

Territorial food self-sufficiency under climate change through optimised crop rotations and STICS simulations

Tom Desmarez ¹, Mathieu Delandmeter ², Jérôme Bindelle ³, Benjamin Dumont ¹

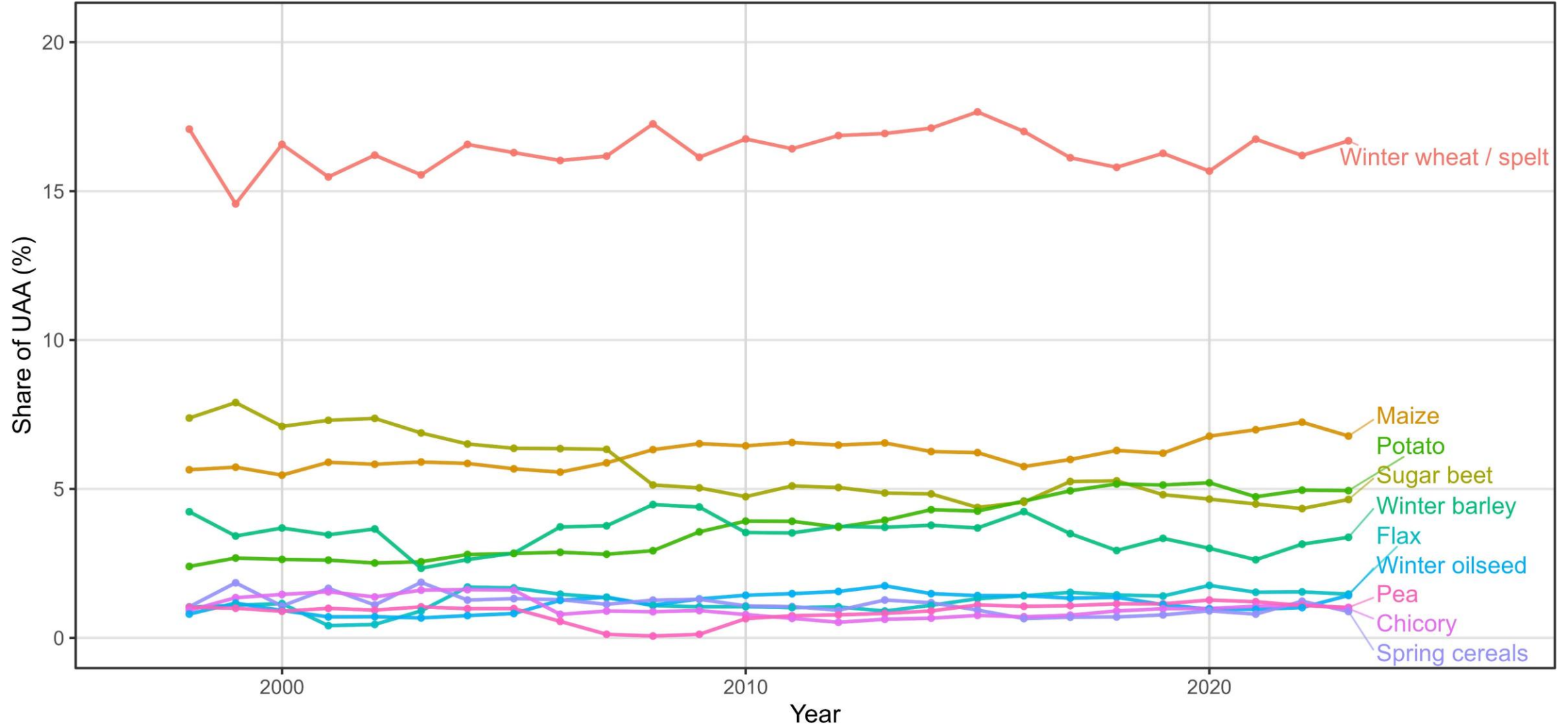
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³ Liege University, Gembloux Agro-Bio Tech, TERRA Teaching and Research Centre, Animal sciences axis. 5030 Gembloux, Belgium

CONTEXT

(Desmarez et al., *in review*)



• 5 cultures = 82 % des terres arables

• Maïs +12 %

• Betterave -25 %

• Colza + 35%

• Froment et orge ~ constant

• Pommes de terre + 64%

• Chicorée -30 %

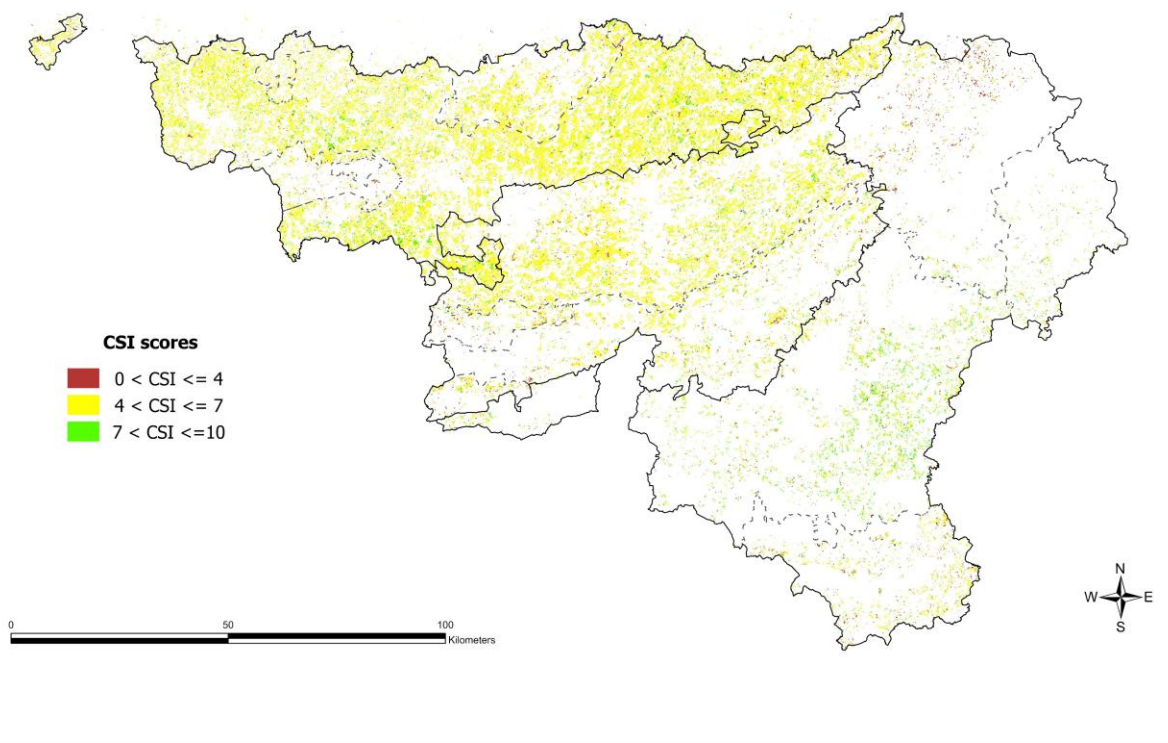
• Légumineuses + 50%

CONTEXT

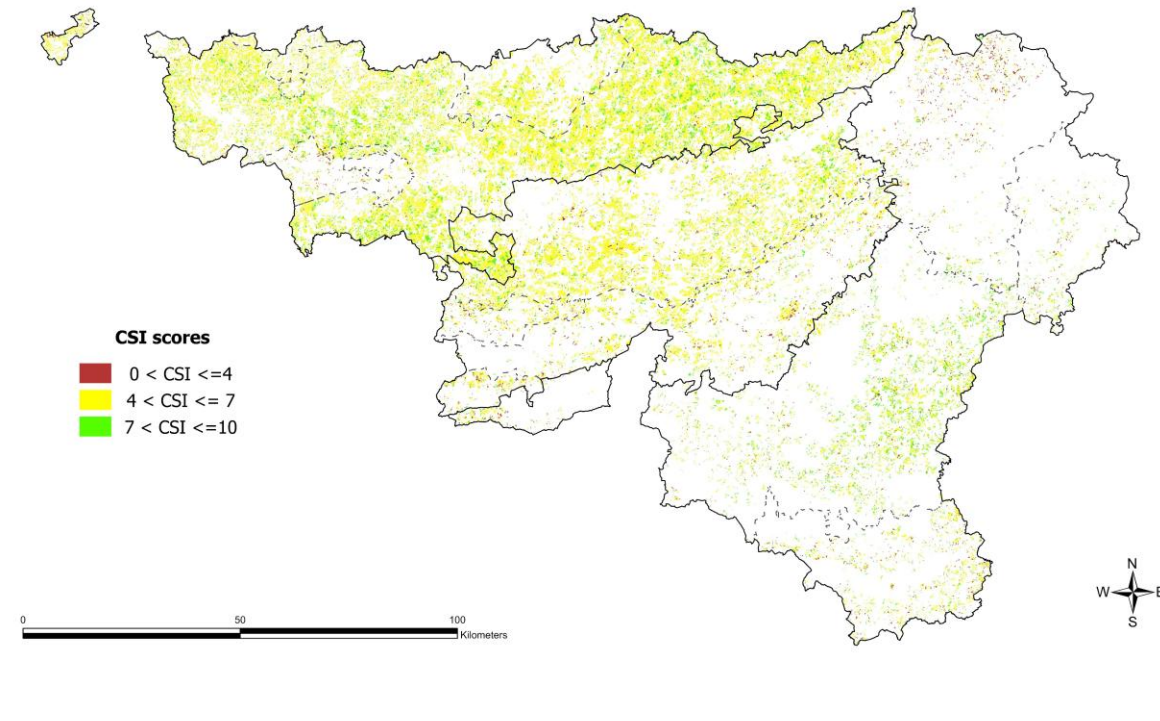
(Desmarez et al., *in review*)

Agronomic quality

1998-2010



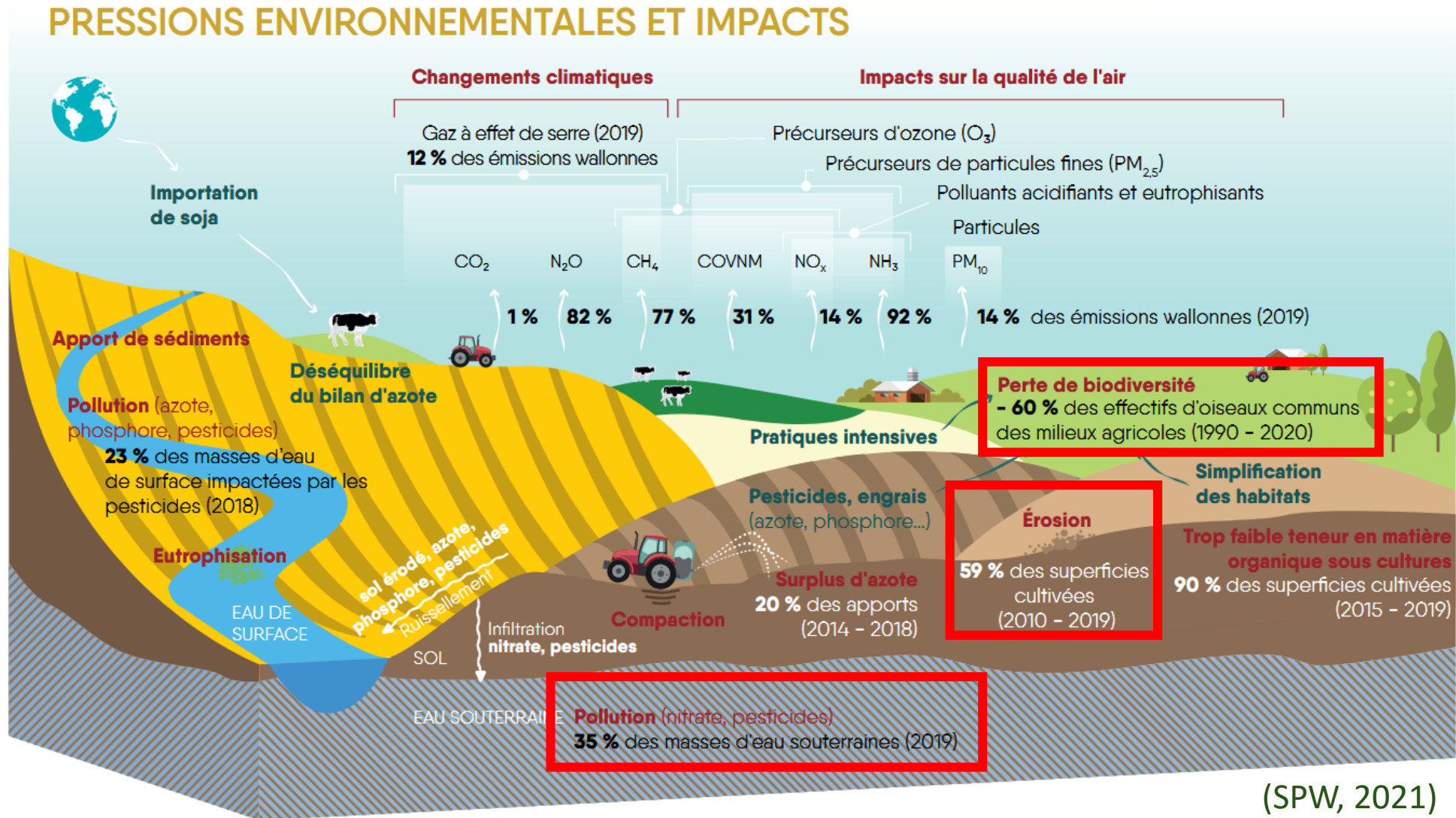
2011-2023



Improvement of agronomic quality of crop rotations

Public policy ?

CONTEXT



Every euro spent by households on food in Belgium generates €2.2 in hidden costs within the country, and an additional €2 abroad (Fian, 2025).

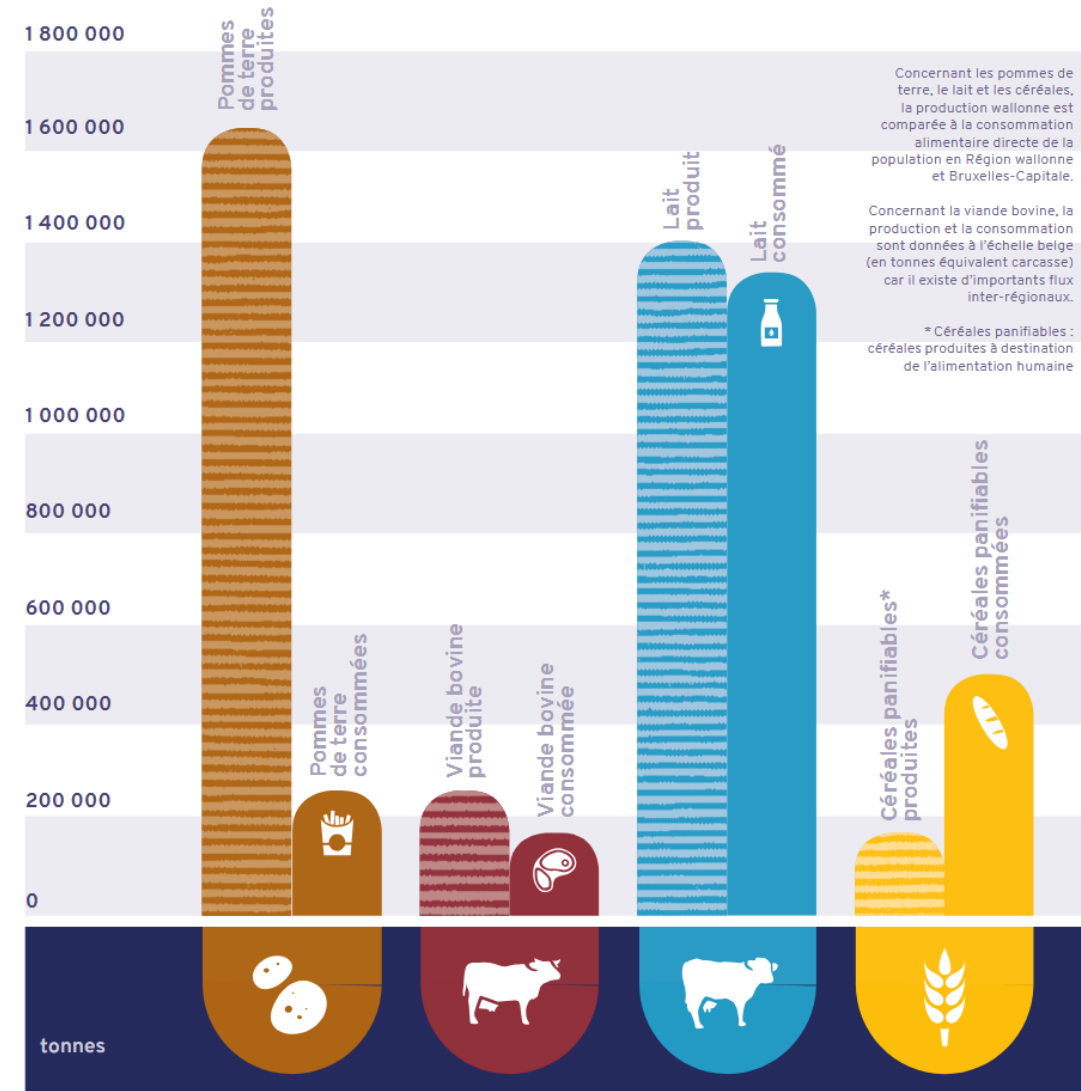
CONTEXT

5 crops = 82 % of arable land

Belgium: 80% of our ecological footprint related to food is outside our borders (Galli et al., 2023)

Wallonia production (IWEPS, 2024) :

- 10% of its food consumption
- 44% comes from Flanders + Brussels
- 46% from abroad



(Scenagri, 2019)

CONTEXT

Assessing the capacity of the Walloon territory to feed its population with a sustainable diet and farming system

SCENARIO



TYFA (Poux & Aubert, 2018)



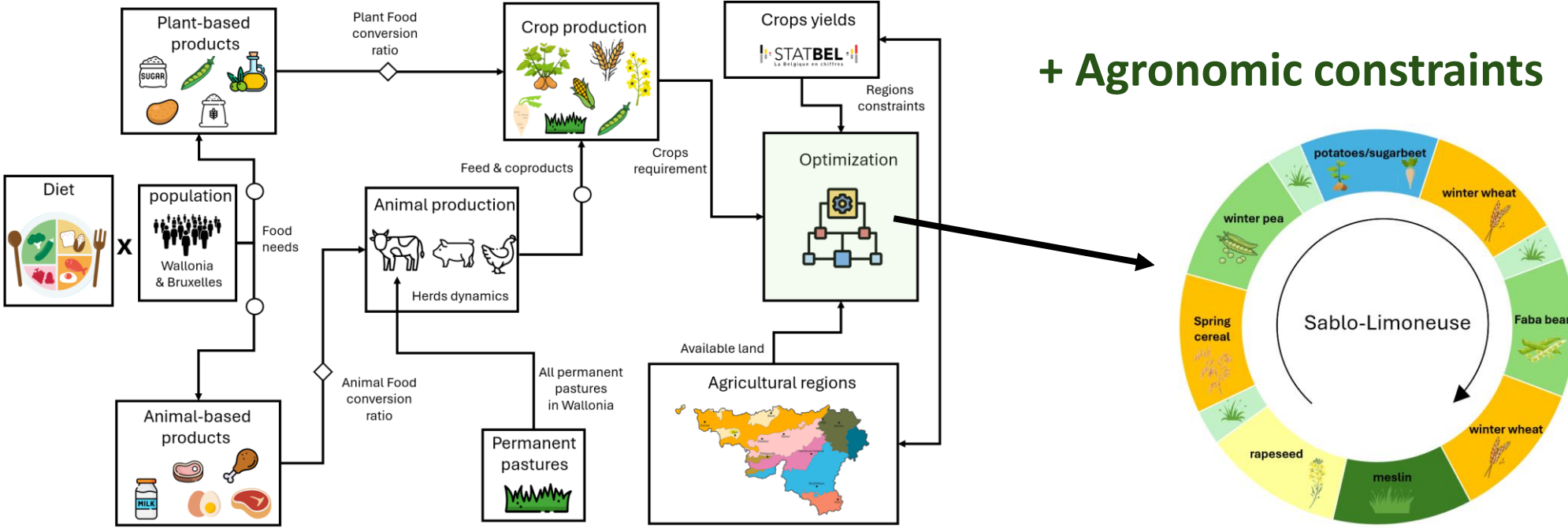
25% (HLPE, 2014)

Food category	CURRENT	TYFA
Cereals	278	300
Oilseeds	34	34
Potatoes	116	80
Sugar	36	23
Legumes	5	30
Vegetables	134	300
Beef	37	36
Pork	88	36
Poultry	58	20
Dairy	505	300
Eggs	20	10



Current

→ Optimisation algorithm for crop allocation in Wallonia's agricultural regions to achieve full food self-sufficiency



+ Agronomic constraints

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Towards sustainable diets and farming systems through land use optimisation

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Designing crop rotations to sustain territorial food self-sufficiency

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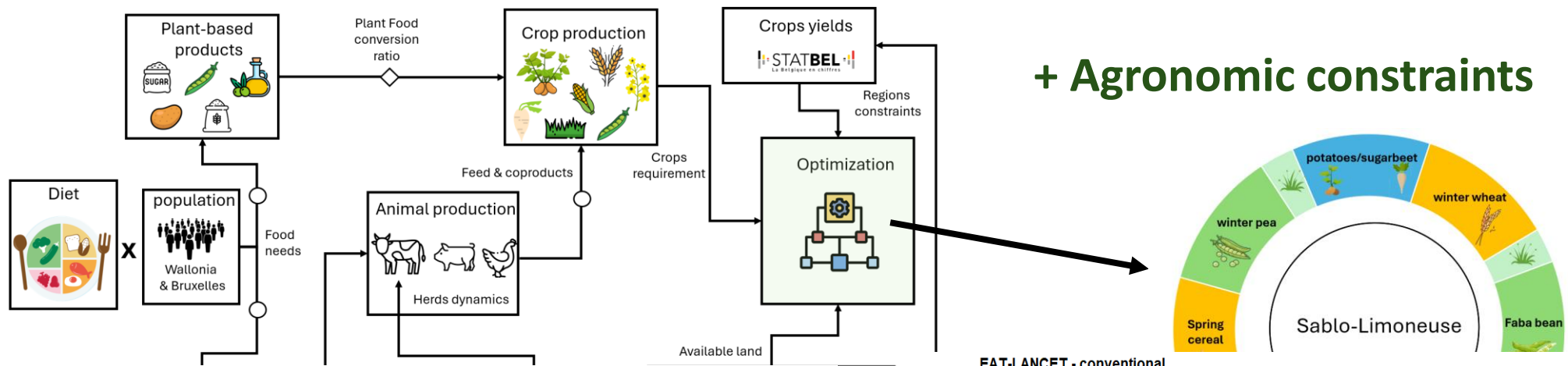
¹ Liege University, Gembloux Agro-Bio Tech, TERRA Teaching and Research Centre, Plant sciences axis. 5030 Gembloux, Belgium.

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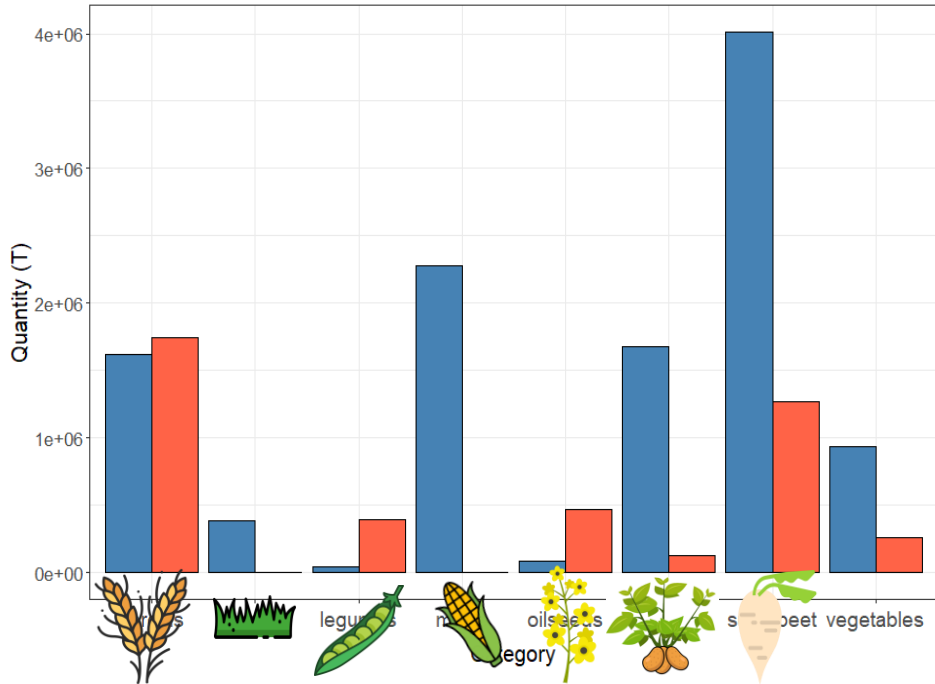
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*Corresponding author: tom.desmarez@uliege.be

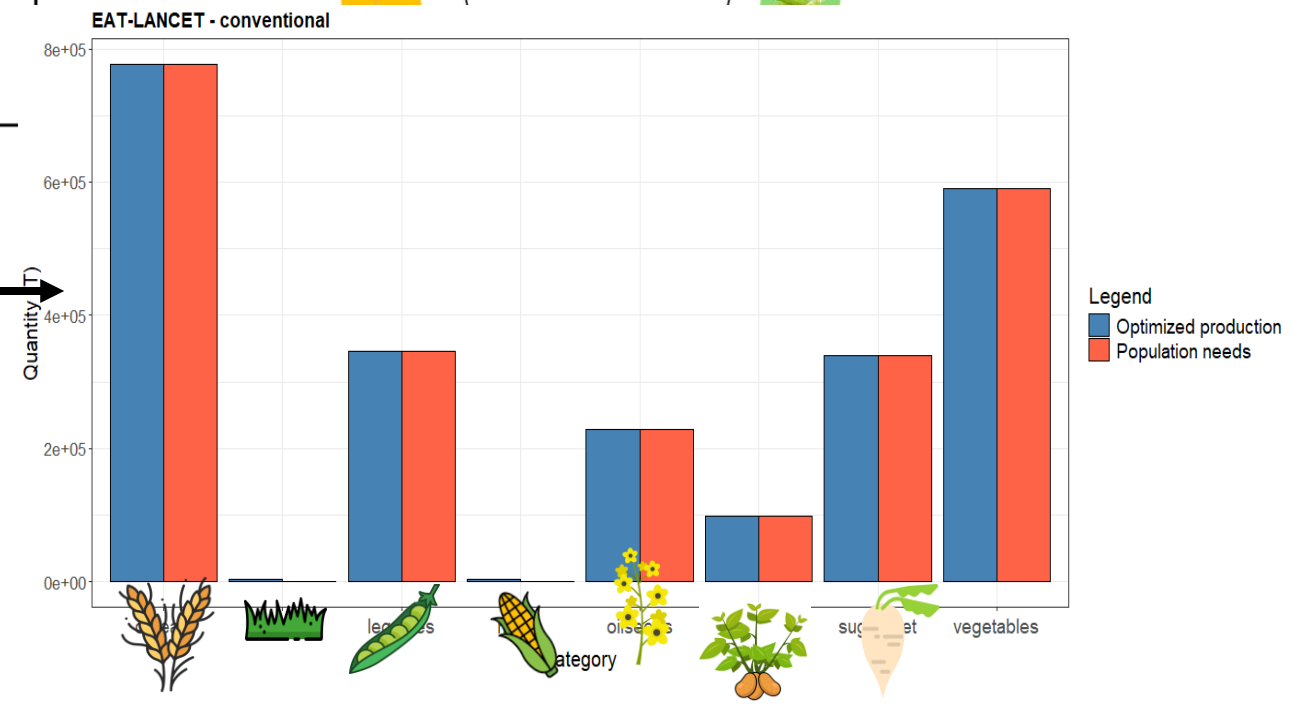
→ Optimisation algorithm for crop allocation in Wallonia's agricultural regions to achieve full food self-sufficiency



+ Agronomic constraints

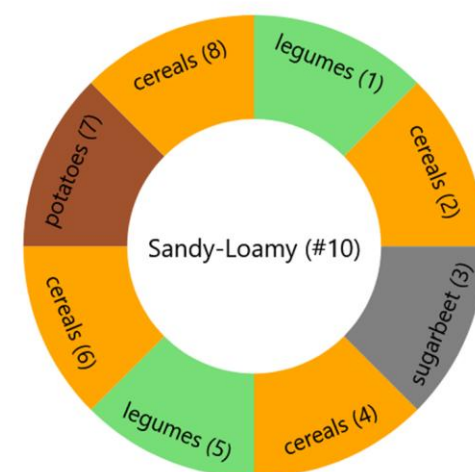
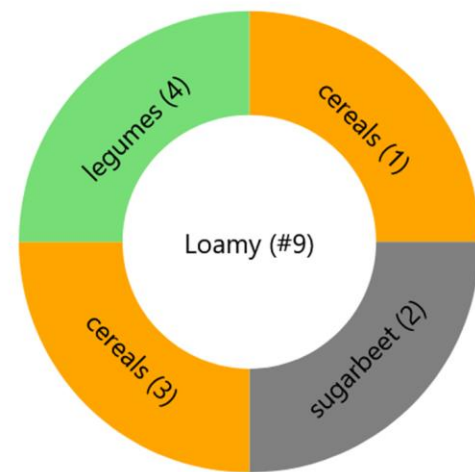
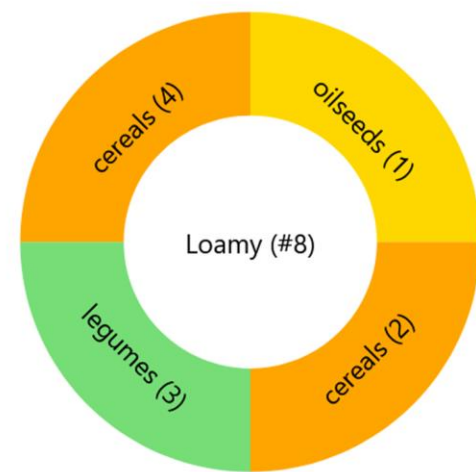
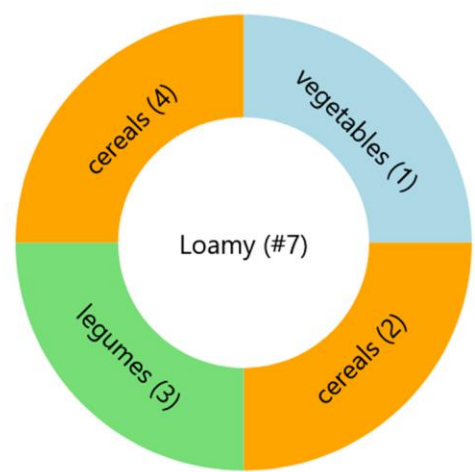
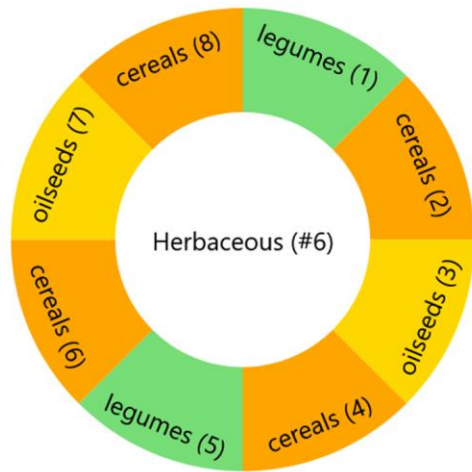
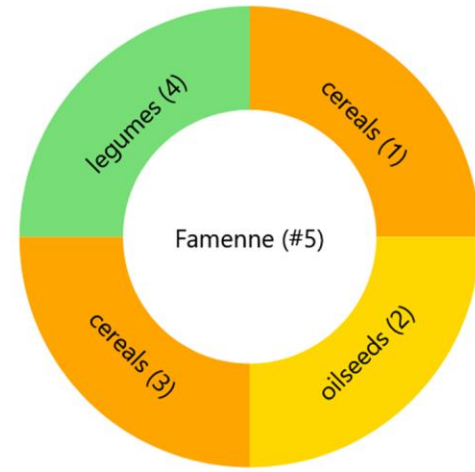
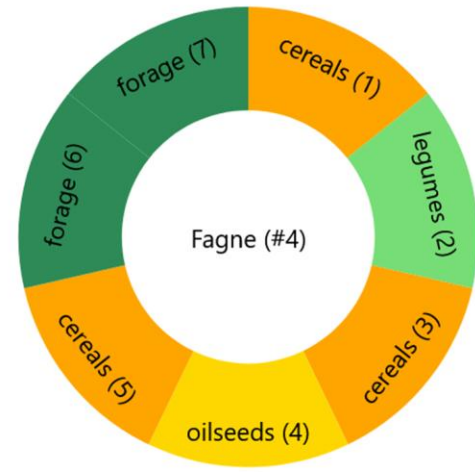
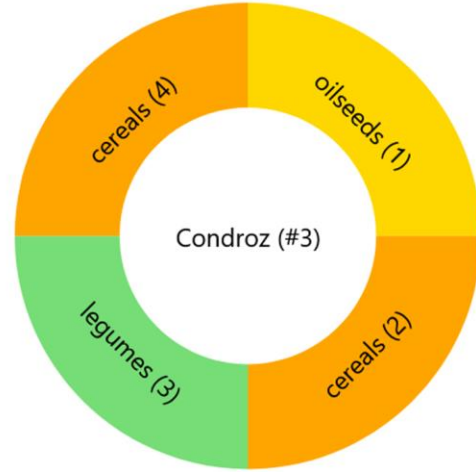
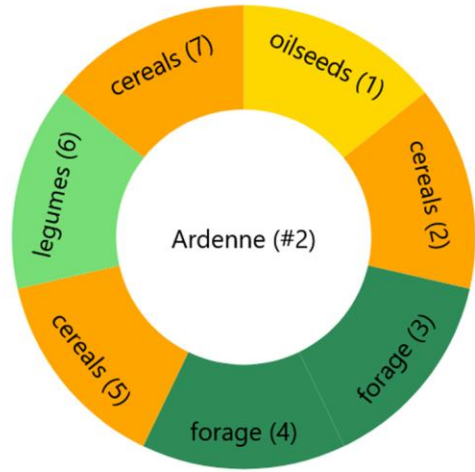
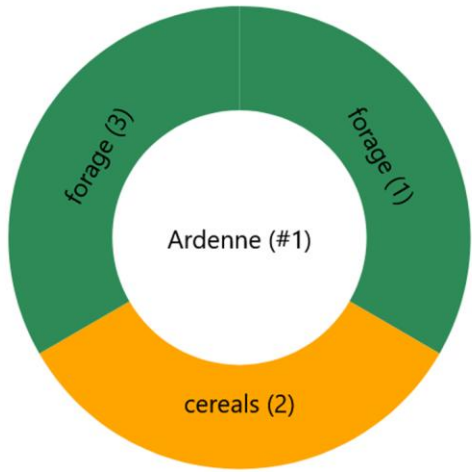


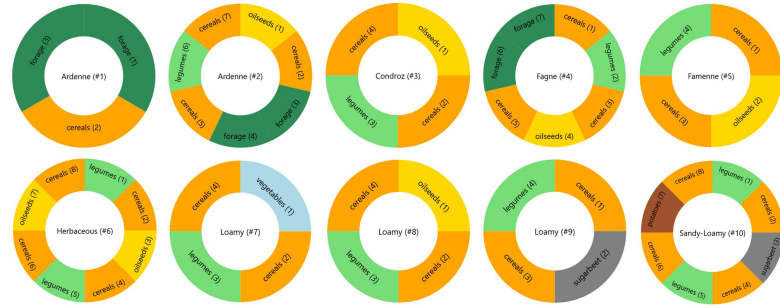
Legend
■ Current production
■ Population needs



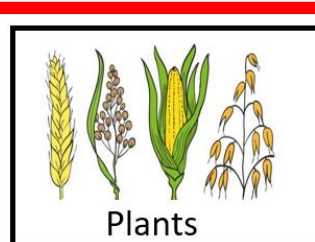
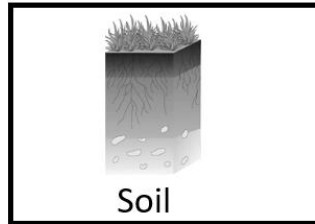
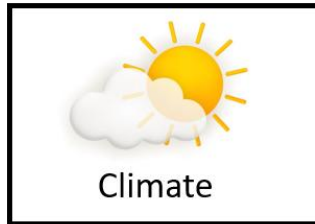
Legend
■ Optimized production
■ Population needs

Food self-sufficiency : 106%
Land use : 90%

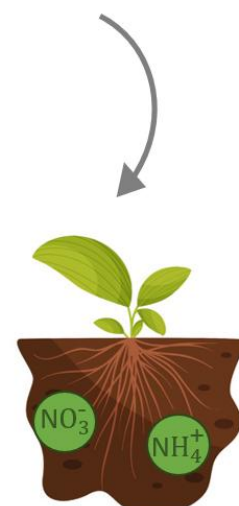




INPUTS



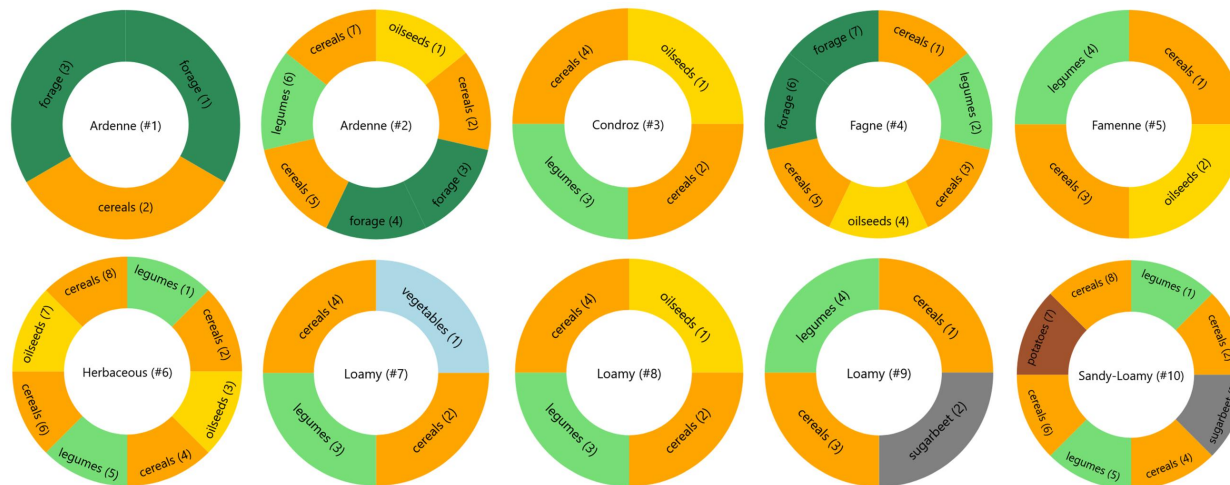
stics



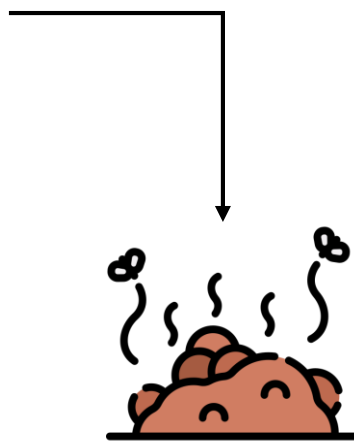
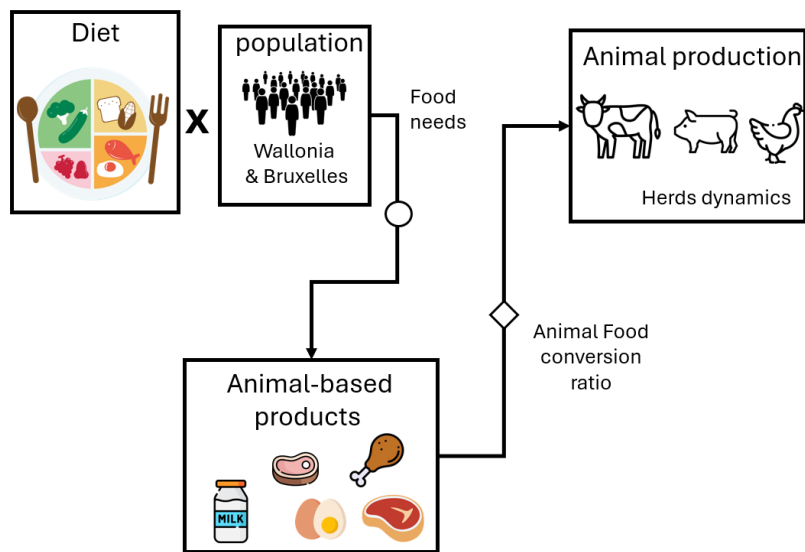
OUTPUTS



Management practices



Standard crop management practices in conventional agriculture in Wallonia




Equal repartition






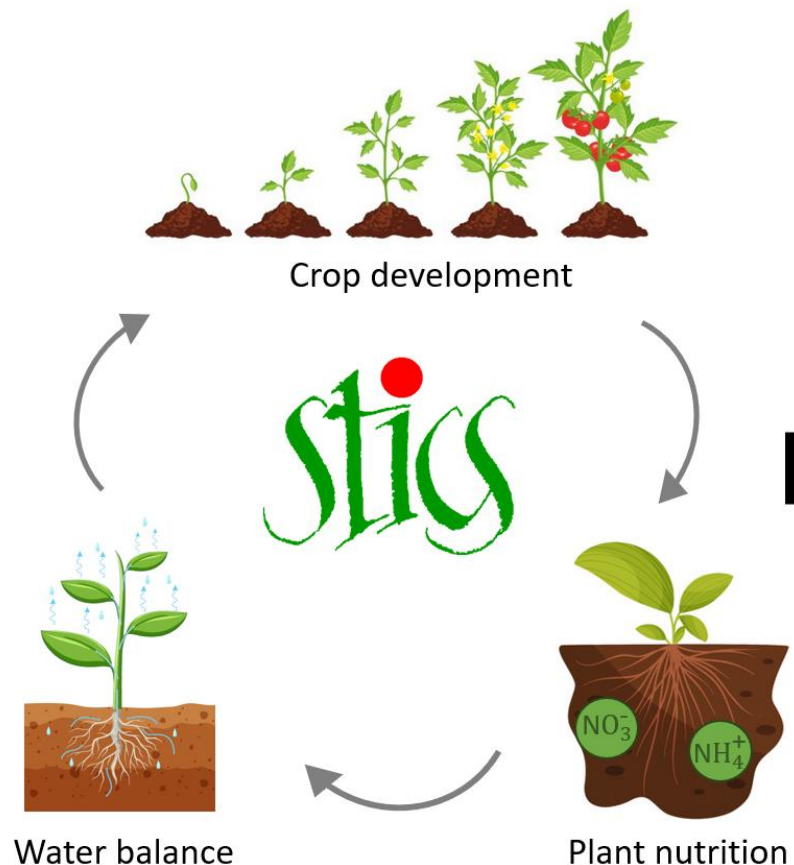
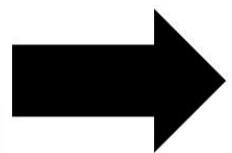
INPUTS


Climate


Soil


Crop management


Plants



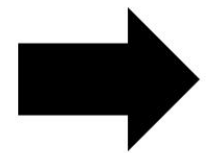
OUTPUTS

Yield

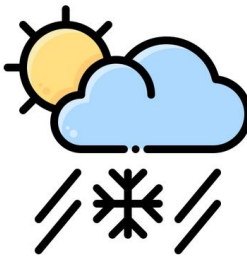
Stresses

Soil bio-chemical state (SOC, N)

Water balance



Climate models



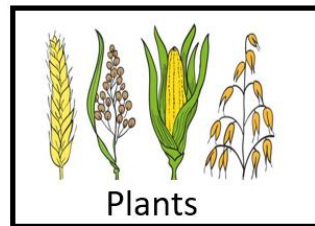
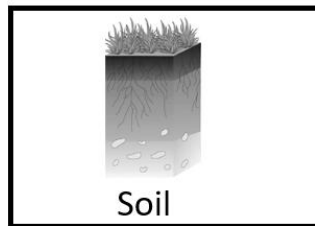
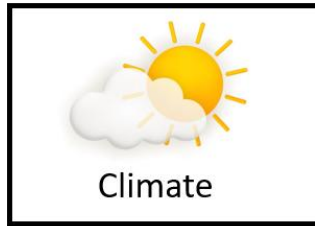
Historical climate data (1980-2010) vs future climatic conditions

Global Climate Models (GCMs) : CMCC, MIROC, MPI

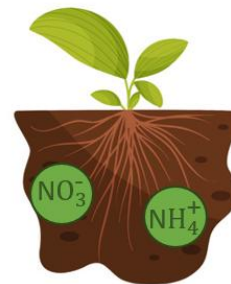
Climate classified by **warming levels** (+2, +3, +4 °C) rather than fixed years

- drier summers
- wetter springs and winters
- more frequent extreme rainfall events

INPUTS



stics



OUTPUTS

Yield

Stresses

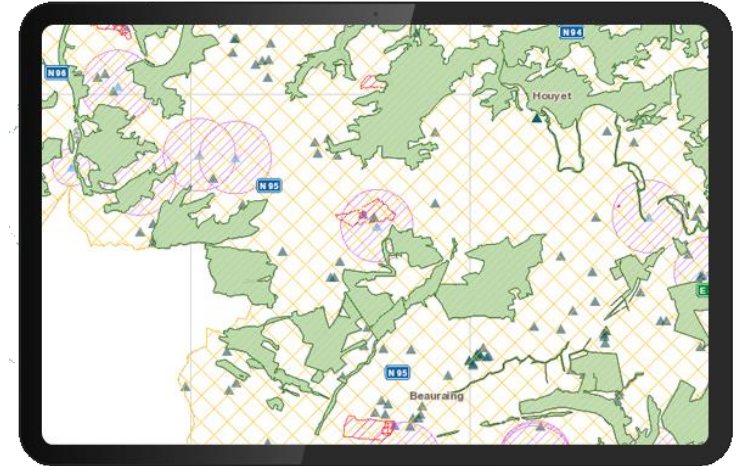
Soil bio-chemical
state (SOC, N)

Water balance

Soil Data



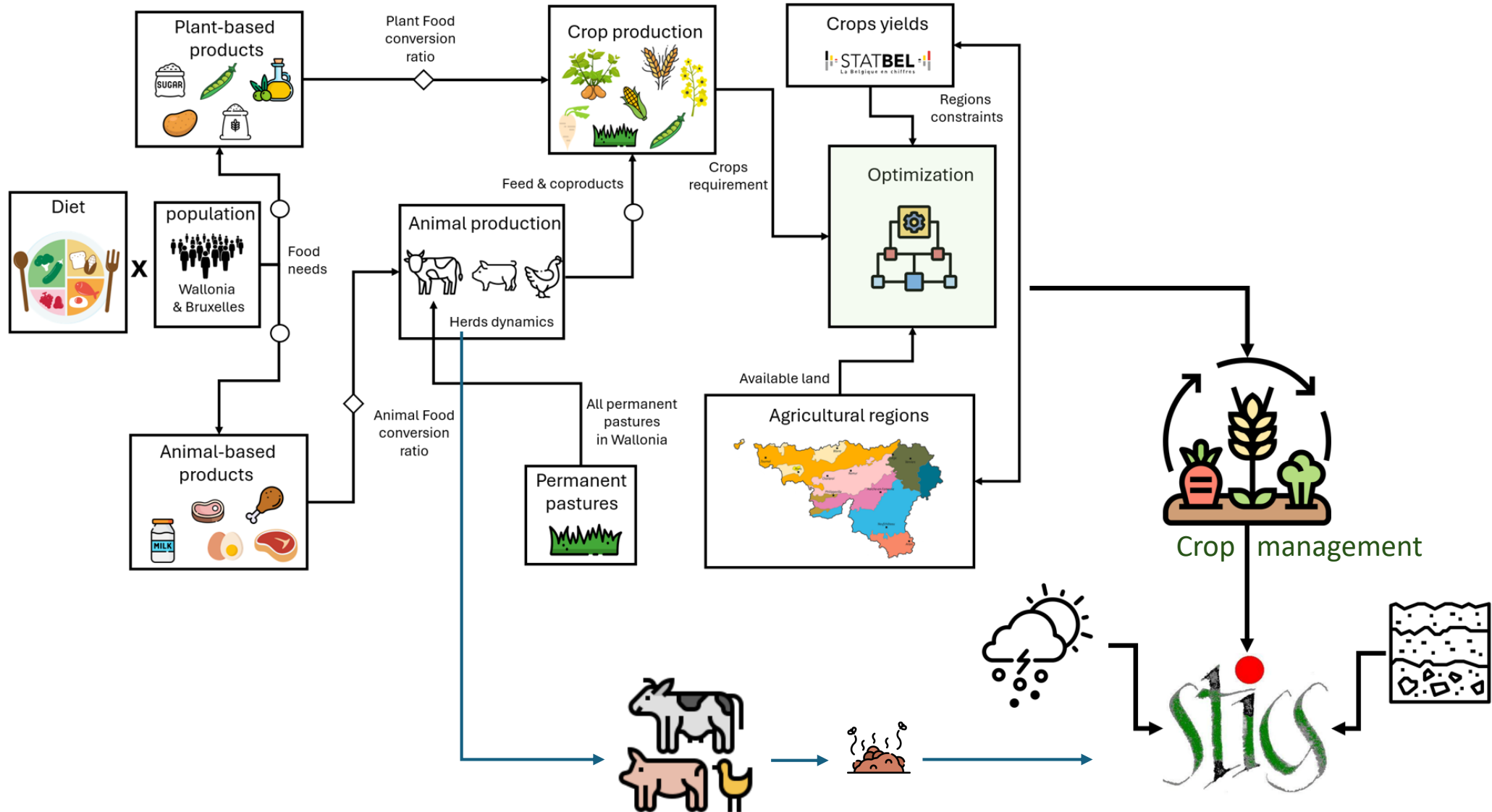
- Soil properties derived from **WalOnMap** and **SoilGrids (ISRIC)**
→ Key variables: texture, soil depth, bulk density, SOC, CaCO₃, pH, total N
- Non-arable land excluded (based on **IACS parcel declarations**)
- Soils aggregated using **k-means clustering** within pedoclimatic blocks
- Final dataset: **~7,000 representative soils**



WalOnMap

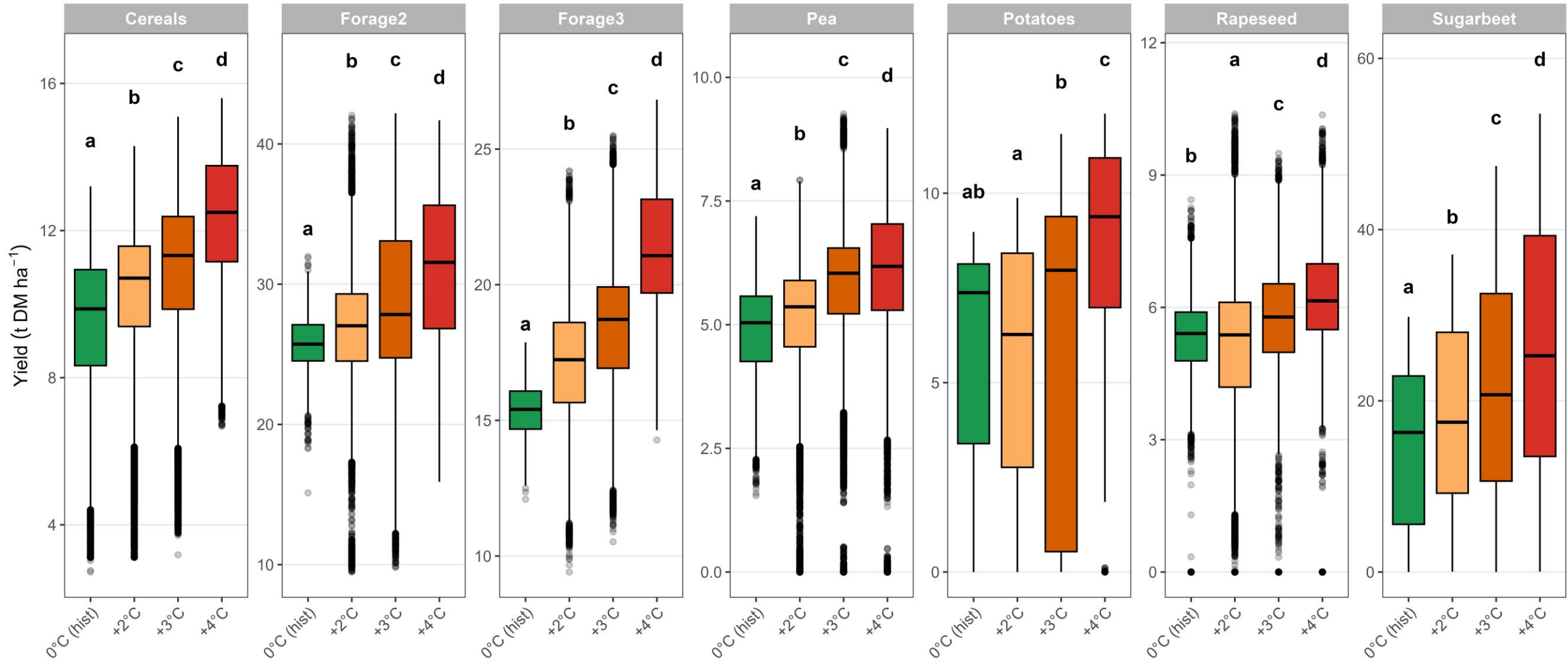


To sum-up



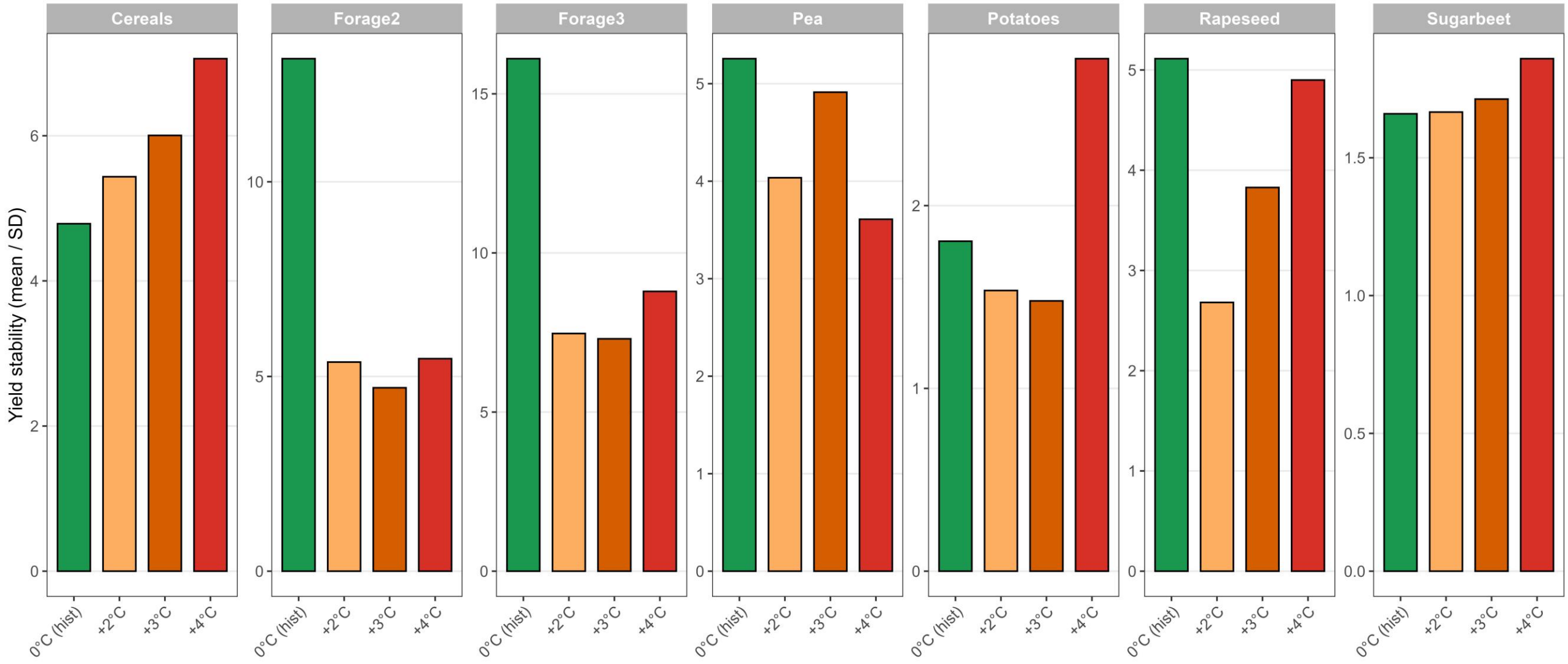
RESULTS

(Desmarez et al., *in writing*)



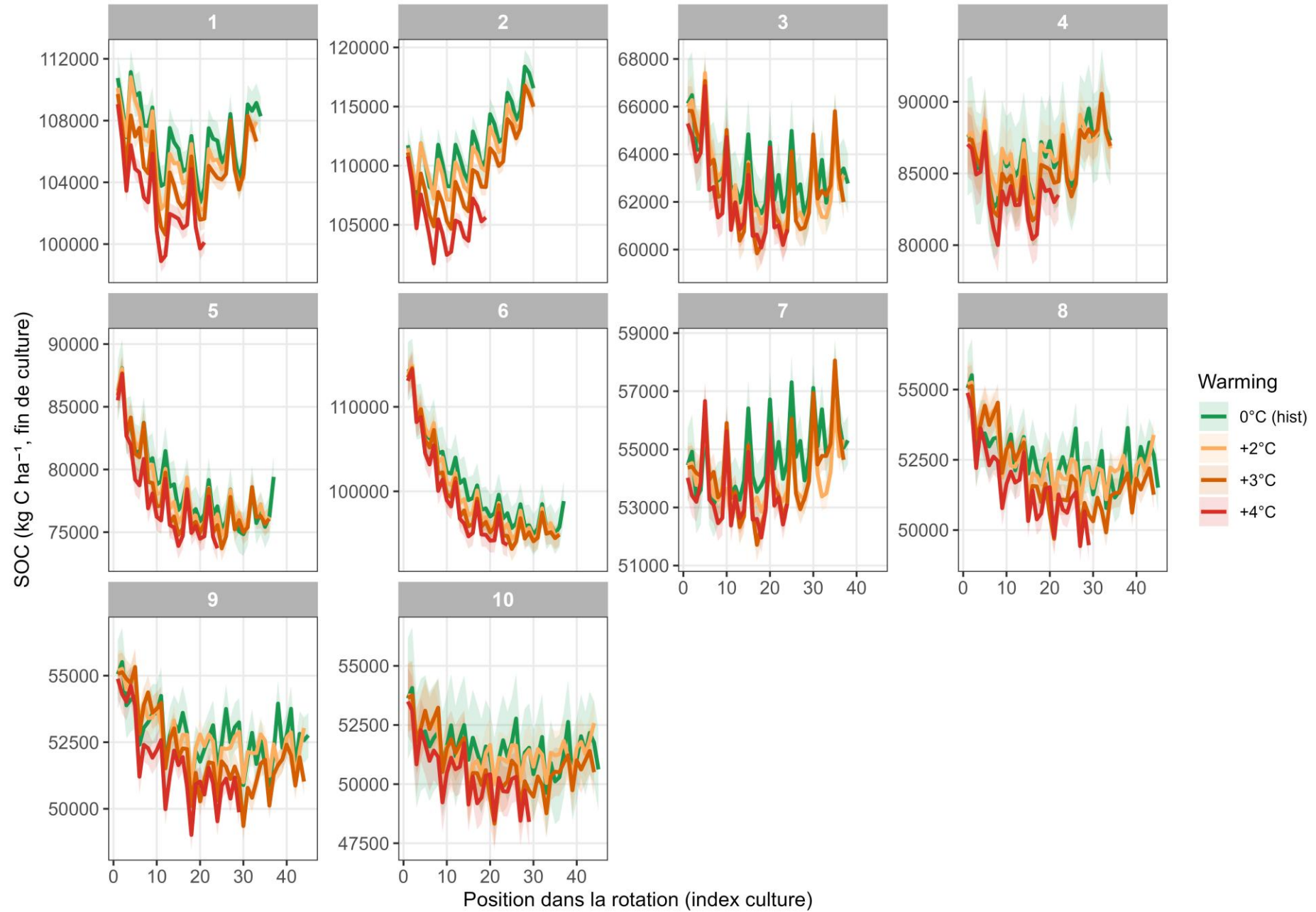
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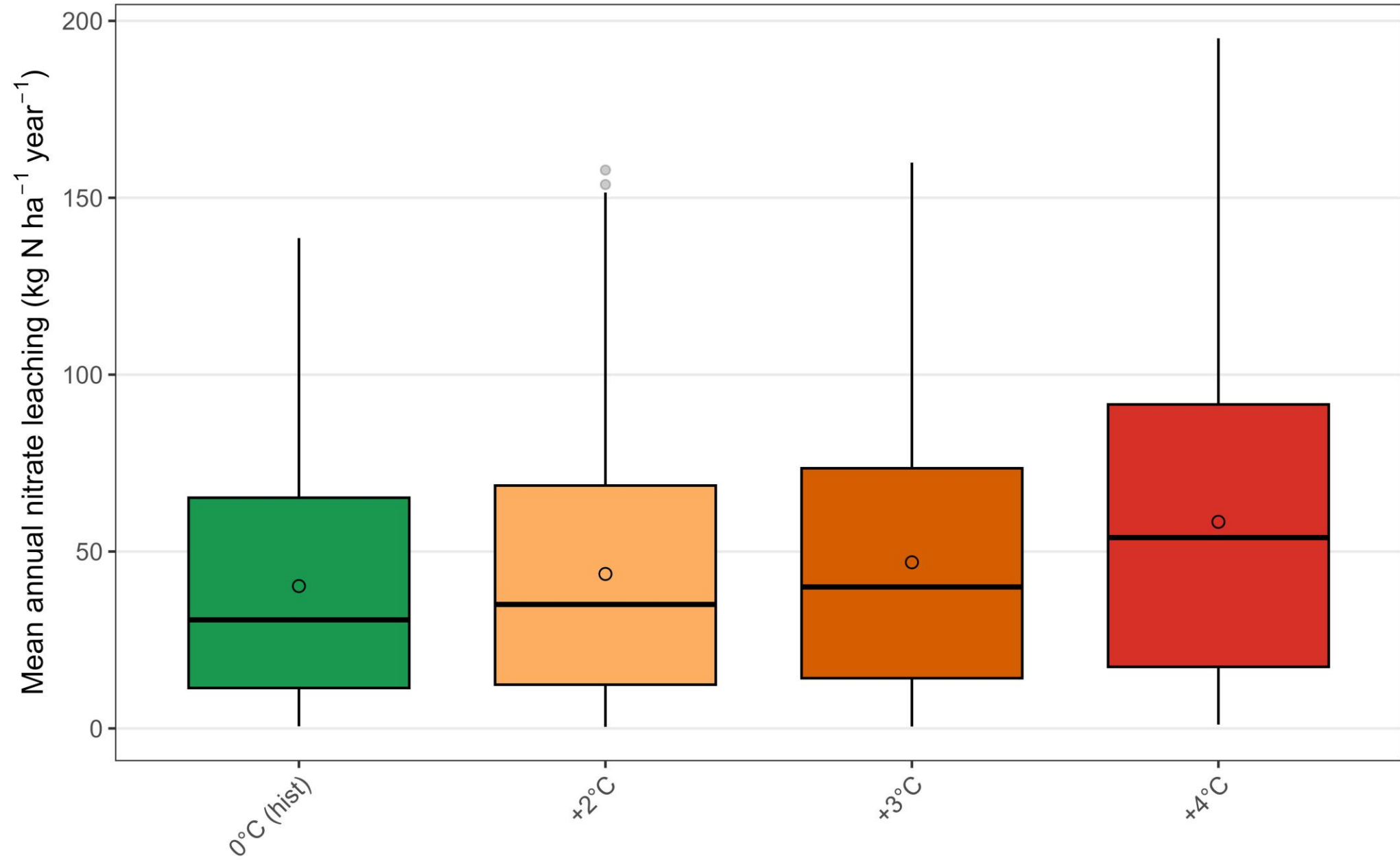
RESULTS

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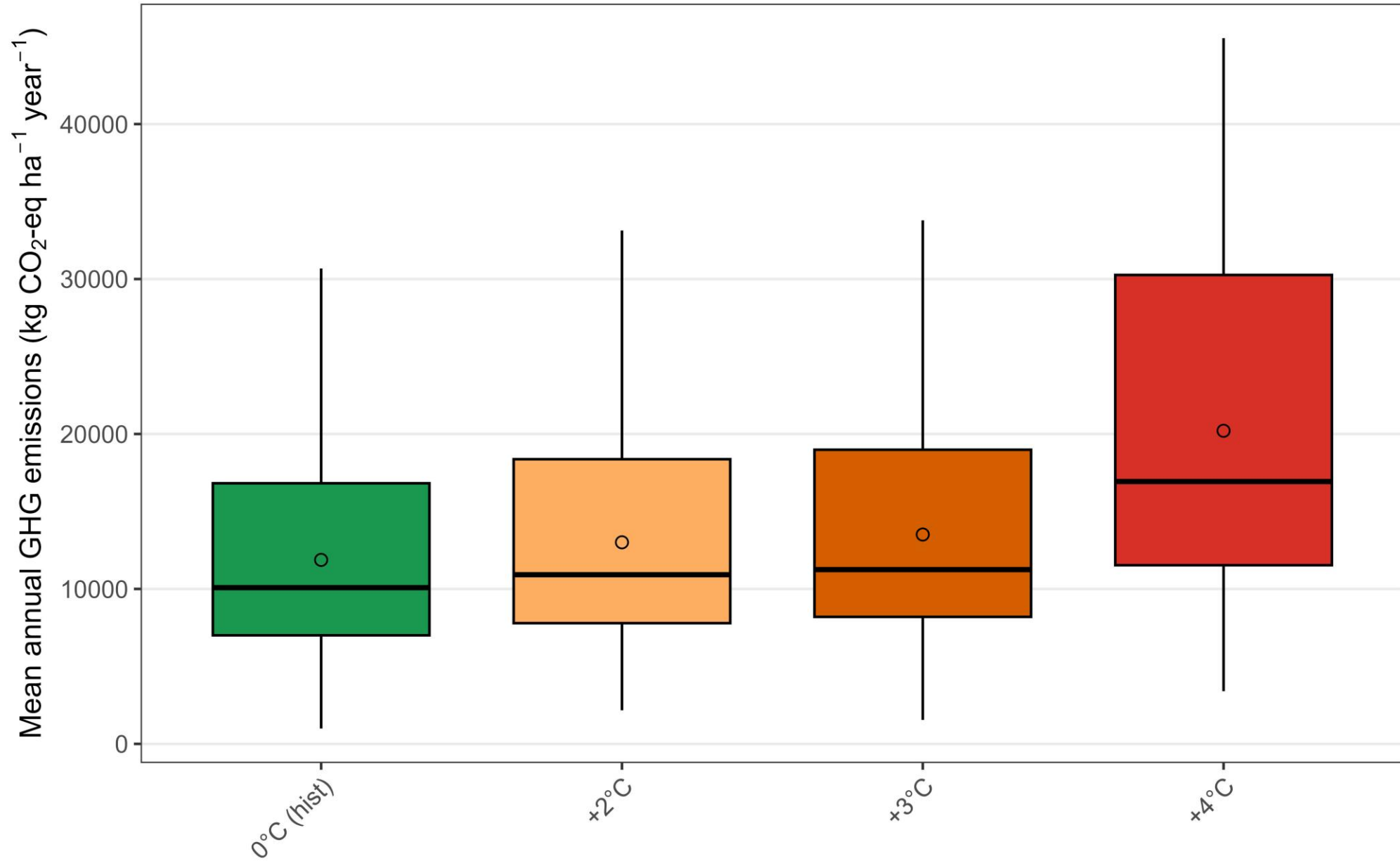
RESULTS

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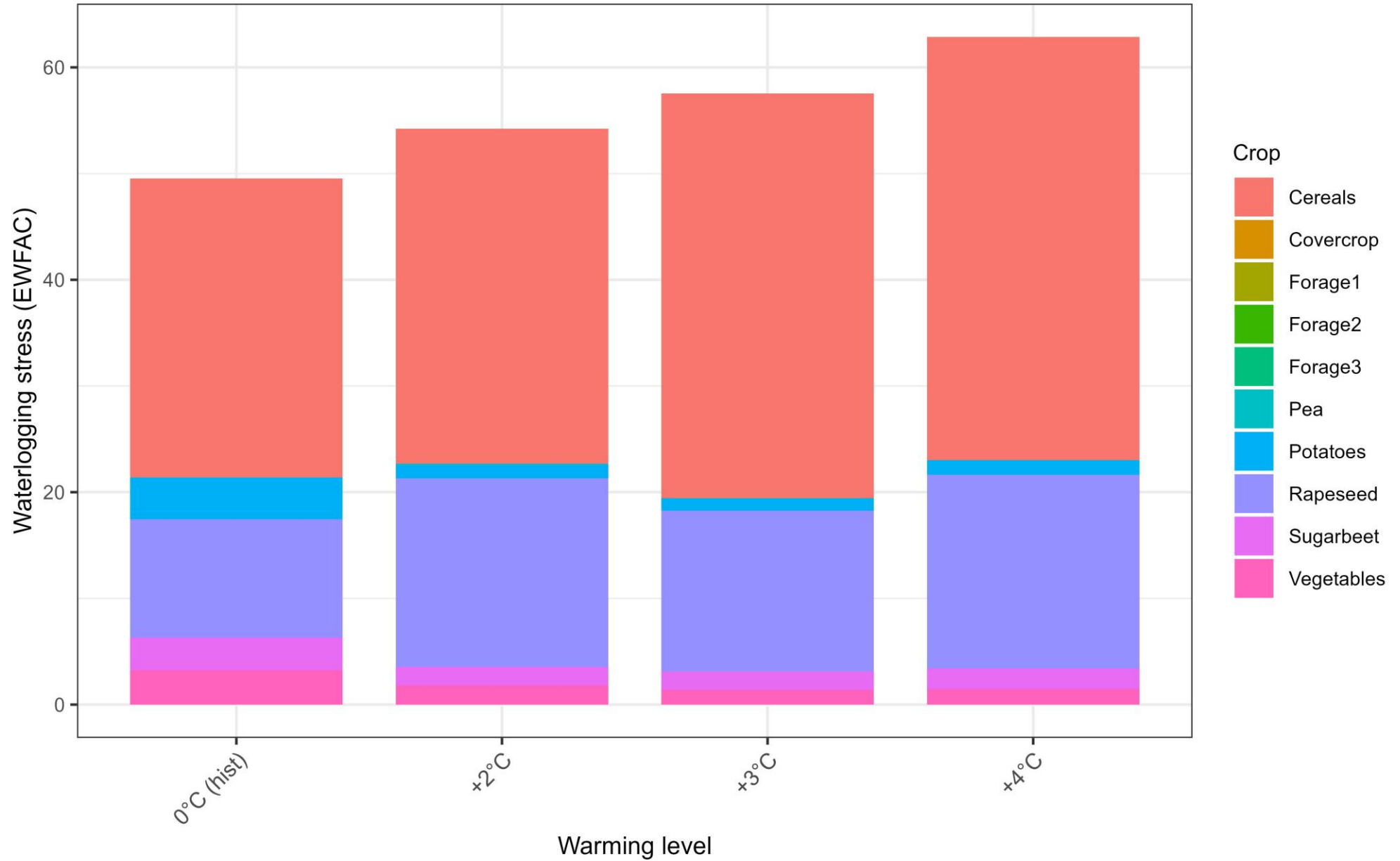
RESULTS

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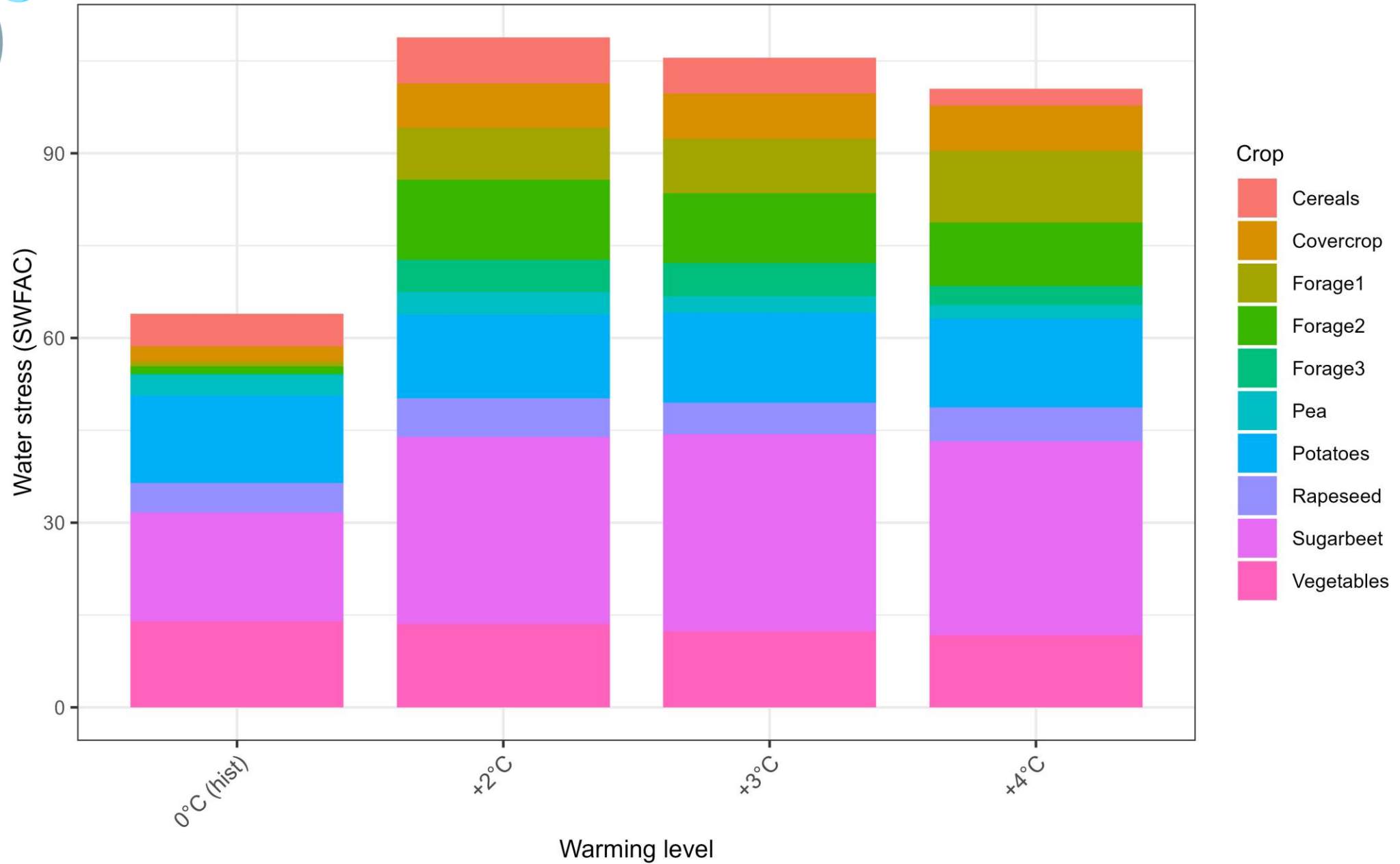
RESULTS

(Desmarez et al., *in writing*)



RESULTS

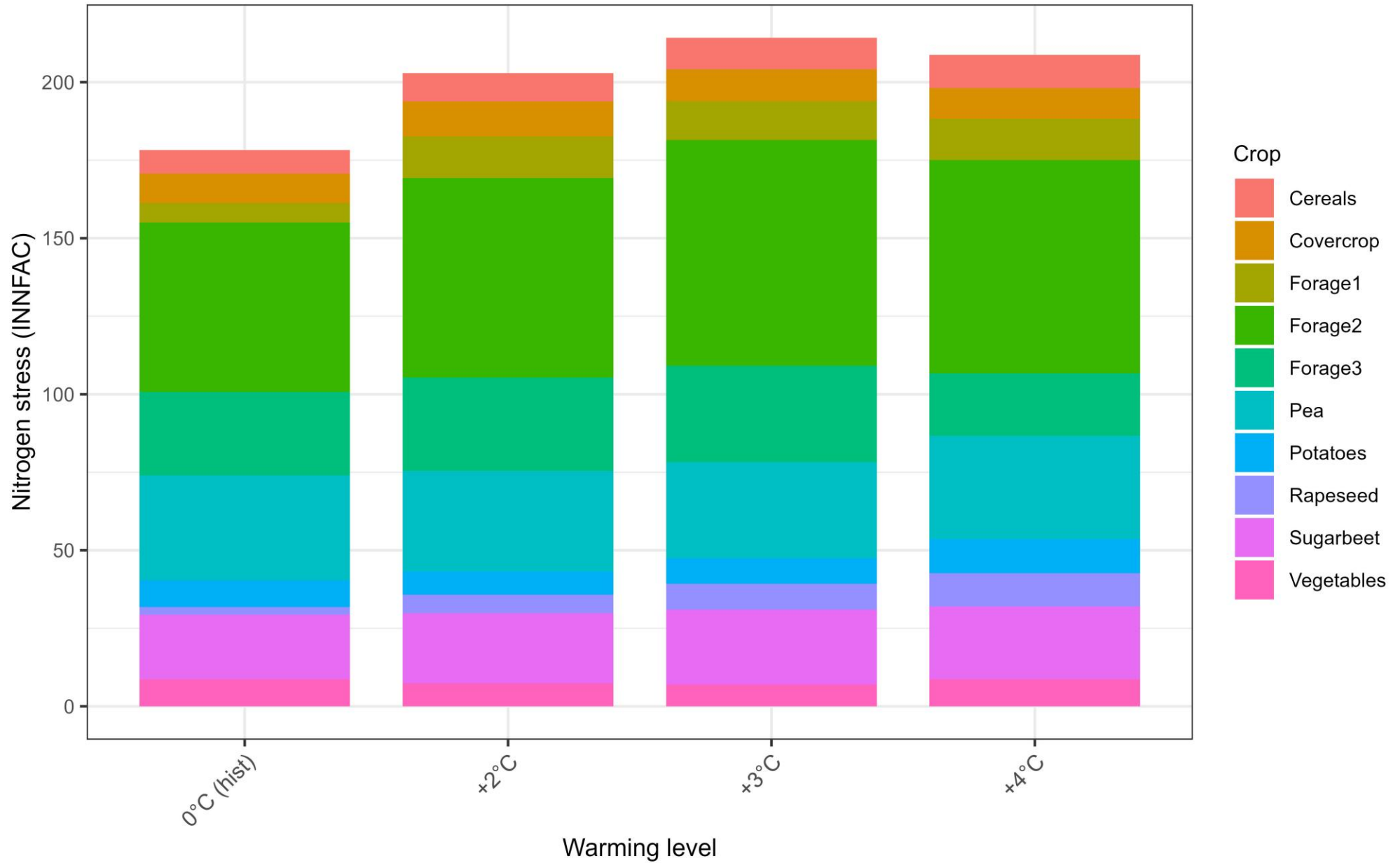
(Desmarez et al., *in writing*)





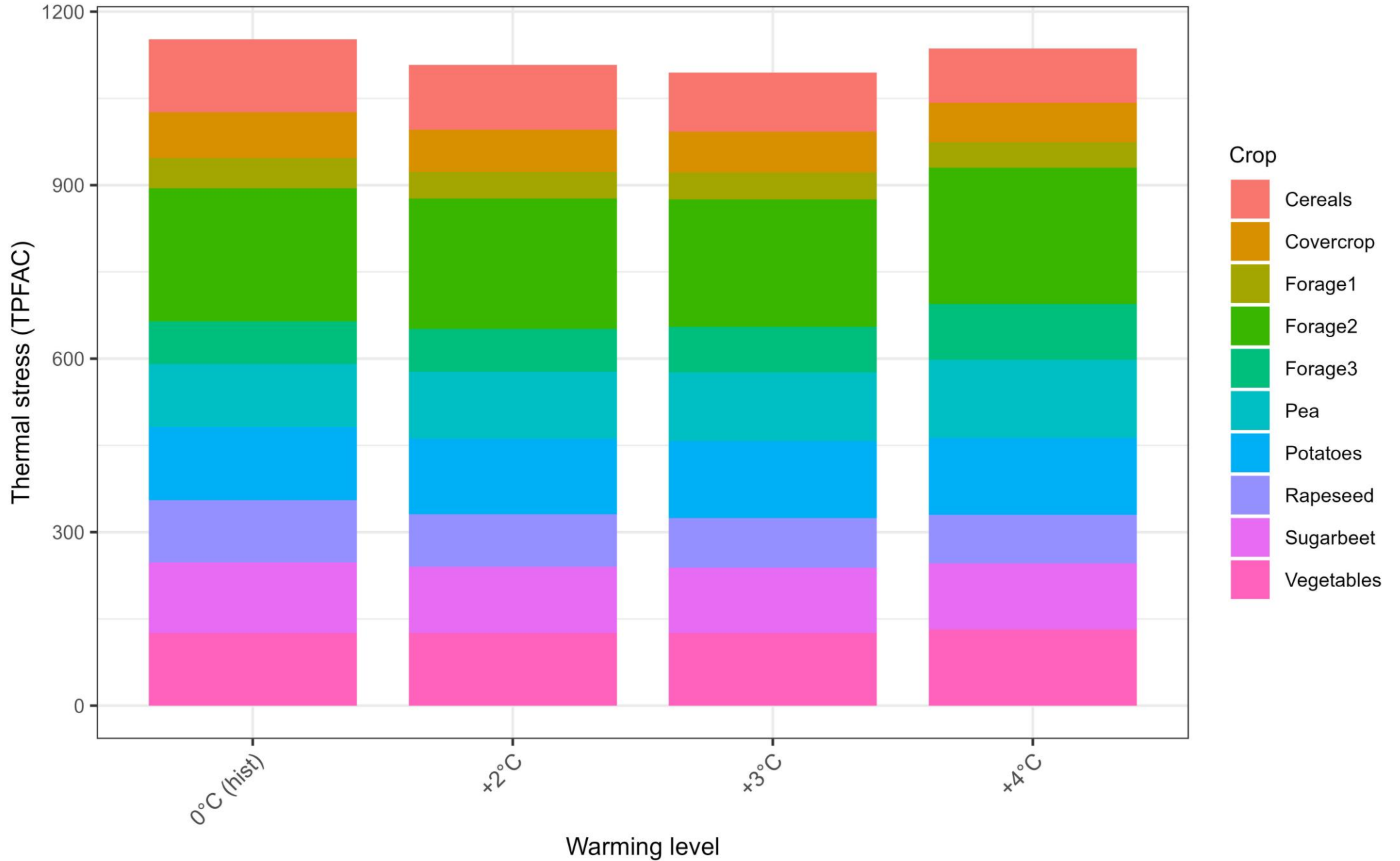
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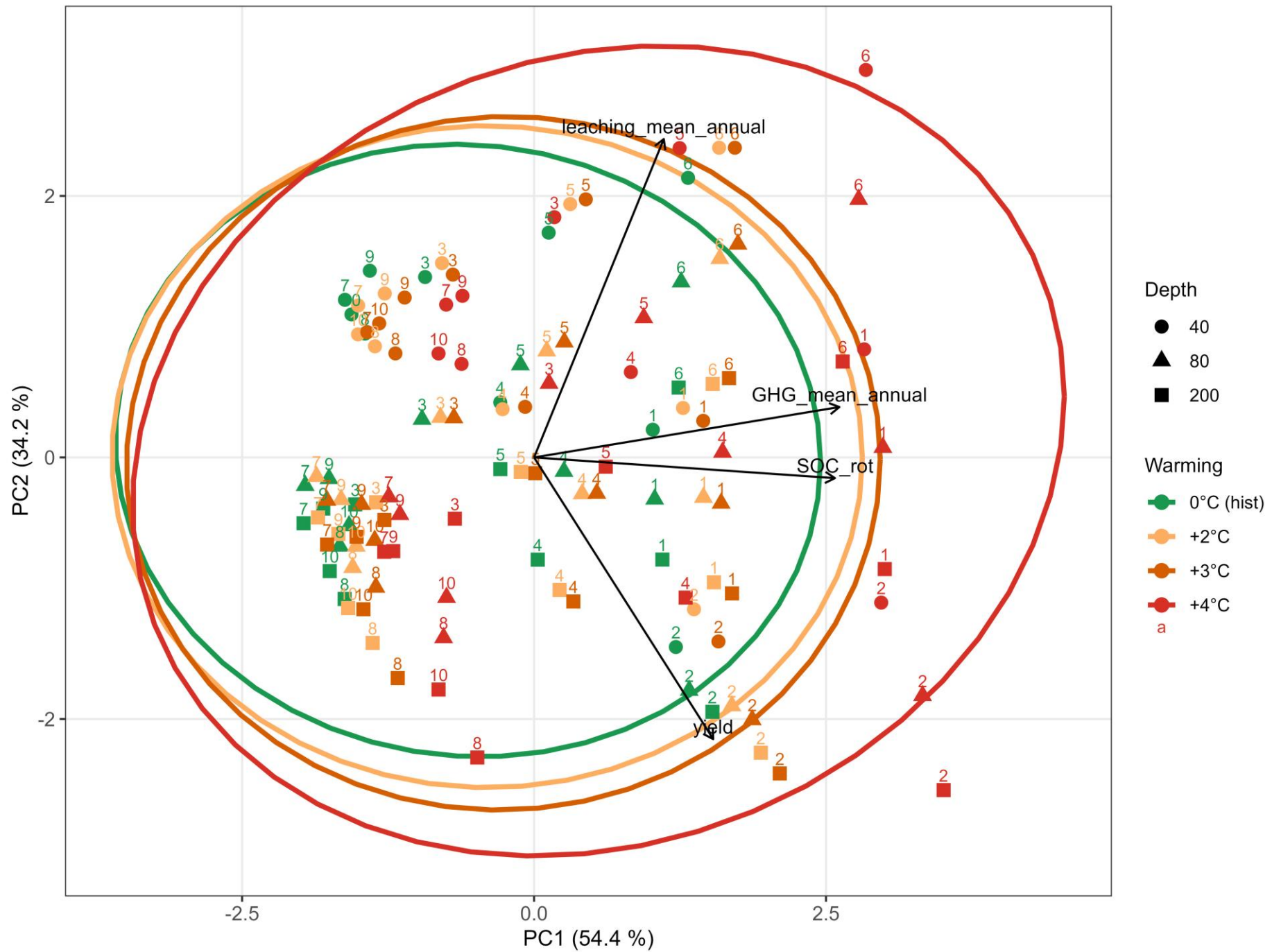


RESULTS

(Desmarez et al., *in writing*)



PCA of rotations by warming level and soil depth



KEY MESSAGES

- **Optimizing crop rotations could allow Wallonia to reach food self-sufficiency.**
- **Climate change may increase average crop yields.**
- **But yield stability is likely to decline for most crops.**
- **Environmental indicators of crop rotations are expected to decline with warmer temperatures**

Thank you for your attention !!
Do you have any question ?

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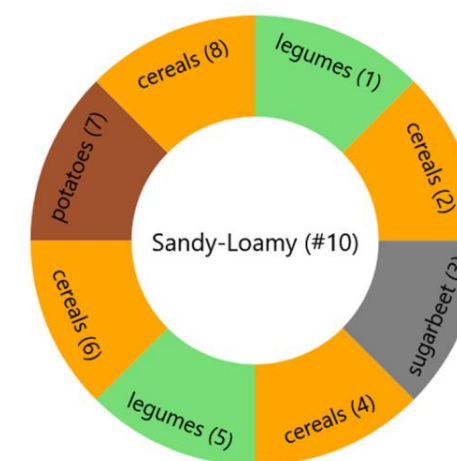
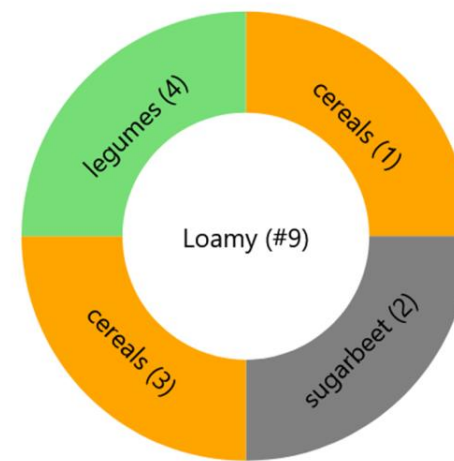
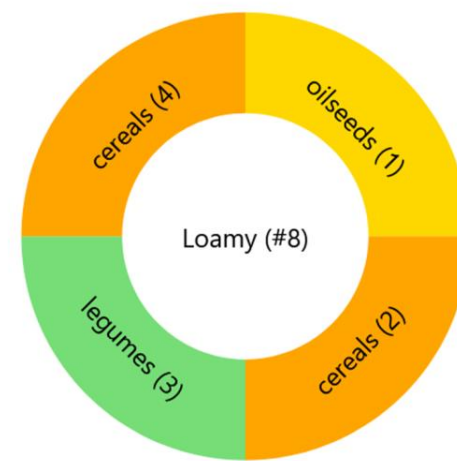
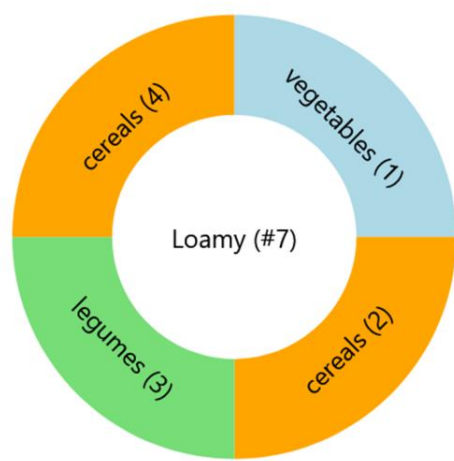
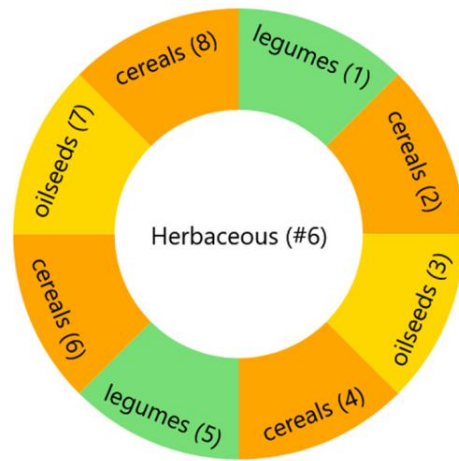
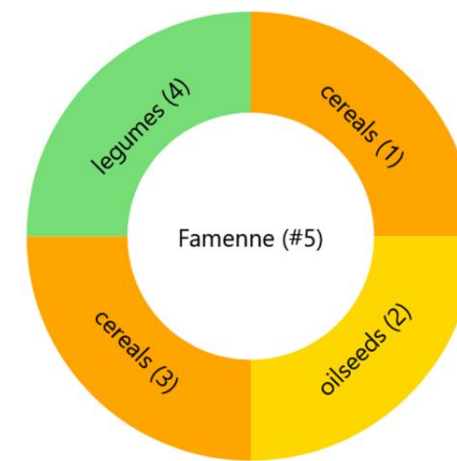
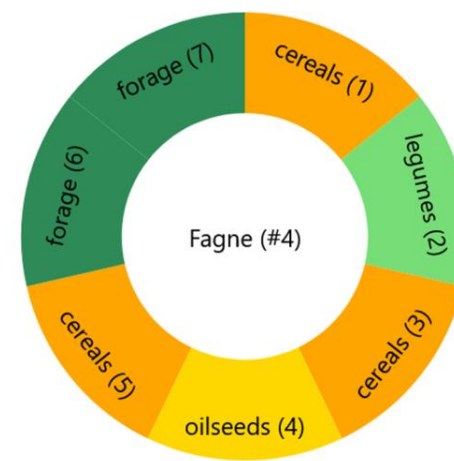
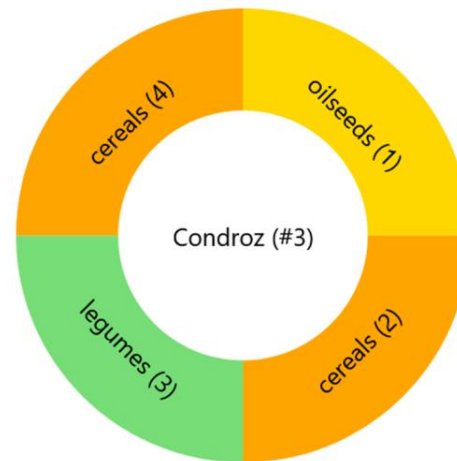
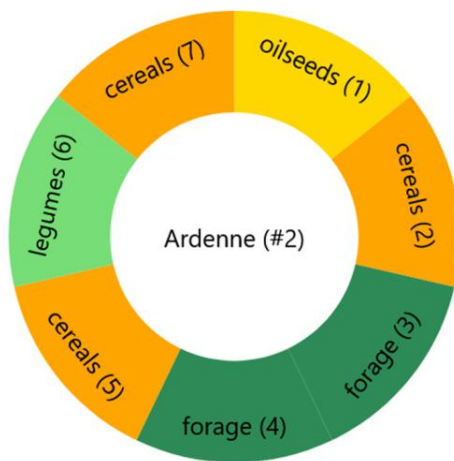
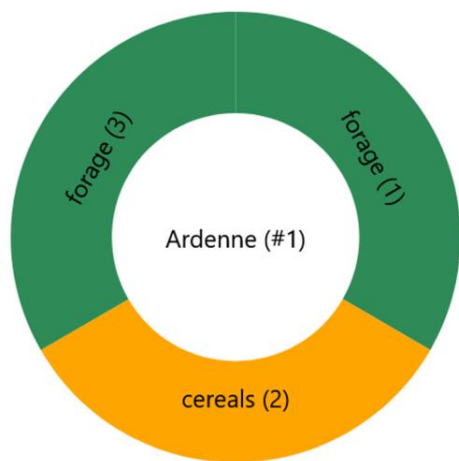
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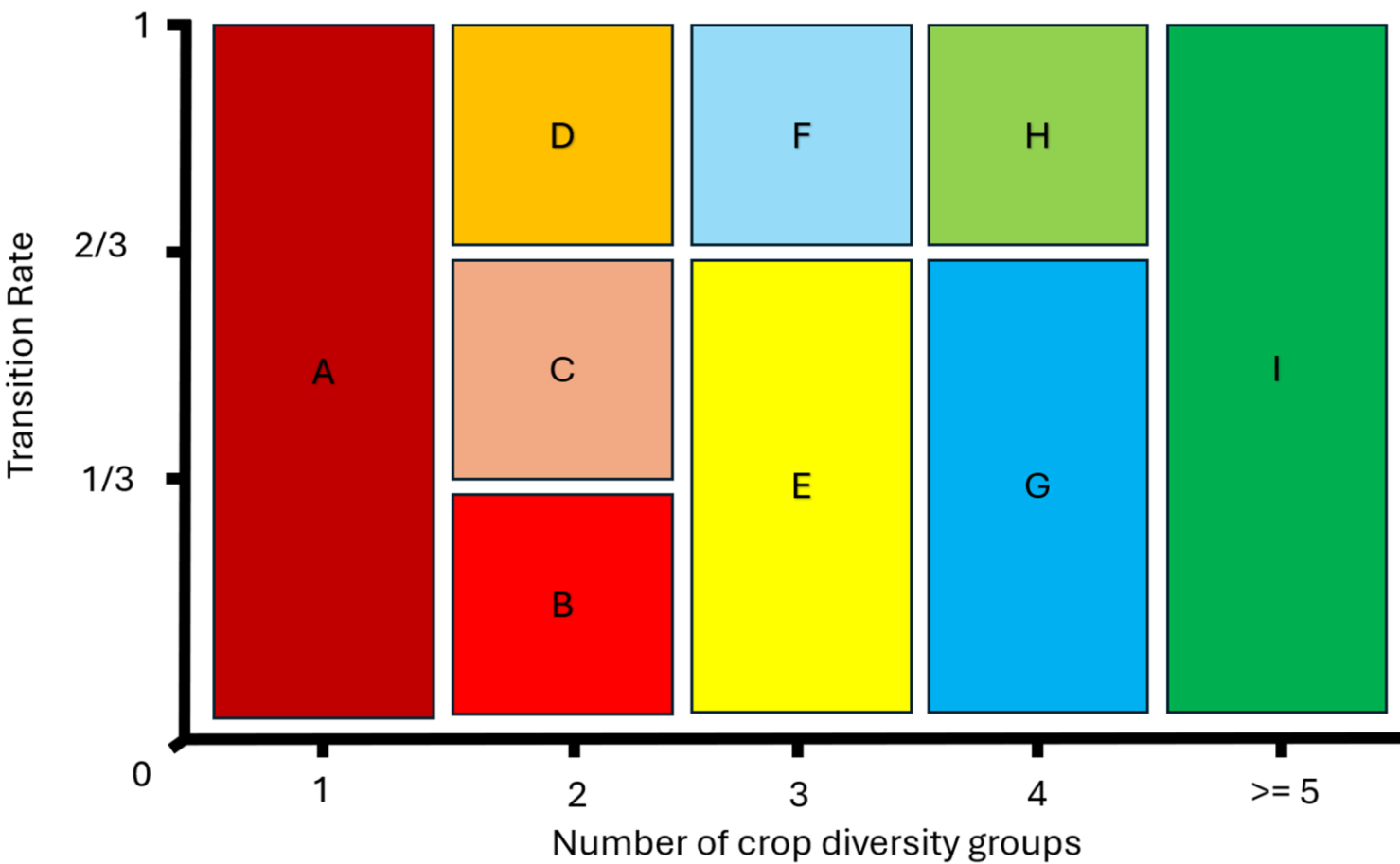
RESULTS

(Desmarez et al., *in review*)

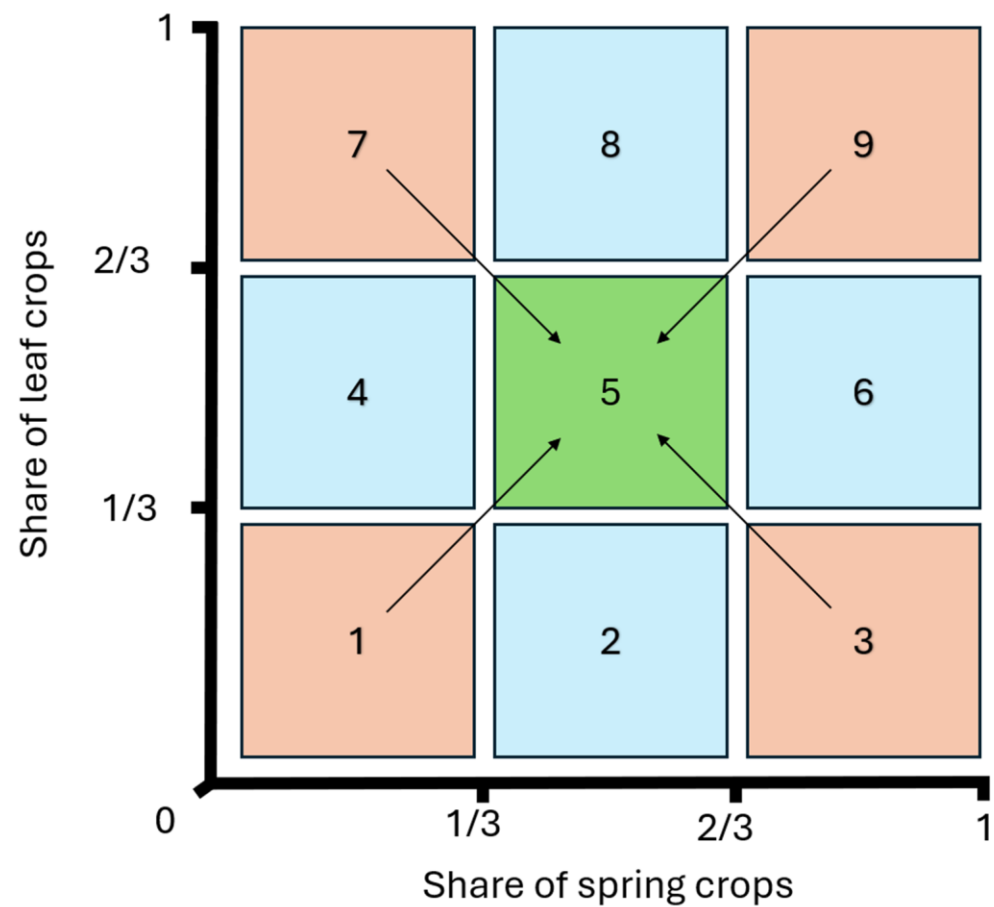
Scenario	FSS (%)	Land use (%)
#1 TYFA_Exclusions_Only	100%	83%
#2 TYFA_Return_Times	105%	89%
#3 TYFA_Region_Suitability	106%	90%
#4 EAT-Lancet_Region_Suitability	113%	99%



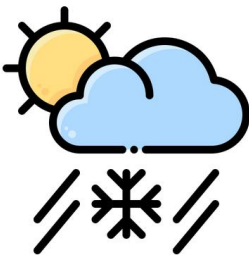
Structural diversity



Functional diversity



Climate data



Climate projections based on Shared Socioeconomic Pathways (SSPs)

Scenarios combine **socio-economic development pathways** with **radiative forcing levels** by 2100 ($\text{W}\cdot\text{m}^{-2}$)

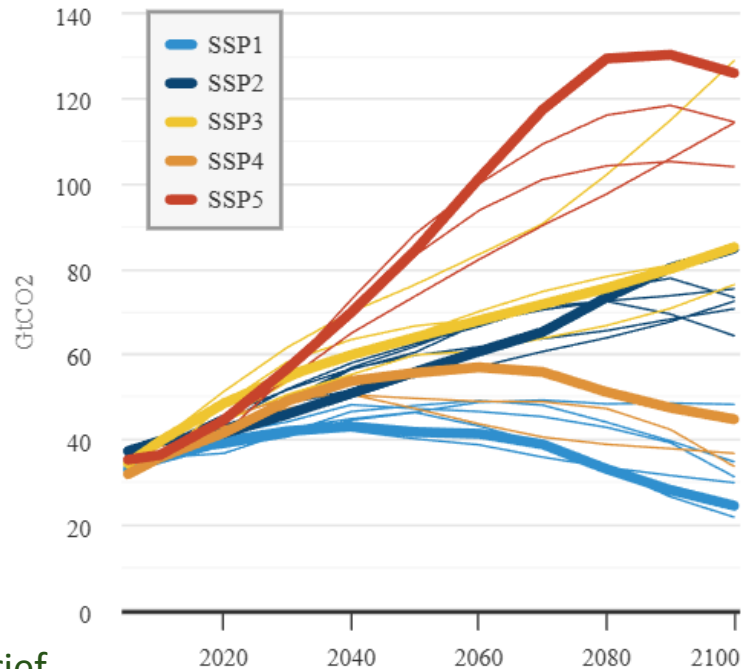
SSP3-7.0

Regional fragmentation · demographic pressure · low innovation · weak governance · high vulnerability · high emissions

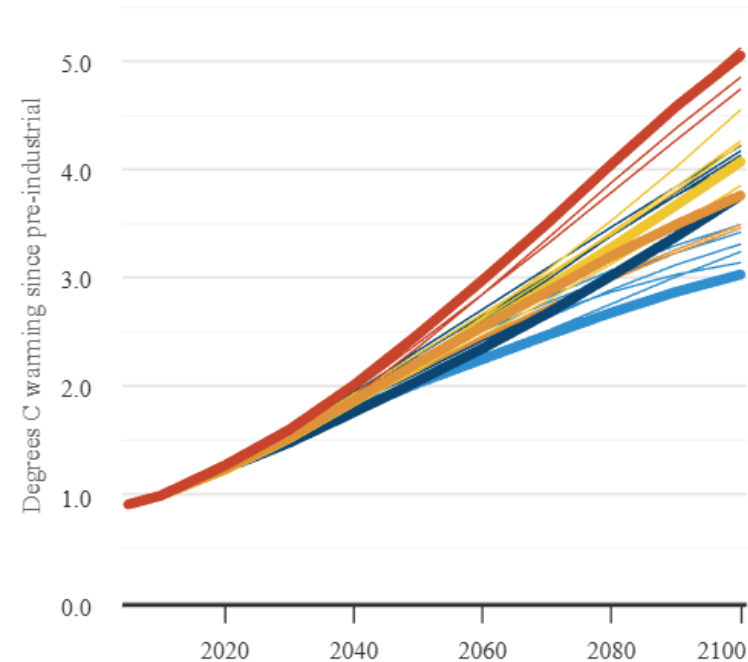
SSP5-8.5

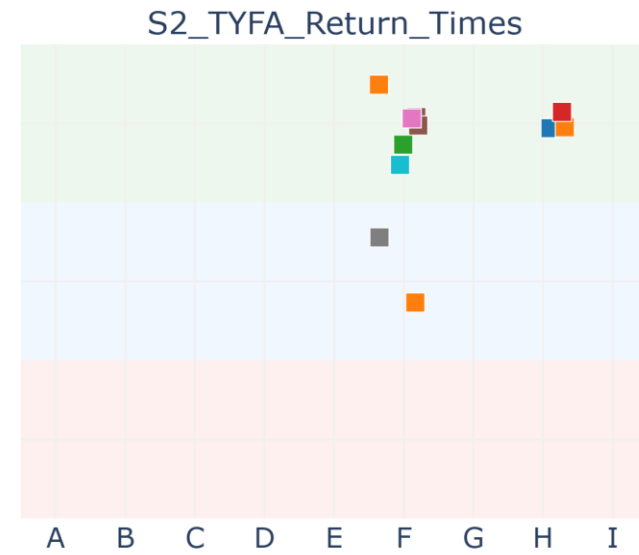
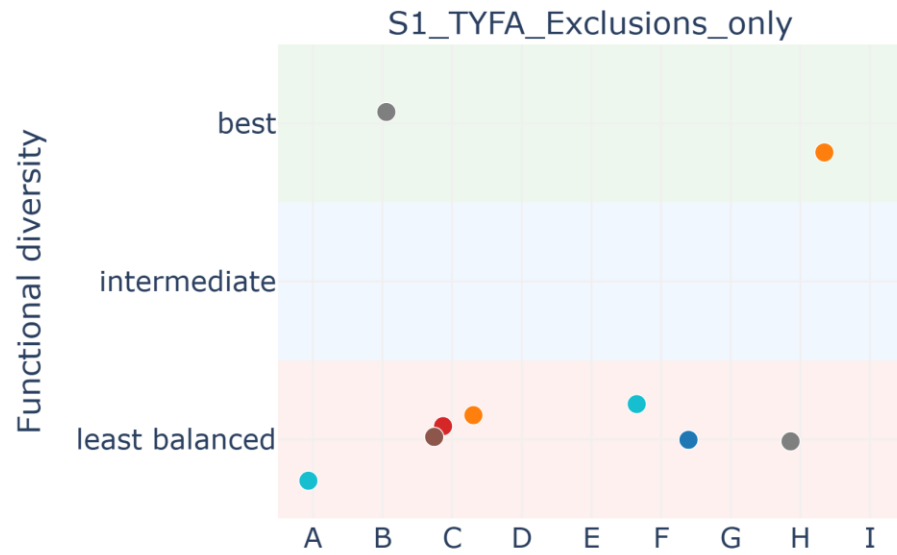
Fossil dependence · economic growth · energy intensity · technological optimism · low population growth · very high emissions

CO2 emissions for SSP baselines



Global mean temperature





- #### Regions
- Ardenne
 - Condroz
 - Fagne
 - Famenne
 - High Ardenne
 - Herbaceous
 - Jurassic
 - Loamy
 - Sandy-Loamy

