Cropland nutrient budget database

CPCN Webinar, 25 January 2023

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Why?

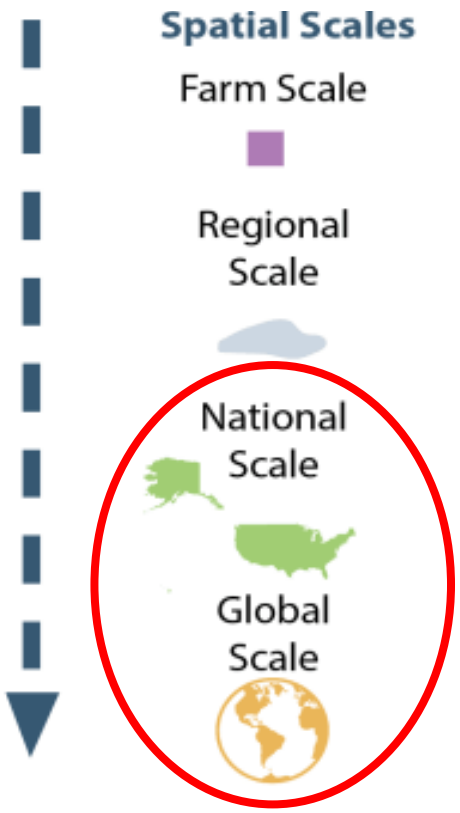
Estimates of nutrient inputs & outputs on cropland are used for:

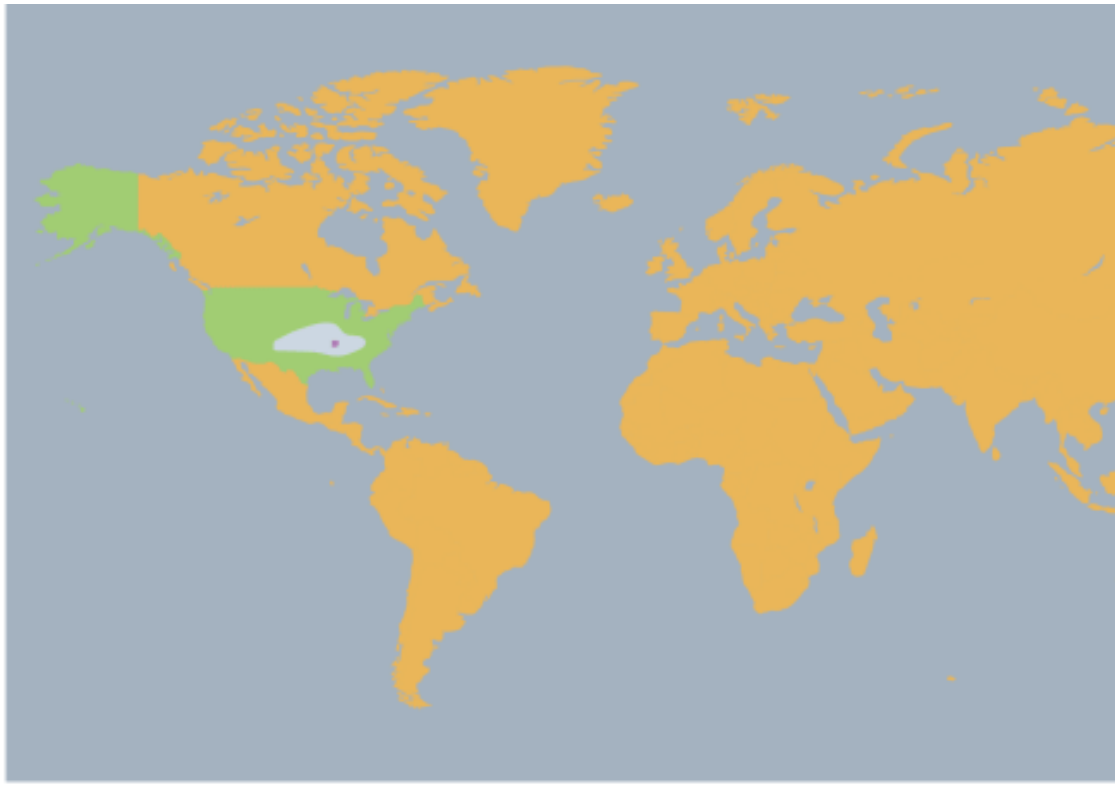
- Quantifying nutrient balances and nutrient use efficiency (NuUE):
  - Nutrient balance (surplus, deficit) = ∑nutrient inputs - ∑nutrient outputs
  - Nutrient Use Efficiency (NuUE) = ∑nutrient outputs / ∑nutrient inputs

Farm

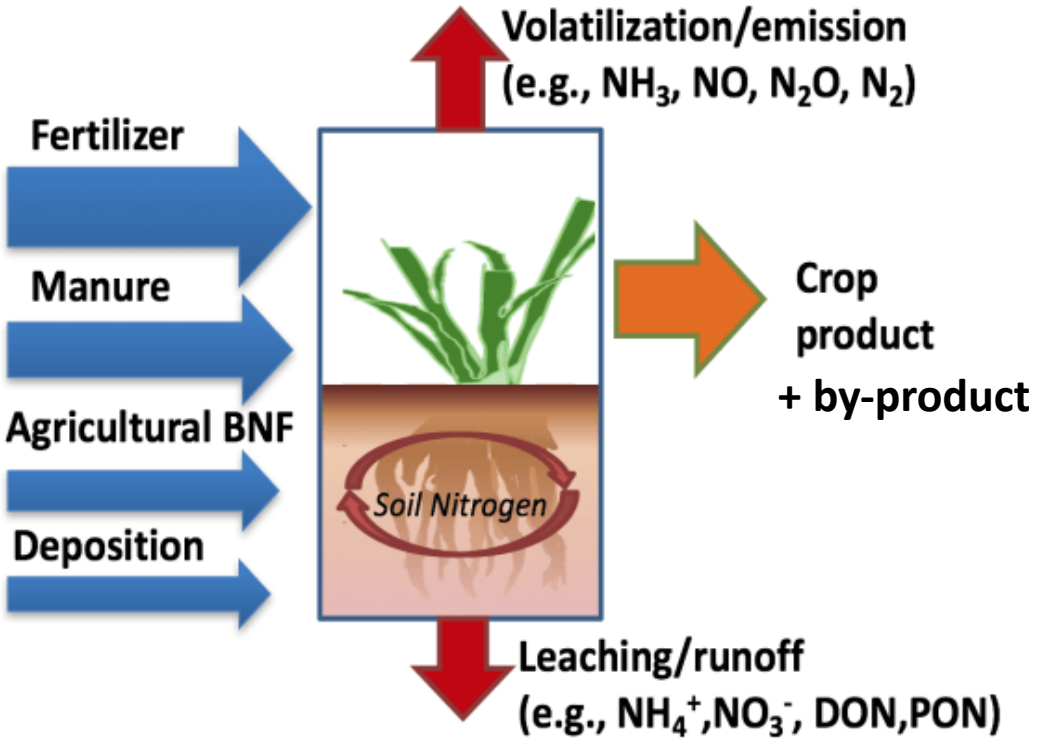
- Nutrient management recommendations: fertilizer algorithms, models, benchmarking of farmers etc.
- Assessing trends and identifying hotspots: impact of nutrient use on food production, biodiversity, global climate, water and air quality
- Nutrient targets, roadmaps and policies, and monitoring progress towards them (e.g. to reduce pollution, to reduce GHG emissions, to avoid nutrient mining, ESG reporting, sustainability ratings, etc.)
- Nutrient intelligence: fertilizer demand forecasting and market development

World





Our focus here



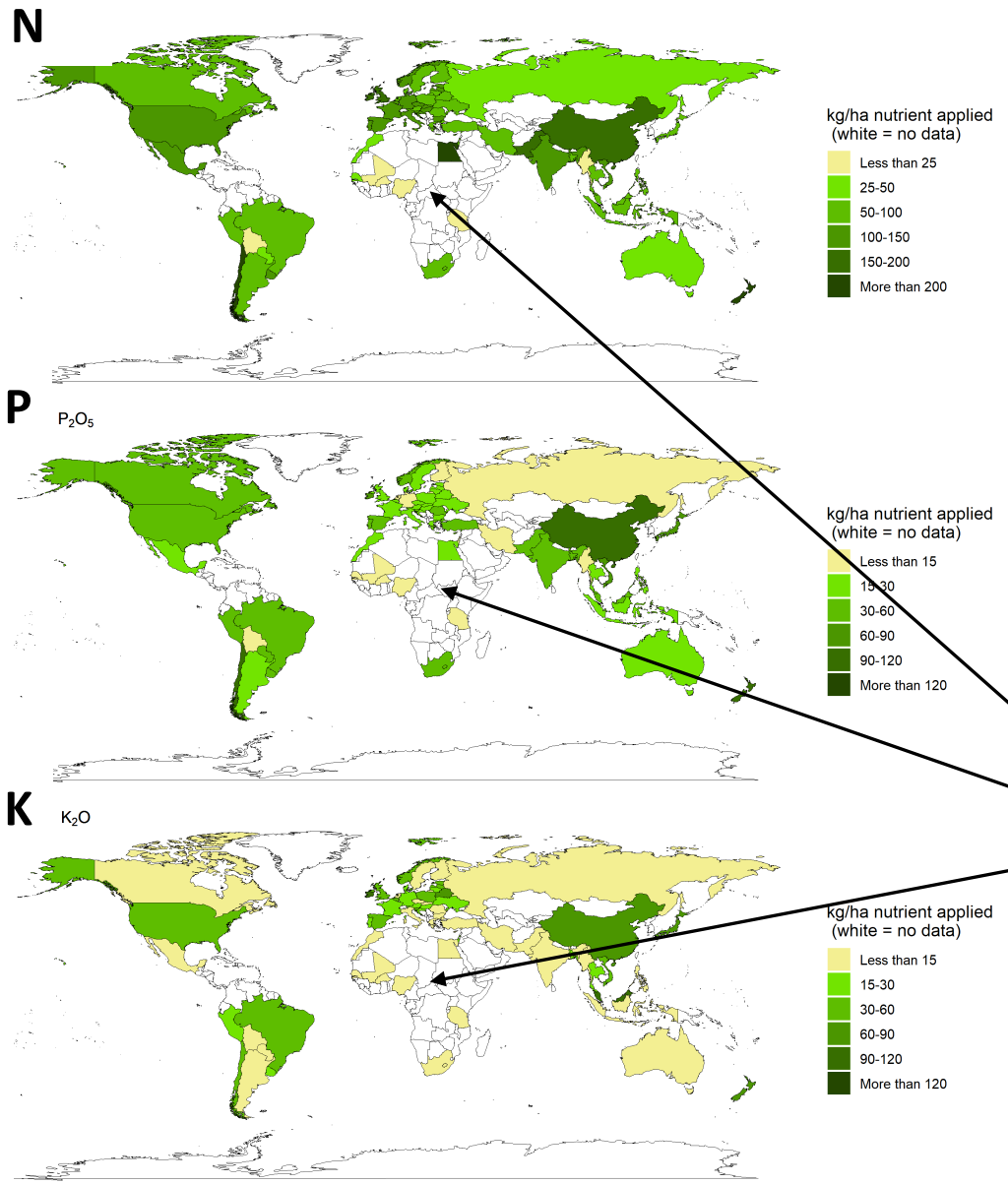
Zhang et al. 2021. Nature Food
https://www.nature.com/articles/s43016-021-00318-5

Common issues:

- Lack of historical and recent data
- Varying assumptions made in the calculations
- Use of 'average coefficients'
- Use of fixed coefficients over time
- Insufficient new primary data collection (or modeling), sharing and standardized processing

→ Similar issues also apply at finer scale, e.g. in algorithms or models for making fertilizer recommendations

Many data gaps



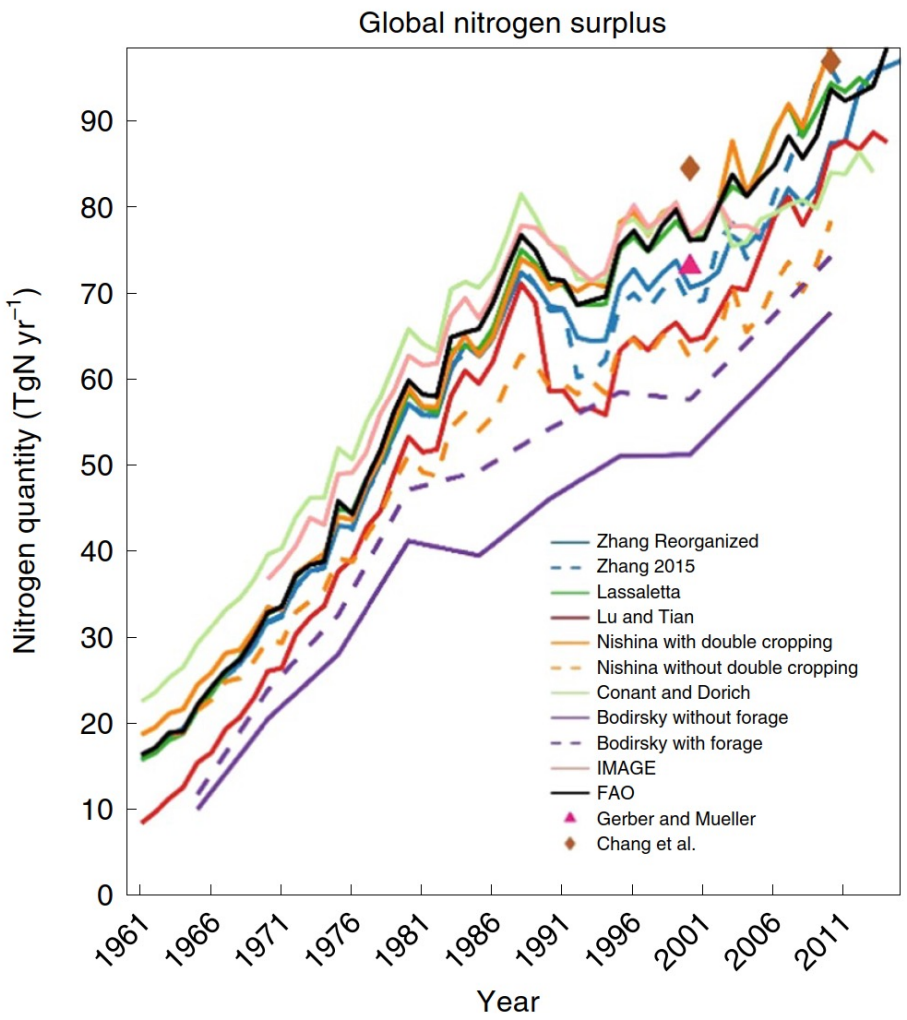
Why is information about fertilizer use by different crops grown in a country important?

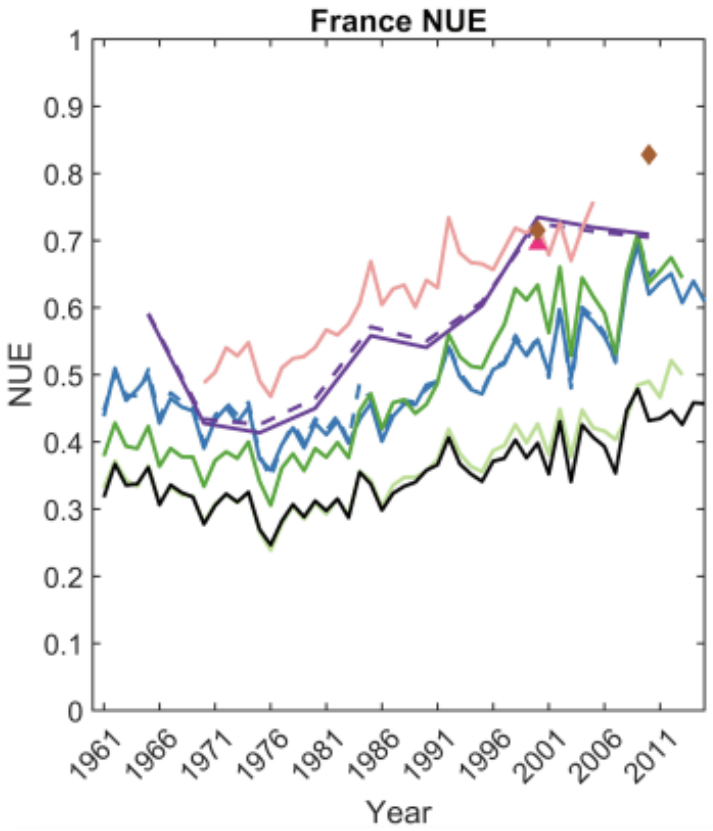
- Fertilizer application rates and efficiency vary by crops.
- Changes in crop mix, e.g. influenced by markets, diet change and energy policies, impact nutrient use, efficiency and pollution risks.

Only 64 countries in latest **Fertilizer Use by Crops and Country** survey conducted by IFA
→ Uncertain estimates in many countries
→ Often older data
→ Huge gaps in Africa

IFA. 2022. Fertilizer use by crops and country for the 2017-2018 period.
https://www.ifastat.org/consumption/fertilizer-use-by-crop

Large discrepancies in nutrient budgets and NUE estimates





Zhang et al. 2021. Nature Food
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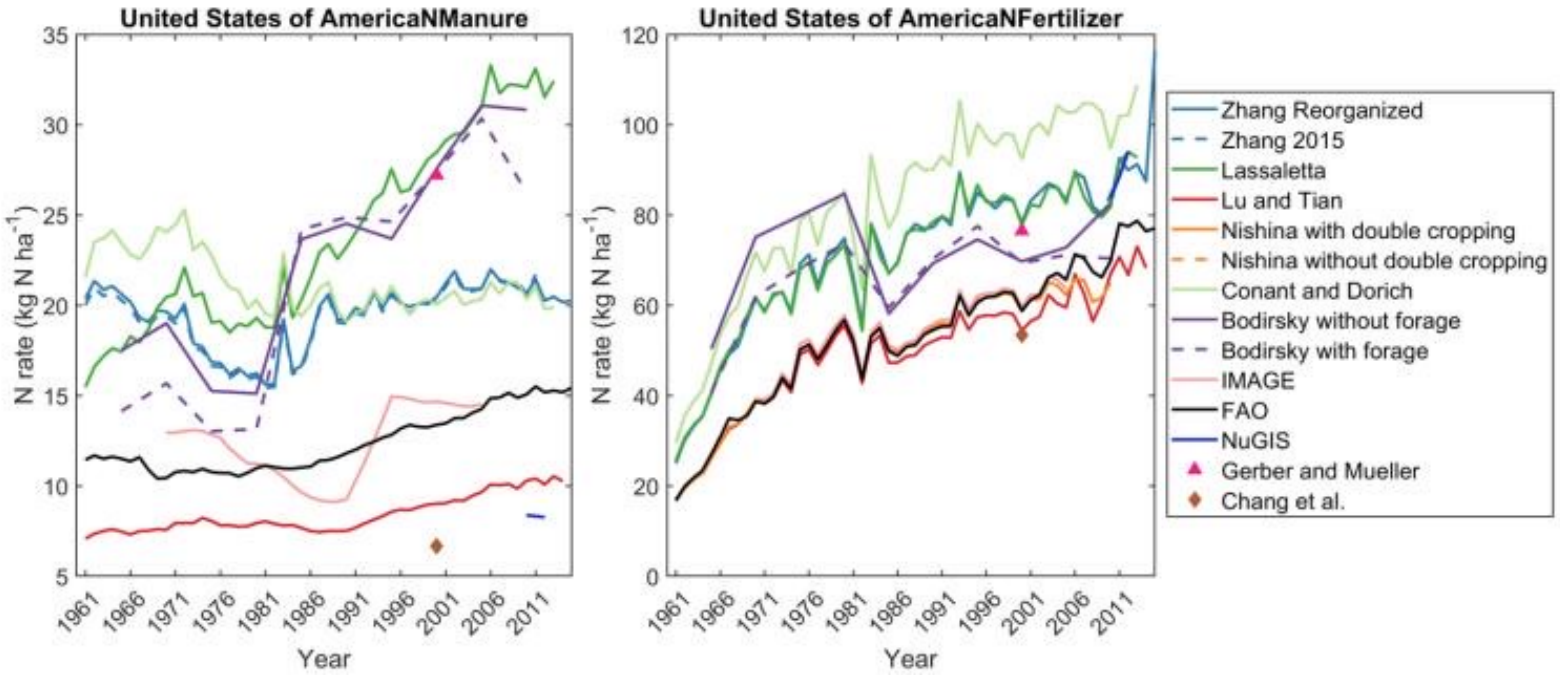
Large uncertainties in key components of the nutrient budget

	Dominating method	Key parameters	Uncertainty	Importance
N Manure	$QN_{man,j} = \sum_{lv} Liv_{lv,j} \cdot Ex_{lv,j} \cdot Collect_{lv,j} \cdot frac\_crop_{lv,j}$	$Liv_{lv,j}$	*	***
		$Ex_{lv,j}$,$Collect_{lv,j}$, $frac\_crop_{lv,j}$	***	***



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Our vision

- Jointly create, manage and improve a harmonized '**global nutrient budget reference database**'
- Cover **N, P and K on <u>all</u> agricultural land**
- **Sub-national and crop-specific nutrient budgets**
- **Annual updates** and **more timely data**: t-1 & 'now-casting'
- **Improve data quality**:
  - Systematically improve the most uncertain components through wide collaboration, new methodologies, and fusion of multiple data sources.
  - Tap new sources of critical agronomic data, including industry data, targeted crowd sourcing, remote sensing, etc.
- Create **better visualization and analytical tools**

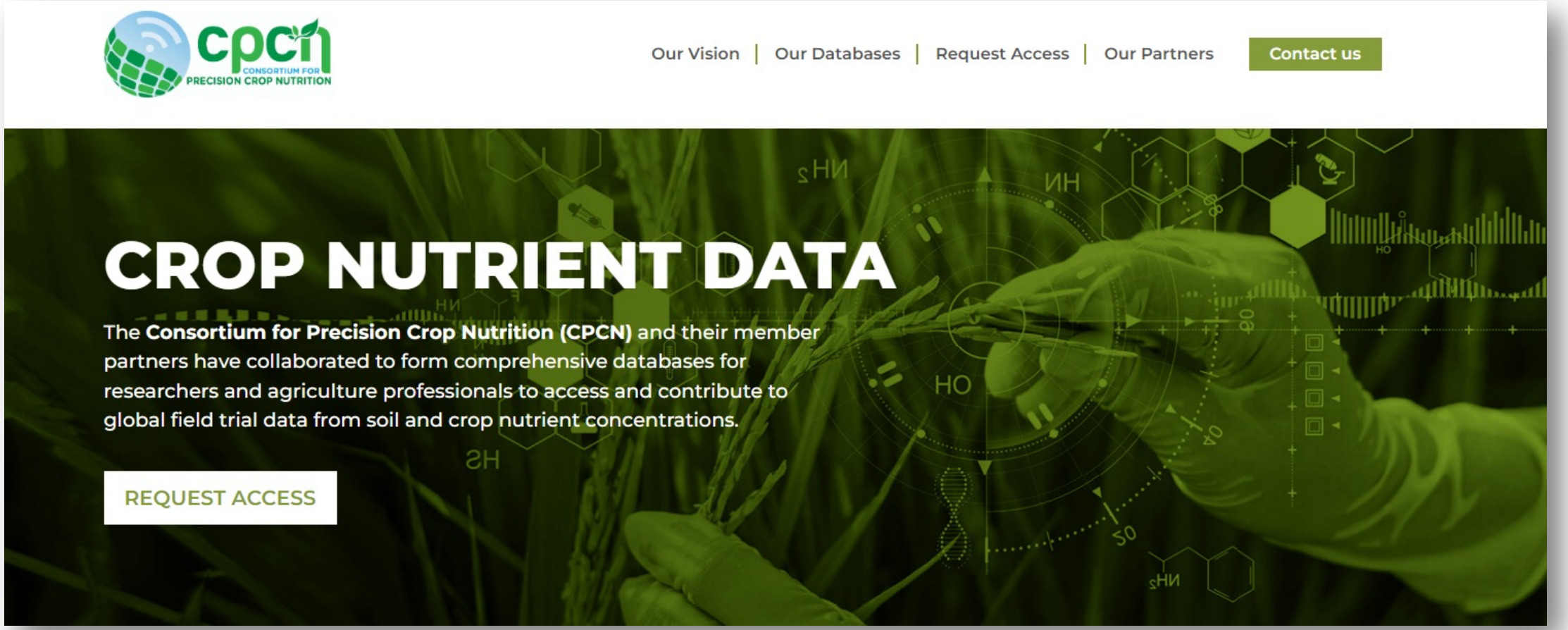
How?

- **Voluntary & community-steered**, co-facilitated by FAO, IFA and selected research groups
- **Distributed responsibilities** for specific thematic layers of nutrient inputs & outputs data or regions, but based on common data and review standards
- **Open access** – all data are fully documented, made widely available and can be used in different data platforms for integration, analysis and visualization

Examples:

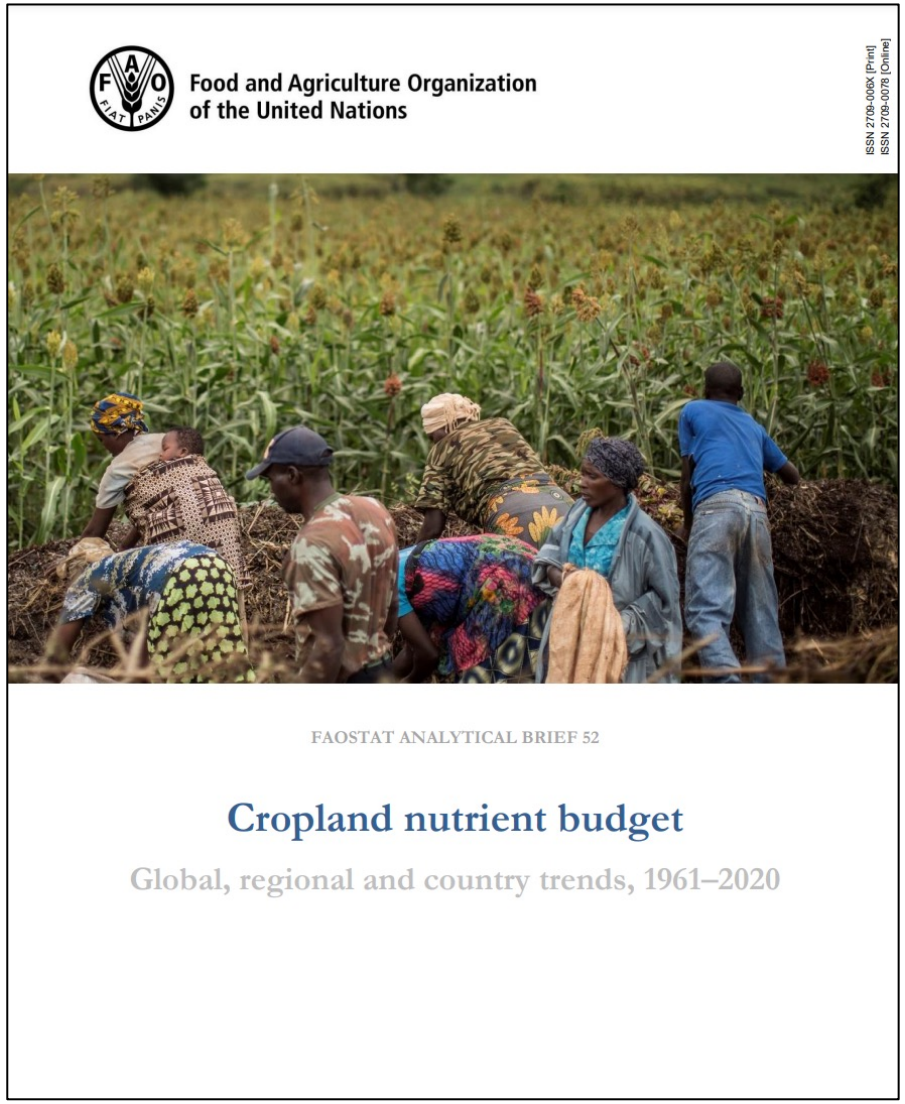
- Global data on fertilizer use by crop and by country. https://datadryad.org/stash/dataset/doi:10.5061/dryad.2rbnzs7qh
- Global data on crop nutrient concentration and harvest indices. DRYAD dataset publication. https://doi.org/10.5061/dryad.n2z34tn0x
- Quantifying nitrogen deposition inputs to cropland: A national scale dataset from 1961 to 2020. https://datadryad.org/stash/dataset/doi:10.5061/dryad.msbcc2g1x

WWW.CROPNUTRIENTDATA.NET



ifa INTERNATIONAL FERTILIZER ASSOCIATION | cpcn CONSORTIUM FOR PRECISION CROP NUTRITION | apni AFRICAN PLANT NUTRITION INSTITUTE | iSDA AFRICA | WAGENINGEN UNIVERSITY & RESEARCH | agmatix

2022 Release through FAOSTAT

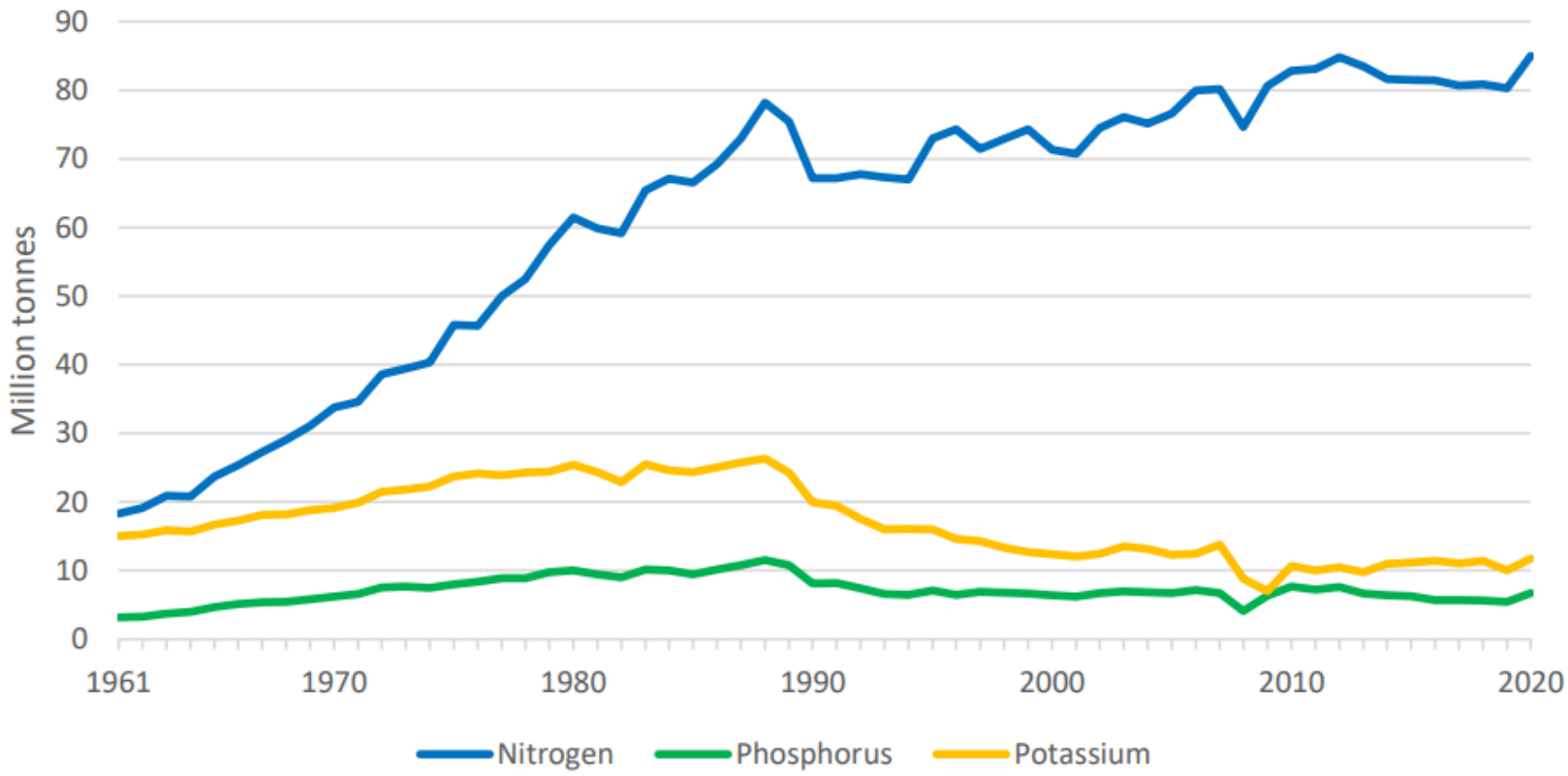


First release November 15th:

- Reference nutrient budgets for global cropland by country (N, P and K)
- 1961-2020 time period
- Consolidated FAO and IFA fertilizer statistics (agricultural use of fertilizers)
- Improved estimates for fertilizer fraction on cropland, crop nutrient removal, biological N fixation, and atmospheric N deposition

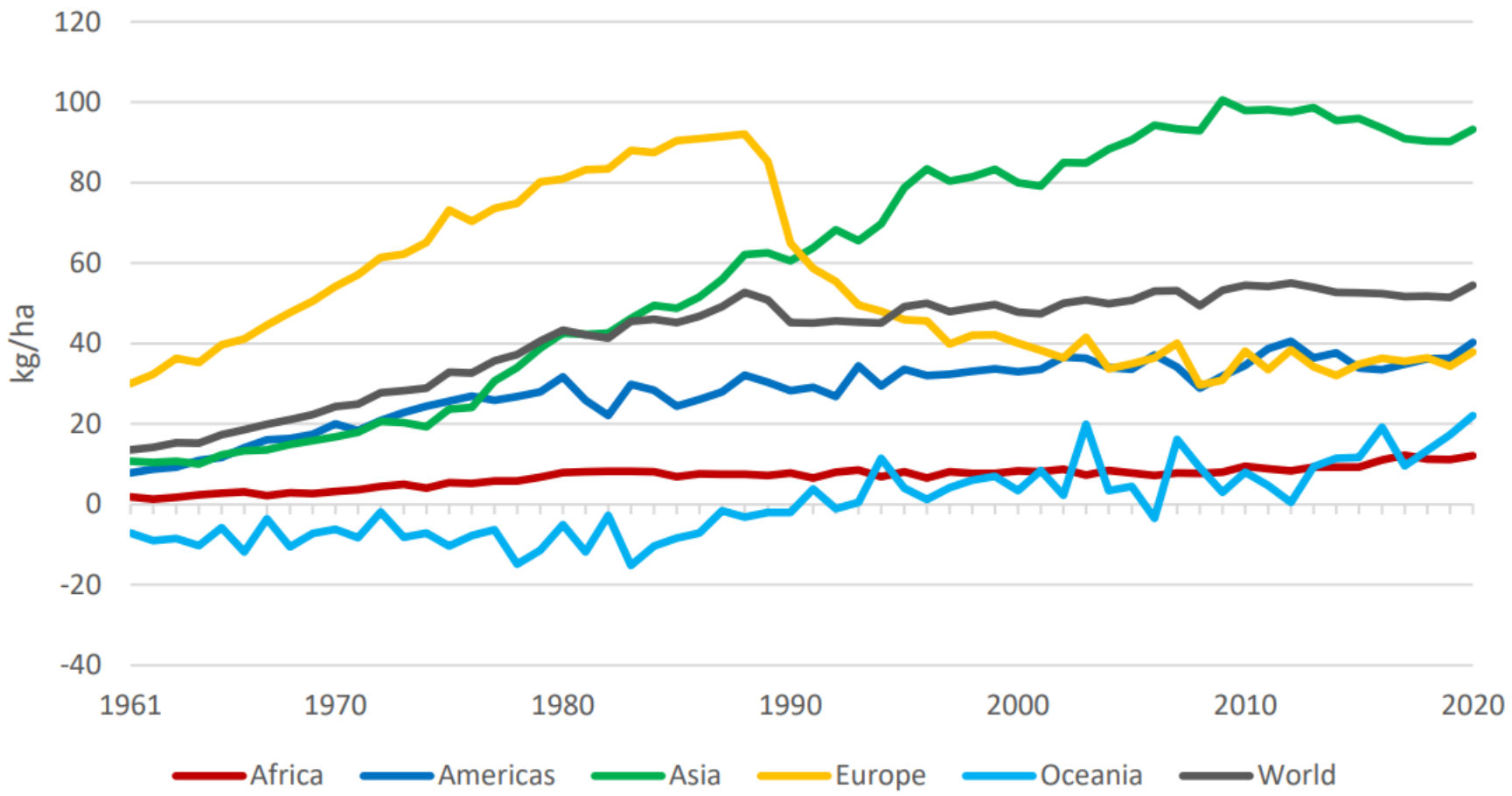
https://www.fao.org/faostat/en/#data/ESB

Figure 2: Global cropland nutrient budget by nutrient



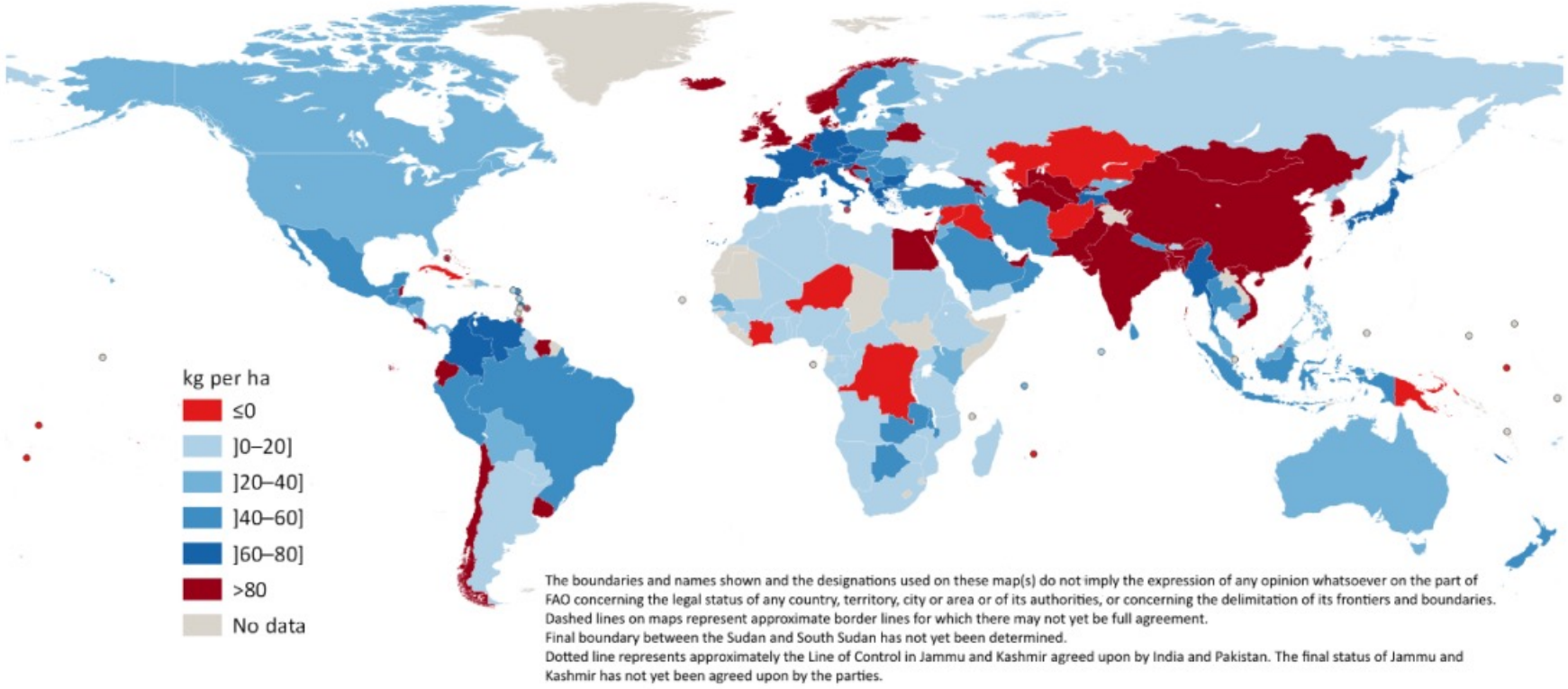
Source: FAO. 2022. FAOSTAT: Cropland nutrient budget. In: *FAO*. Rome. Cited November 2022. https://www.fao.org/faostat/en/#data/ESB

Figure 4: Cropland nitrogen budget per cropland area by region



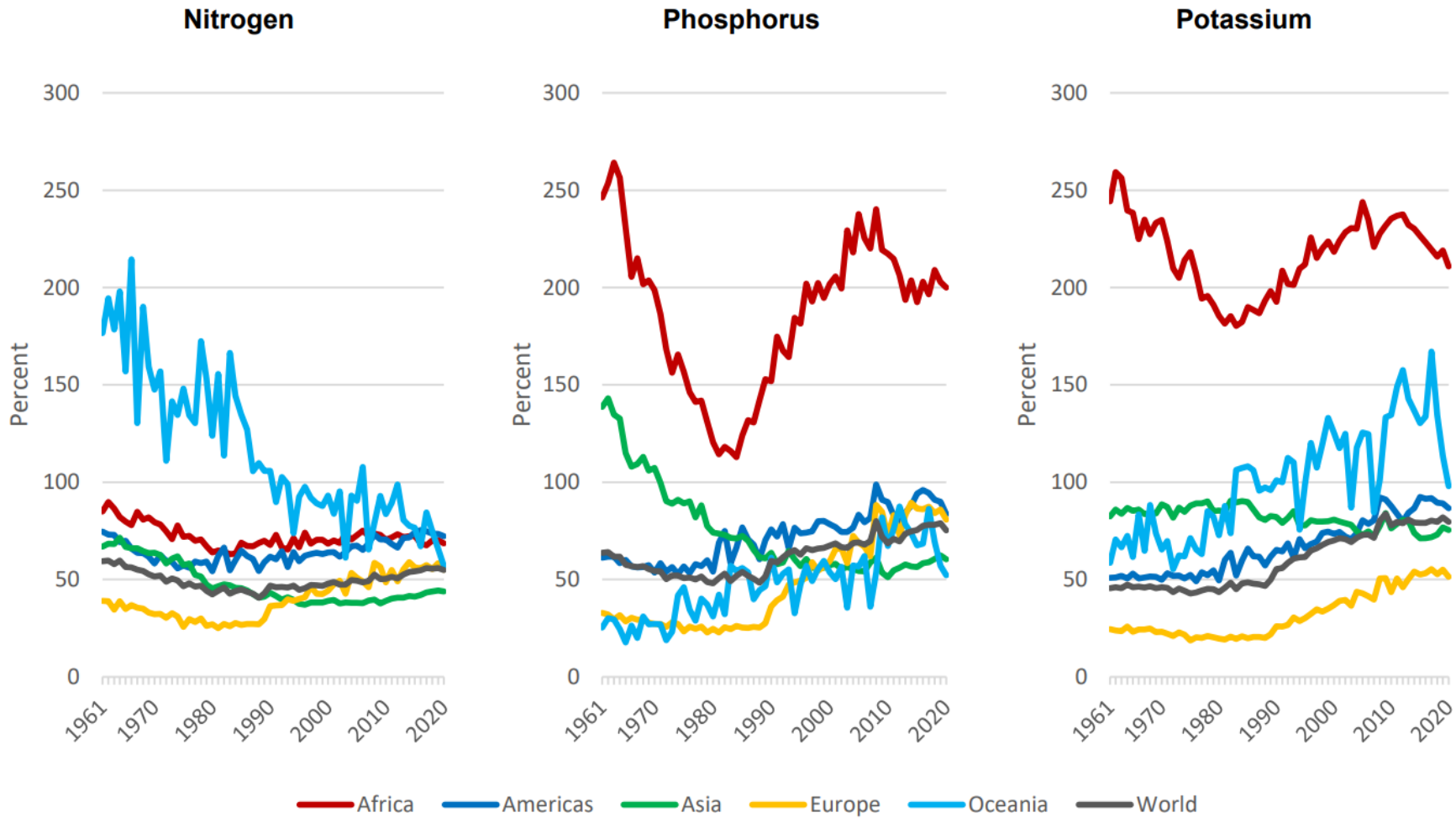
Source: FAO. 2022. FAOSTAT: Cropland nutrient budget. In: *FAO*. Rome. Cited November 2022. https://www.fao.org/faostat/en/#data/ESB

Figure 8: Cropland nitrogen budget per cropland area, 2020



Source: FAO. 2022. FAOSTAT: Cropland nutrient budget. In: *FAO*. Rome. Cited November 2022. https://www.fao.org/faostat/en/#data/ESB based on UN Geospatial. 2020. Map geodata [shapefiles]. New York, USA, UN.

Figure 3: Nutrient use efficiency by region

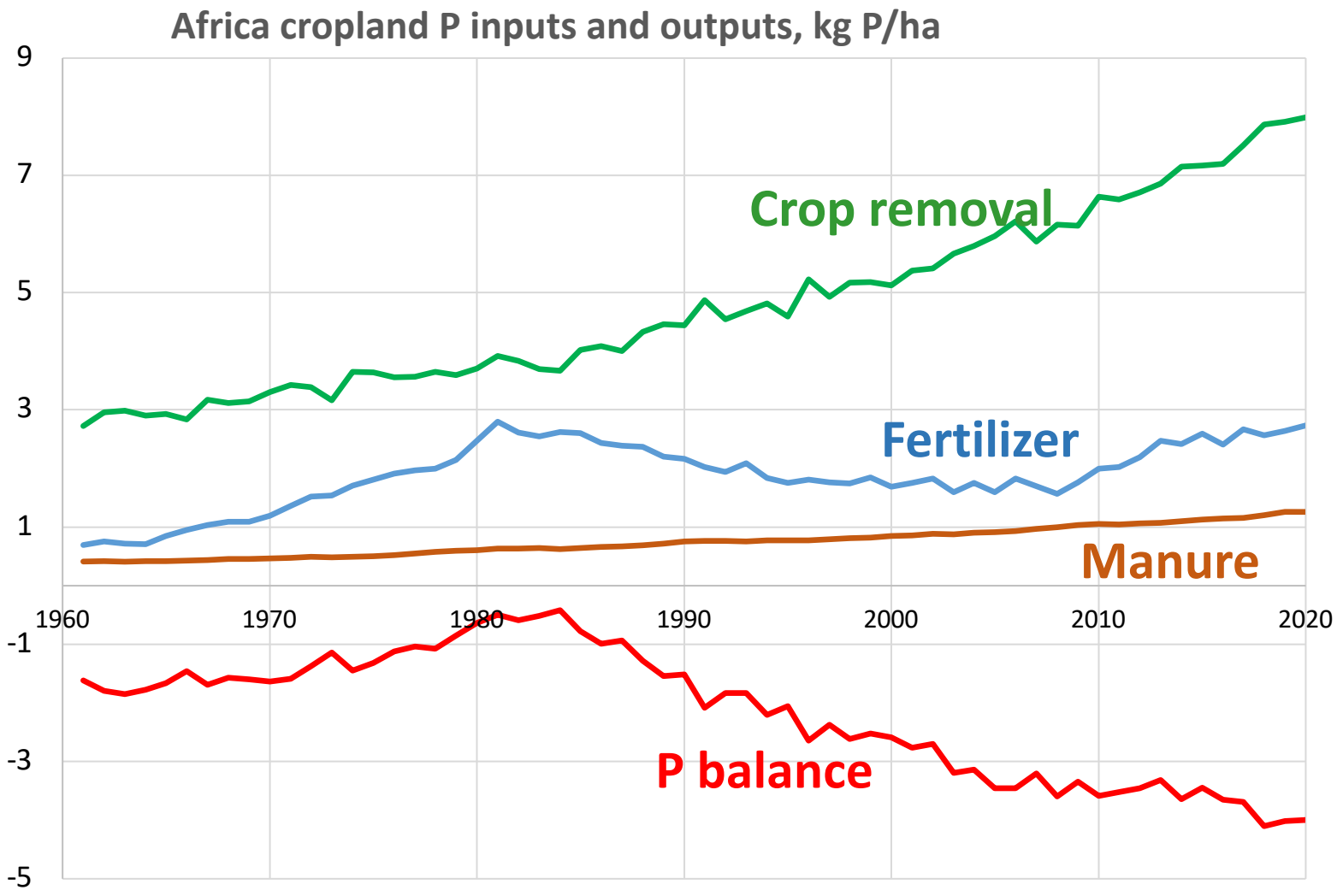


Source: FAO. 2022. FAOSTAT: Cropland nutrient budget. In: *FAO*. Rome. Cited November 2022. https://www.fao.org/faostat/en/#data/ESB

Africa: Decades of soil P mining

Cumulative P balance of -130 kg P/ha cropland in 60 years

- Little manure return?
- Getting worse?
- How variable?



https://www.fao.org/faostat/en/#data/ESB

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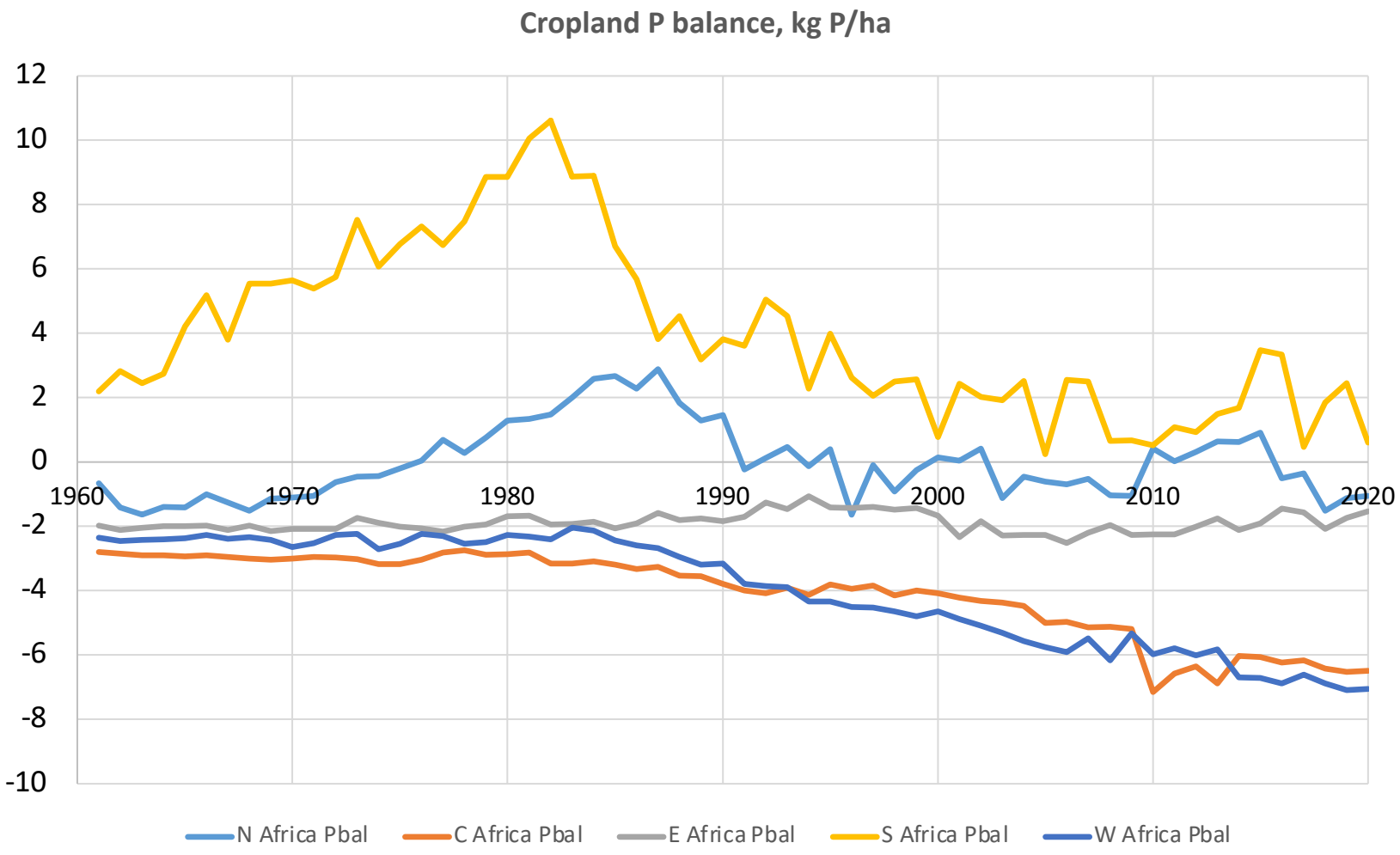
Africa: Decades of soil P mining?

Regional cumulative P balances vary from -245 to +240 kg P/ha cropland in 60 years



https://www.fao.org/faostat/en/#data/ESB

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Further improvements

- Annual updates
- Nutrient budgets for cropland and grassland/forages (all agricultural land)
- Tier 2 and Tier 3 estimates of crop nutrient removal and other components (e.g. Manure, BNF): use of national to sub-national scale coefficients
- Moving to sub-national scale where possible
- Systematic data collection in ~40 countries: national statistics, experts, other sources (fertilizer use, manure, crop residue)
- Crowd-sourcing of local experts (agronomists, extension workers, companies etc.): bottom-up, stratified agronomic data collection and standardized processing (fertilizer use by crops, crop residue, manure, other practices affecting the nutrient budget)

  → Can the CPCN lead on that?

Agronomic data collection at national scale

1. Crop disaggregation
- Combine crops based on area overlap

2. Selection of Climate Zones (CZ)
- Select climate zones (CZ) with >3% of national crop area

3. Delineation of candidate sampling areas (SA)
- Create candidate sampling areas of 100-km radius and select those that account for >1% of national harvested area

4. Selection of sampling areas (SA)
- Within each selected CZ, identify SAs with largest national harvested area until 50% of total national area was covered

5. Collection of agronomic data
- Within each selected SA, data of the variables of interest are collected via surveys or expert opinion

6. Upscaling
- Upscale value from local to CZ and to national level weighting by crop area

Fatima Tenorio, Patricio Grassini, others, University of Nebraska-Lincoln (submitted)

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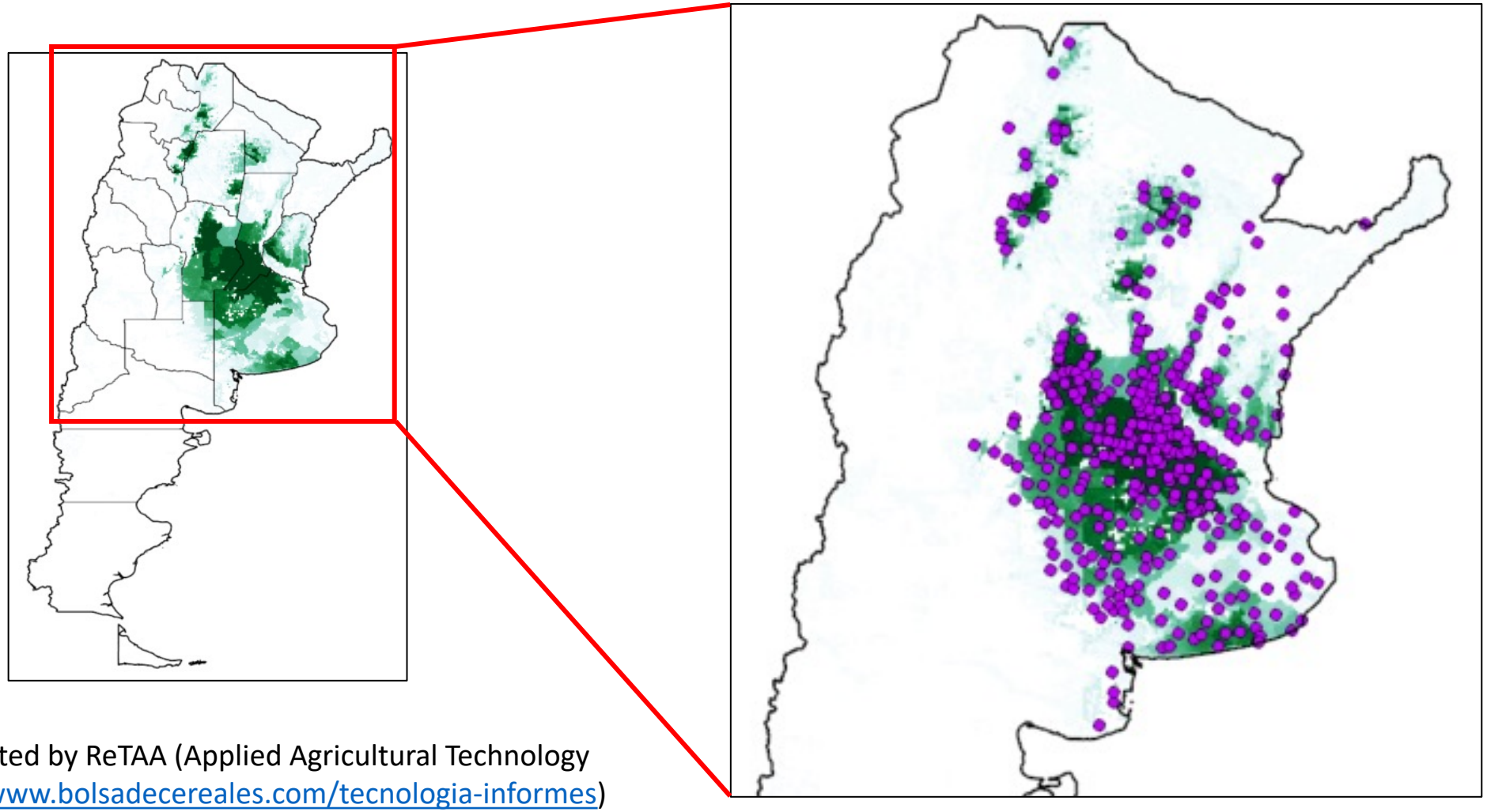
University of Nebraska Lincoln

Proof of concept: fertilizer use by crop in Argentina

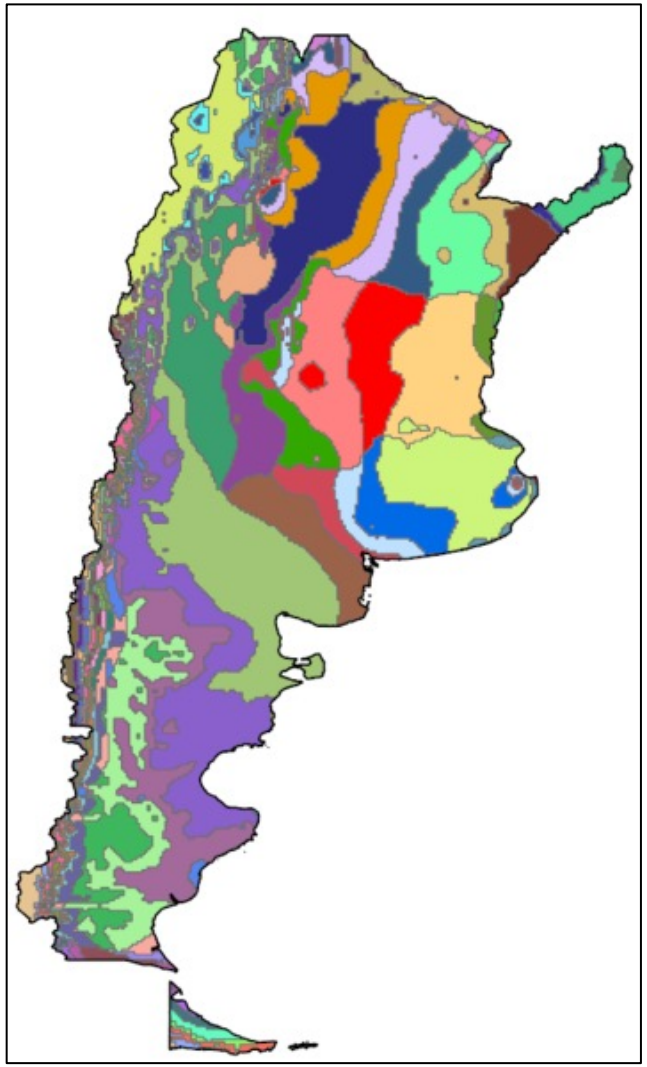
- Large producing country with ca. 25 million ha planted with maize, soybean, and wheat
- Data from 300 qualified informants reporting average N, P, and S rates over three crop seasons (2017, 2018, and 2019)



Data were collected by ReTAA (Applied Agricultural Technology Survey, https://www.bolsadecereales.com/tecnologia-informes)

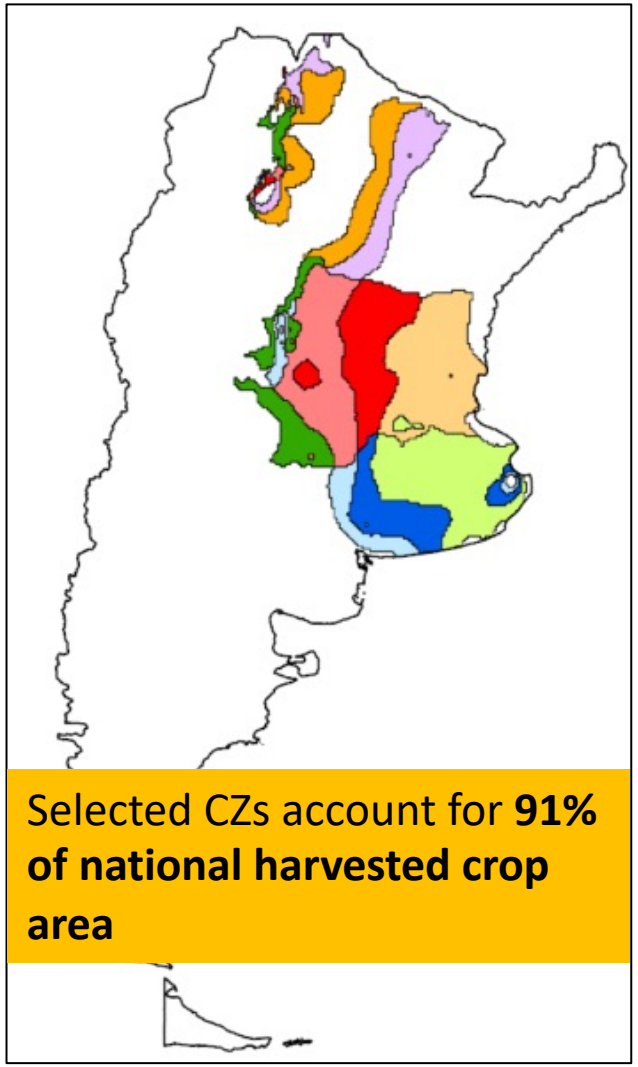
Target **crop(s)/country**

Argentina: Wheat, Maize, Soybean



Selected **Climate Zones (CZ)**

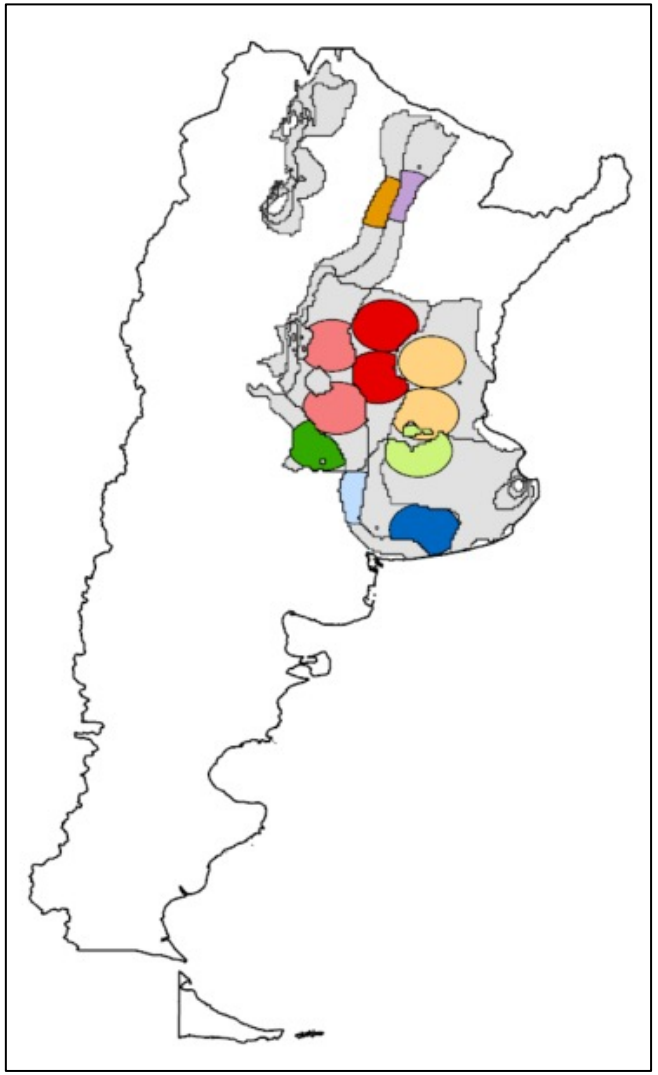
Select climate zones that account for **>3%** of national crop area (**9 CZs**)



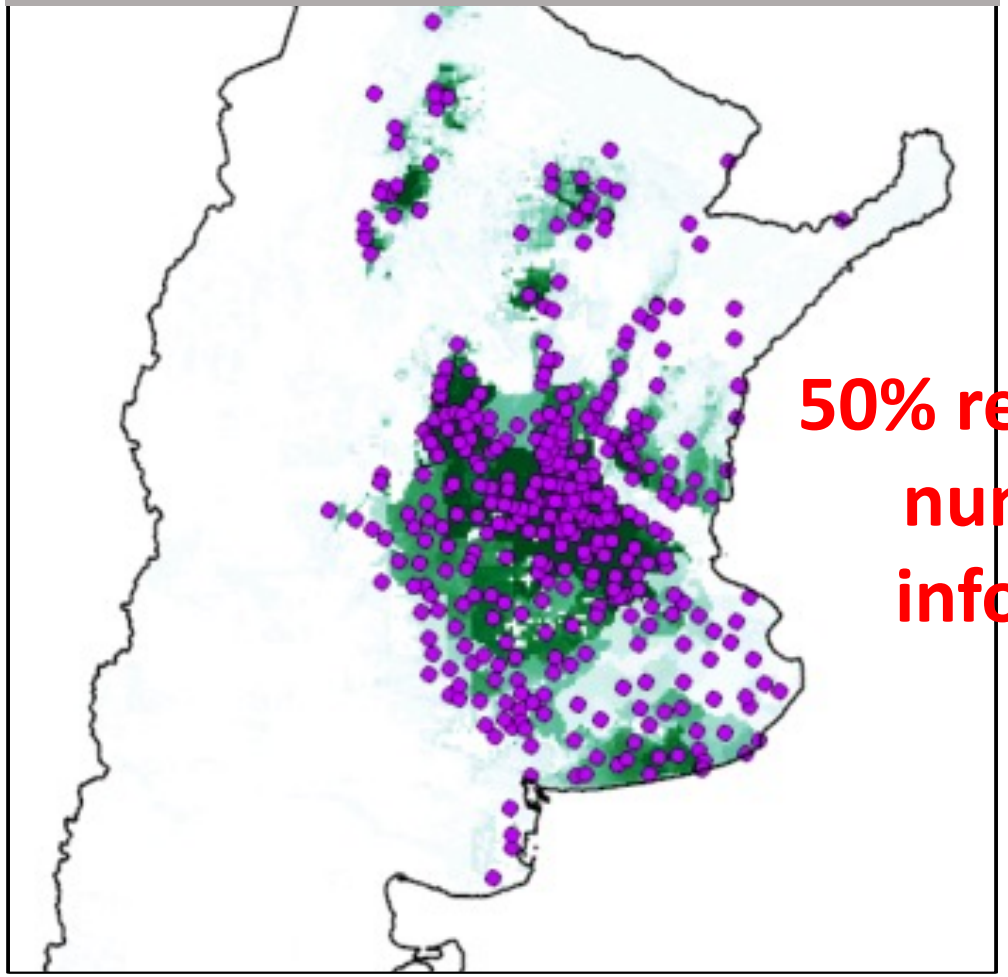
Selected CZs account for **91% of national harvested crop area**

Selected **Sampling Areas (SA)**

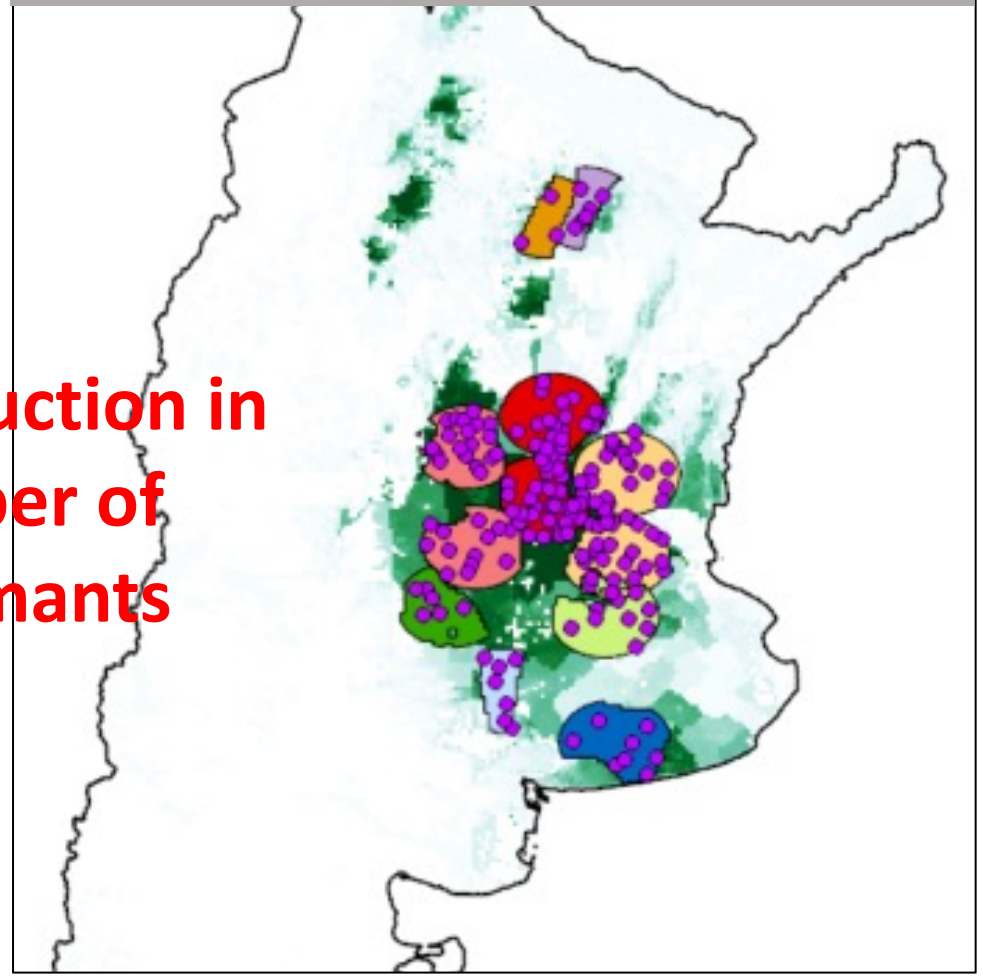
Select the largest SAs until they represent **50%** of total national crop area (**12 SAs**)



Whole database:~ 300 informants per year per crop



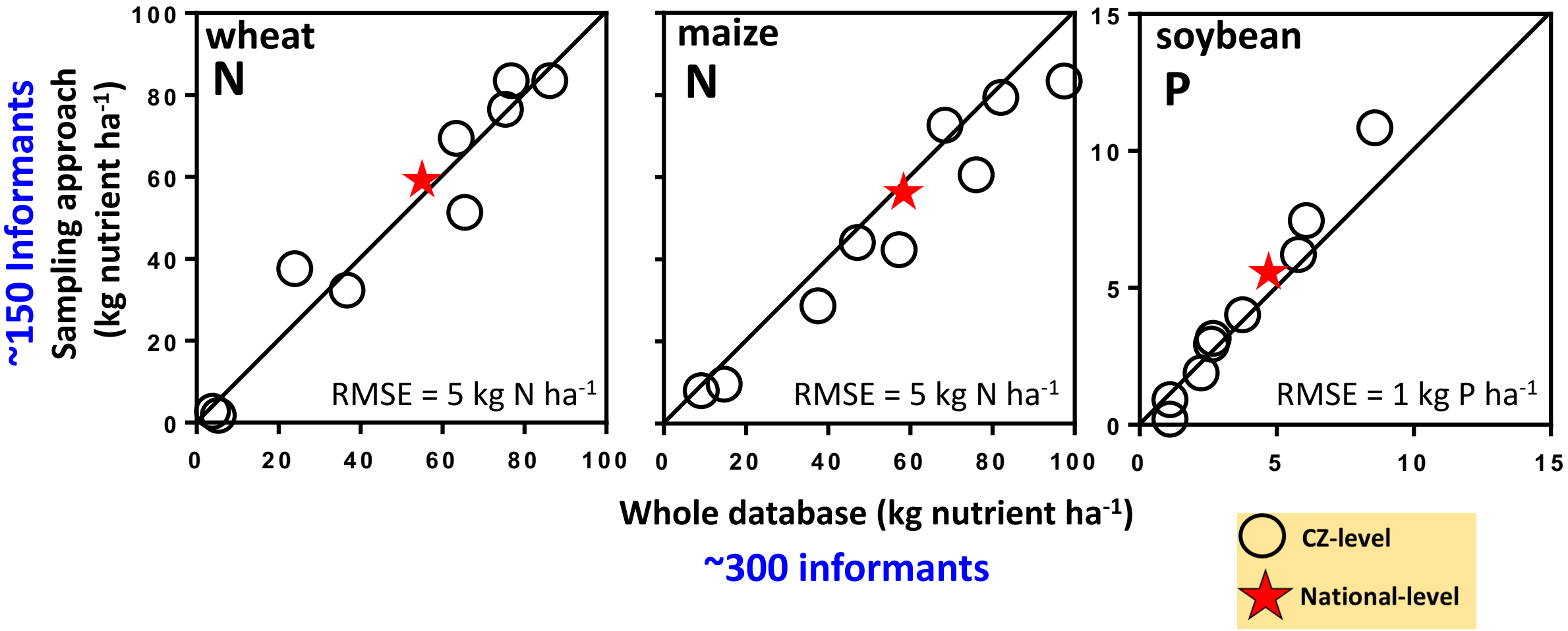
Sampling approach: ~150 informants per year per crop



50% reduction in number of informants

Fatima Tenorio, Patricio Grassini, others, University of Nebraska-Lincoln (submitted)

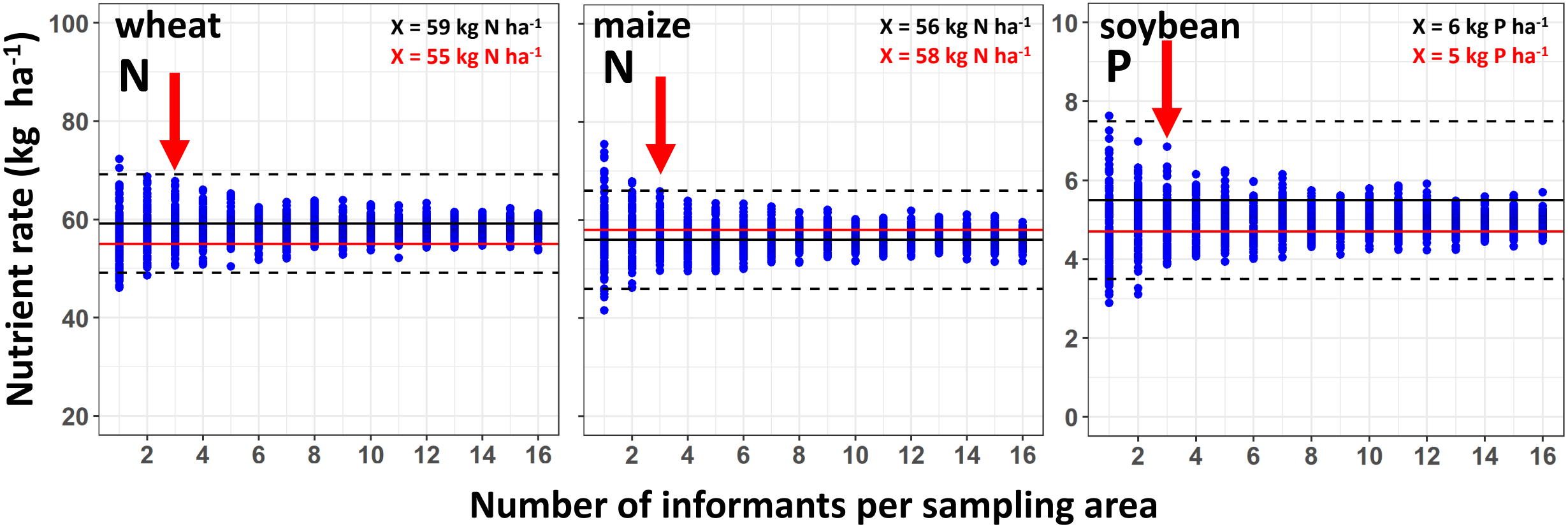
Our sampling data approach delivered estimates of nutrient fertilizer rates that were comparable to those estimated using the entire database either at sub-national (i.e. CZ) and national levels



Fatima Tenorio, Patricio Grassini, others, University of Nebraska-Lincoln (submitted)

Minimum number of enumerators per Sampling Area

Three informants per SA delivered average nutrient rates at national level within ± 10 kg N ha^{-1} and ± 2 kg P ha^{-1} that those estimated using the entire database (300 informants)



X: weighted mean; SA: Sampling areas

Fatima Tenorio, Patricio Grassini, others, University of Nebraska-Lincoln (submitted)

Expand this?

- Apply the stratified approach in other countries to achieve at least 75% coverage for main crops
- Create and regularly survey national networks of agronomists and other experts for minimum agronomic information; process in a standardized manner
- **Agronomic data portal:** nutrient rates (N, P, K & S) at subnational and national level, nutrient balances, actual nutrient use efficiency (benchmarking, monitoring), agronomic information needed for decision tools development and validation, etc.
- Keep it simple & must have tangible benefits for data contributors