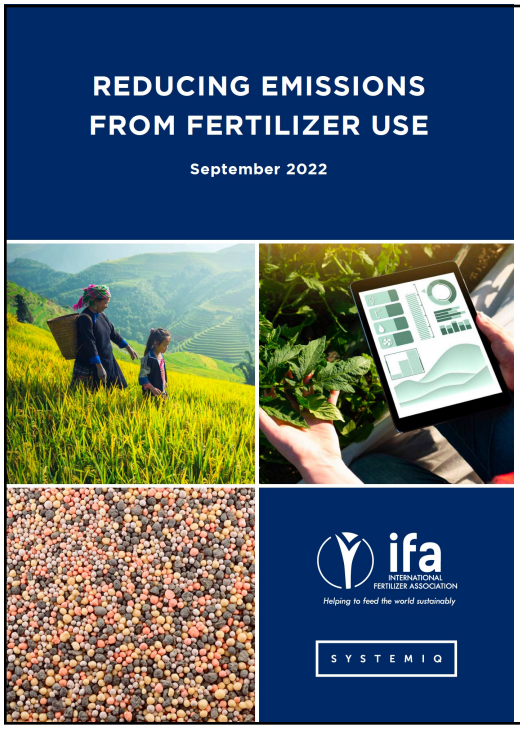

Global Scope – by 2050

- **Baseline** 2020 = 717 Mt CO_2e annually
- Increasing global **NUE** from 50% to 70% could reduce emissions by 320 Mt CO_2e
- **Inhibitors** could reduce emissions by a further 185 Mt CO_2e
- **Soil carbon storage** could remove 400 – 6500 Mt CO_2e

(SystemIQ-IFA, 2022)

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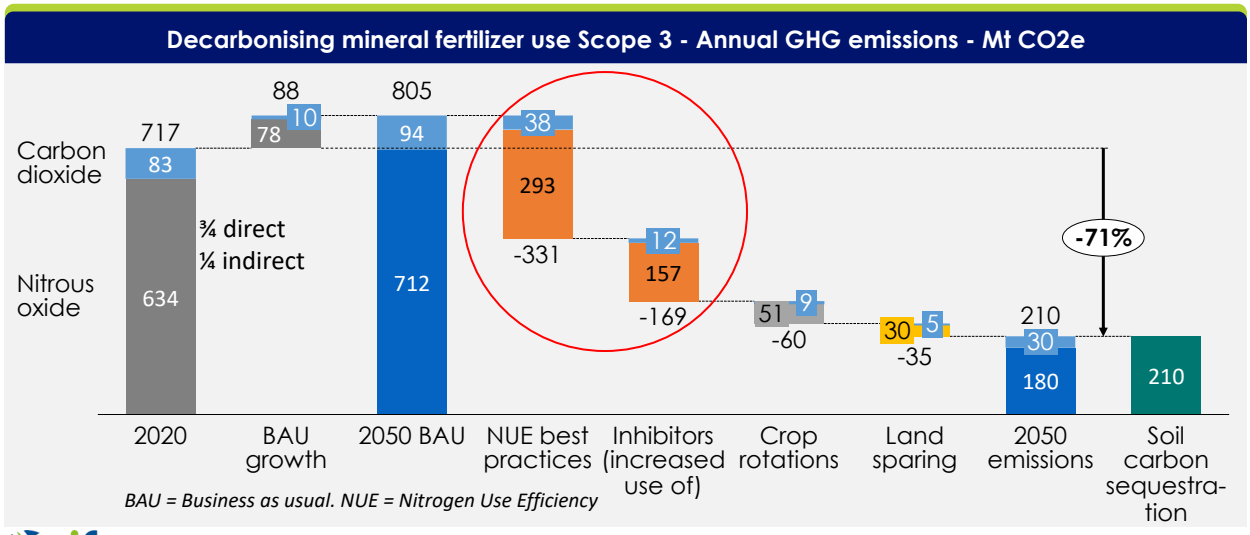
Scope 3 Emissions from the use of fertilizer can be more than halved by 2050 through increasing N use efficiency



ifa INTERNATIONAL FERTILIZER ASSOCIATION SYSTEMIQ

https://www.fertilizer.org/Reducing-Emissions

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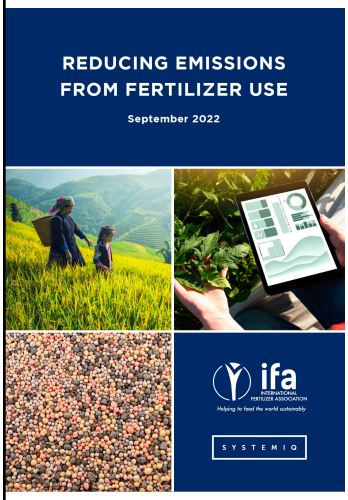
Scope in USA – case study



Annual emissions from use of N fertilizer **in corn**:

45 Mt CO_2e, mostly as N_2O

Possible reductions by 2050:

Eliminating N surplus: 6-12 Mt

Doubling use of inhibitors: 7-10 Mt

30-50%, not 71%

(SystemIQ-IFA, 2022)

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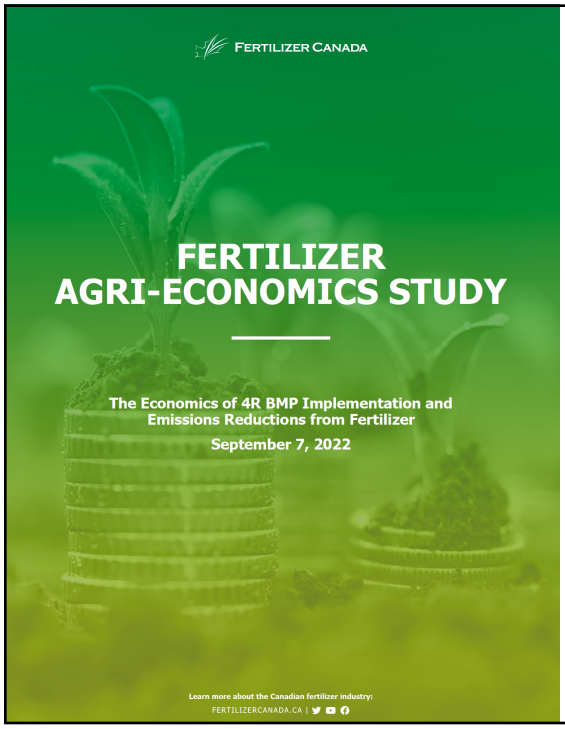

Scope in Canada

- Meeting the target of an ABSOLUTE 30% reduction would require either very large cost-share, or reduced production.
- Crop production and yields are on increasing trends
- 4R implementation can provide 14% reduction by 2030 while increasing crop yields

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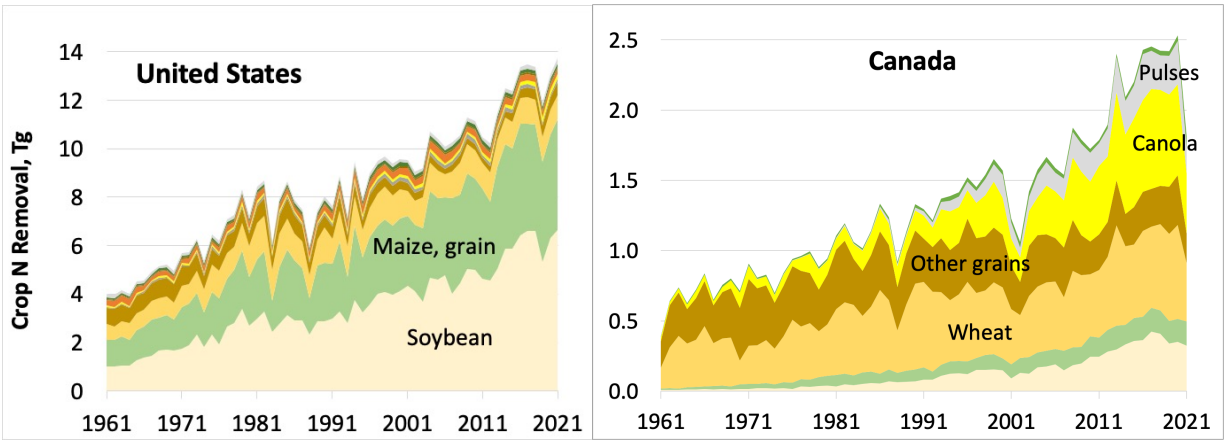
Increasing Trends in Crop Nitrogen Removal



Data sources: Xin Zhang et al., 2021; USDA-NASS & Statistics Canada with NuGIS coefficients.
Note: extrapolation for crops other than soybean and maize from 2015 in US.

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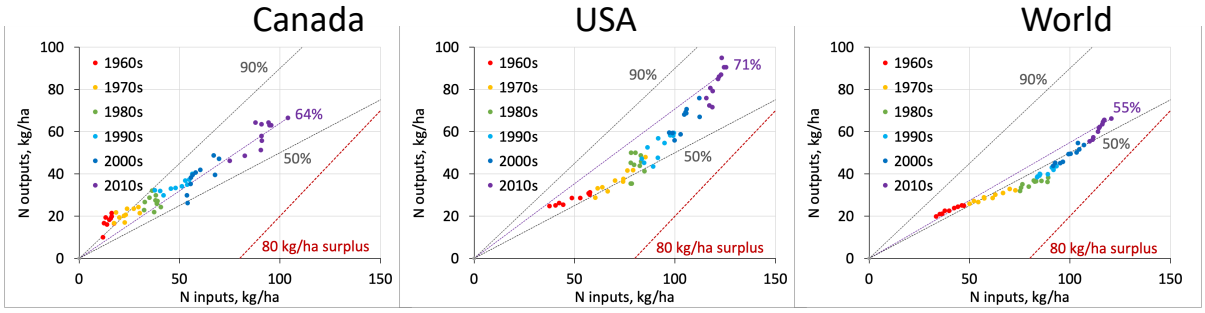
Nitrogen Use Efficiency: outputs/inputs



Nitrogen outputs (crop removal) plotted against inputs (fertilizer, manure, legume fixation, and atmospheric deposition) to cropland from 1961 through 2020. The slopes of lines from the origin represent N use efficiency lower and upper reference values, and for 2020.
Source: FAO, 2022. FAOSTAT and IFA Cropland Nutrient Budget database
http://www.fao.org/faostat/en/#data/ESB

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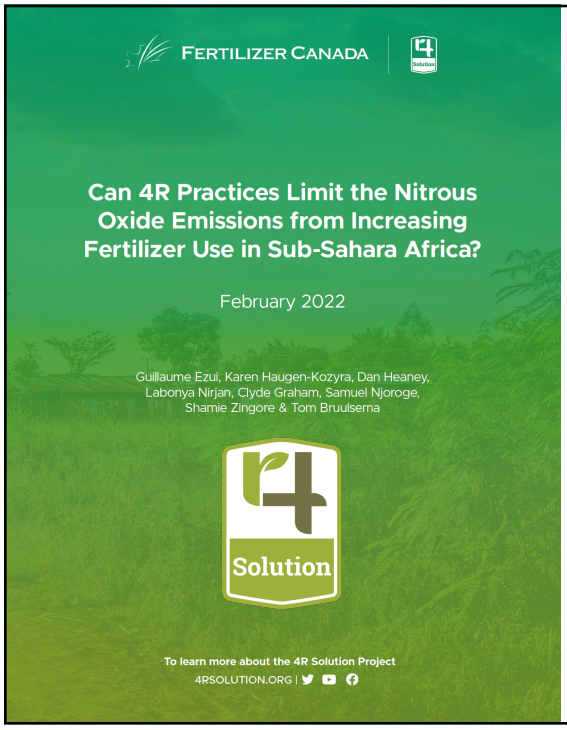
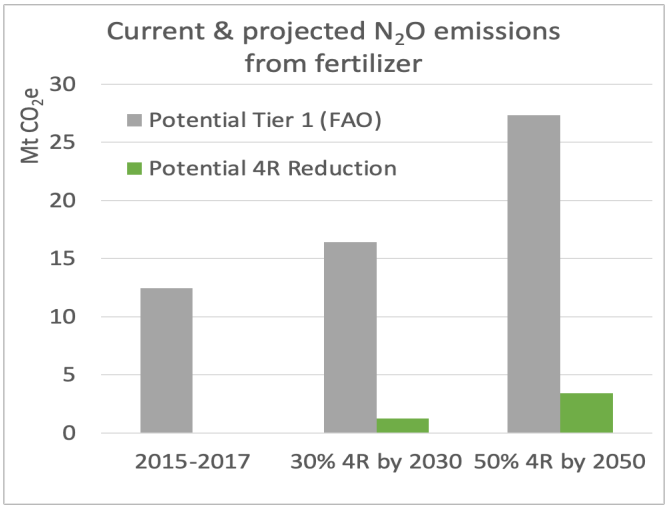


Scope in SS Africa



https://4rsolution.org/documents/

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Reducing N surplus – strengths & limitations

N surplus = N applied – N removed

STRENGTHS

- Measurable
- Relates to every loss pathway
- Applies no limit to yield gain
- Includes upstream emissions

LIMITATIONS

- Neglects inhibitor effects
- Neglects source effects
- Trade-offs with soil carbon
- Limited emission reduction

4R builds on the strengths, and addresses most of the limitations

Eagle, A. J., McLellan, E. L., et al. (2020). Quantifying On-Farm Nitrous Oxide Emission Reductions in Food Supply Chains. *Earth's Future*, *8*(10), e2020EF001504. https://doi.org/10.1029/2020EF001504

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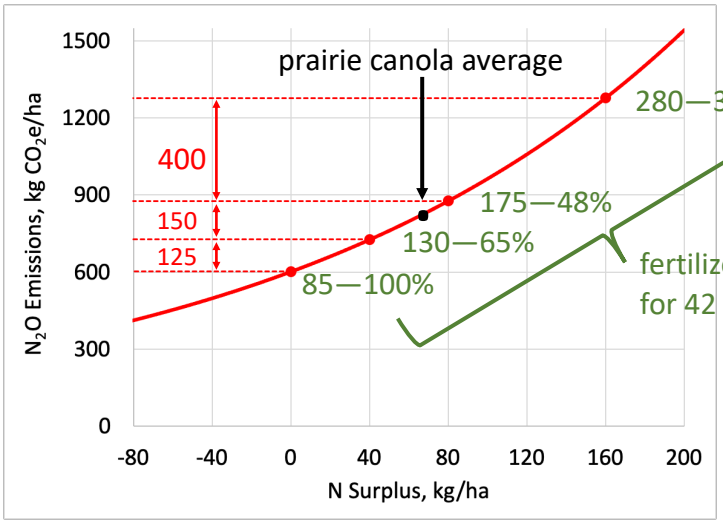
Reducing Nitrogen Surplus – Scope



Generalized relationship between nitrous oxide emissions and nitrogen surplus across 286 sites, mainly in the North American Corn Belt. Adapted from Eagle et al., 2020.

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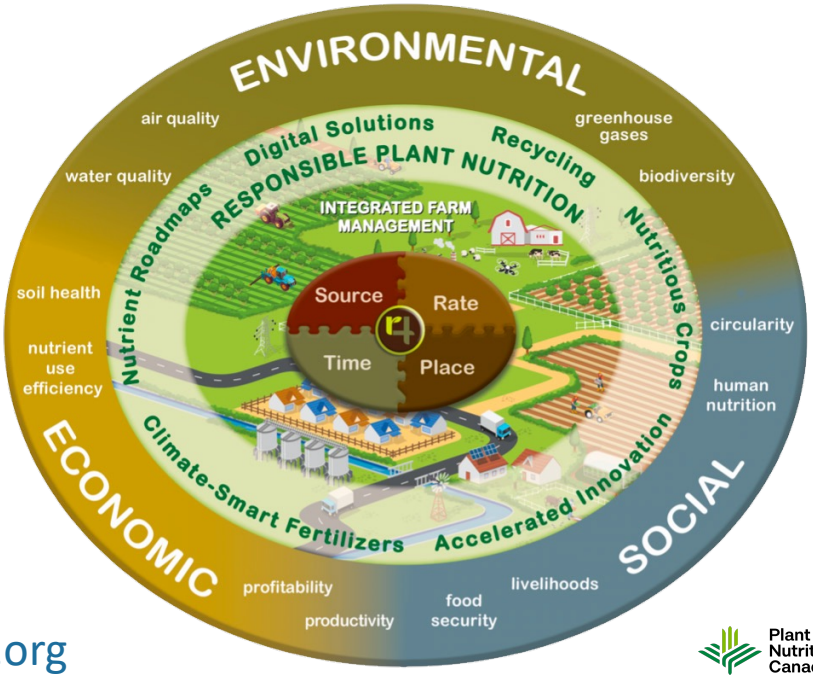
Furthering 4R

Relevant to each of the six actions of responsible plant nutrition.

Connected to performance outcomes, including NUE and N balance.

Site-specific.

Recognized.



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https://www.sprpn.org

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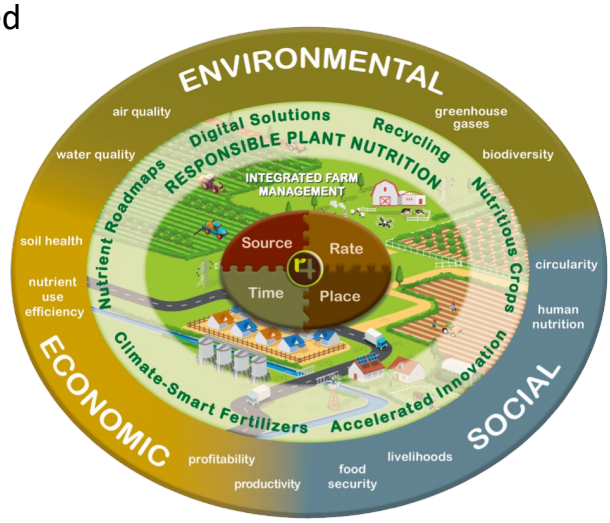
Future Farming Systems Integration

- Farming systems in transition – regenerative, circular, nature-based
  - Soil conservation
  - Integration with livestock
  - Sustainable intensification
  - Better human nutrition, biofortification
- Data-driven digital solutions
  - GPS guidance
  - Decision support tools
- Adaptive management for accelerated innovation
  - Weather-responsive sensing tools and crop models



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Core principles for Right Source

1. **[new] Supply nutrients in quantifiable and available forms.**
2. **[new] Use climate-smart forms.**
3. **[new] Use recycled forms where feasible.**
4. **[new] Consider biological inoculants**.

5. [original] Suit soil physical and chemical properties.
6. [original] Recognize synergisms among nutrient elements and sources.
7. [original] Recognize blend compatibility of materials.
8. [original] Recognize benefits and sensitivities to associated elements.
9. [original] Control effects of non-nutritive elements.

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New source principle #2: Use climate-smart forms.

Climate-smart fertilizers reduce greenhouse gas emissions.

Three attributes:

1. Lower manufacturing CO_2 emissions
   - "green" and "blue" ammonia
2. Inhibit loss of nitrous oxide (N_2O)
   - nitrification inhibitors and polymer coated urea
3. Improve nitrogen use efficiency (NUE)
   - controlled-release, stabilized, "smart fertilizers"

Photo credit: TFI, 2022

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Climate-smart fertilizers emit less N_2O

Inhibitors and polymer coatings

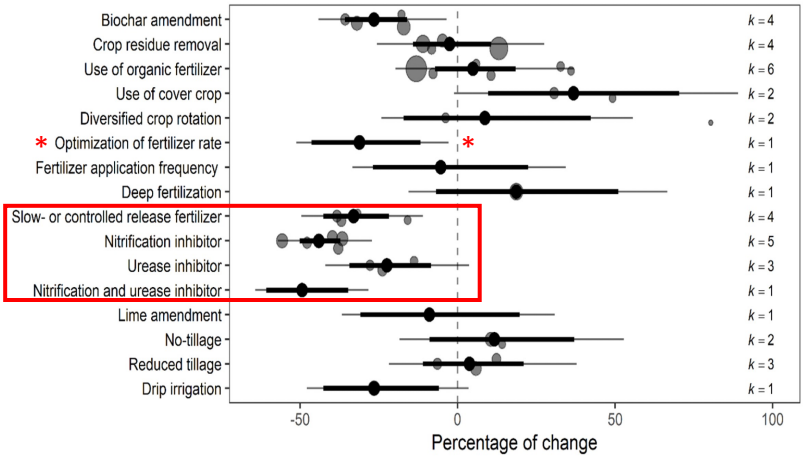
0-7% yield gain

0-15% NUE gain

20-50% less N_2O

Thapa et al. (2016) Effect of enhanced efficiency fertilizers on nitrous oxide emissions and crop yields: a meta-analysis. Soil Sci Soc Am J 80:1121–1134

Abalos et al. (2014) Meta-analysis of the effect of urease and nitrification inhibitors on crop productivity and nitrogen use efficiency. Agric Ecosystems & Environment 189: 136–144



Grados, et al. (2022). Synthesizing the evidence of nitrous oxide mitigation practices in agroecosystems. *Environmental Research Letters*. https://doi.org/10.1088/1748-9326/AC9B50

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New Core Principles

RIGHT RATE: Address variability in crop response

RIGHT TIME: Address changes through the growing season

RIGHT PLACE: Place nutrients to avoid loss

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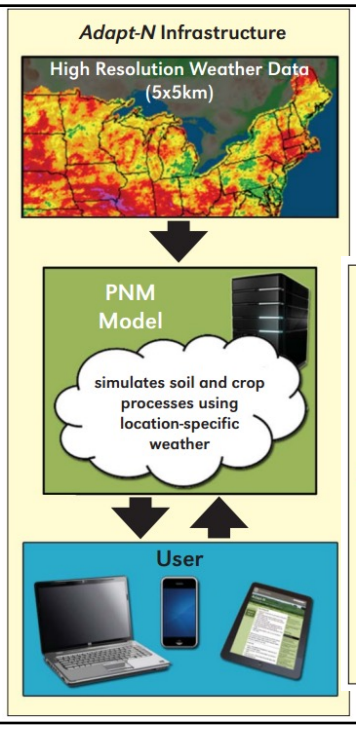
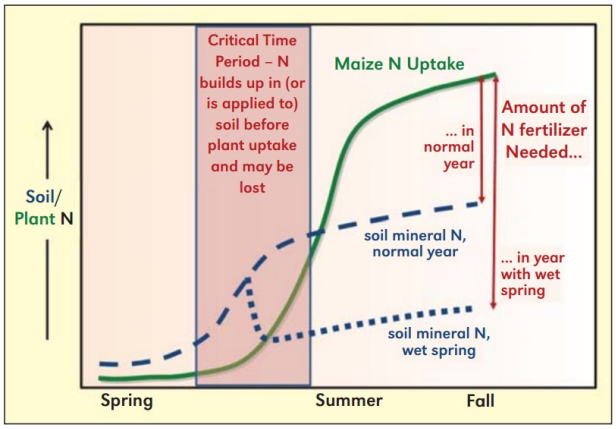


Common elements of model-based nitrogen decision support



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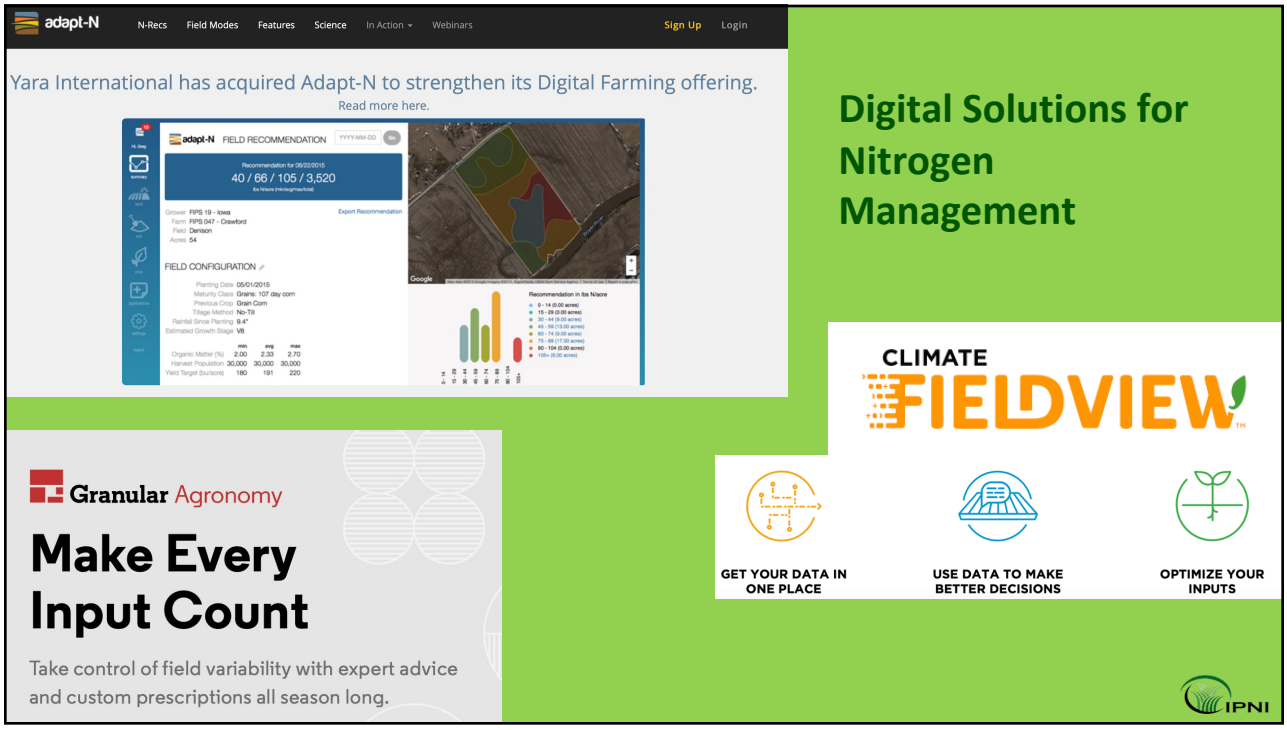

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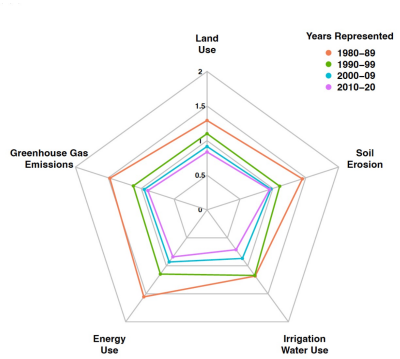
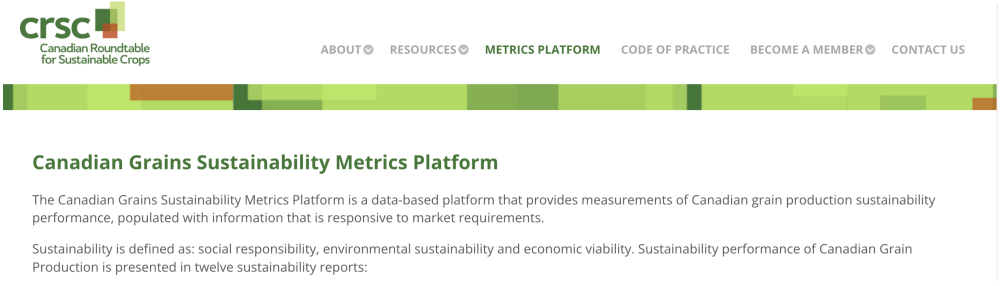
Sustainability Performance Reporting

- Track practices at farm level
- Share tracked data to report performance
- Economic, environmental and social sustainability





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Who needs to do what?

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- **Fertilizer Industry** – collaborate to put 4R practices into sustainability standards
- **Agri-service providers** – facilitate farm reporting of 4R practices and outcomes
- **Farmers** – share data on 4R practices and their outcomes
- **Governments** – recognize, incentivize, and reward 4R practice adoption; facilitate collection of statistical data on 4R practices
- **Scientists** – define & describe 4R practice standards and quantify their outcomes
- **Food industry** – Recognize and reward 4R practices in sustainability standards
- **Investors** – Invest in technologies, businesses and organizations that support 4R

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Furthering 4R to Verify Sustainable Emissions Reduction

1. The scope is substantial.
2. 4R principles and practices deliver recognized benefits.
3. 4R tracks practices AND outcomes:

   NUE, nitrogen surpluses, soil health (soil carbon as GHG sink)
4. Monitoring, reporting, validation require collaboration.

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