A New Paradigm for Plant Nutrition

TROPAGS, Georg-August-Universität Göttingen
24 November 2021

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Chief Scientist

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ifa INTERNATIONAL FERTILIZER ASSOCIATION

SCIENTIFIC PANEL ON RESPONSIBLE PLANT NUTRITION

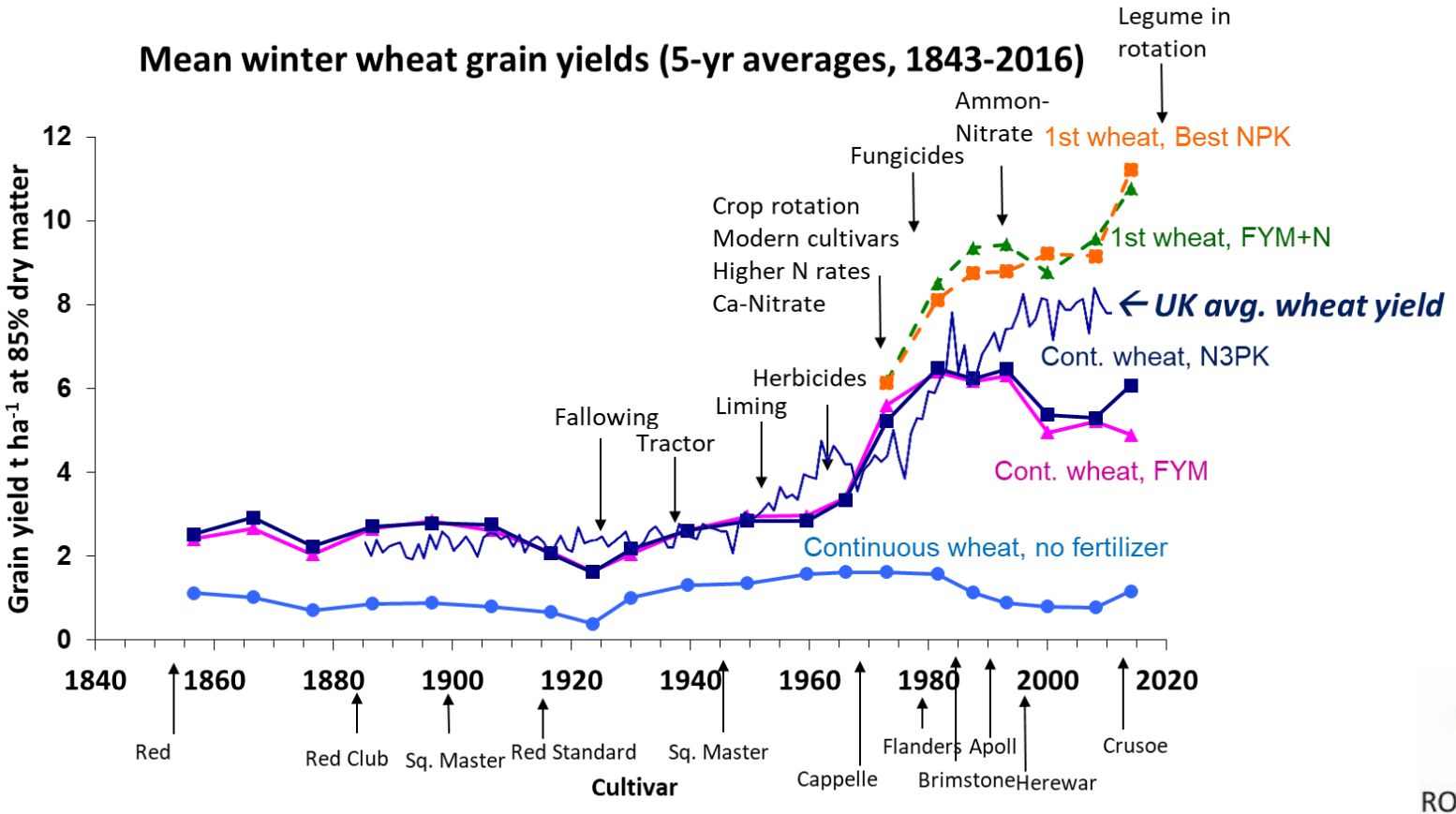
About IFA

IFA's vision: Productive and sustainable agricultural systems contribute to a world free of hunger and malnutrition.

IFA's mission: IFA promotes the efficient and responsible production, distribution and use of plant nutrients.

- The International Fertilizer Association (IFA) was founded in 1927 and is the **only global fertilizer association**.
- Members include fertilizer producers, traders and distributors, as well as their associations, service providers to the industry, research organizations, and non-governmental organizations.
- 45% of IFA's membership is based in developing economies. **IFA Members represent about 75-80% of global fertilizer production.**

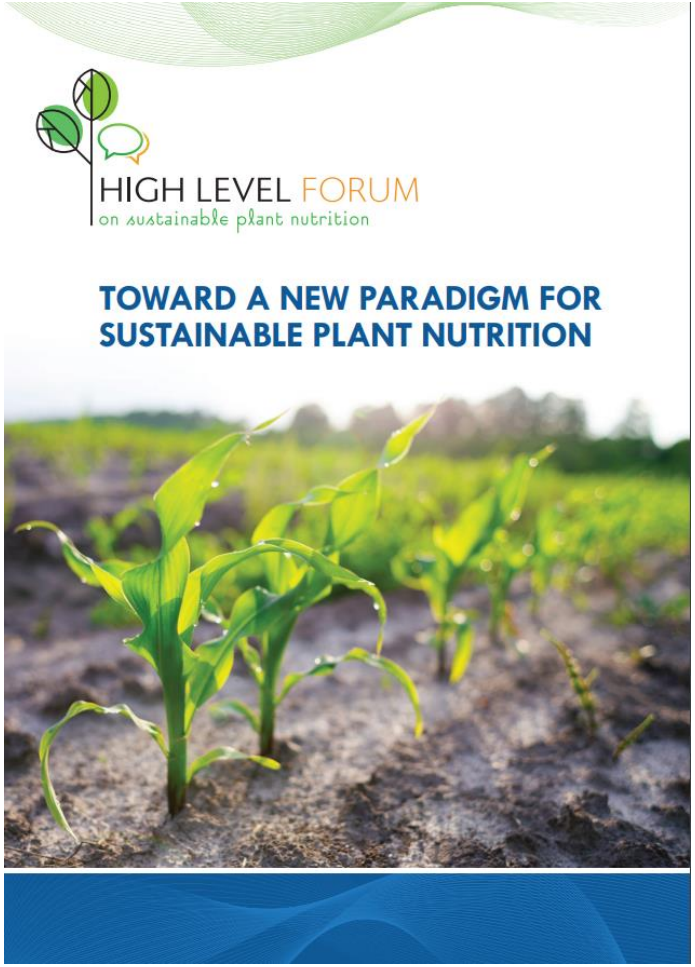
Broadbalk LTE – the story of modern agriculture



ROTHAMSTED RESEARCH

Productivity and food security are still critical needs, but the new paradigm for plant nutrition must embrace a food systems approach with all of its sustainability dimensions, including

- **GHG emission reduction, carbon sequestration**
- **Pollution and biodiversity**
- **Waste and nutrient recycling**
- **Nutrition and health**



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https://www.highlevelforum.org/

November 2019

Scientific Panel on Responsible Plant Nutrition

Vision: *Responsible plant nutrition nourishes plants in a sustainable manner that enhances earth's capacity to support healthy life*

Objectives: *Provide independent science-based knowledge to IFA and other stakeholders involved in food and agriculture on global issues of responsible plant nutrition*

Achim DOBERMANN
Scientific Panel on Responsible Plant Nutrition
Chief Scientist

Tom BRUULSEMA
Scientific Panel on Responsible Plant Nutrition
Chairperson

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Assistant Professor

Bruno GERARD
CIMMYT - Centro Internacional de Mejoramiento de Maiz y Trigo
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Professor of Plant Nutrition

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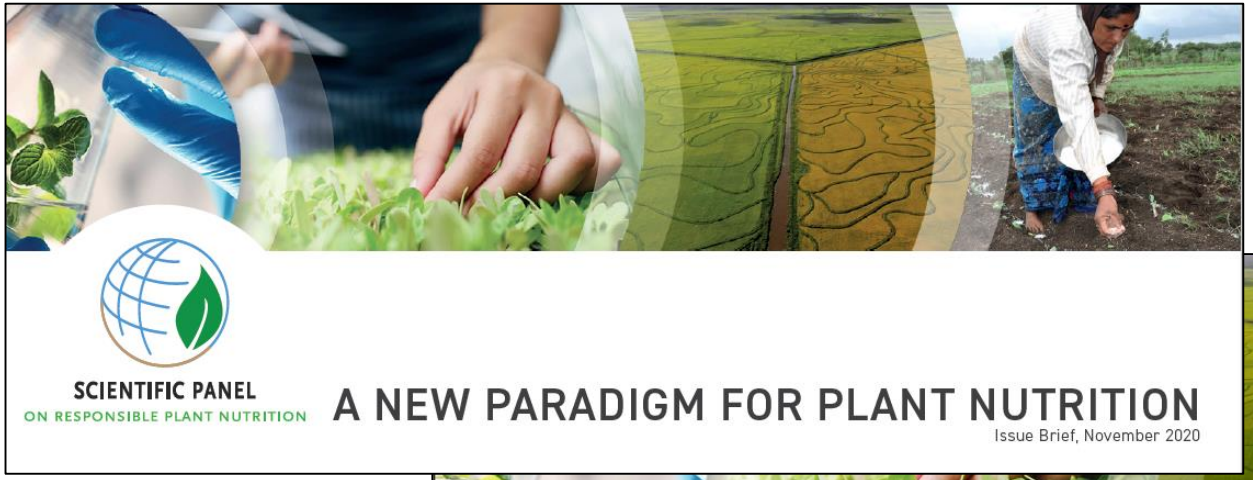
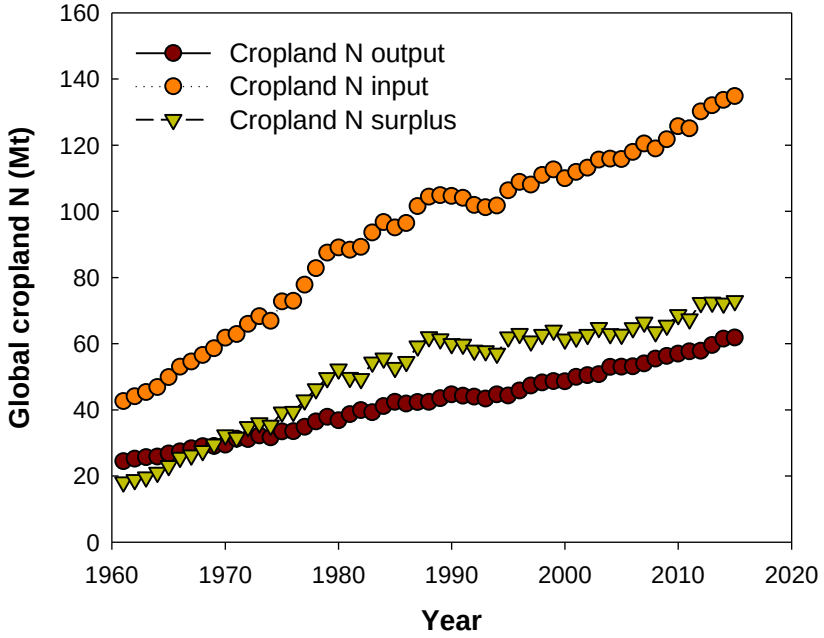


What is the issue?
What can be done?
Who needs to do what?
What will success look like?

https://www.sprpn.org/issue-briefs

What is the issue?

1 **How can future growth in crop production be decoupled from growth in fertilizer consumption, how can we overcome the global nutrient imbalance?**



Global trends in crop nitrogen inputs and outputs (million t)

N surplus = total N input to cropland minus harvested N as crop products

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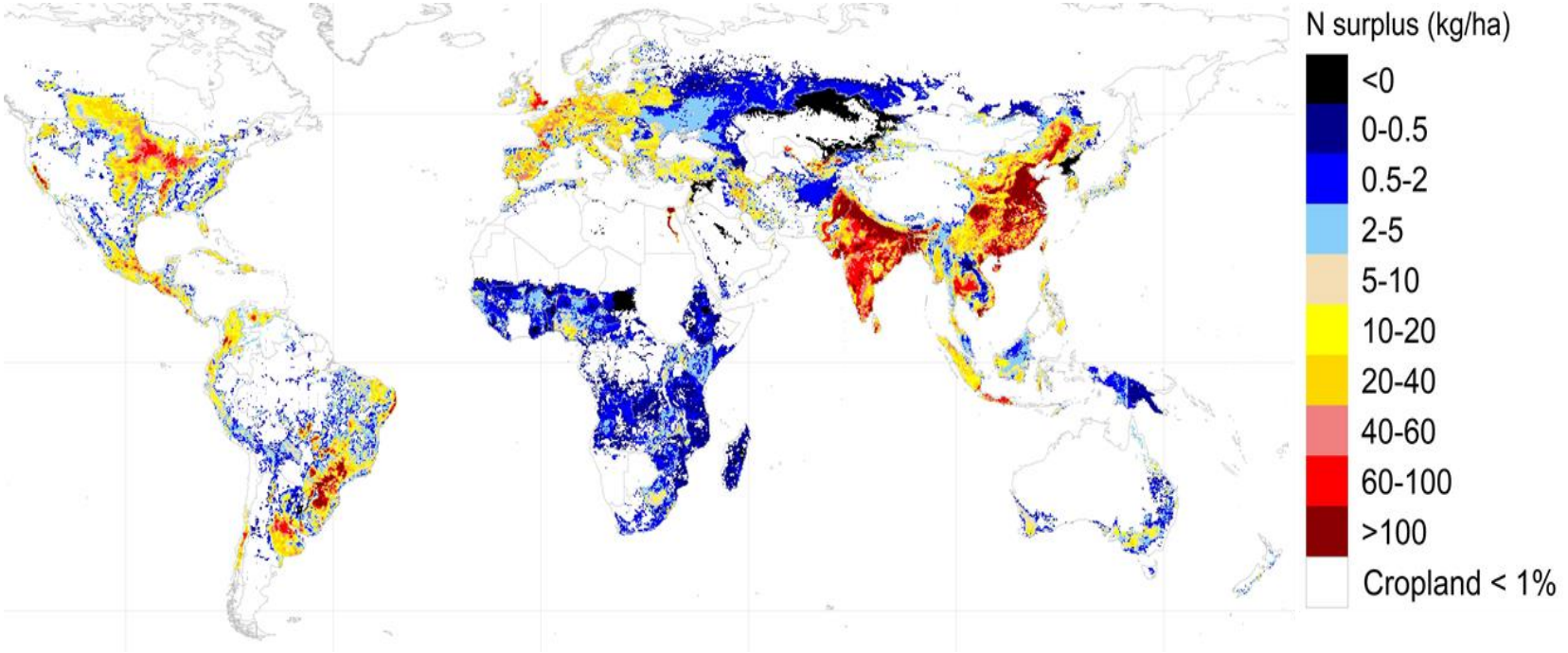
Source: Xin Zhang and Guolin Yao, University of Maryland Center for Environmental Science

What is the issue?



Cropland nitrogen surplus or deficit in 2015 (kg N/ha)

N surplus (or deficit) is defined as the total N input to cropland minus N harvested as crop products

Source: Xin Zhang and Guolin Yao, University of Maryland Center for Environmental Science

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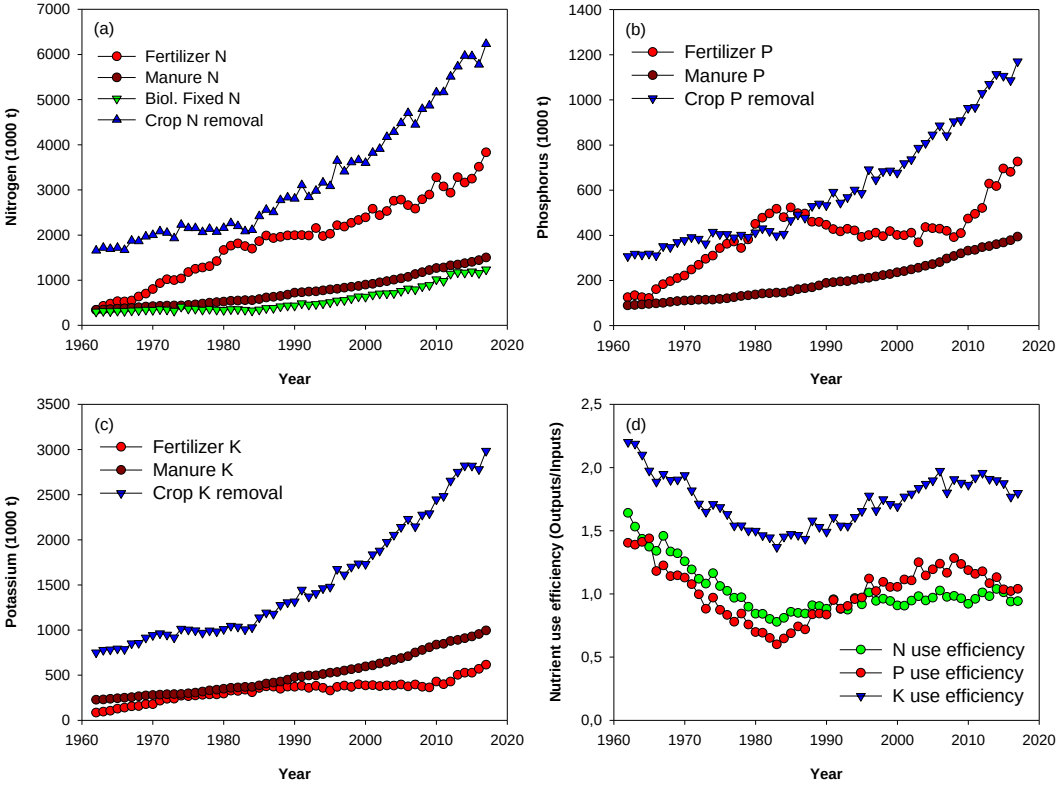
What is the issue?



2 **What are the key measures to double or triple crop yields in Africa with increasing and balanced nutrient inputs?**

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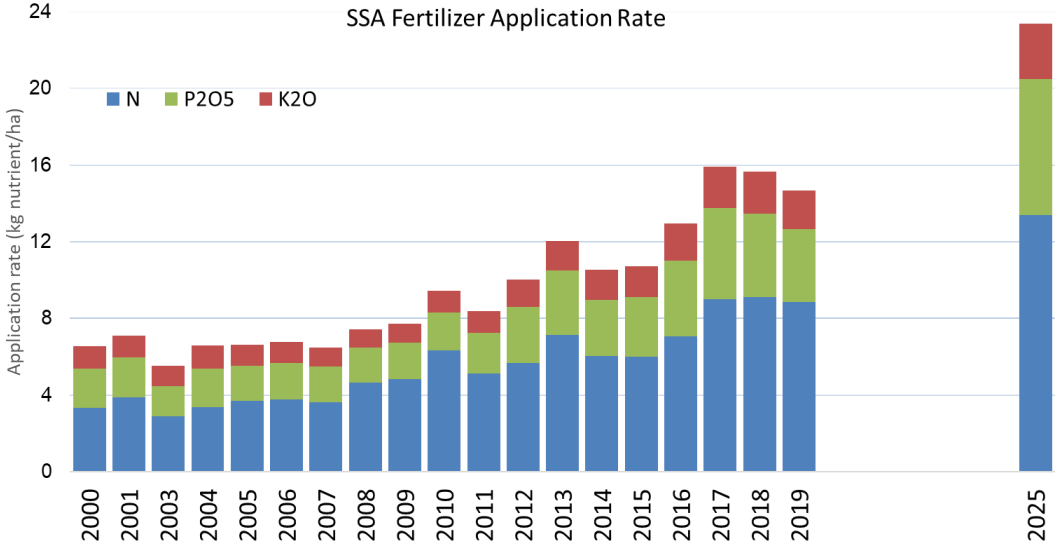
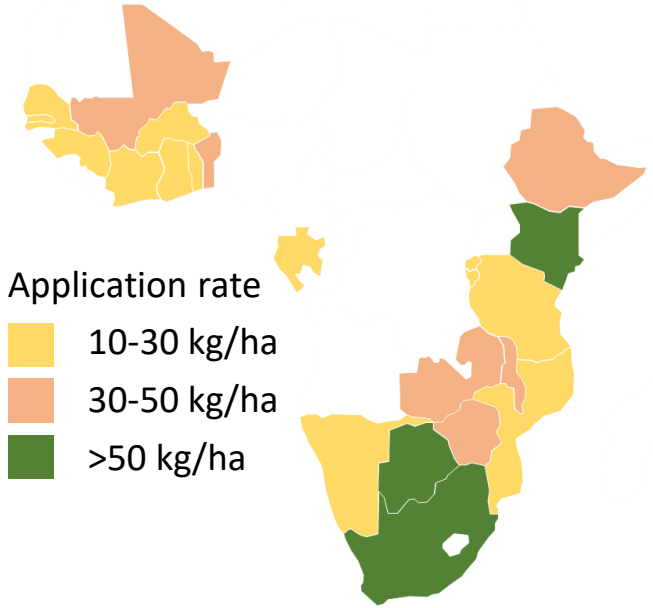
Crop N, P and K removal by far exceeds nutrient inputs from fertilizer, manure and other sources in Africa (1000 tons of N, P and K). Source: IFA Nutrient Use Efficiency database, 1961-2017.

SSA average application rate declines to 15 kg/ha in 2019



2019 average fertilizer use
(kg nutrients/ha cropland)



Average rates of fertilizer-nutrient application (NPK) to cropland in Sub-Saharan Africa (excluding South Africa).
Calculated using IFASTAT and FAOSTAT cropland.
2025 forecast from IFA Medium Term, July 2021.

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What is the issue?

3. What data-driven technologies, business solutions and policies will accelerate the adoption of more precise nutrient management solutions by farmers?
4. Can nutrient losses and waste along the whole agri-food chain be halved within one generation?
5. How can nutrient cycles in crop and livestock farming be closed?
6. How can we improve soil health?
7. How should we manage nutrition of crops in changing climates?
8. What are options and targets for reducing fertilizer-related GHG emissions?
9. How can cropping systems deliver high quality, more nutritious food?
10. How can we better monitor nutrients and implement high levels of sustainability stewardship?

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What can be done?

Following a **food systems & circular economy** approach....

a new paradigm of responsible plant nutrition encompasses the scientific and engineering know-how, agronomic practices, business models and policies that directly or indirectly affect the production, utilization and recycling of mineral nutrients in agri-food systems.

towards developing **integrated, tailored plant nutrition solutions** that

minimize tradeoffs between productivity, environment and health –
and are viable in the farming and business systems of different regions, nations and localities

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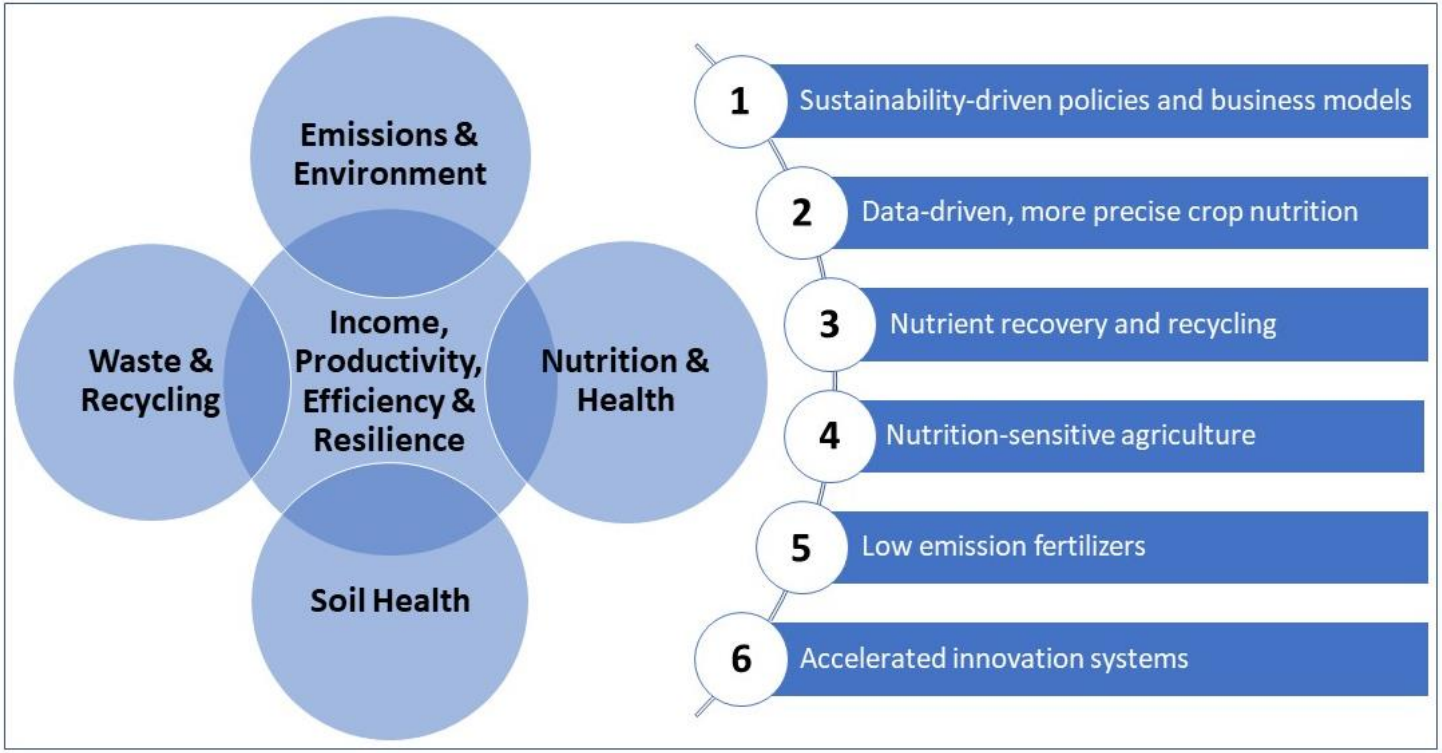
What can be done?

The five interconnected aims of a new paradigm for responsible plant nutrition - and six key actions to take



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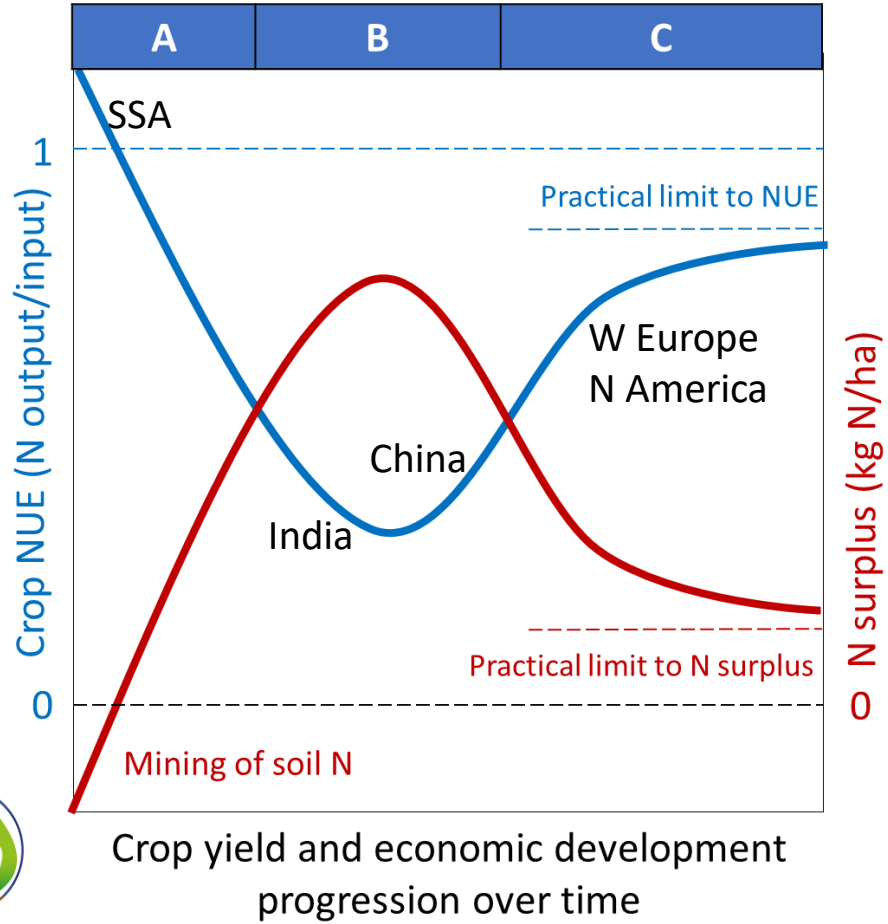
What can be done?



Action 1

Sustainability-driven nutrient policies and business models must be tailored to specific food systems in every country.

Specific targets and priorities for managing nutrients will vary, depending on a country's position along the general nutrient use efficiency pathway.

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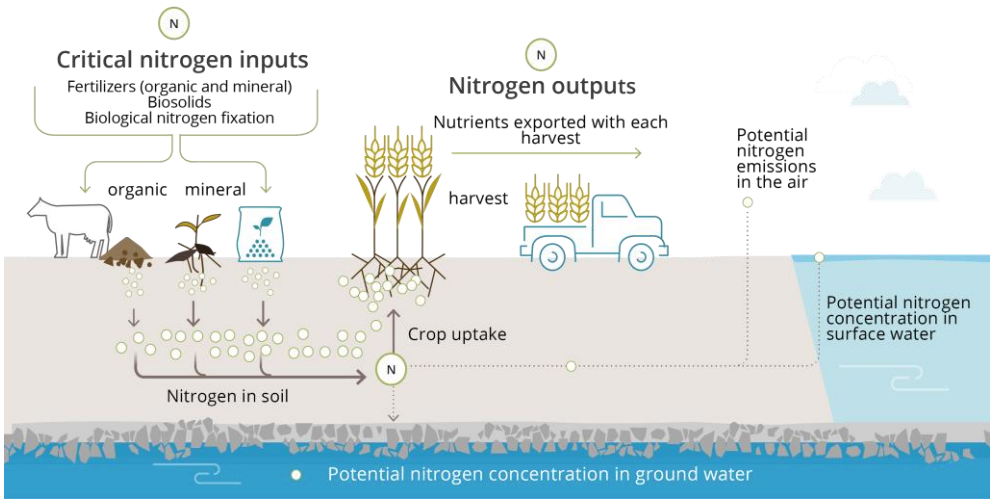
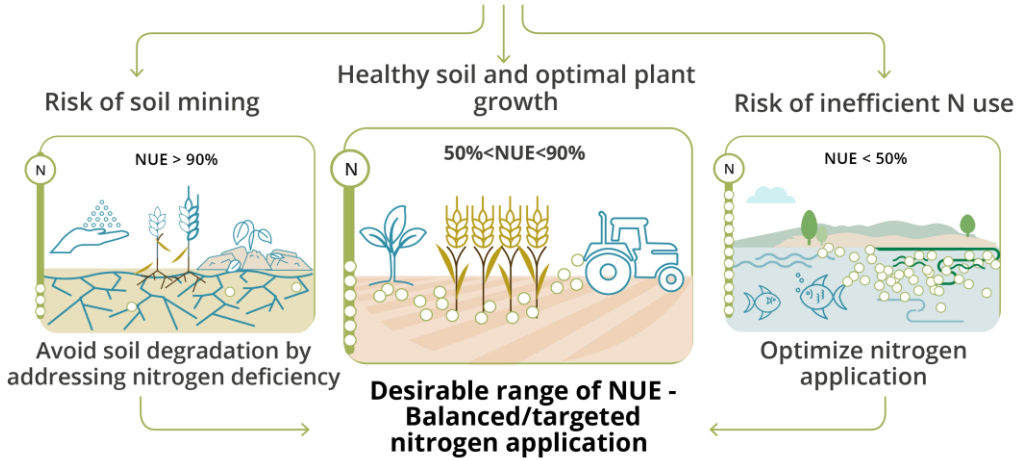


Nitrogen Use Efficiency (NUE): An indicator for the utilization of nitrogen in agriculture and food systems

3 Crop production scenarios



EU Nitrogen Expert Panel

http://www.eunep.com/

What can be done?

Action 2

Knowledge-driven solutions and novel technologies will allow tailoring nutrient formulations and applications to local needs in an increasingly precise manner.

They need to be upscaled to millions of farmers through digitally supported advisory systems and integrated business solutions.

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Precision agronomy = small details make a big difference

Strategic practices that require change in behavior

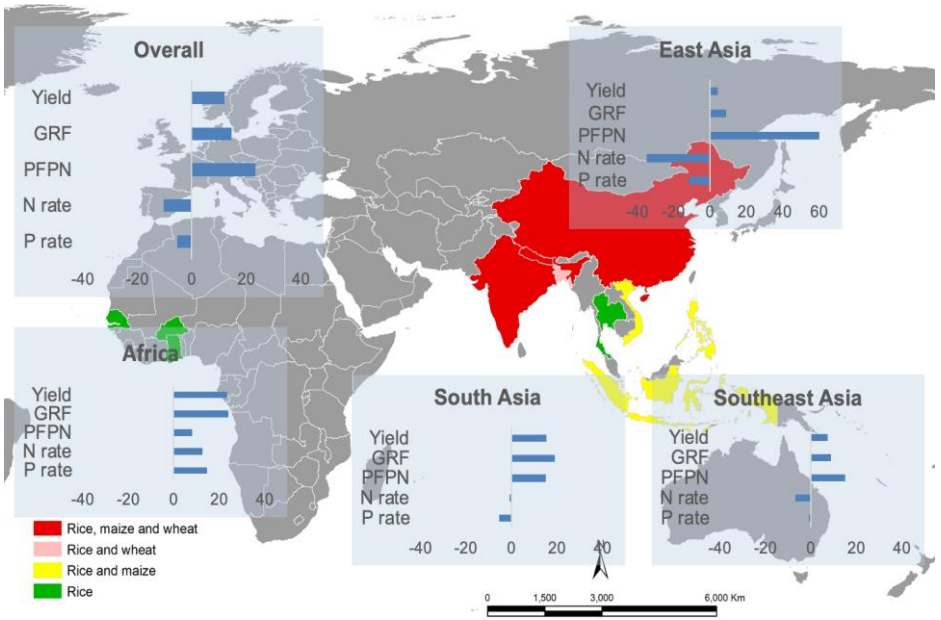
1. **Choose the right crop rotation and crop**
2. **Prepare the land early and properly**
3. **Get good seed and plant it at the right time, depth & density**
4. **Early weed control**
5. **Balanced plant nutrition with high N efficiency**
6. **Irrigate at the right time & well (if available)**
7. **Preventive, integrated pest management**
8. **Harvest at the right time**
9. **Manage the field after harvest**

10-20 specific management decisions per crop cycle
Data, metrics and targets for each
Ability to implement each at high quality in the field

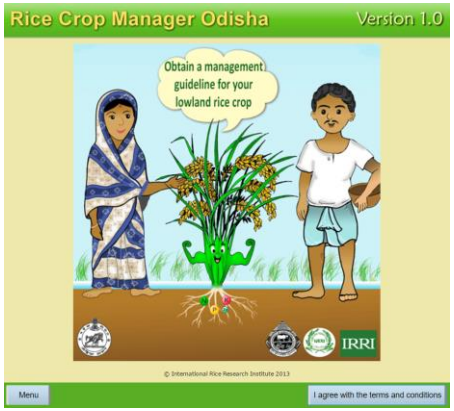
Site-specific nutrient management for smallholder farmers

Performance in rice, wheat & maize:

10-20% more yield & profit
10% less N, 5% less P, some more K
20-50% higher fertilizer NUE
Less GHG emissions & water pollution
Less soil nutrient mining
Less pests & diseases



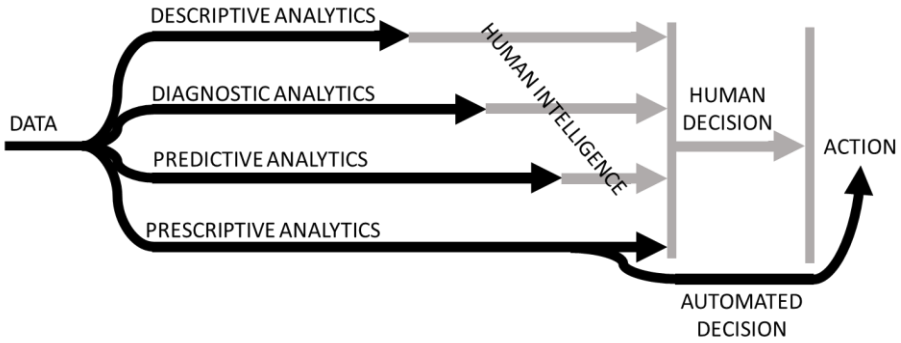
GRF is return above fertilizer cost; PFP N is partial factor productivity of N



NUTRIENT EXPERT®

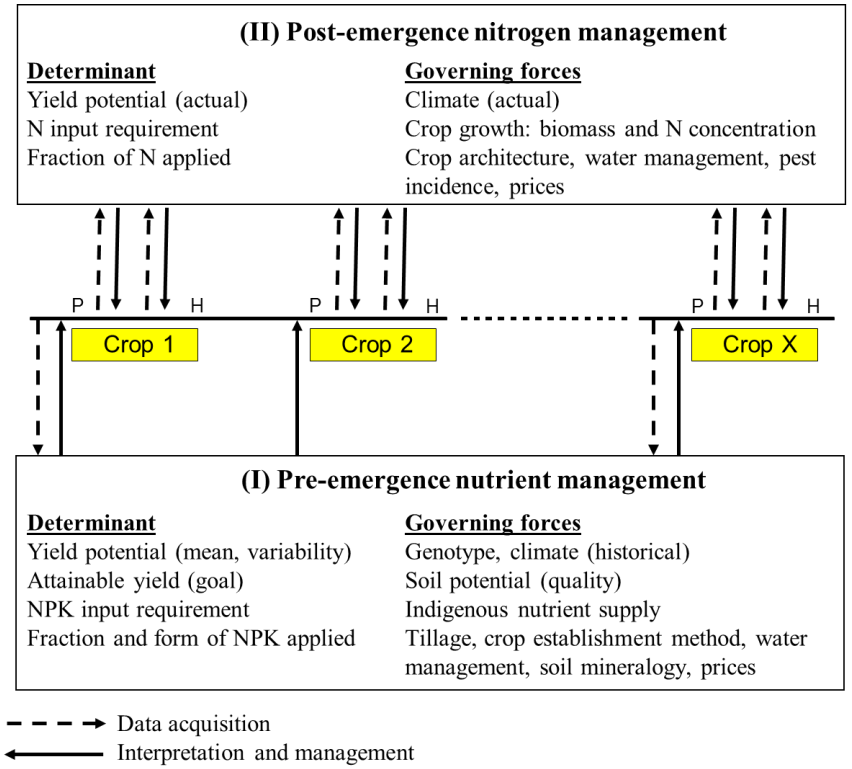
Chivenge, P. et al. 2021. Co-benefits of nutrient management tailored to smallholder agriculture. Global Food Security 30: 100570, https://doi.org/10.1016/j.gfs.2021.100570

Data-driven, self-learning nutrient management?



Matthew Smith, Agrimetrics, UK
Getting value from artificial intelligence in agriculture. *Animal Production Science* (2018), https://doi.org/10.1071/AN18522

Self-learning fertilizer recommendations + real-time guidance throughout the life cycle of a crop, and for whole cropping systems



Dobermann, A. & Cassman, K.G. 2002. Plant nutrient management for enhanced productivity in intensive grain production systems of the United States and Asia. Plant Soil 247: 153-175. (modified)

Consortium for Precision Crop Nutrition

- Enabling Data-Driven Nutrient Management -

Global data and innovation platform to support the development of digital crop nutrition advisory solutions in public sector and industry

- → A common “core operating system” for methods, data and digital tools
- → Open to everyone; Pre-competitive innovation
- → Initial focus on small-medium size farming in Asia, Africa and similar areas - but not only

Methods & Data

Decision algorithms, rules & tools

39 members so far: industry, CGIAR, Universities, Research Inst, NGOs, Others

https://www.precisioncropnutrition.net/

E-mail: cpcn@apni.net

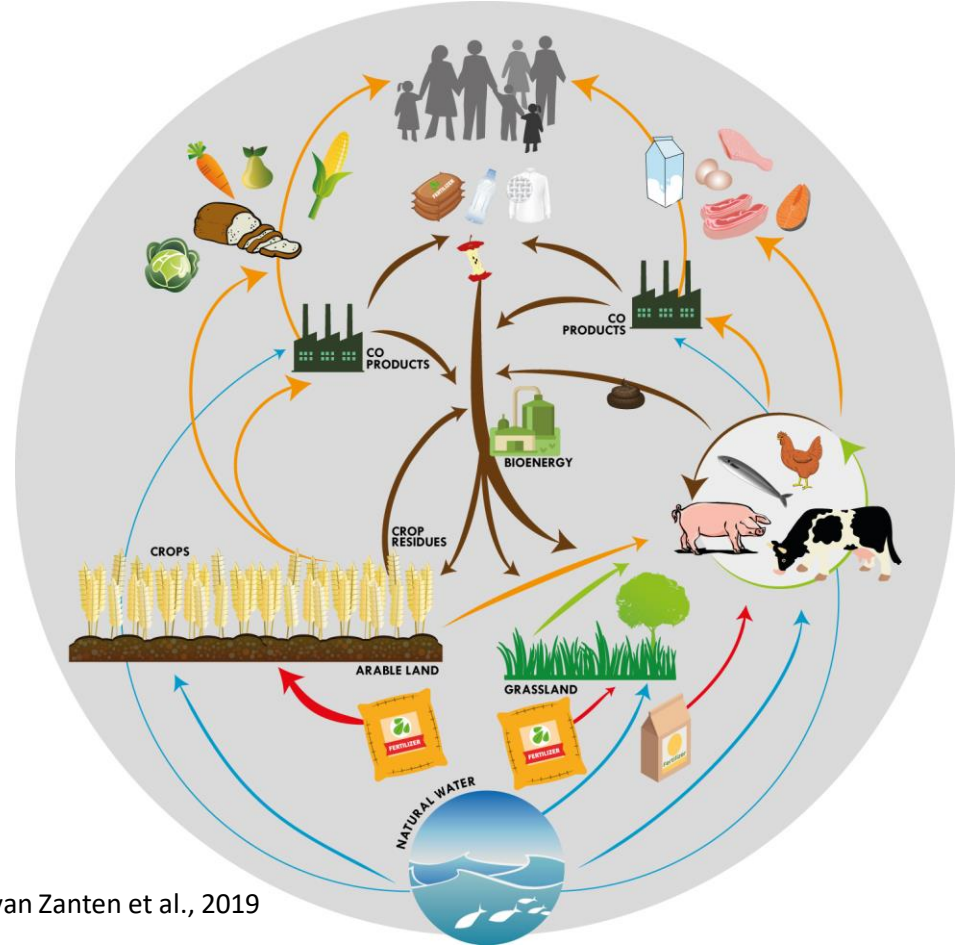
cpcn CONSORTIUM FOR PRECISION CROP NUTRITION

What can be done?

Action 3

Crop-livestock integration, less food waste, by-products use and increased nutrient recycling are key measures to optimize nutrient use efficiency across the full food chain.

Political incentives, novel technologies and shifts in behavior will drive greater nutrient recovery from multiple waste streams, as part of circular, bio-based economies.



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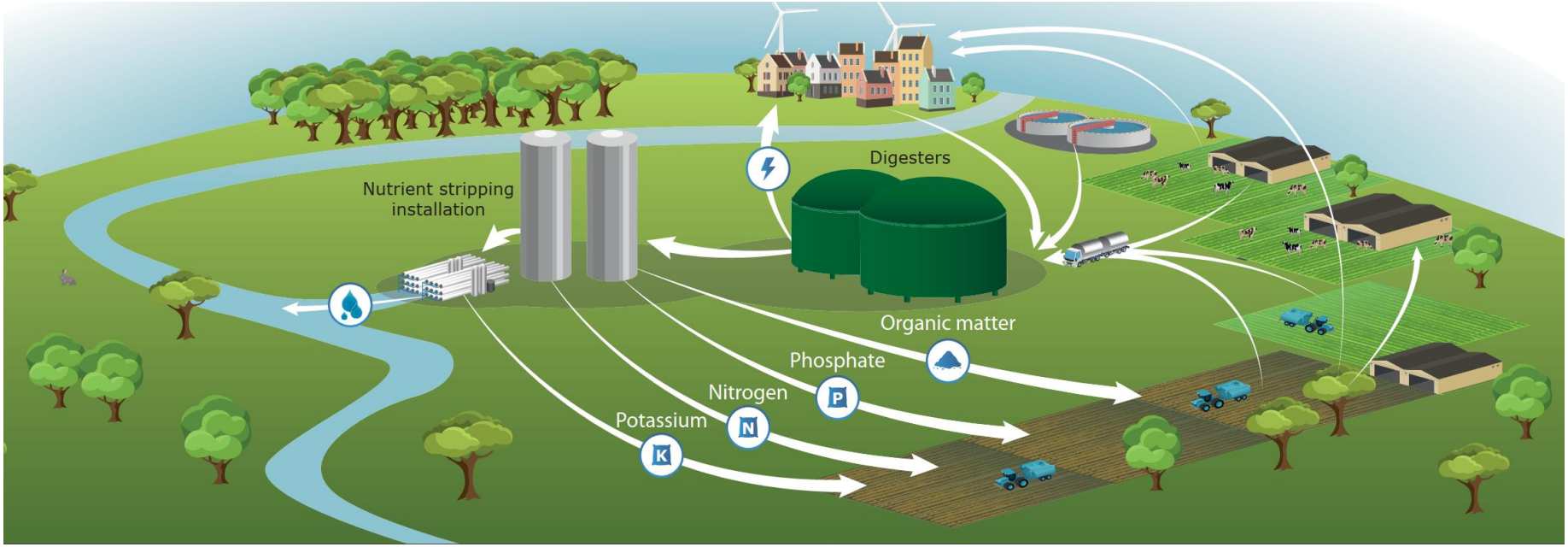
Re-drawn and modified from van Zanten et al., 2019

Circular solutions for biowaste

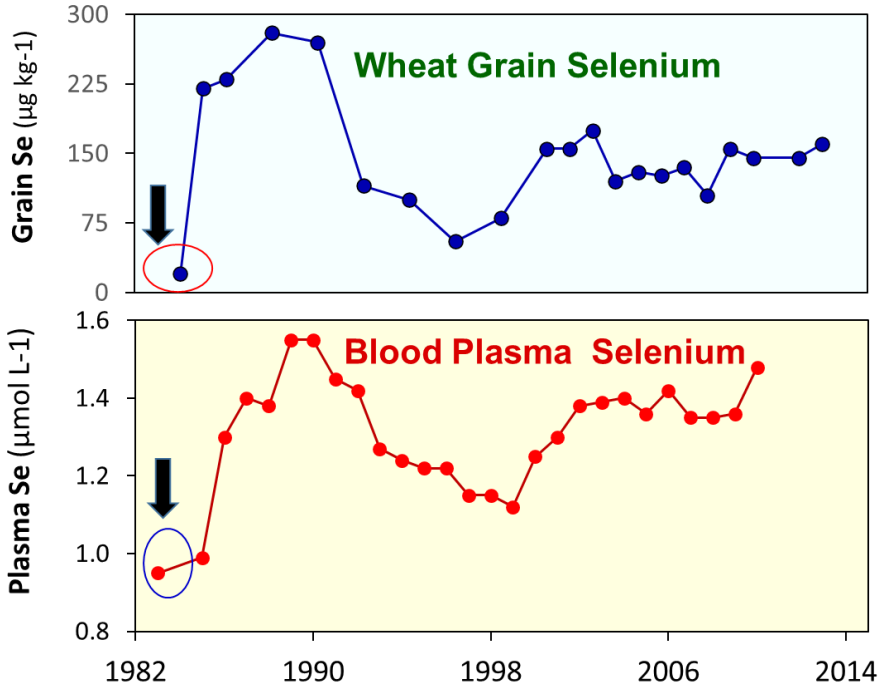


https://systemicproject.eu/

What can be done?

Action 4

Nutrition-sensitive agriculture includes the targeted enrichment and application of fertilizers to deliver micronutrients of importance to crop, animal and human health (e.g. Fe, Zn, Se, I).



Changes in grain and blood selenium since 1985 in Finland after Se-enrichment of NPK fertilizers

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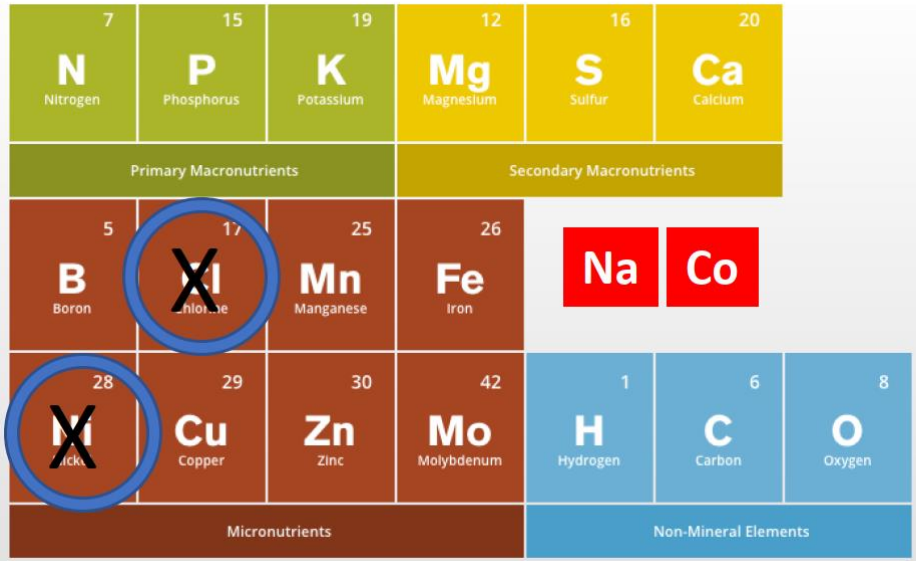
The scientific ‘Essential Elements’



Inconsistency between science and regulation:

Table 1 Current definition of selected elements as plant nutrients (Marschner 2012) and their respective classification in the current EU Fertilising Products regulation 2019/1009

Elements	Marschner (2012)	EU (FPR 2019/1009)
Al	Beneficial	Not a nutrient
Cl	Essential	Not a nutrient
Co	Beneficial	Nutrient
Na	Beneficial	Nutrient
Ni	Essential	Contaminant
Se	Beneficial	Not a nutrient
Si	Beneficial	Not a nutrient

Plant Soil
https://doi.org/10.1007/s11104-021-05171-w

SPECIAL ISSUE S97 - 30 YEARS

Check for updates

What is a plant nutrient? Changing definitions to advance science and innovation in plant nutrition

Patrick H. Brown · Fang-Jie Zhao · Achim Dobermann

A mineral plant nutrient is an element which is needed for plant growth and development or for the quality attributes of the harvested product, of a given plant species, grown in its natural or cultivated environment.

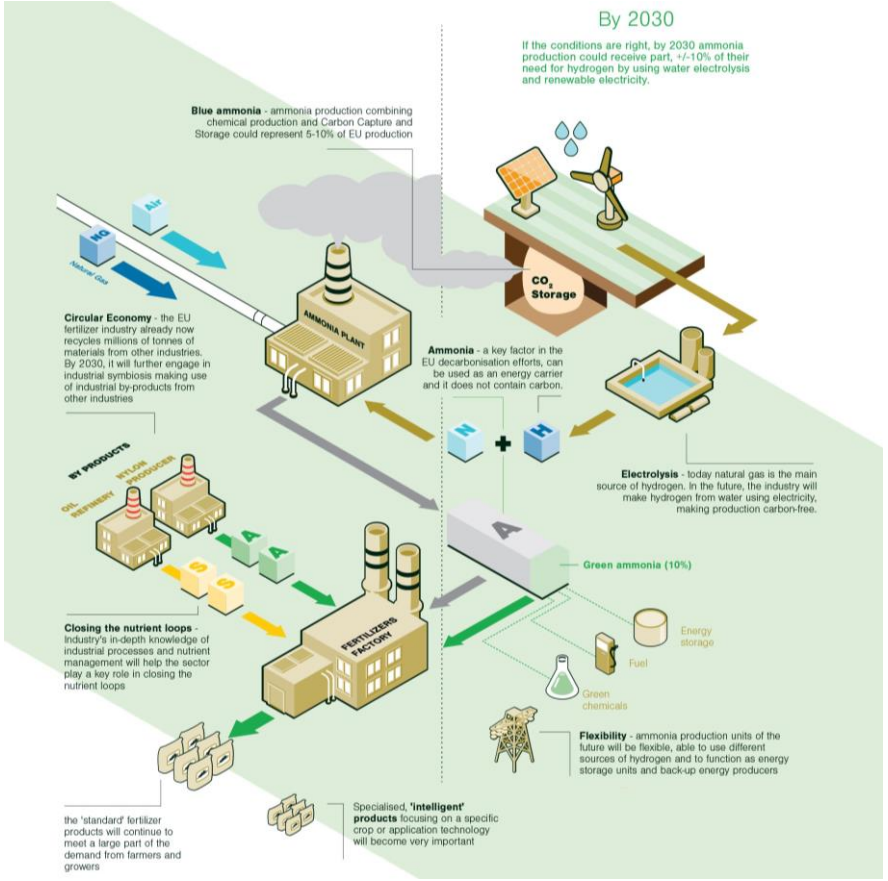
Debate welcome! https://www.sprpn.org/debate

What can be done?

Action 5

Fertilizers will increasingly be produced in an environmentally friendly manner and they will embody greater amounts of knowledge to control the release of nutrients to the plant.

A new “green ammonia economy” could feed and power the world in a whole new, decentralized manner.



Fertilizers Europe

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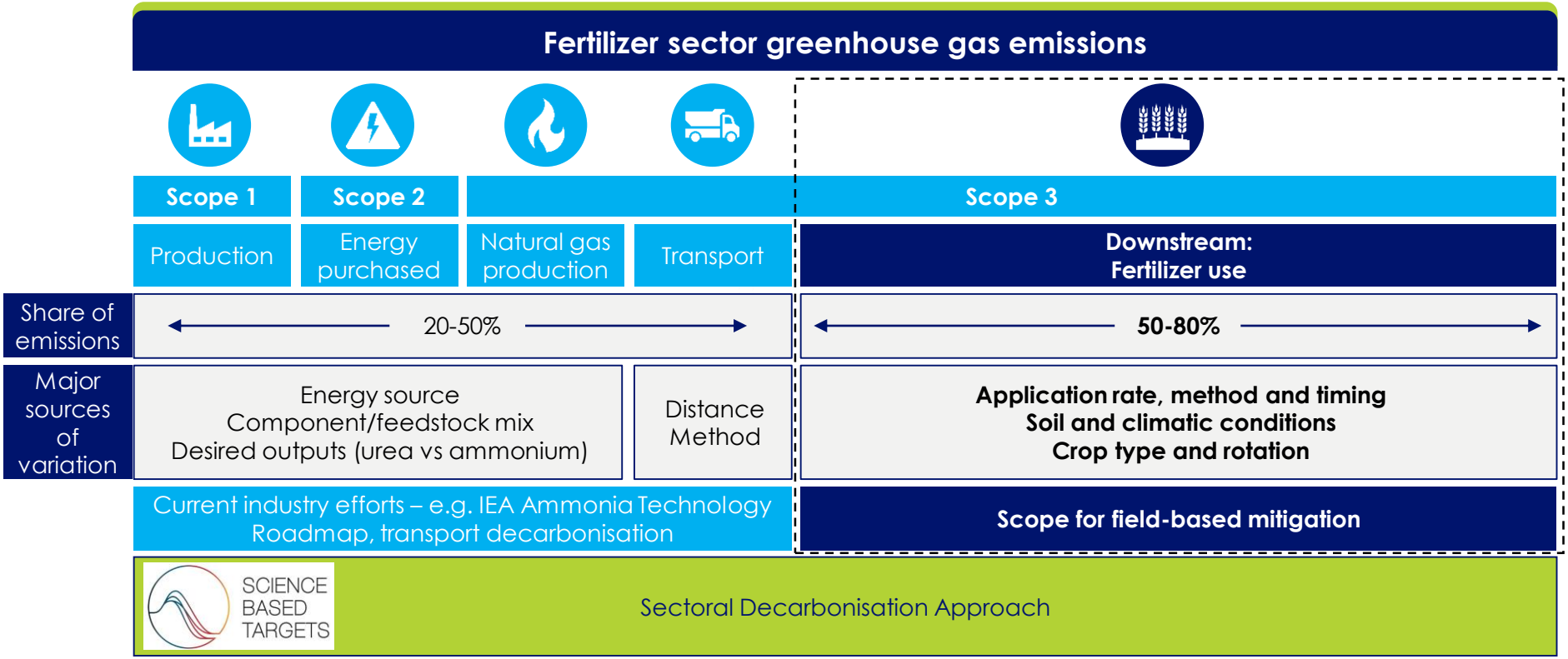


The IEA Ammonia Technology Roadmap, released in October 2021, sets out pathways for reducing CO_2 emissions from ammonia production by 70-95% by 2050.

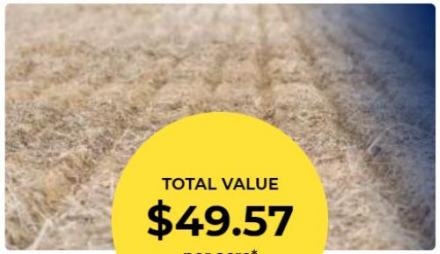
SYSTEMIQ

Example Practices & Finances for Row Crop in the US

agoro CARBON™ ALLIANCE

Tillage Management

Reducing or eliminating tillage keeps carbon in your fields, and cuts down costs



TOTAL VALUE
$49.57
per acre*

$10.87/acre
CARBON CREDIT EARNINGS PER YEAR

$38.70/acre
PRACTICE BENEFITS PER YEAR

+

Cover Crops

Cover crops improve soil health, and also help keep carbon "locked-in"

TOTAL VALUE
$30.18
per acre*

$6.05/acre
CARBON CREDIT EARNINGS PER YEAR

$24.14/acre
PRACTICE BENEFITS PER YEAR

+

Nitrogen Efficiency Practices

Intelligently managing how and when you apply nitrogen increases efficiency and yield

TOTAL VALUE
$10.00
per acre*

$0.91/acre
CARBON CREDIT EARNINGS PER YEAR

$9.09/acre
PRACTICE BENEFITS PER YEAR

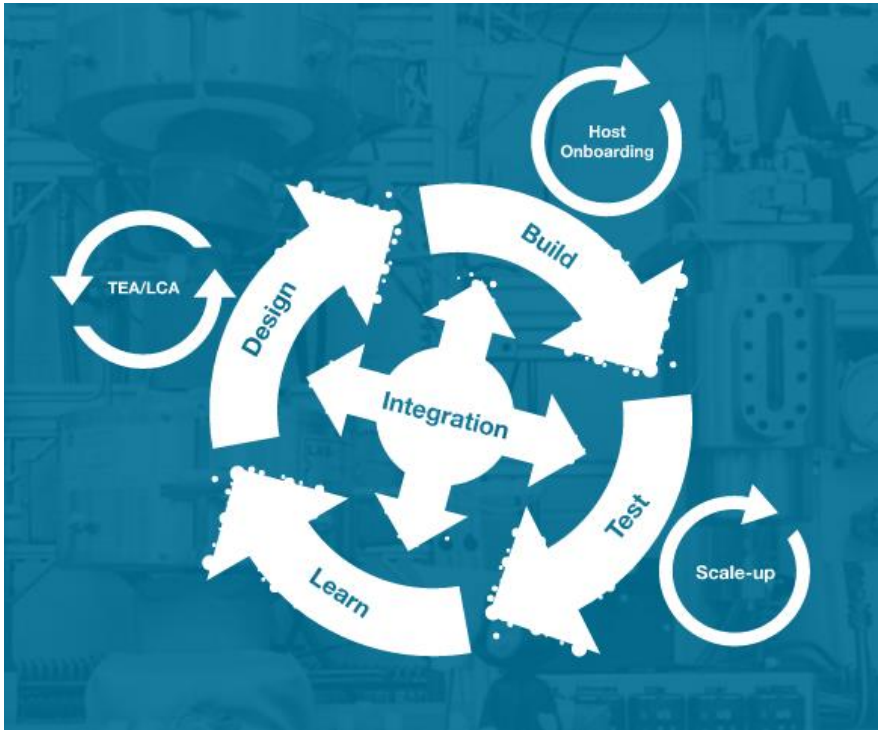
https://www.agorocarbonalliance.com/

What can be done?

Action 6

Accelerated, more open innovation systems for faster translation of new ideas into practice.

This requires more investment, collaboration, risk taking and entrepreneurship by industry, but also a massive culture change in science and science funding.



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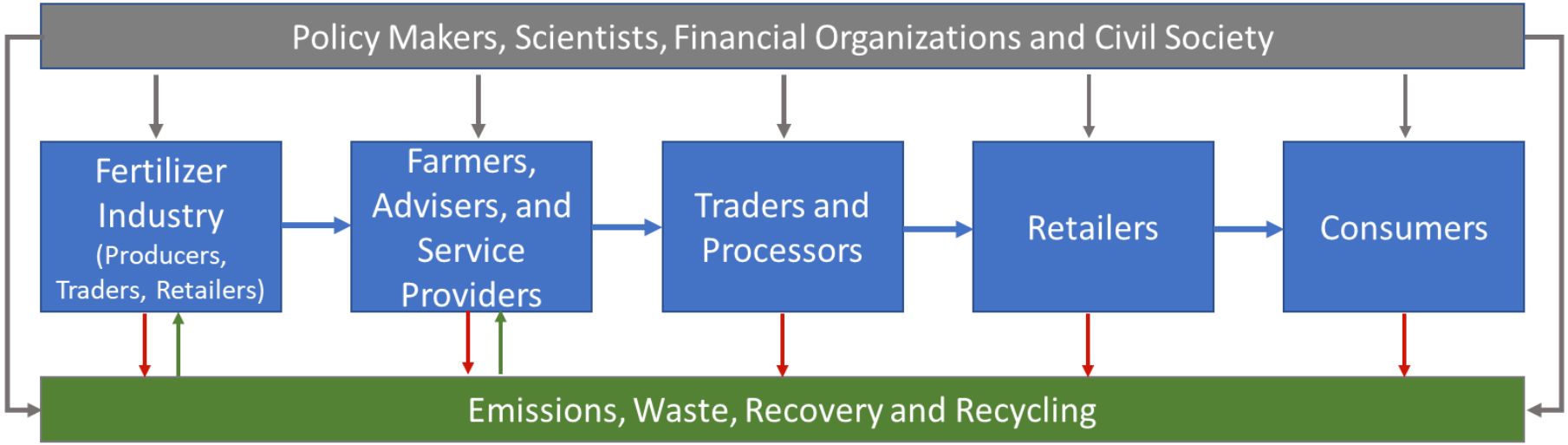
Who needs to do what?



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Fertilizer Industry Ambitions

1. Reduce greenhouse gas emissions associated with the production of nitrogen fertilizers by at least 30 % per ton by 2040
2. Improve average global N use efficiency in crop production from the current level of 50% to 70% by 2040
3. Improve soil health and soil carbon sequestration
4. Double nutrient application rates in sub-Saharan Africa by 2030 and triple them by 2040 to close the large nutrient and yield gaps, eliminate hunger, and improve soil health
5. Scale up fertilizer-based solutions to eliminating malnutrition caused by micronutrient deficiencies (agronomic x genetic biofortification)
6. Contribute to increasing nutrient efficiency across the whole food chain

ifa
INTERNATIONAL FERTILIZER ASSOCIATION
Helping to feed the world sustainably

IFA, May 2021