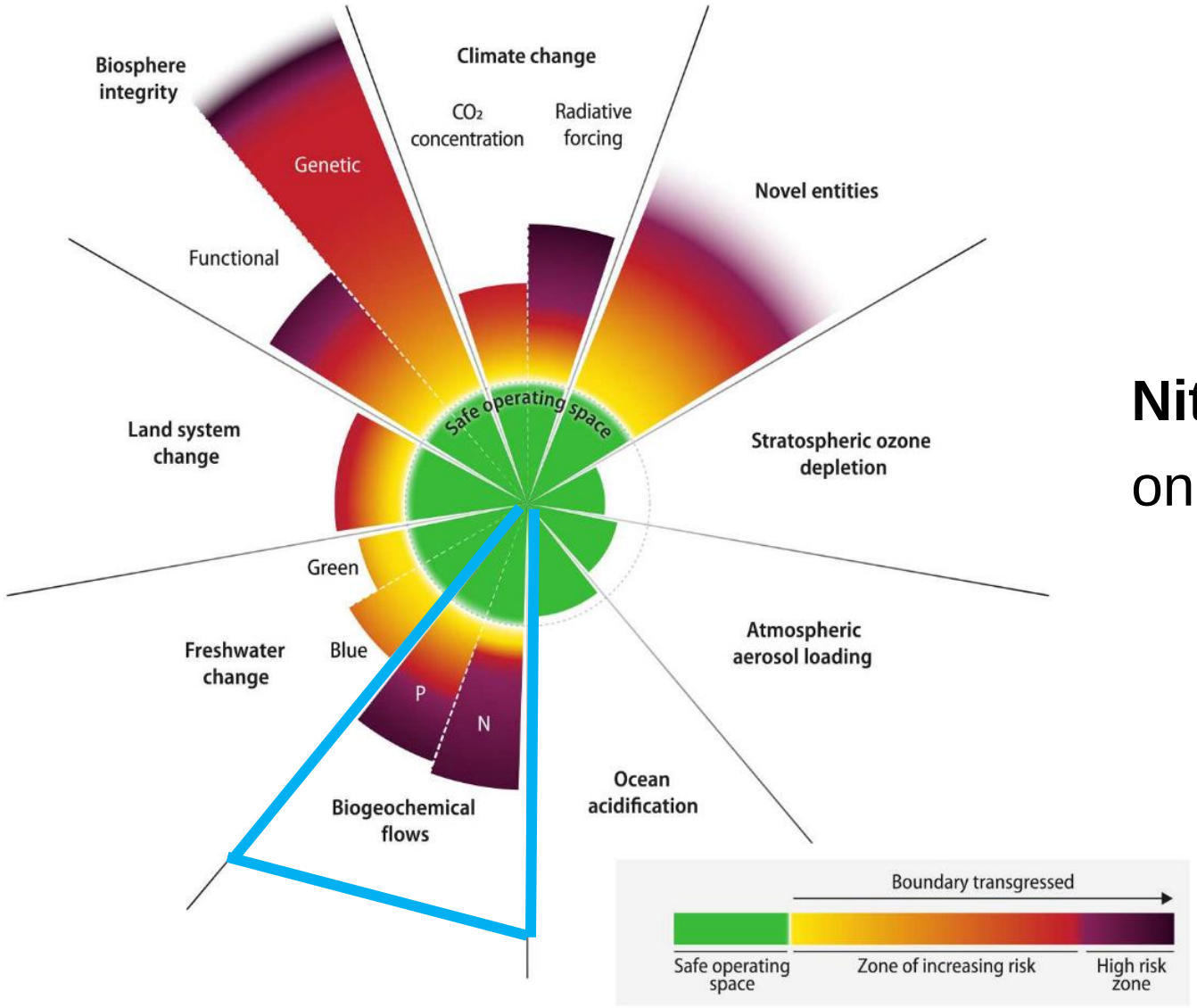
Source-separation for circularity of nutrients and reuse in agriculture

Julien Le Roux, Régis Moilleron, Fabien Esculier, Tanguy Fardet, Thomas Starck

18-20. Septembar 2024. Novi Sad

Planetary boundaries



Nitrogen and phosphorus cycles:

one of the six transgressed boundaries

Richardson *et al.*, Science Advances, 2023

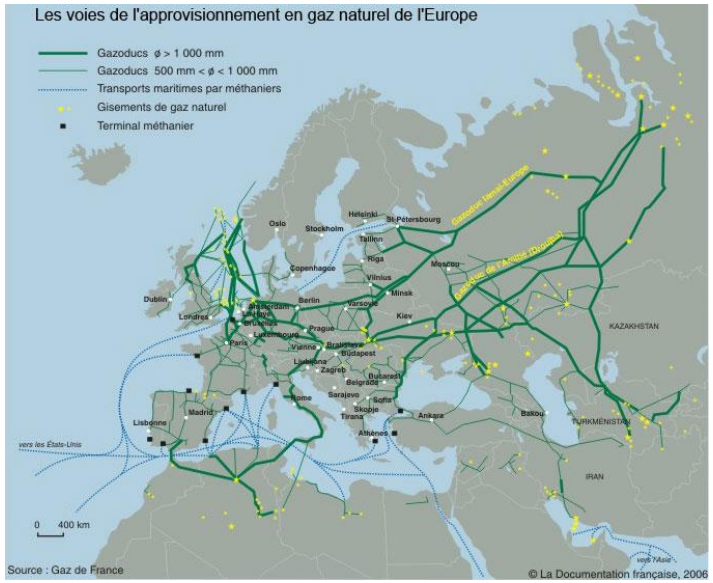
The nitrogen path to our plates

N_2

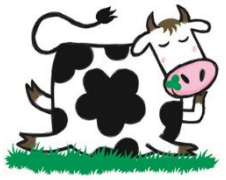
Haber-Bosch process

2.5% of greenhouse gases emissions in France

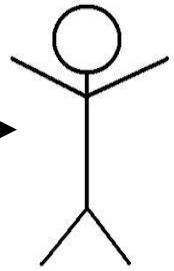
Methane (natural gas)



Chemical fertilizers

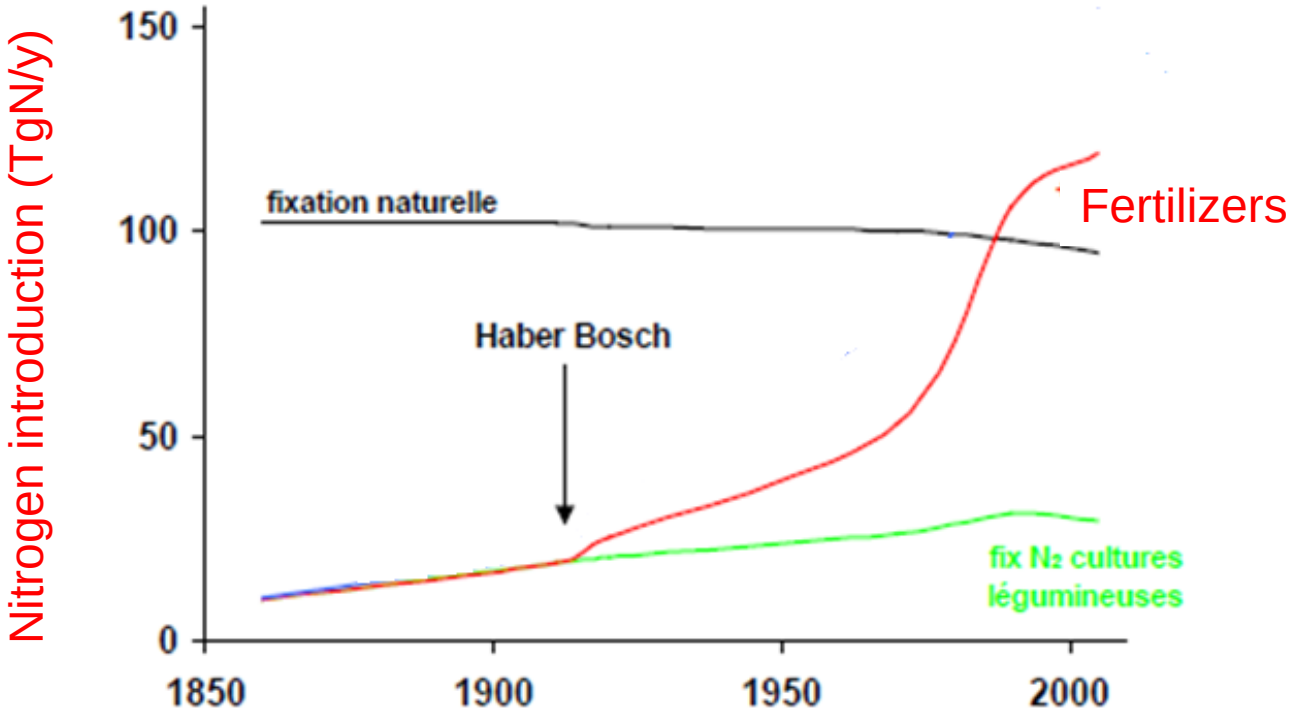


20-50 kg N



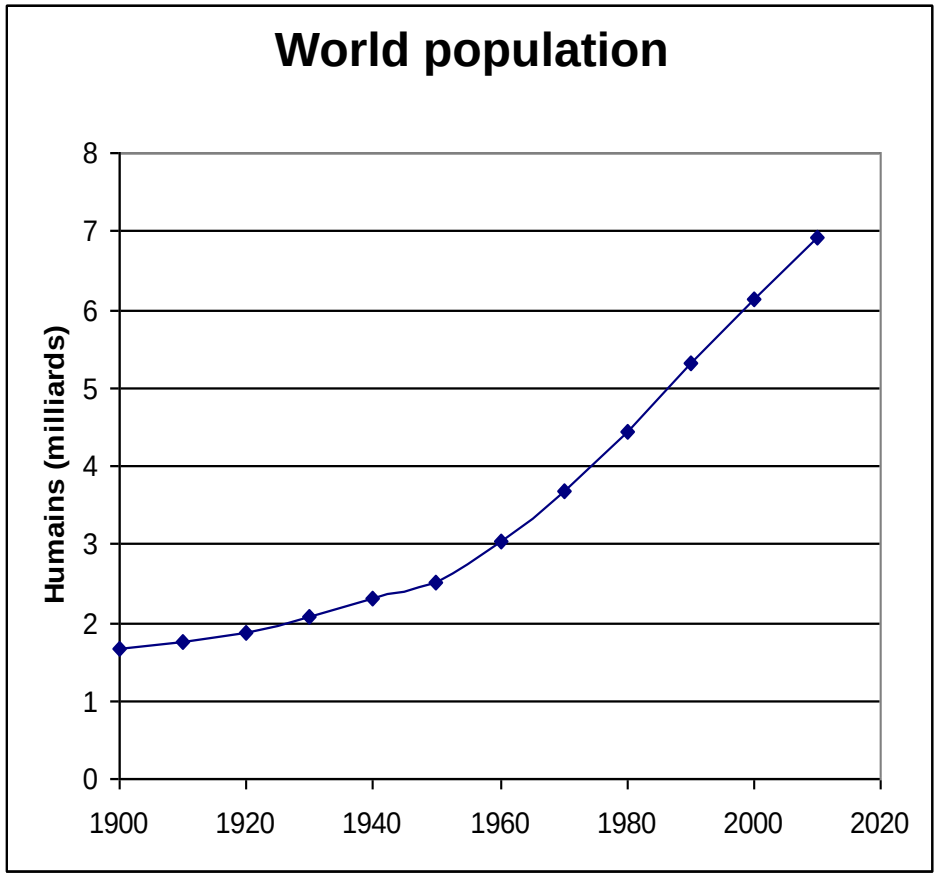
5 kg N

More than a revolution



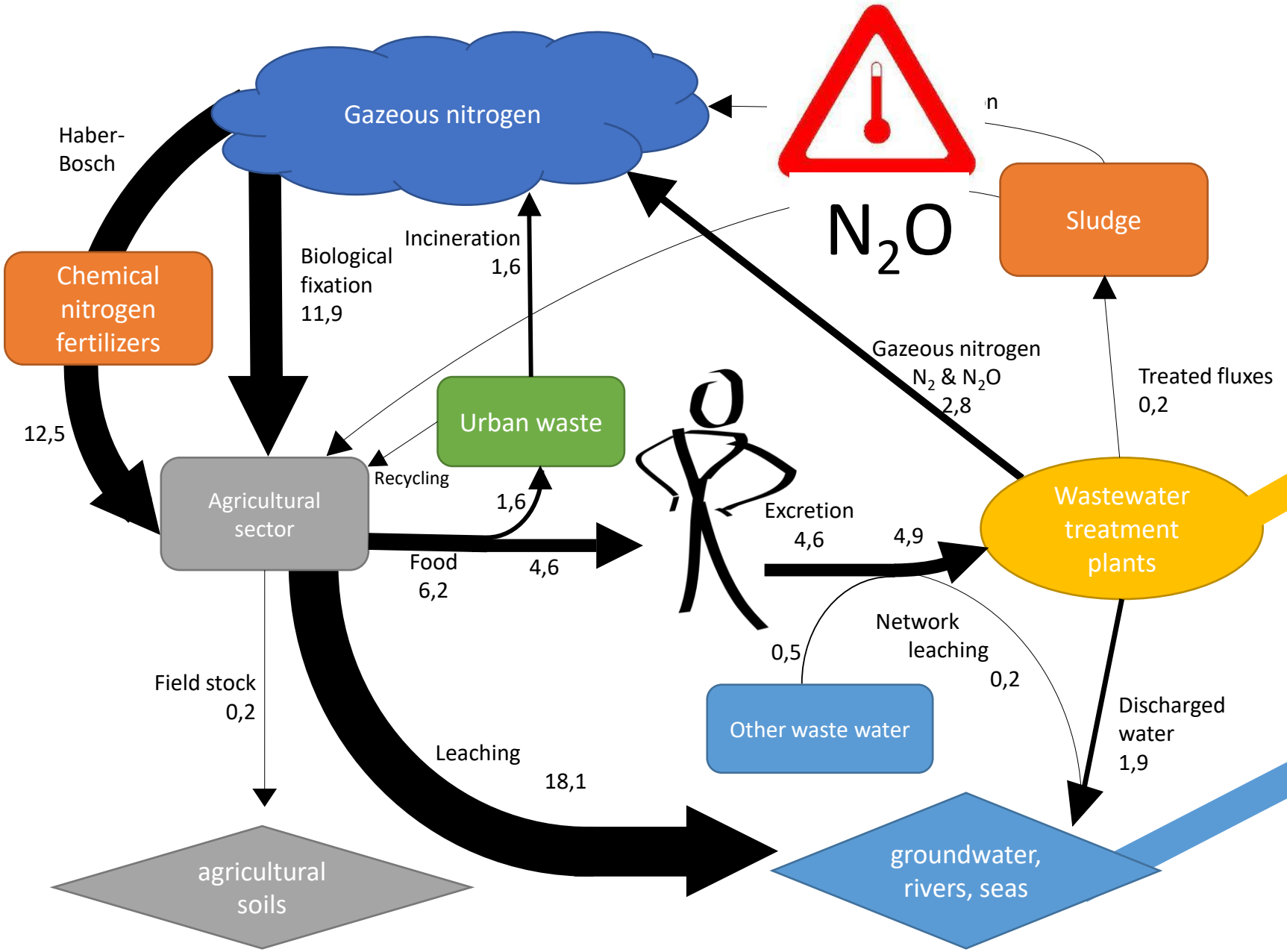
« Anthropocene »

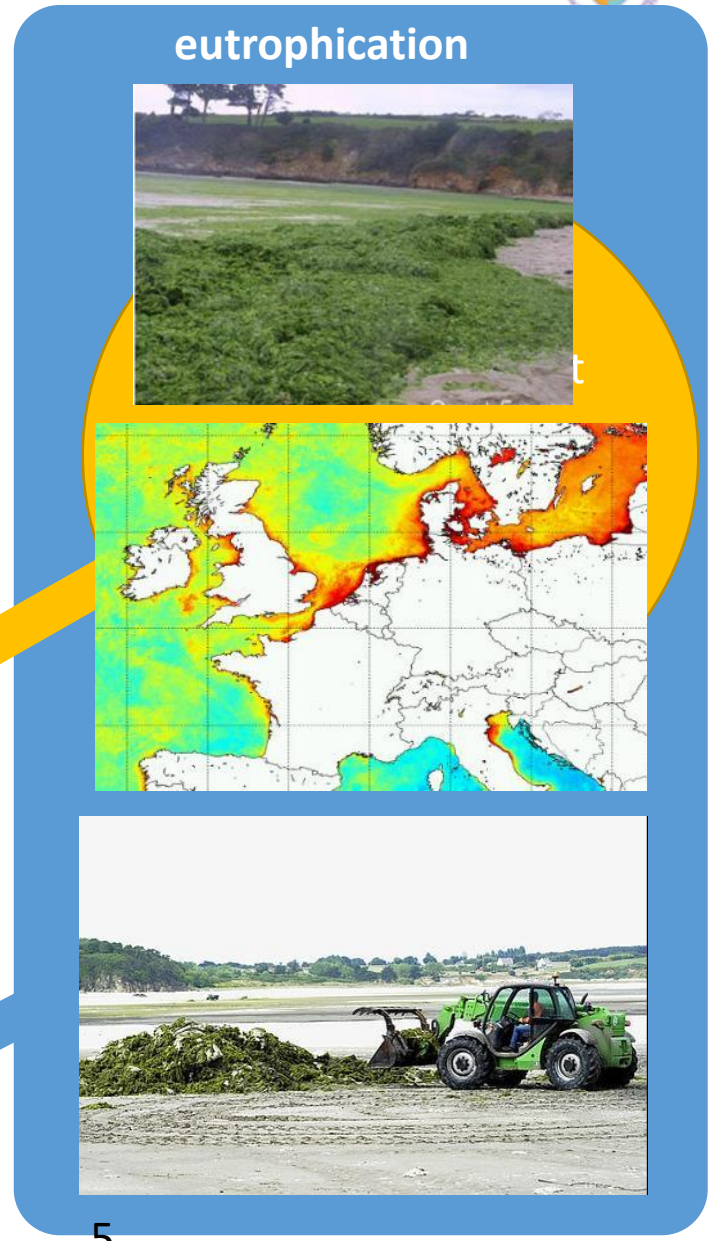
(Paul Crutzen, 2002)



US Census Bureau ; ONU, 2012

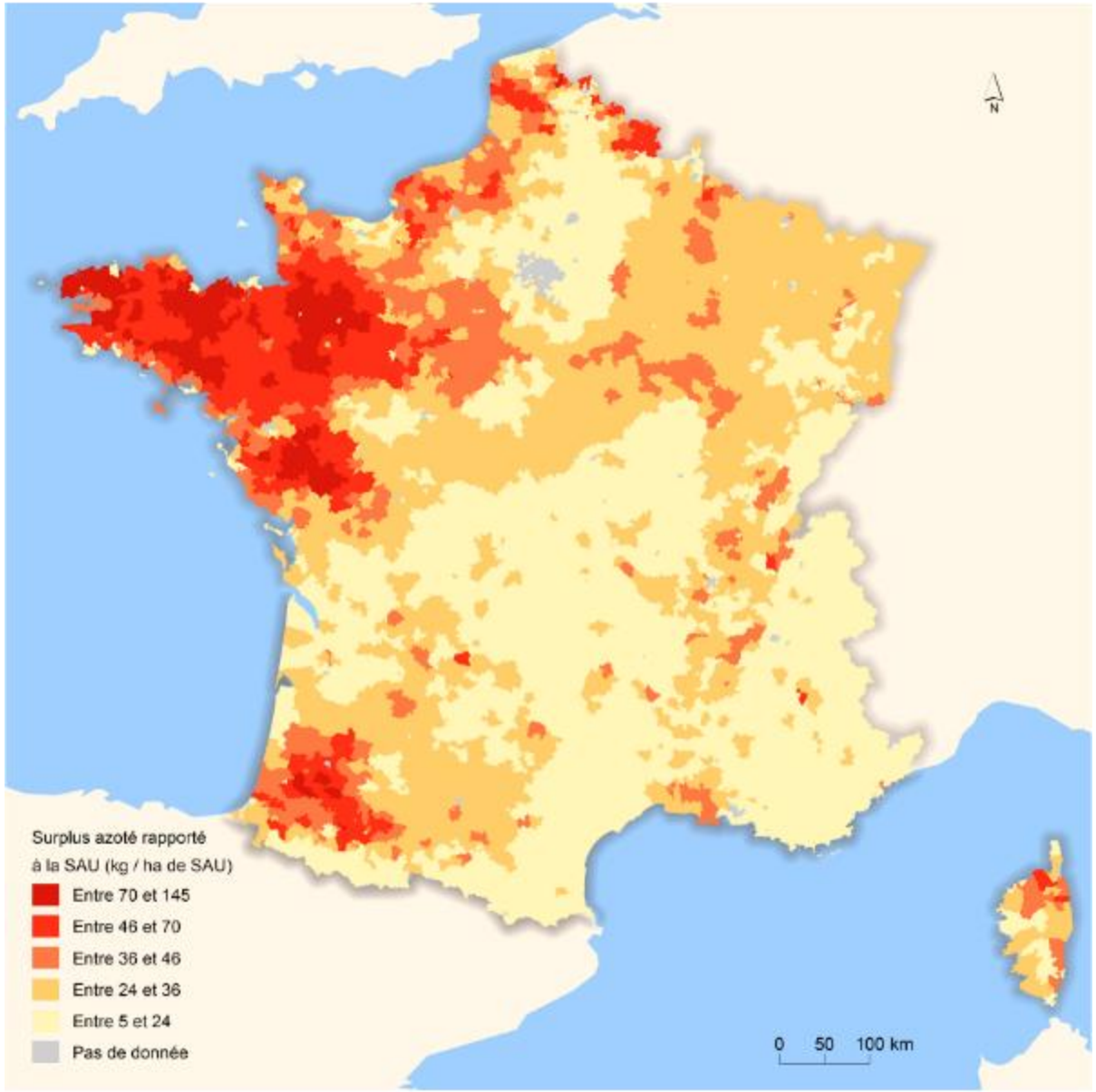
A crazy nitrogen cycle ? (kgN/year/inhab)





Esculier & Créno 2015

Répartition territoriale du surplus azoté en 2010 à l'échelle du canton



Champ : France métropolitaine.
Source : SOeS, Nopolu - agri 2010. Traitements : SOeS, 2014

AFP/Damien Meyer

Regulation

Urban Wastewater Treatment Directive

European Framework Directive 21 may 1991 (91/271/CEE)

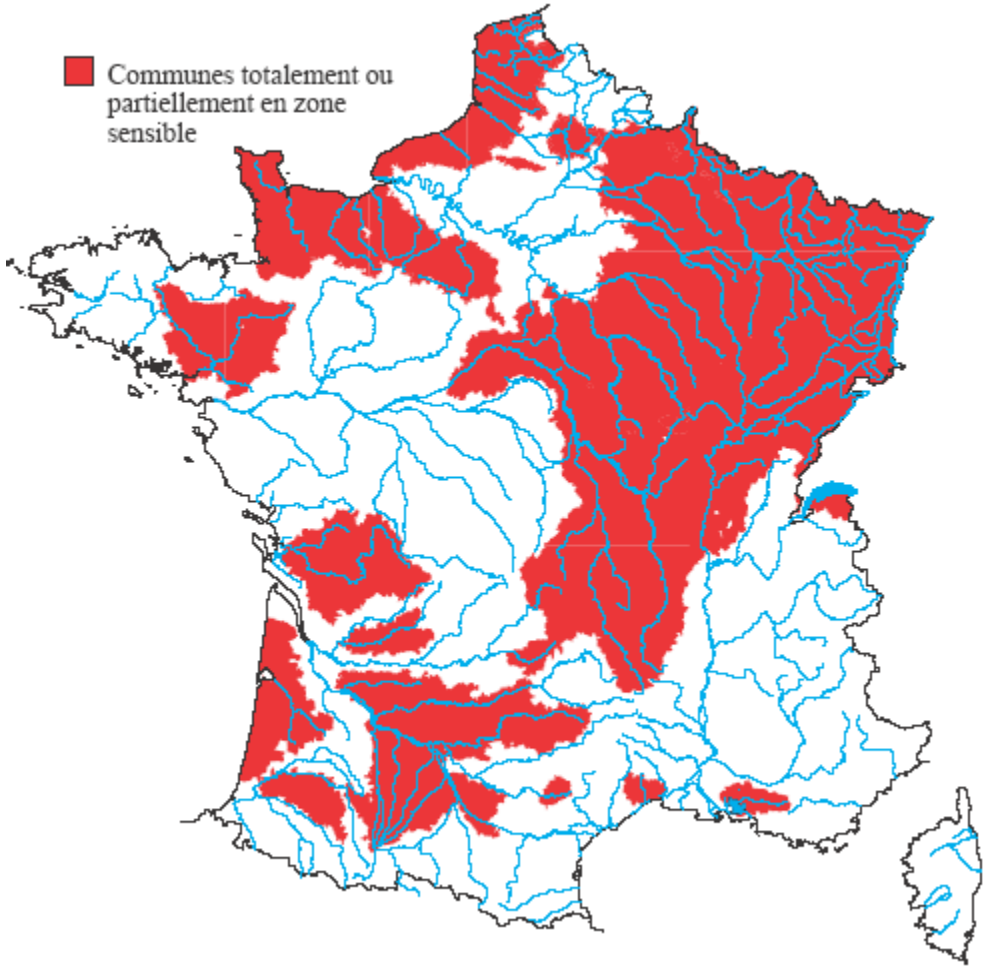
French Water Law 1992 - Decrees n°94-469 & 2000-318
➔ **France : Decree 21 july 2015** for collection, transportation and treatment of wastewater in urban areas, and for individual *on-site* sanitation systems
(+ modifications in decree 31 july 2020)

- **Minimum levels of treatment**
- deadlines for **conformity of WWTPs**
(depends on city size, and sensitive areas)

➔ **sensitive areas**
Sensitive to eutrophication: N & P discharges to be reduced
Specific protections of: water intakes, swimming areas, fish farming…

Sensitive areas

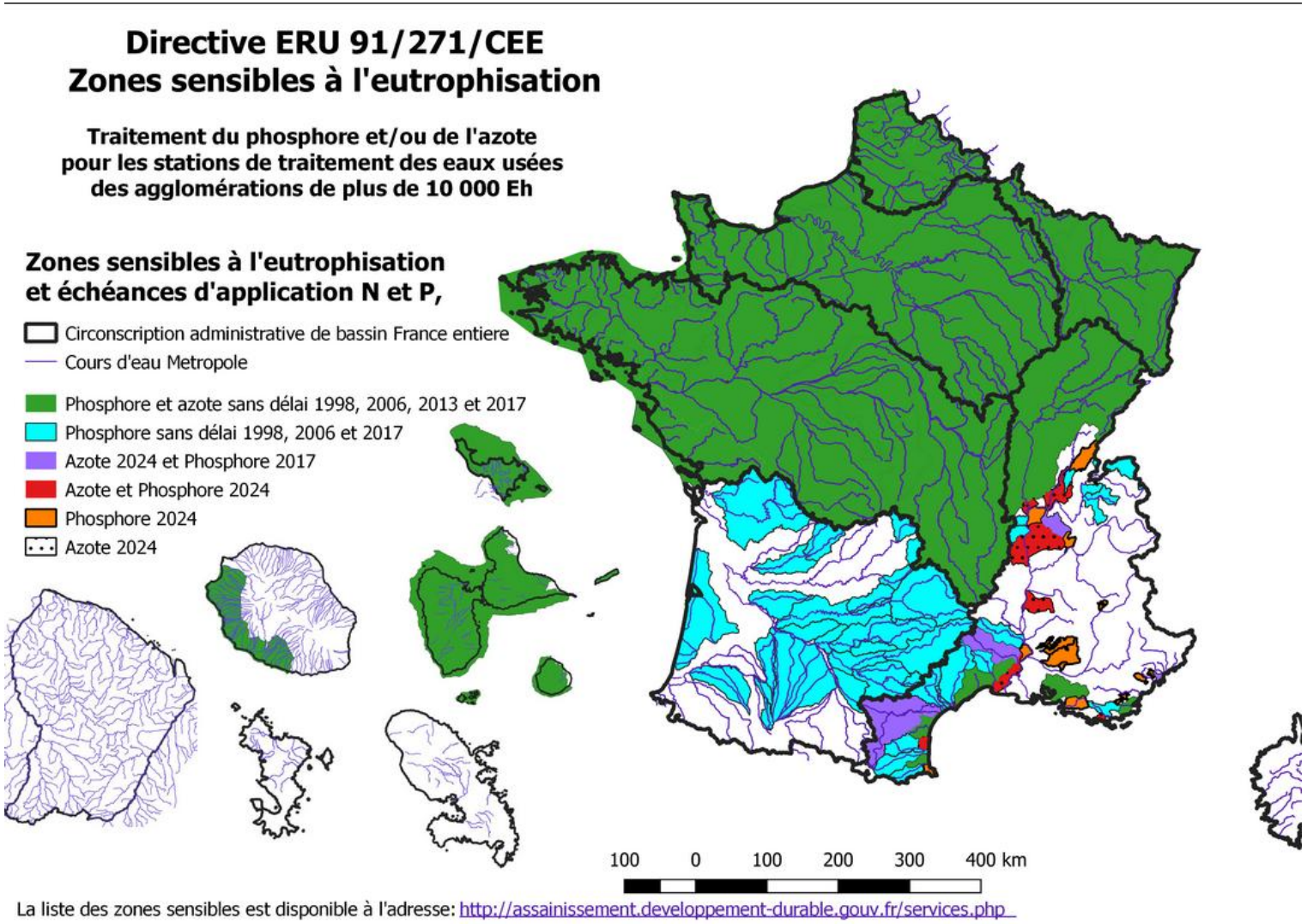
- 1998: 45% of surface
- 2006: 69%



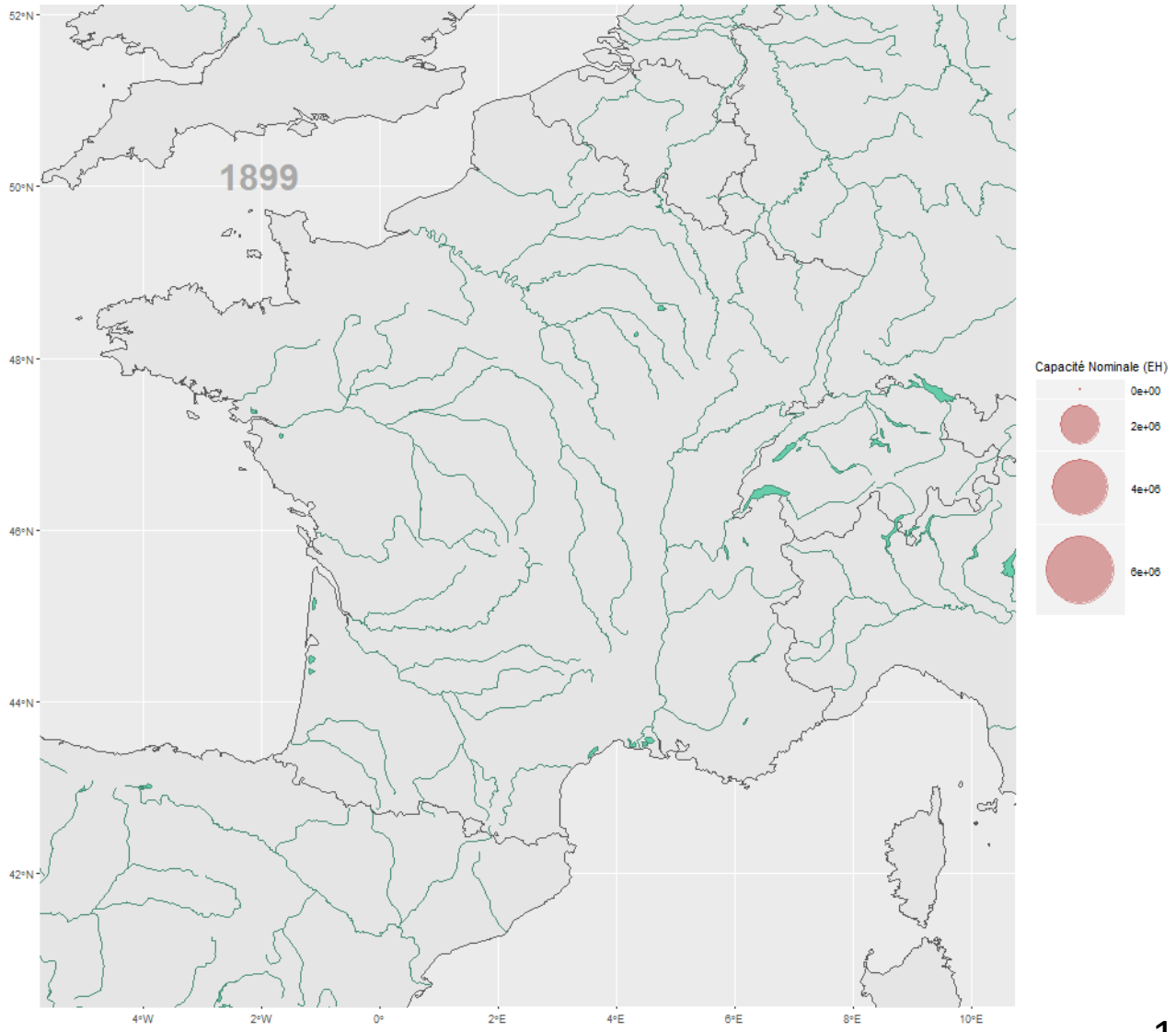
2006

Sensitive areas

2020

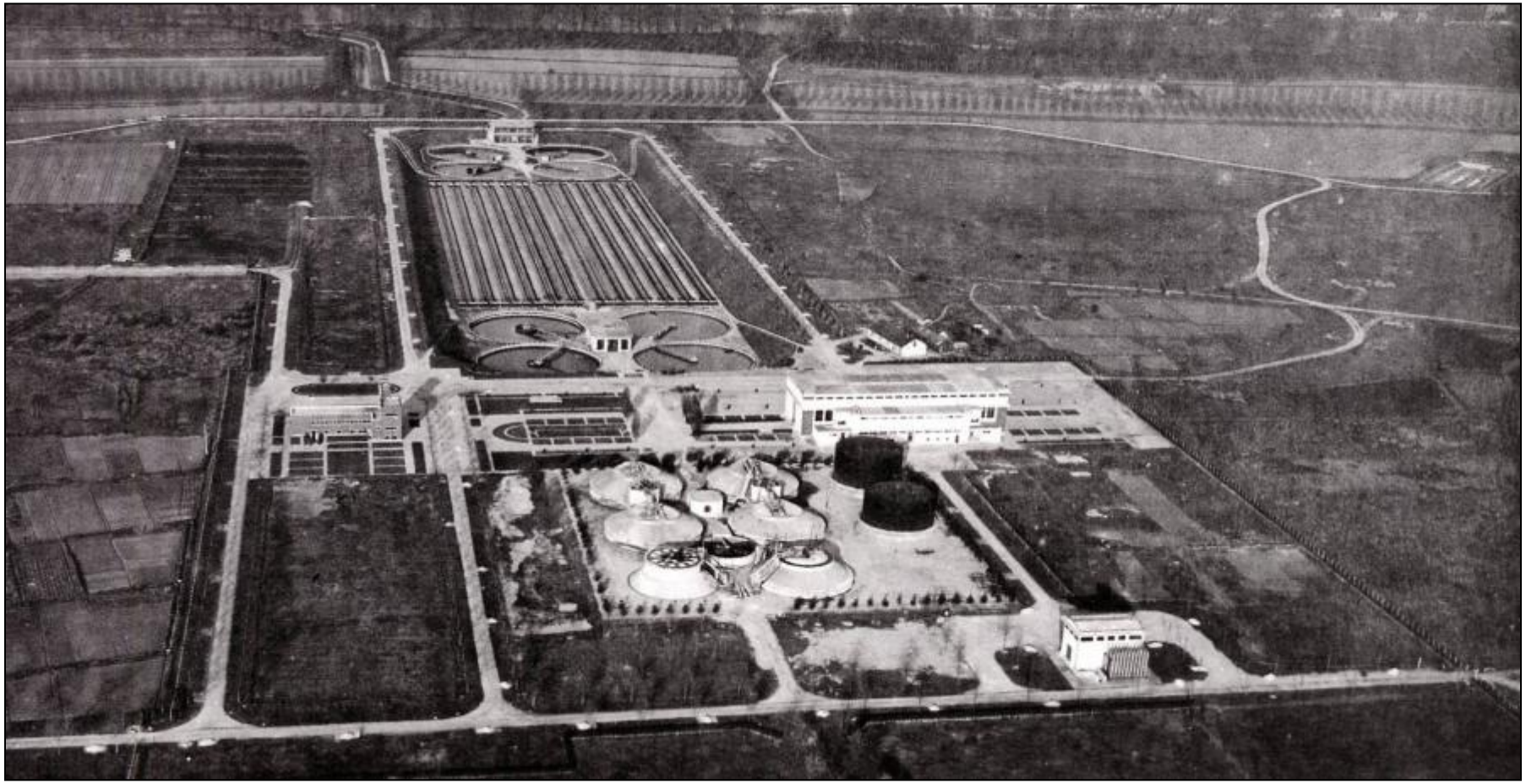


WWTPs built in France over the years

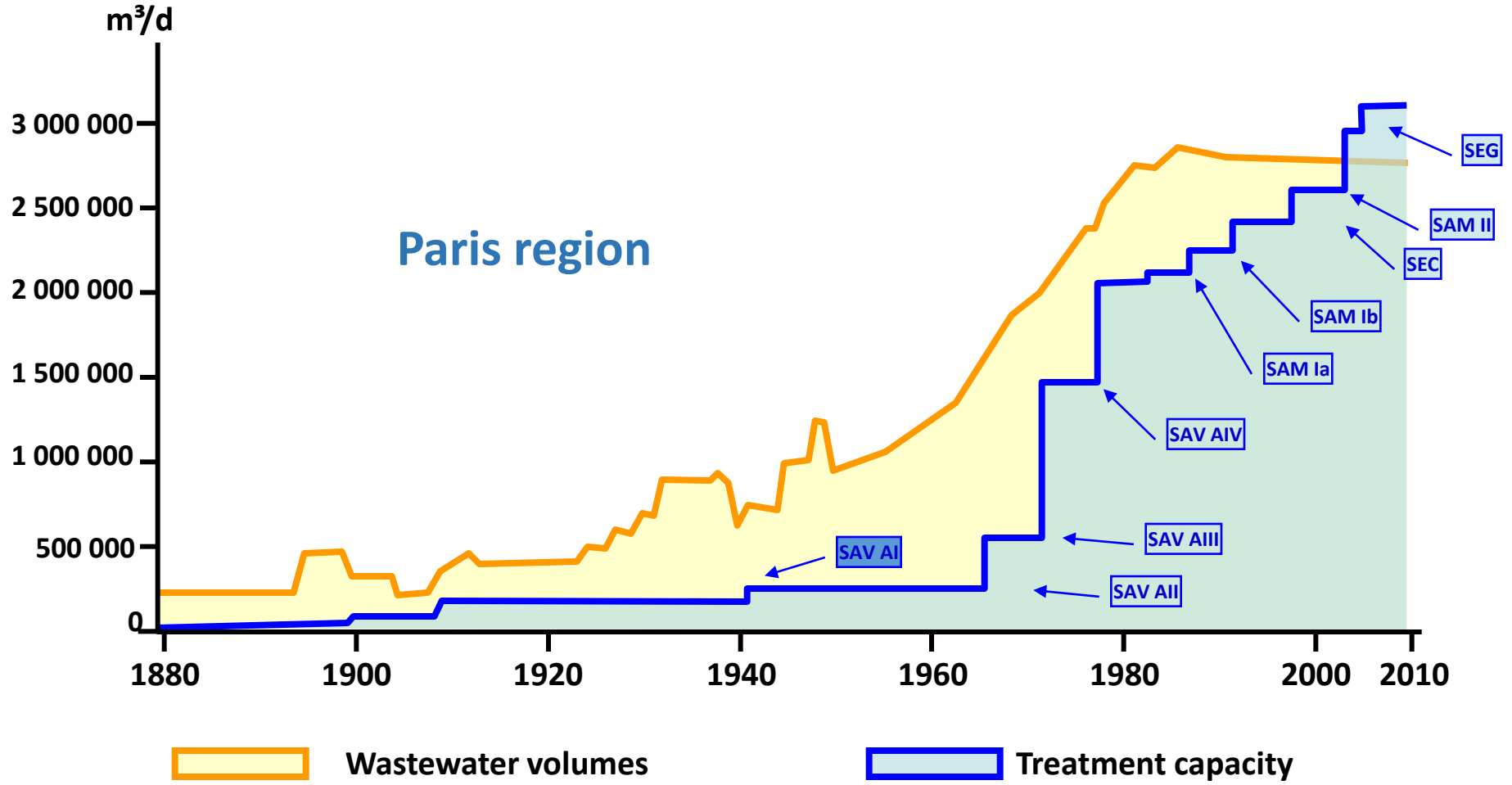


Data from geo.data.gouv.fr

1940: Achères 1



WWTPs trying to catch up



Regulation

Conformity of WWTPs in France

Situation in 12/2019 for 3 989 WWTPs (> 2 000 inh.)

3234 (81%) with good performances
718 (18%) not complying with treatment efficiency (for C and/or P & N)

Each year: 2 à 3% of WWTPs need to be replaced/renovated because of insufficient capacity (or old equipment).

50 to 100 WWTPs each year! (for cities > 2000 inh.)

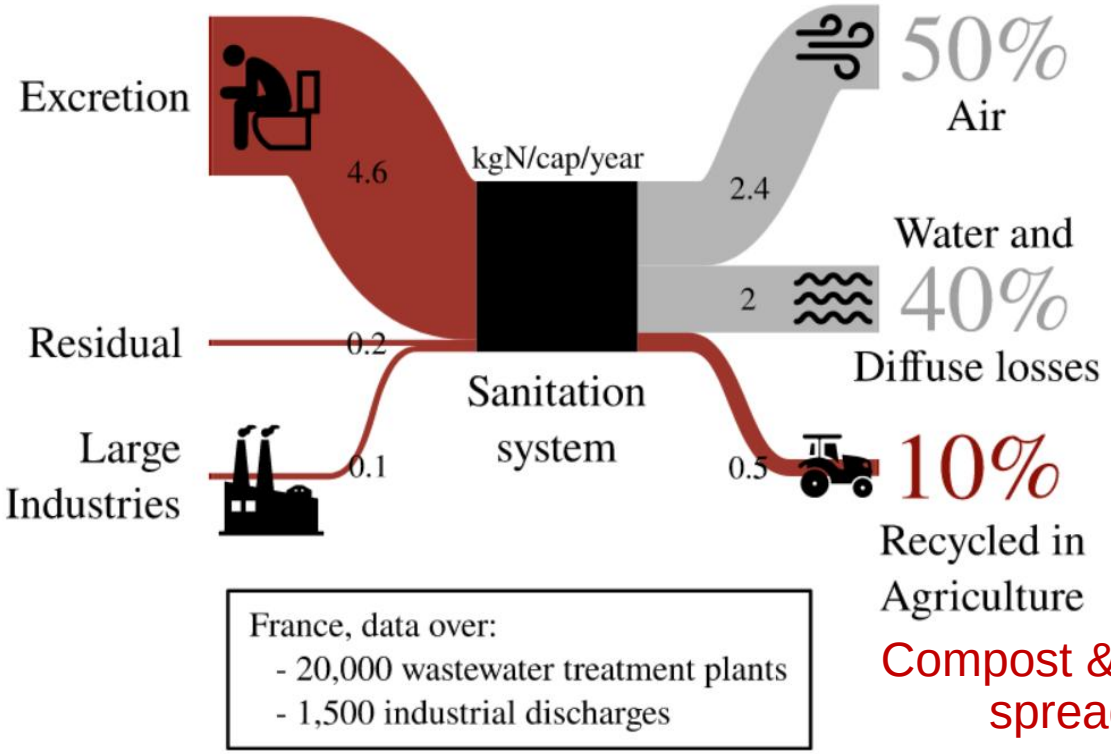
Water Workshop 2024

SmartWaterTwin

Funded by the European Union

SmartWater Summer FORUM

Nitrogen as a resource?



https://doi.org/10.1016/j.scitotenv.2023.168978

Thomas Starck PhD thesis

What is the potential of human N excretions for fertilization?

Spatial constraint: How to match excretions and uses in crops?

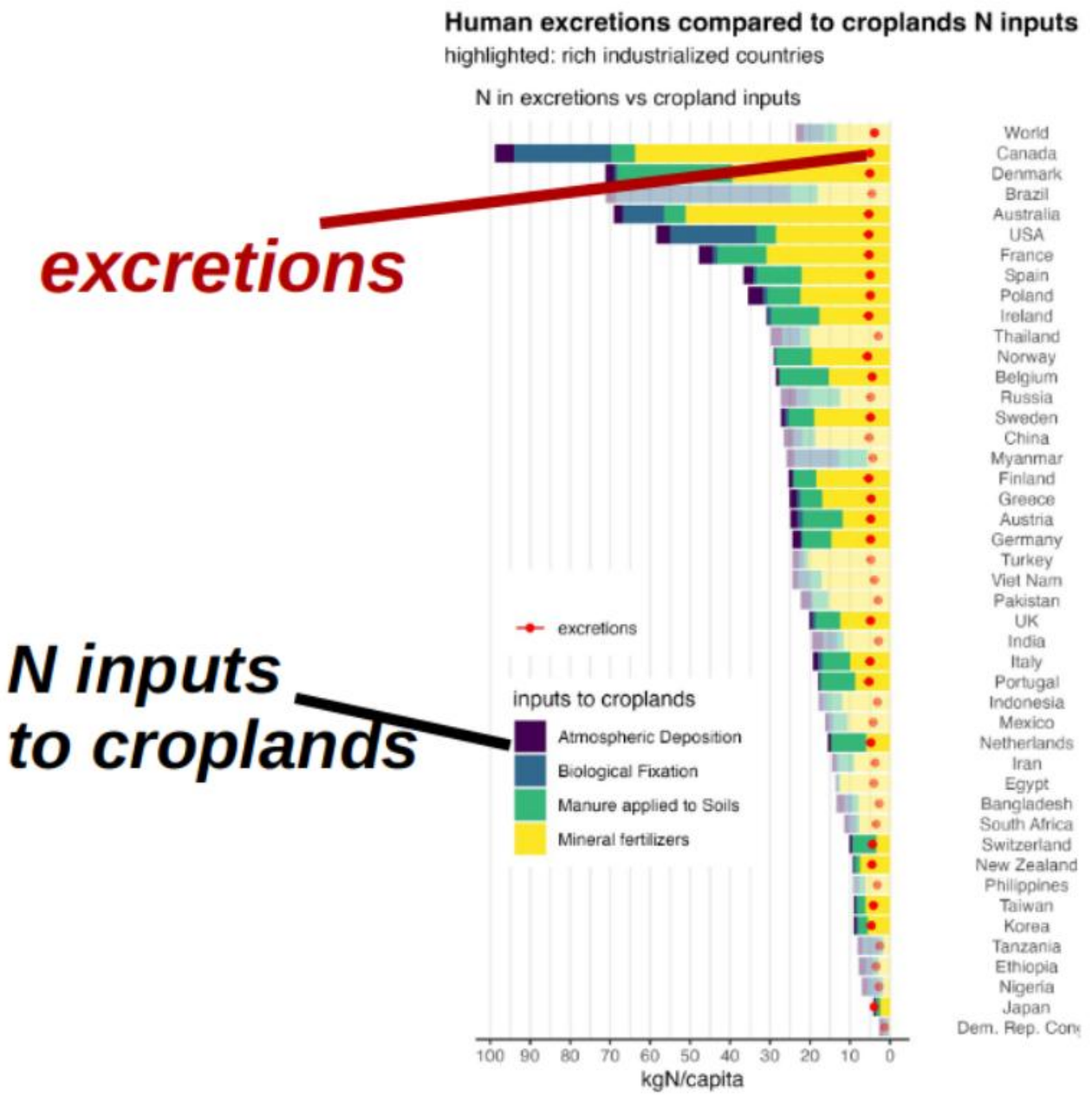
FAOSTAT data

on cropland N inputs

vs

human N excretion

(3-5 kgN/cap)



Water Workshop 2024

SmartWaterTwin

Funded by the European Union

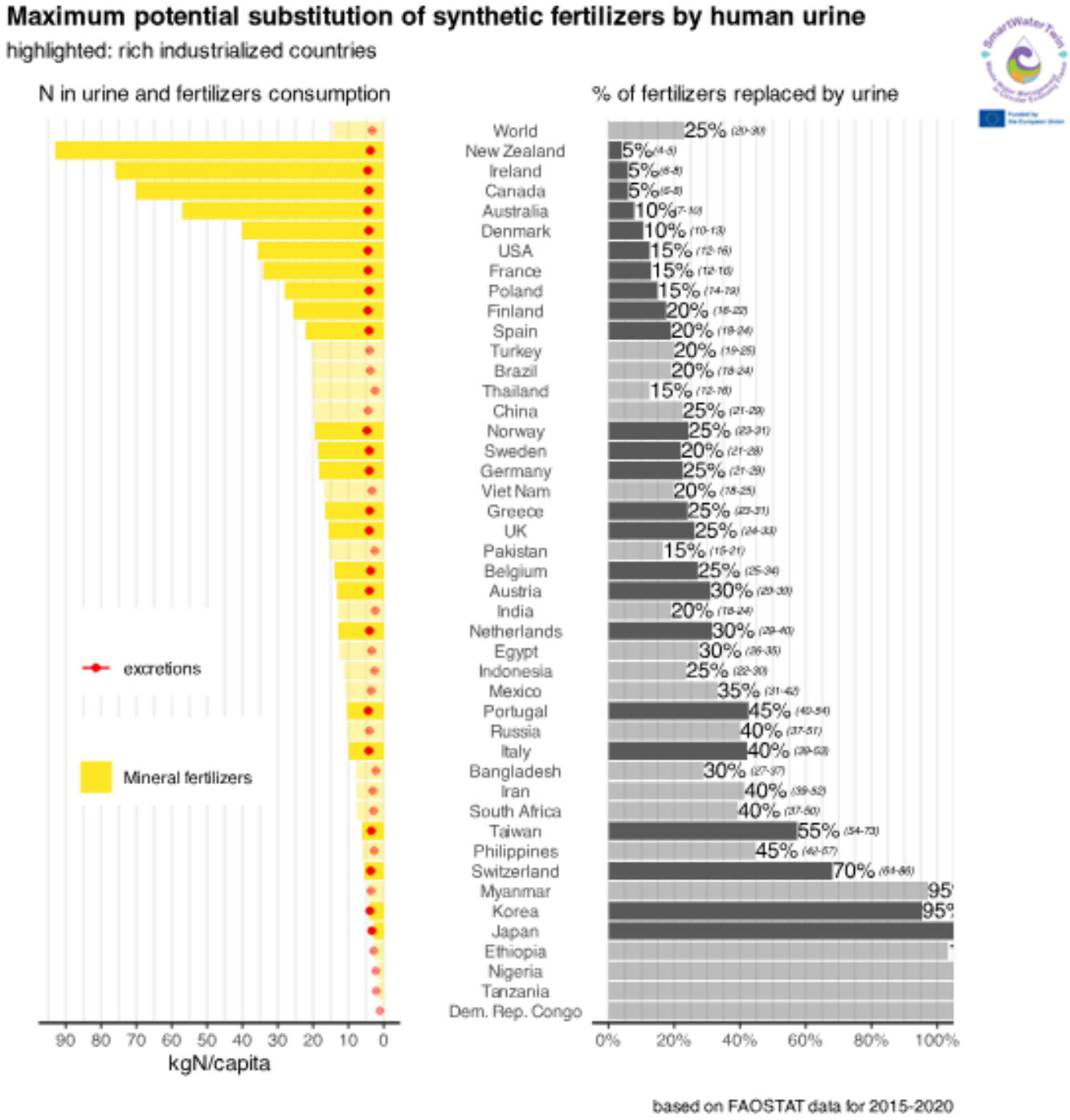
SmartWater Summer FORUM

How much fertilizer can be replaced by urine?

15% in France

25% worldwide

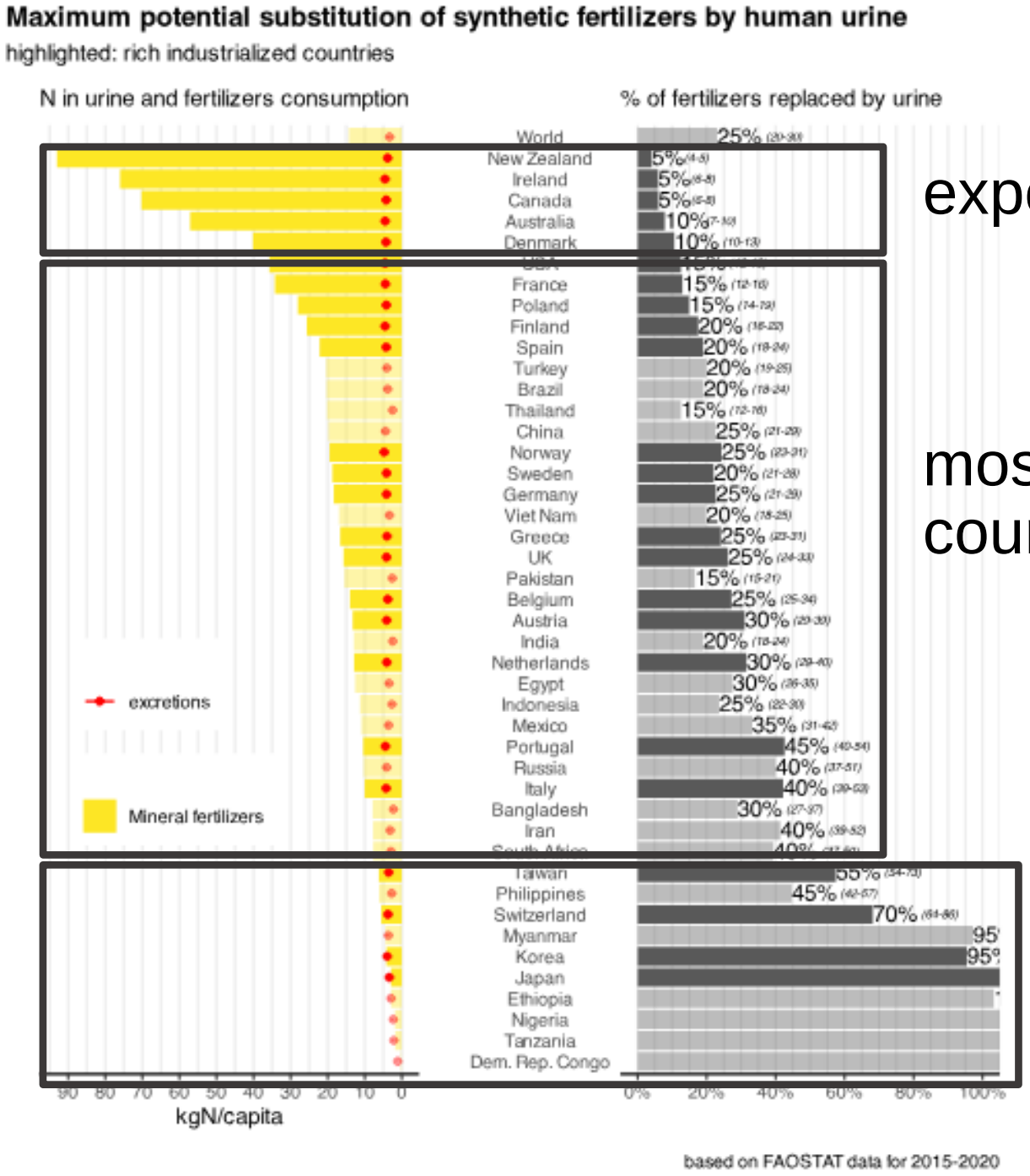
https://thomas-starck.github.io/potential-human-excretions-fertilization/potential.html



How much fertilizer can be replaced by urine?

15% in France

25% worldwide



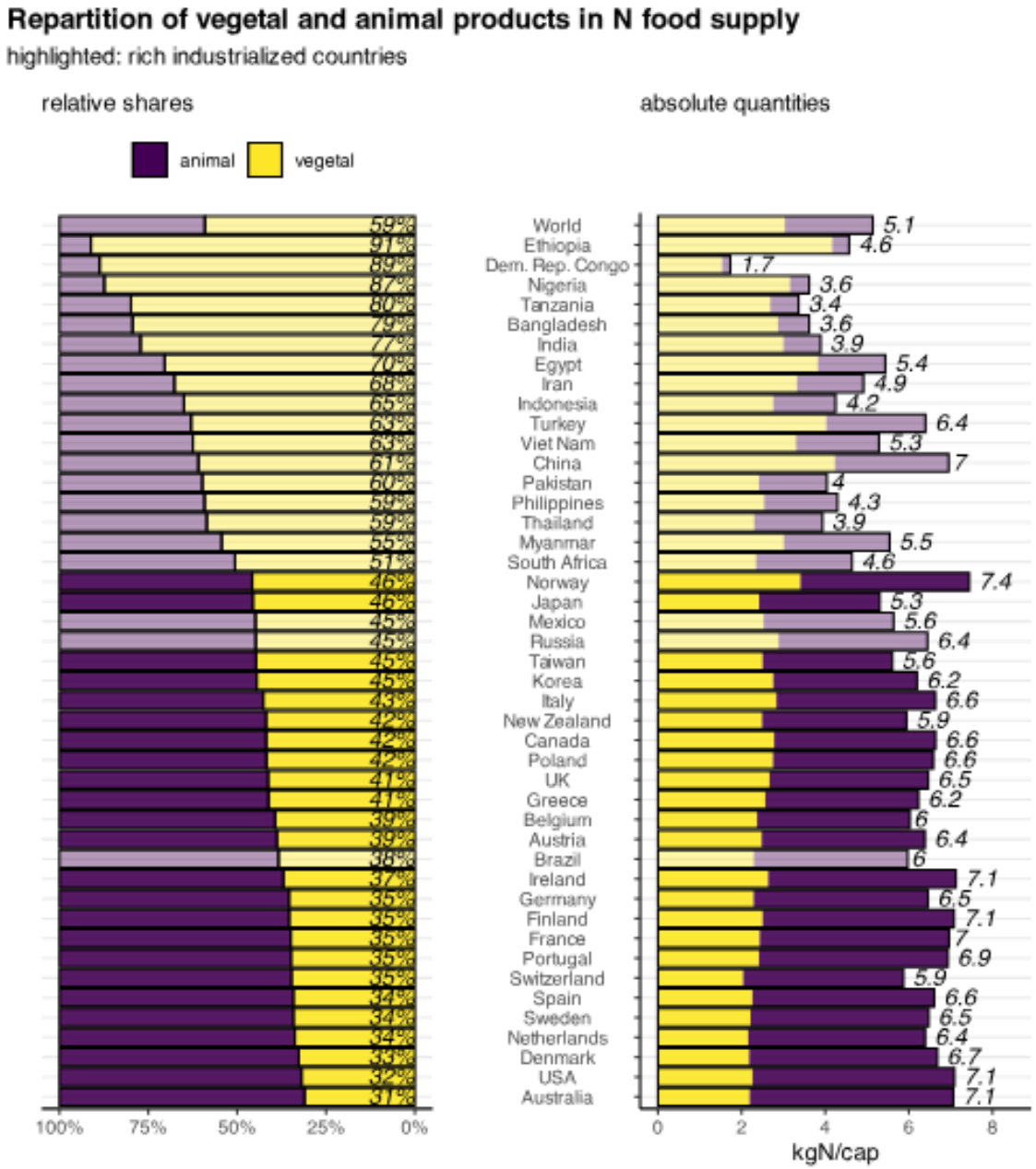
exporters

most countries

sub-saharan Africa & rich idnustrialized Asia

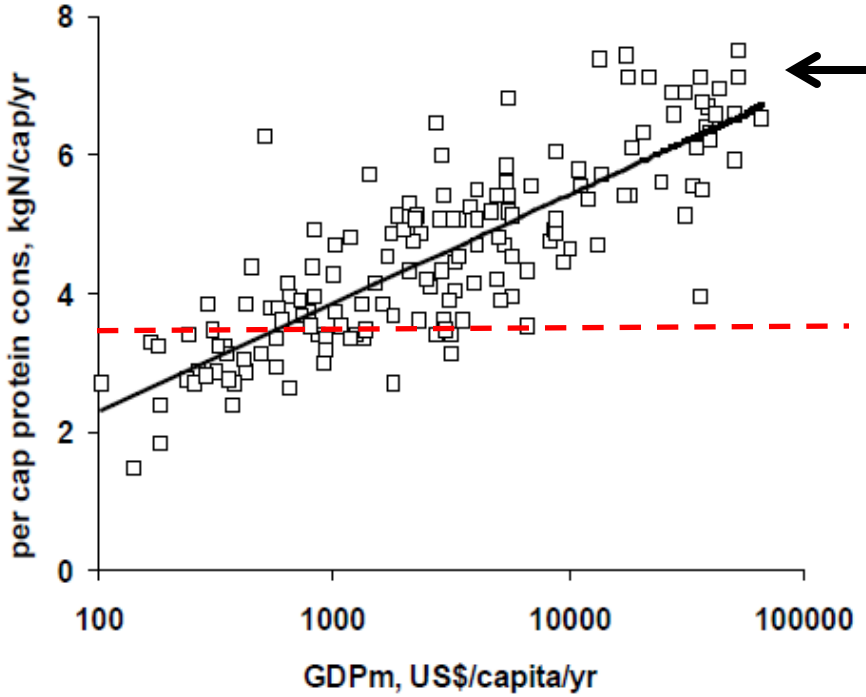
https://thomas-starck.github.io/potential-human-excretions-fertilization/potential.html

Most N used for animal production in rich industrialized countries



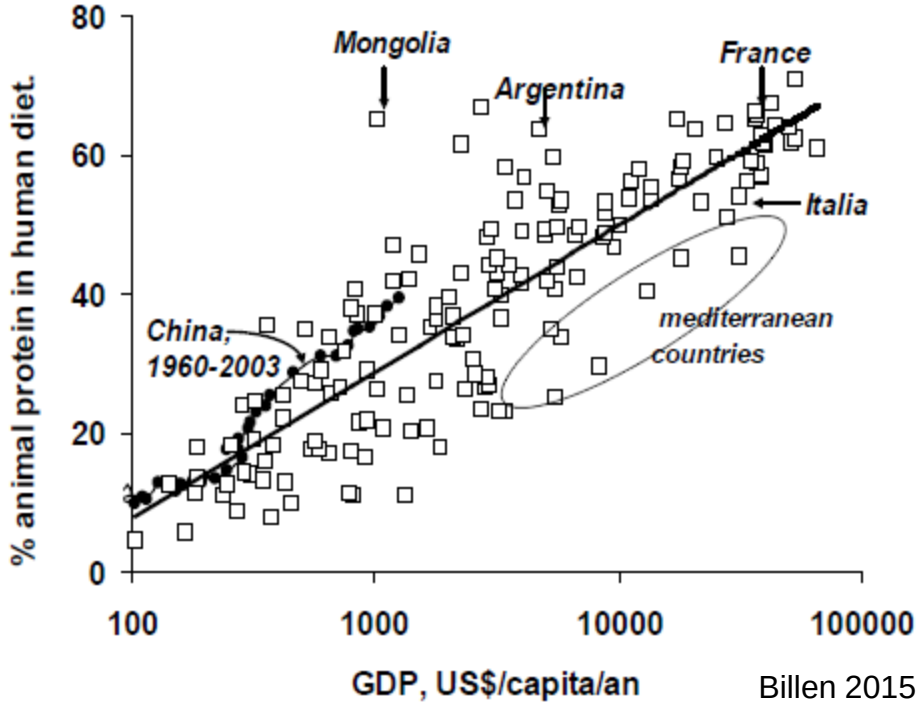
https://thomas-starck.github.io/potential-human-excretions-fertilization/potential.html

Protein consumption



France

Recommendations from WHO



Billen 2015

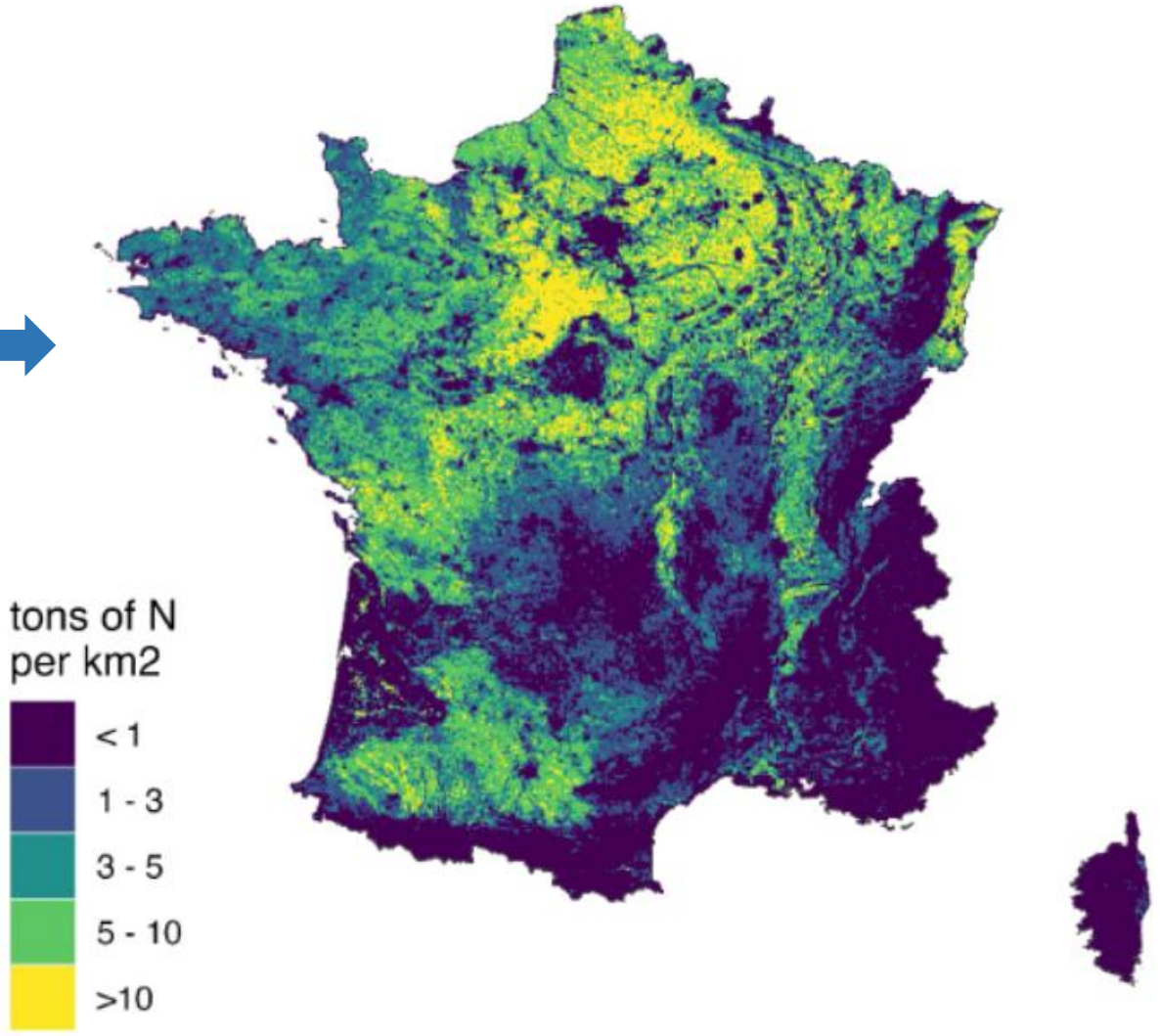
1. Limit the consumed amounts
2. Favor vegetal proteins

Where can we use source-separated urine?

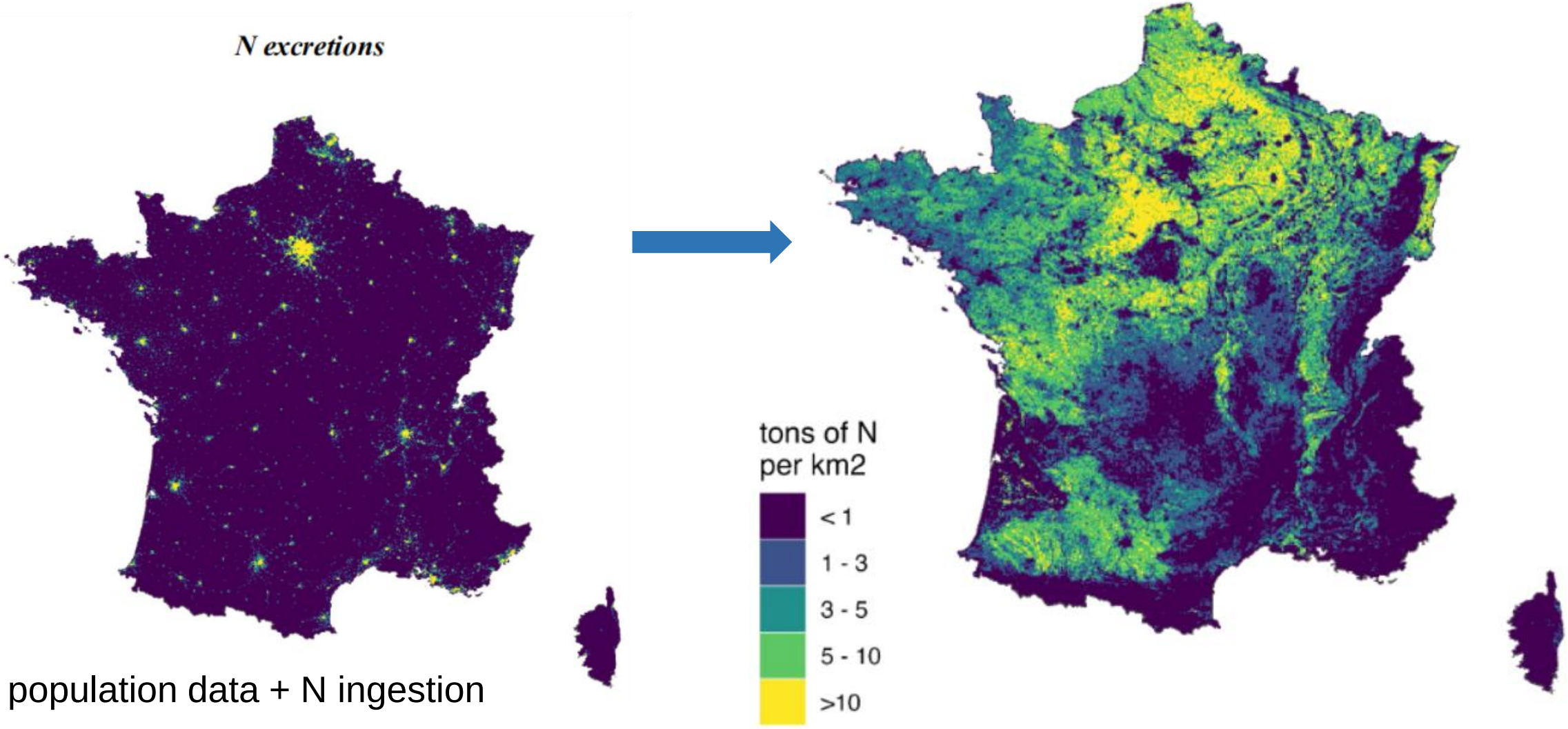
Substitute this

by human N excretions?

(~300 ktN/y)



Where can we use source-separated urine?

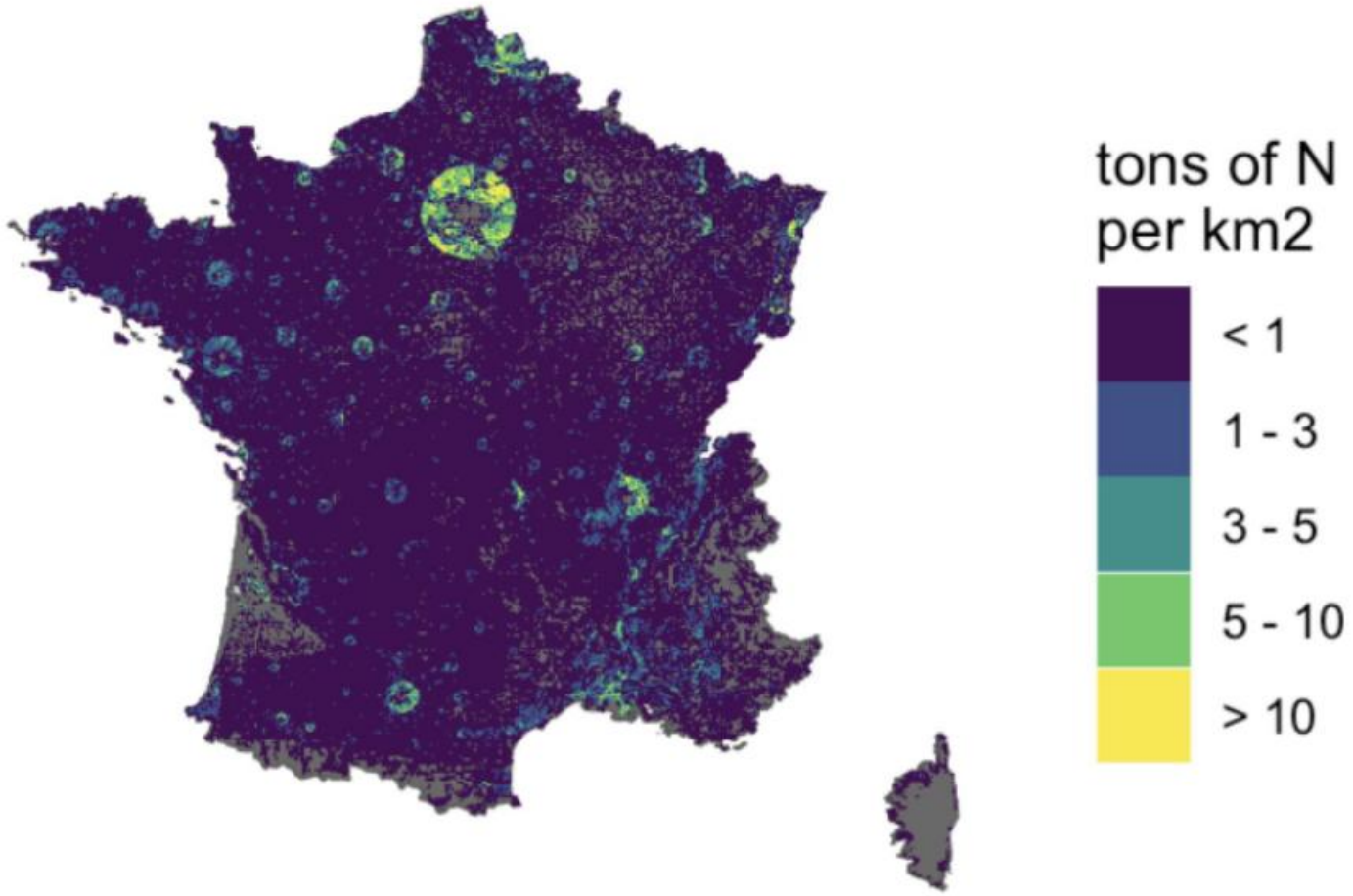


population data + N ingestion

Where can we use source-separated urine?

Algorithm to substitute mineral N by human excretions on neighbouring parcels

Most excretions could be spread at < 10 km!

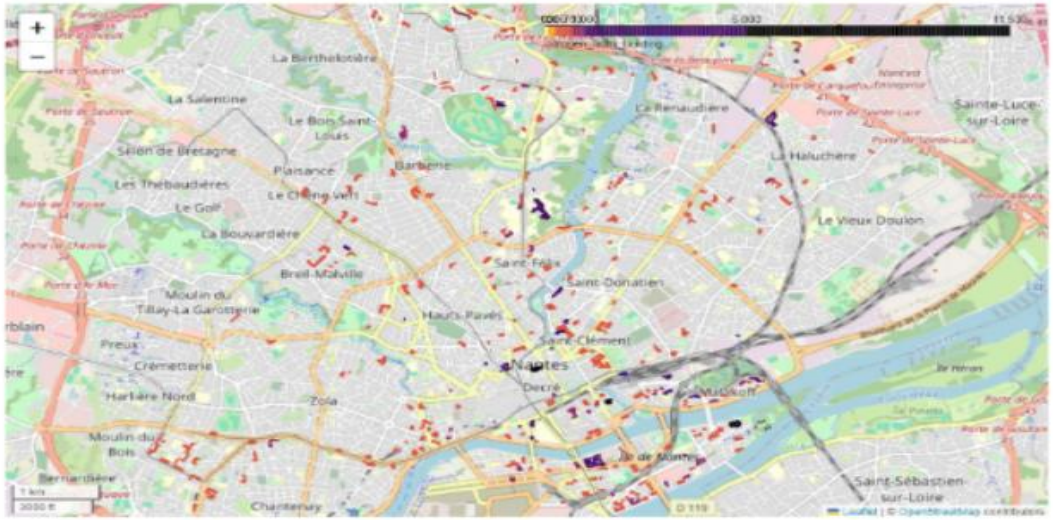


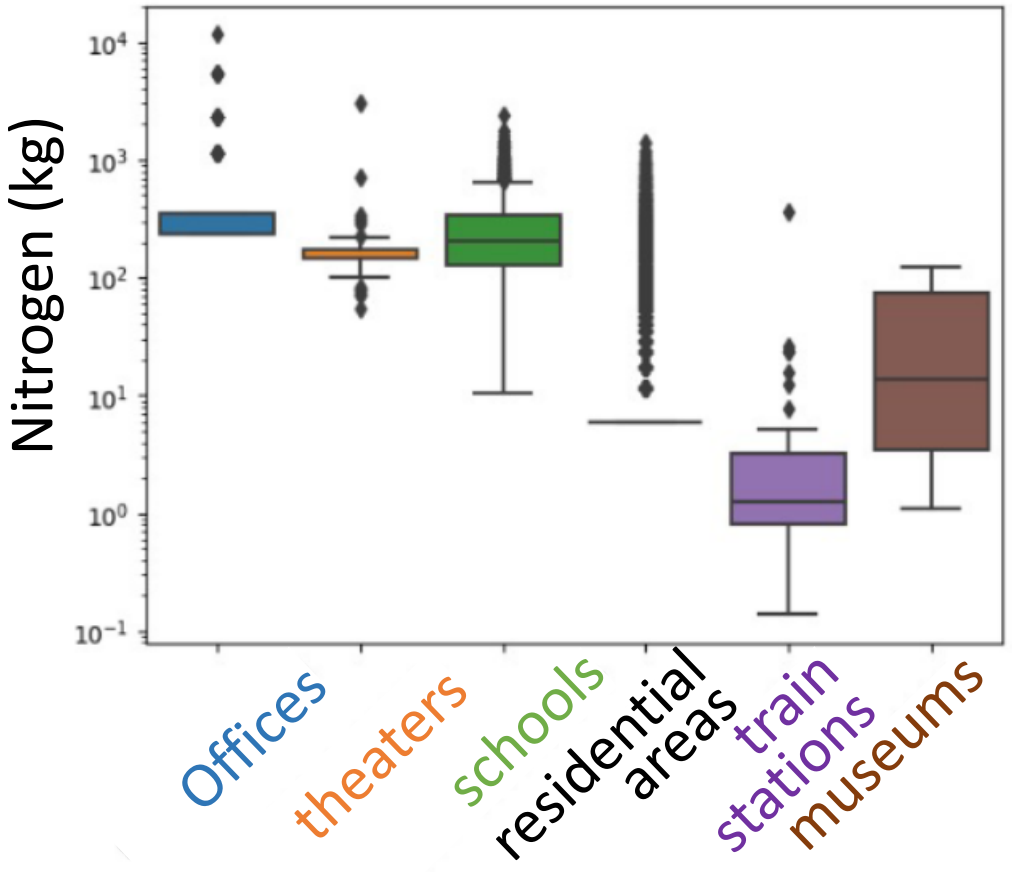
But how?

CAFE project: optimize recovery

(T. Fardet)

- Identify largest deposits in cities
- establish recovery scenarios
- LCA to assess impacts





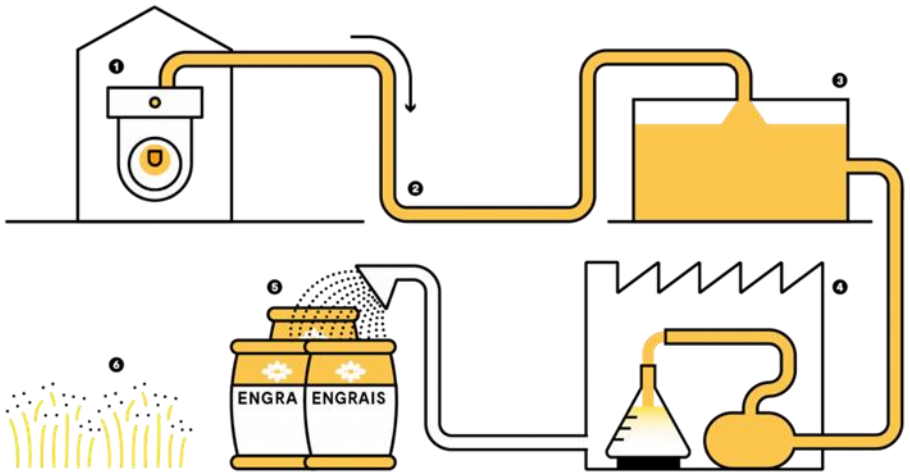
Water Workshop 2024

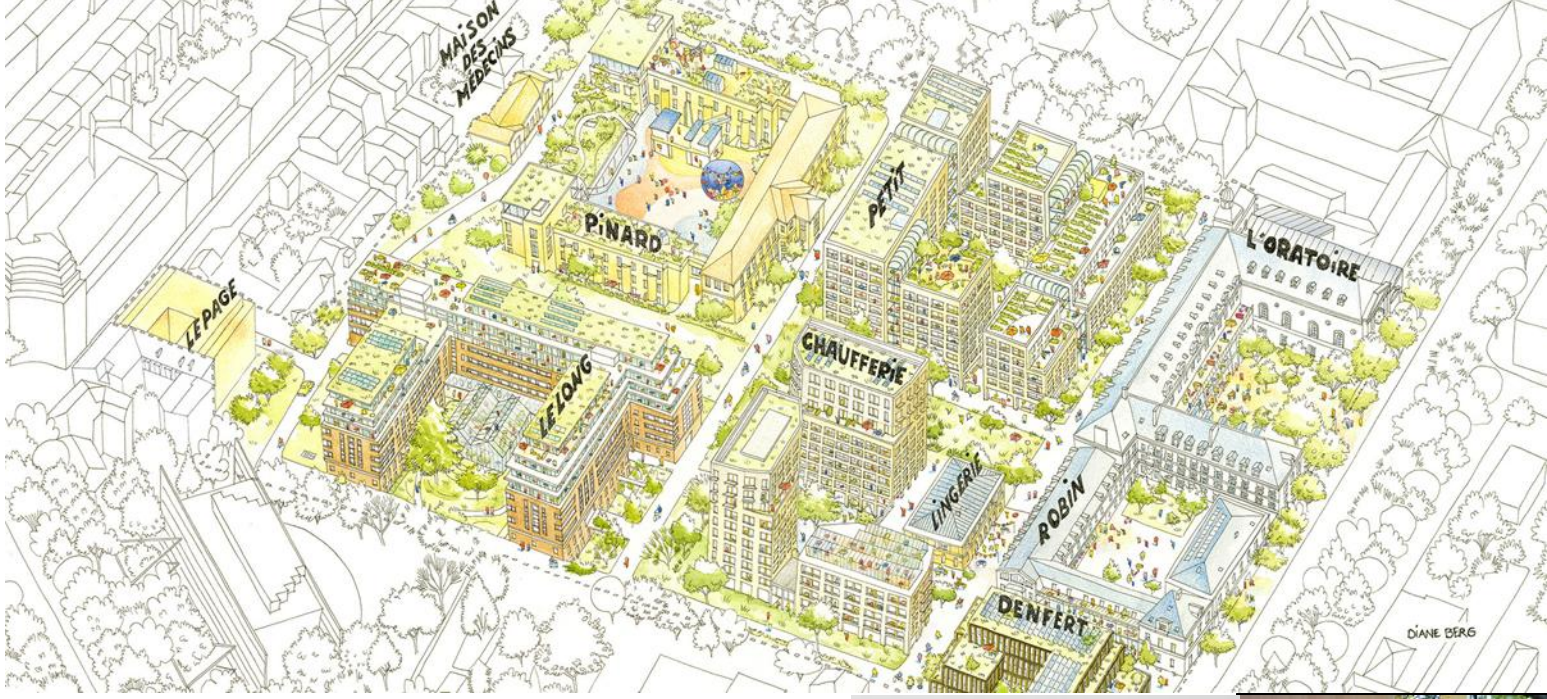
SmartWaterTwin

Funded by the European Union

SmartWater Summer FORUM

Paris example





47 000 L/y:
Used for green spaces in Paris

Saint-Vincent-de-Paul neighborhood - Paris
2018-2020 then 2024: 1st project for whole neighborhood (600 dwellings)
with urine diversion and production of Aurin (nitrification distillation)

Water Workshop 2024

SmartWaterTwin

Funded by the European Union

SmartWater Summer FORUM

Conclusions

- **10% of N from WWTPs reused** in agriculture in France
- Most N excretions could be spread at < 10 km
- Need for low-tech concentration/recycling systems
- But also moderation (meat consumption)

Hvala na pažnji!

Хвала на пажњи!