

Digital tools to redesign land use and assess the impacts of climate change in agriculture

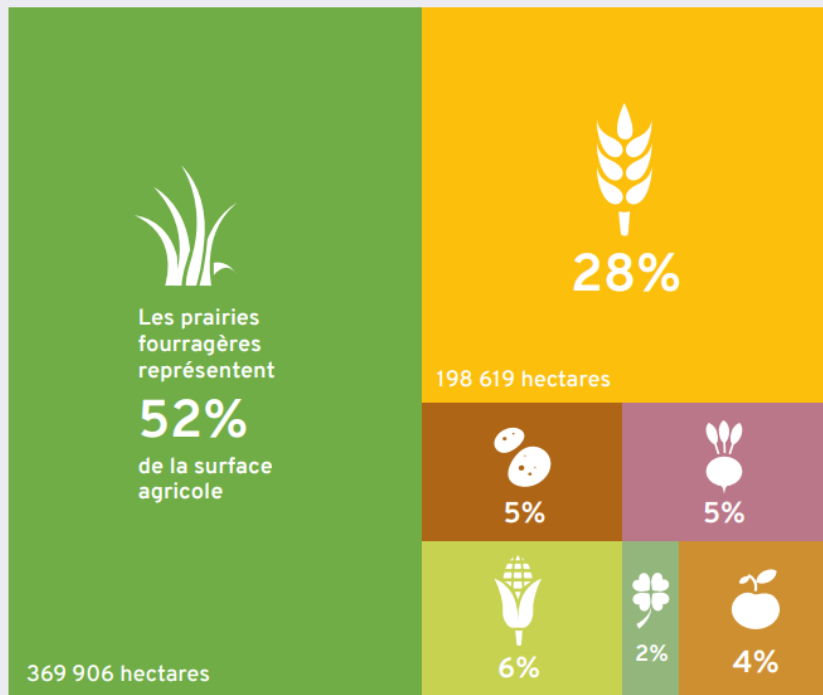
Prof. B. Dumont & team
ULiège – Gembloux Agro-Bio Tech
Plant sciences Axis – Crop Science Lab

Wallon agriculture in a nutshell

TIME FOR CHANGE ?

Agro-Environmental context

Surface agricole : 717 527 hectares

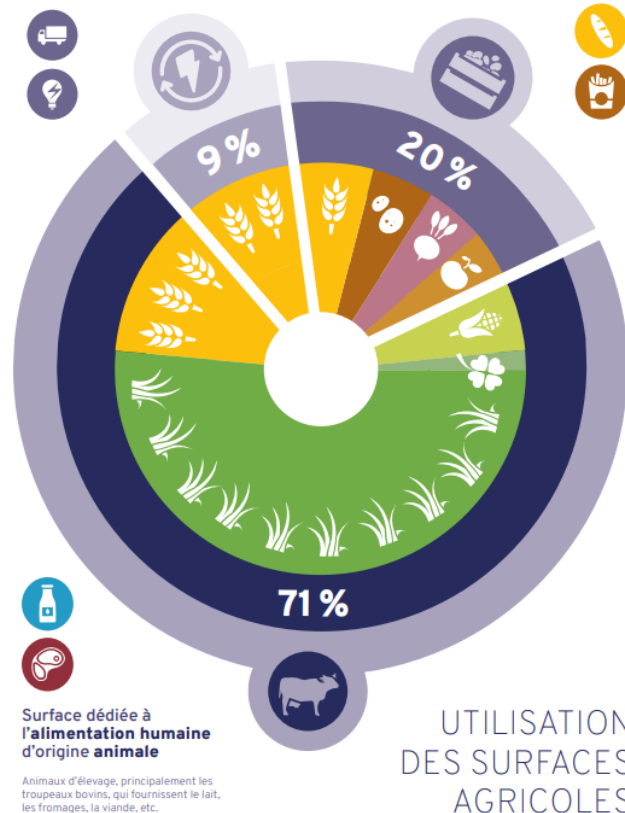


Surface dédiée à la production d'énergie d'origine végétale

Production d'énergie par combustion pour le chauffage, l'électricité ou le carburant

Surface dédiée à l'alimentation humaine d'origine végétale

Céréales, betteraves sucrières, pommes de terre, et autres cultures (fruits, légumes, etc.)

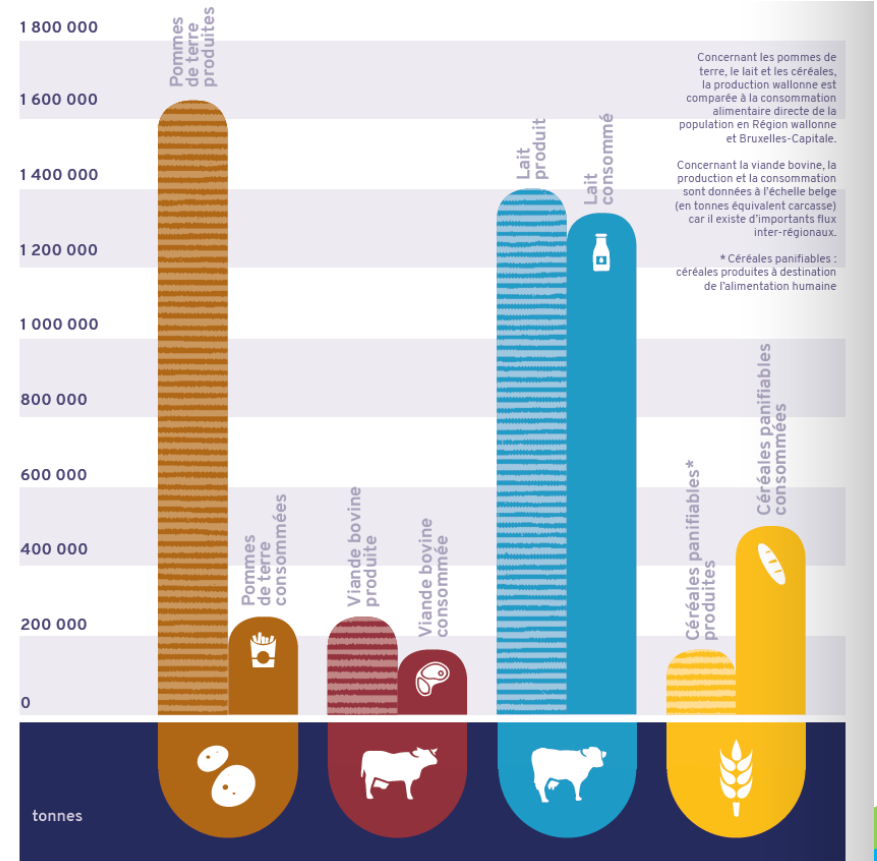


Surface dédiée à l'alimentation humaine d'origine animale

Animaux d'élevage, principalement les troupeaux bovins, qui fournissent le lait, les fromages, la viande, etc.

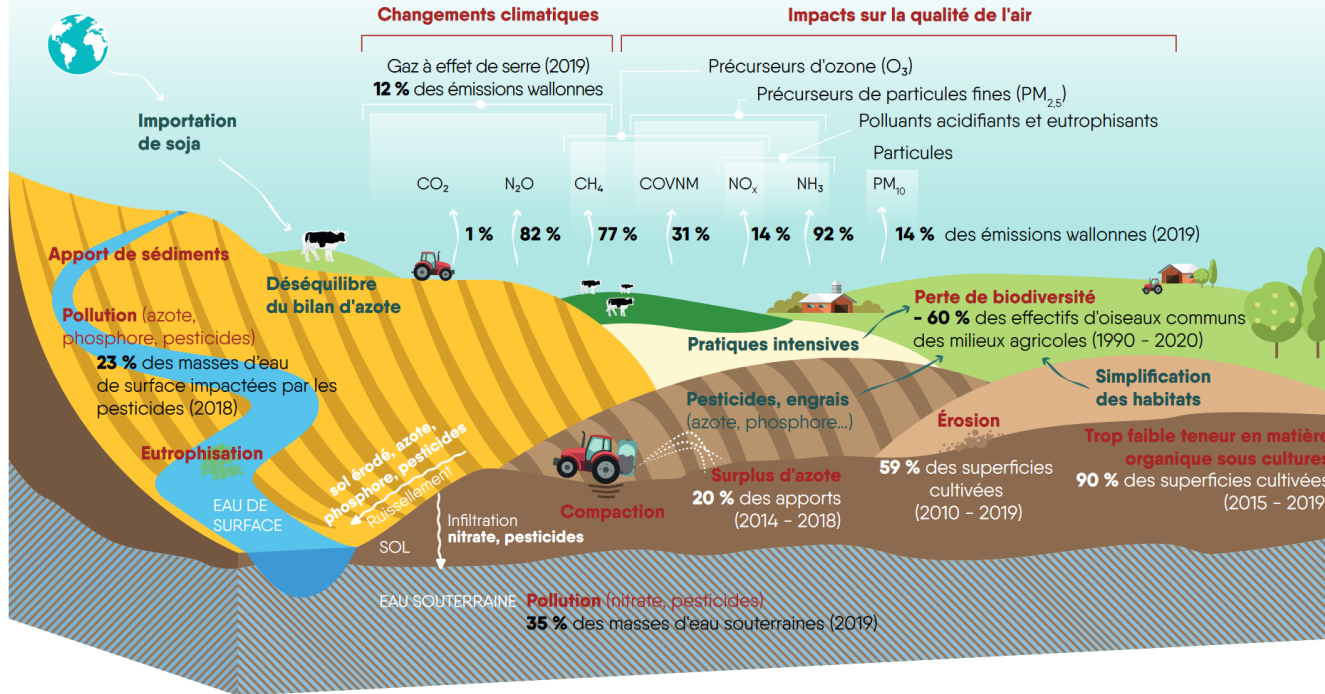
Agro-Environmental context

Imbalance between production and local needs !



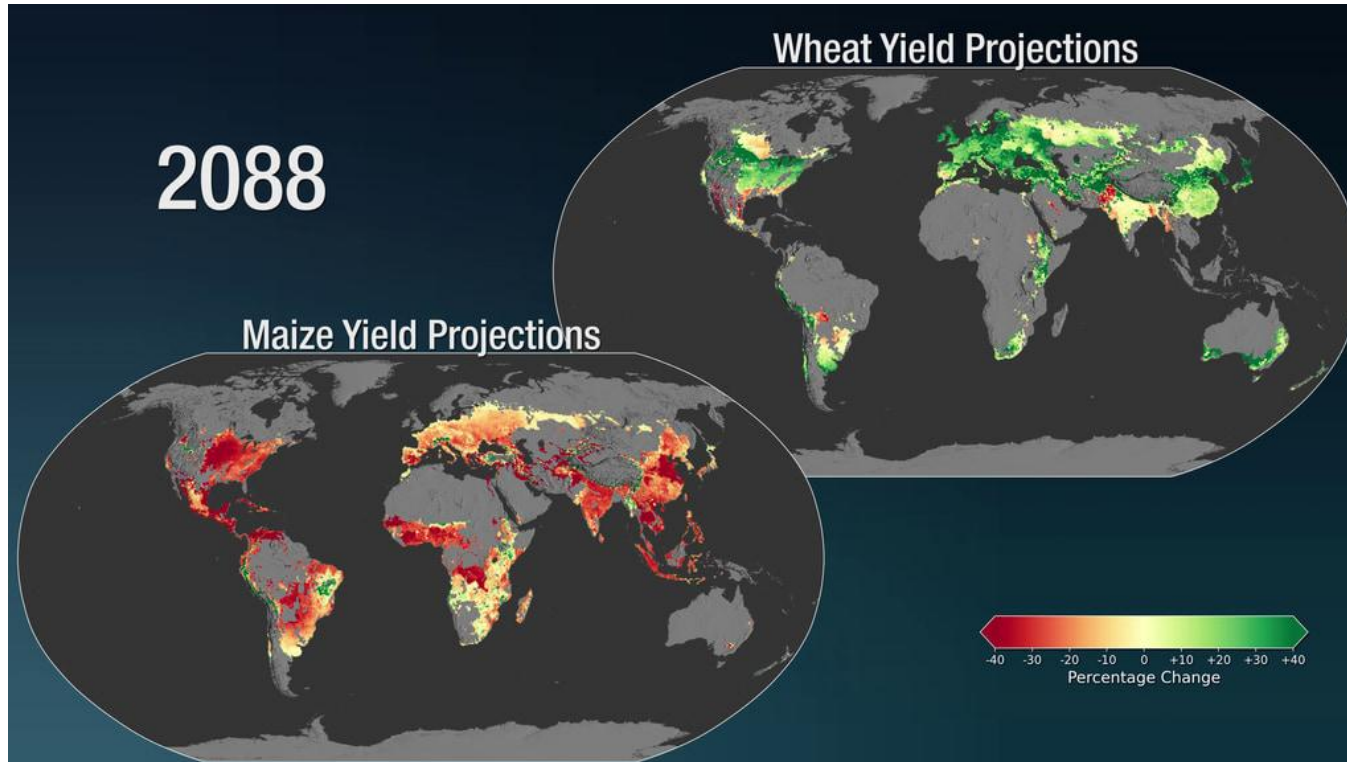
Agro-Environmental context

PRESSIONS ENVIRONNEMENTALES ET IMPACTS



We need to face the fact that agriculture impacts negatively environment in many ways and is a threat to biodiversity !

Agro-Environmental context



Climate change imposes additional threats



Tom Desmarez PhD Thesis



Land Use optimization to match sustainable diets

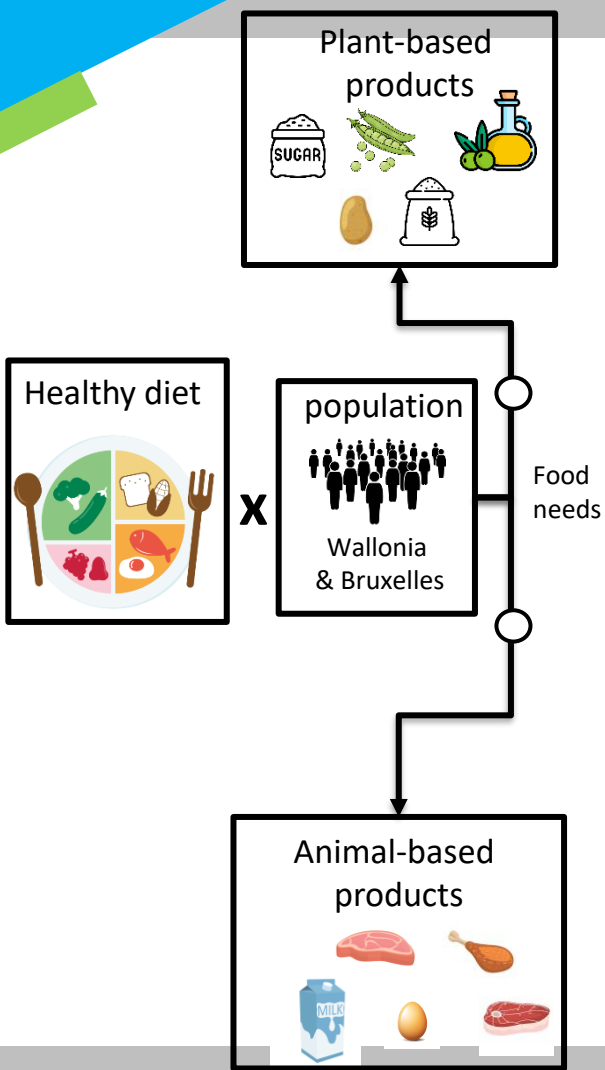
BACK TO THE BASICS

Development of an land use optimization algorithm

- We decided to start from the plate...



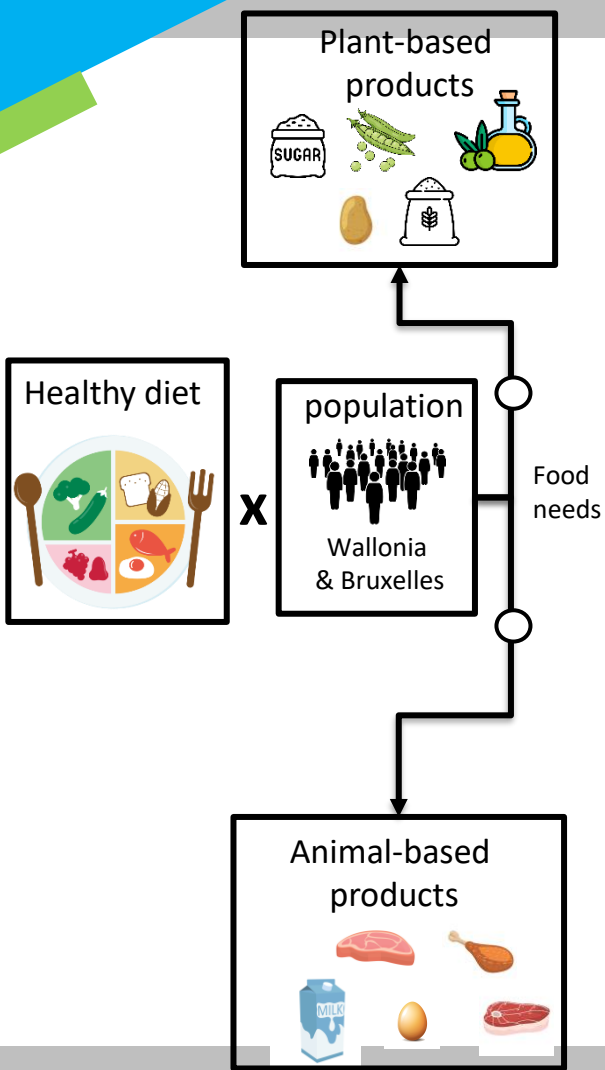
Example with the planetary healthy diet proposed by the Eat-Lancet commission



Consumption and intake	total	Energy	Protein	Carbohydrates	Lipid	Sugar	Fibre
	g/day	Kcal	g/day	g/day	g/day	g/day	g/day
Cereals	300	1 047	32	197	9	6	21
Oilseeds	34	306	0	0	34	0	0
Fruit and vegetables	400	331	11	23	18	19	11
Potatoes	80	65	2	13	0	1	1
Sugar	23	92	0	23	0	23	0
Legumes	30	100	8	15	0	0	2
Meat	92	165	17	0	17	0	0
Fish from fisheries	10	16	2	0	1	0	0
Dairy products	300	137	4	0	0	0	0
Eggs	10	14	1	0	0	0	0
Sweetened beverages	204	79	1	16	0	16	1
Alcoholic beverages	14	101	0	20	0	20	0
Total with beverages		2 265	82	286	82	64	36
Total without beverages		2 445	83	323	82	100	37

In g/day	2010	2050 / TYFA
Beef	32	31
Pork	88	36
Poultry	58	20

Source : Poux & Aubert, 2018

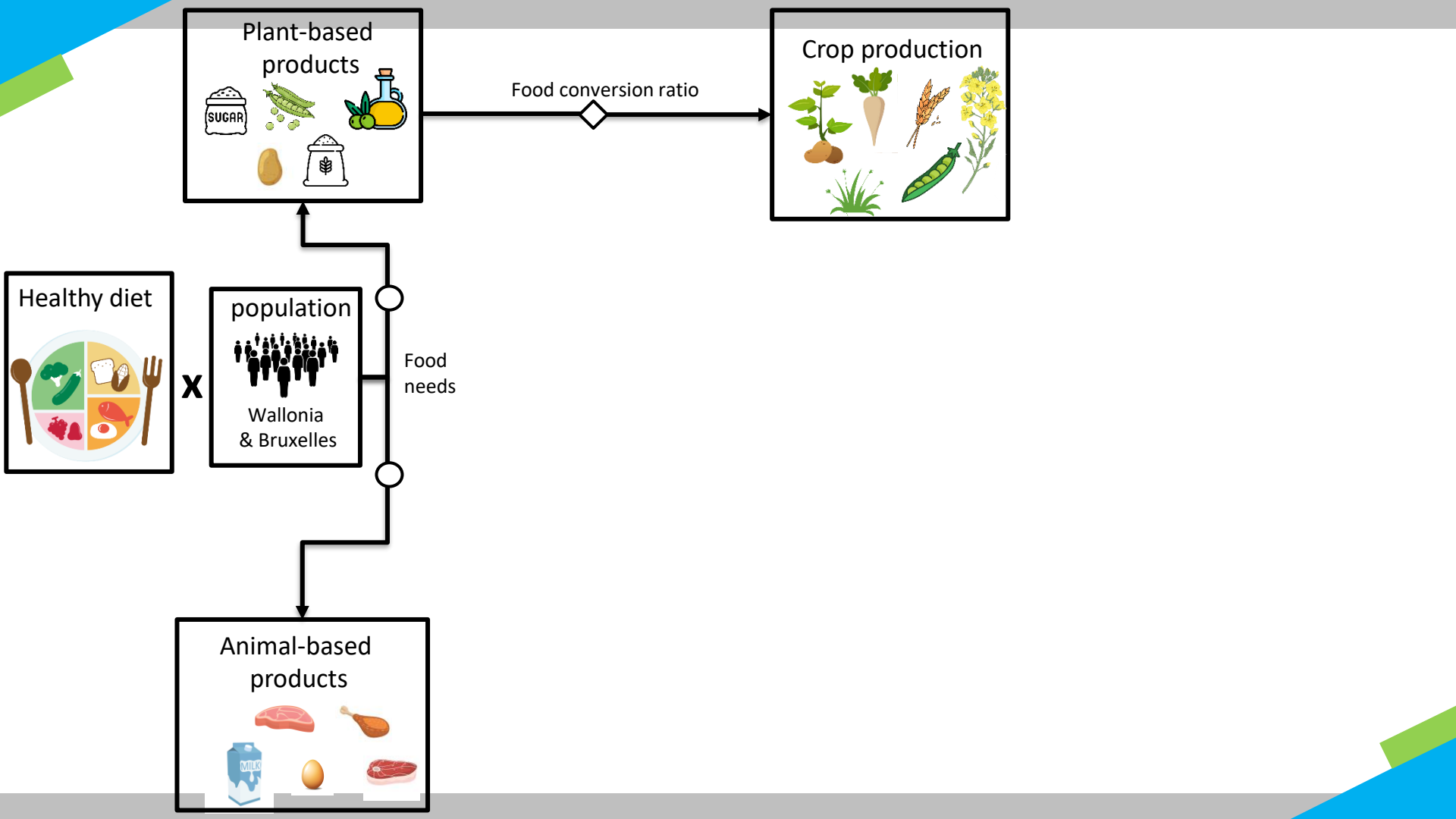


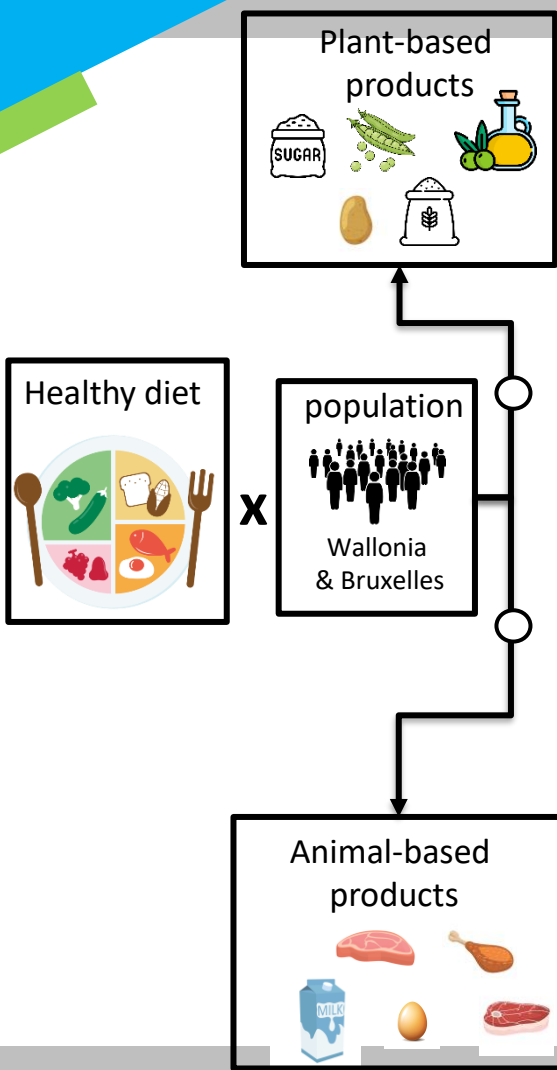
Conversion	Conversion ratio
Sugar beet → sugar	0,18
Rapeseed → oil	0,44
Winter wheat → flour	0,75
Sugar beet → sugarbeet pulp	0,22
Rapeseed → rapeseed meal	0,56
Winter wheat → wheat bran	0,25

Sources : INRAE et al., n.d. ; Raffinerie Tirlémontoise (personnal communication)

Product	% DM
forage	100
Sugarbeet pulp	23
Rapeseed meal	90
legumes	87
maize	30
cereals	87

Sources : INRAE et al., n.d. ; Raffinerie Tirlémontoise (personnal communication)





Animal	hypothesis	numeric
Bovine	Milk / cow / year	4000 l
Bovine	Veal / cow / year	1
Bovine	Replacement rate	25%
Bovine	Age for first veal	36 months
Bovine	Cow carcass weight	400 kg
Bovine	Bull carcass weight	450 kg
Bovine	Bull slaughter age	24 months
Bovine	Female Veal slaughter age	8 months
Bovine	Meat yield	65%
Bovine	Age for first veal	36 months
Bovine	Ingestion capacity 1 UGB	14

Sources: BlueSel, 2012 ; Vanvinckenroye et al., 2016 ; Decruyenaere, 2017

Animal	hypothesis	numeric
chicken	Consumption index	1,7
chicken	Living weight slaughter	2,7 kg
chicken	Carcass yield	75%
chicken	Meat % on carcass	83%
Laying hen	Eggs / animal / year	300
Laying hen	Egg weight	55 g
Laying hen & chicken	Parental populations	/

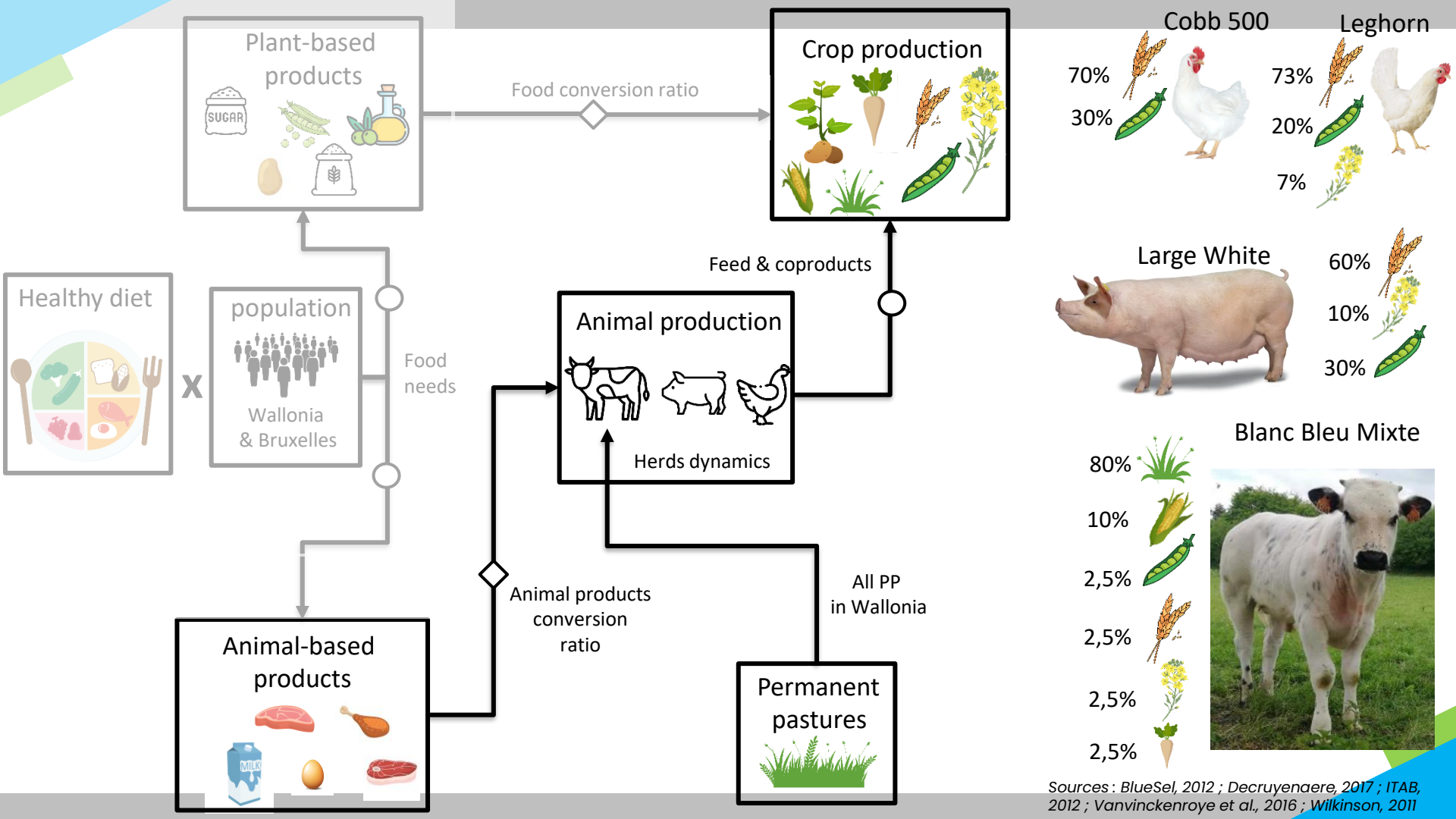
Sources: Shahin and Abd Elazeem, 2005 ; Corzo et al., 2010 ; Taschetto et al., 2012 ; Abu Hafsa and Ibrahim, 2018 ; Savaris et al., 2024

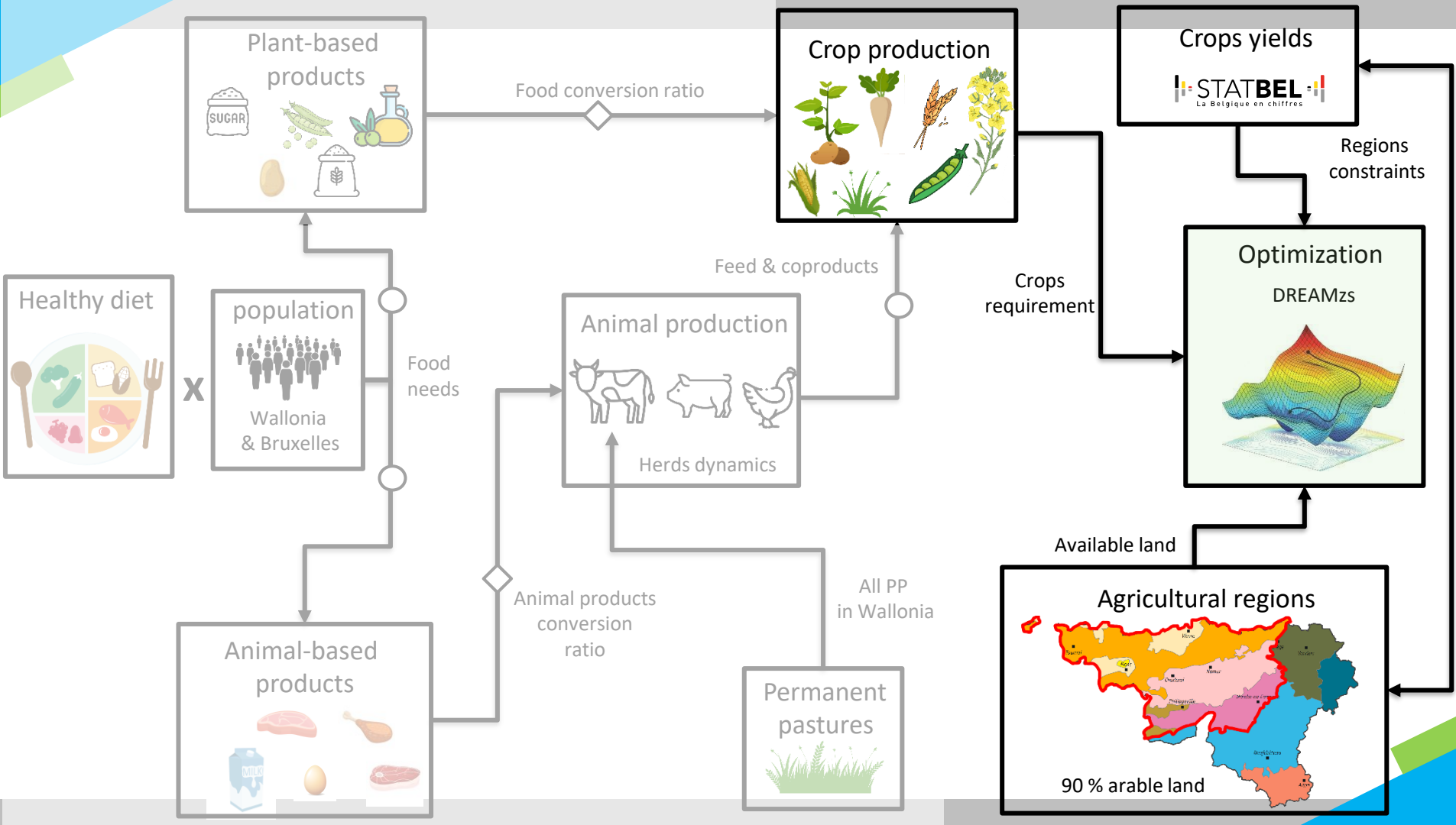
Category	UGB
Milking Cow	1
Heifer < 1 year	0,35
Heifer < 2 years	0,6
Heifer < 3 years	0,8
Bull < 1 year	0,4
Bull < 2 years	0,8
Female veal < 8 months	0,3
Cull cow	0,8

Source : Benoit & Veysset, 2021

Animal	hypothesis	numeric
pig	Piglet / sow / year	35
pig	Feed / sow / day	3,7 kg
pig	Living weight slaughter	105 kg
pig	Consumption index post-weaning	2,3
pig	Muscle rate	0,6
pig	Feed / boar / day	/

Sources : Hansen et al., 2006; Moerman, 2017 ; Homma et al., 2021 ; Zhou et al., 2021 ; DanBred, 2023

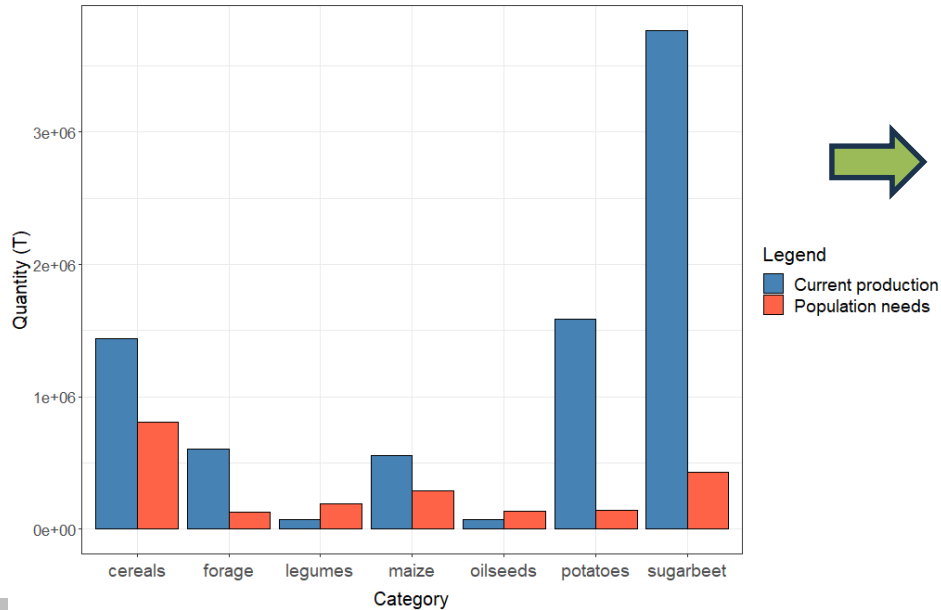




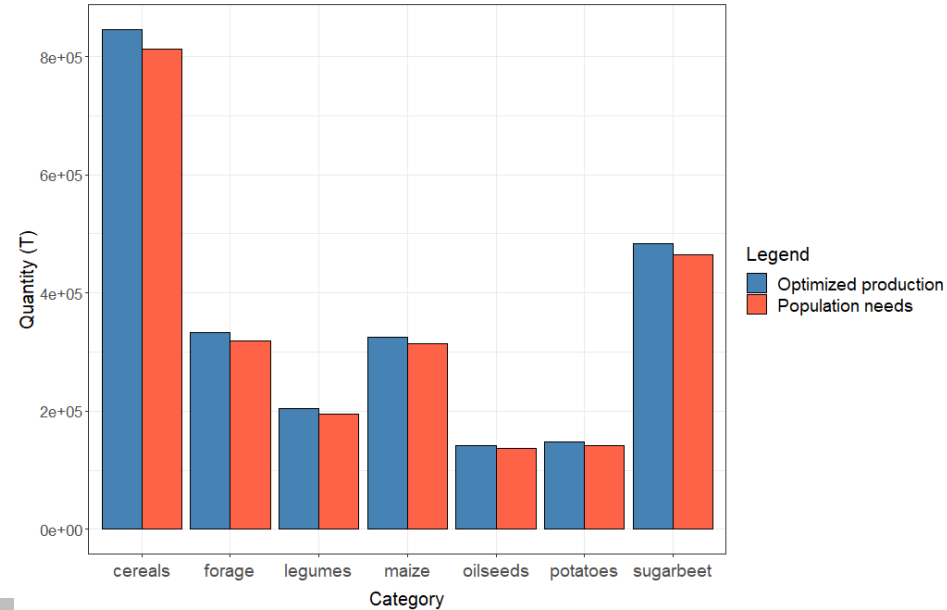
Development of an land use optimization algorithm

➤ Consumption \gg Production

Current Production

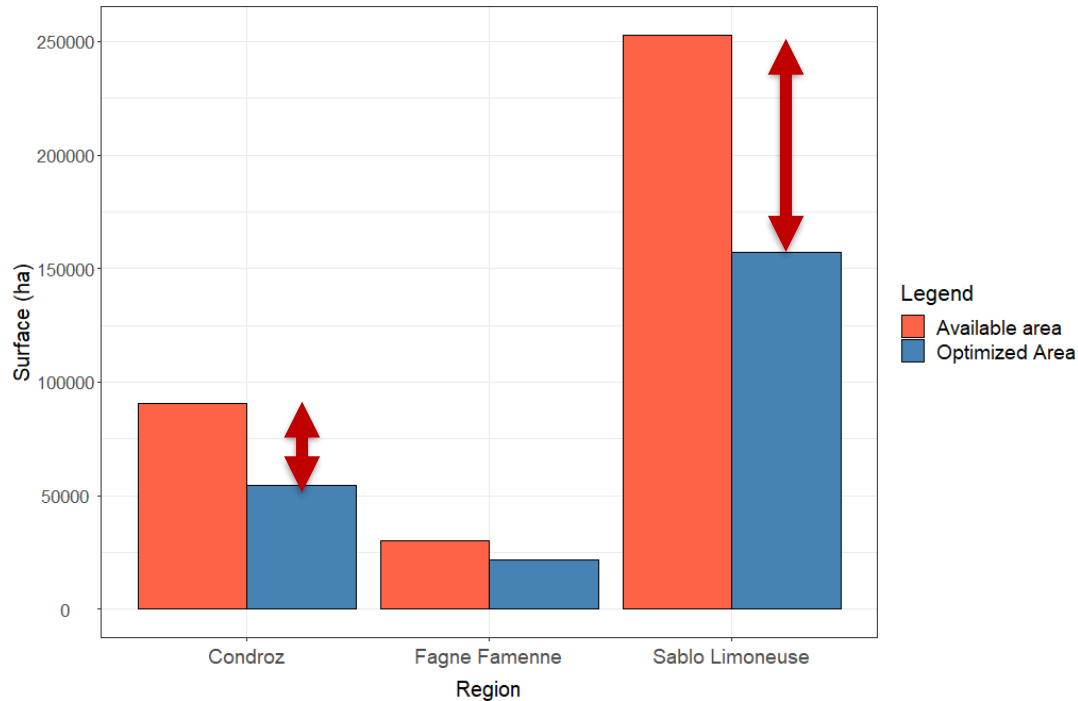


Optimized situation



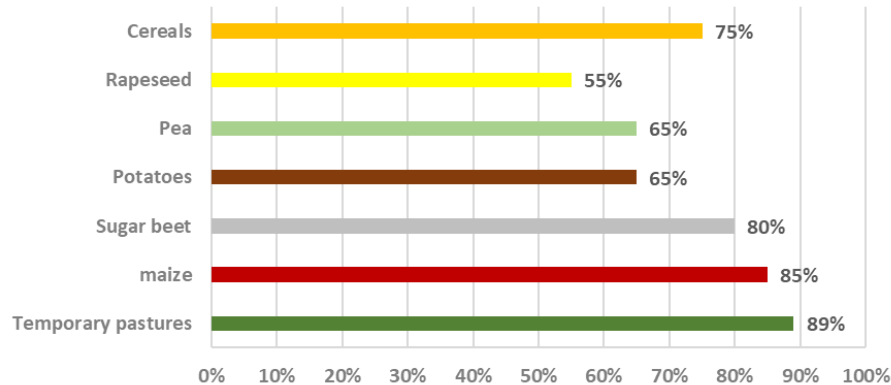
Development of an land use optimization algorithm

➤ Impact on Walloon Land Use

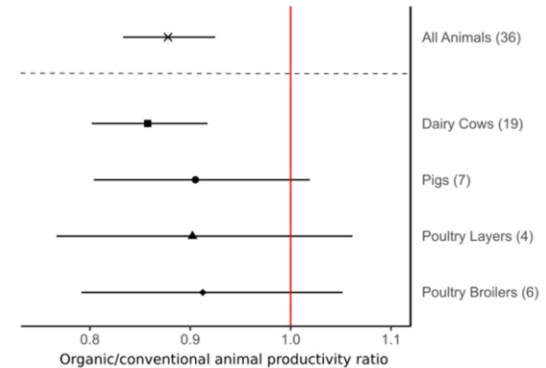


Development of an land use optimization algorithm

- Could we go « Organic » ?



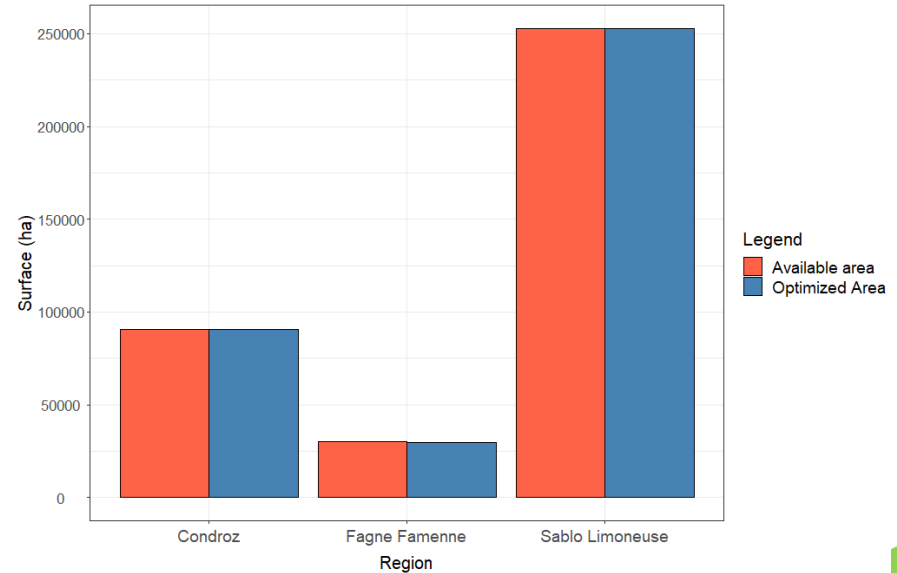
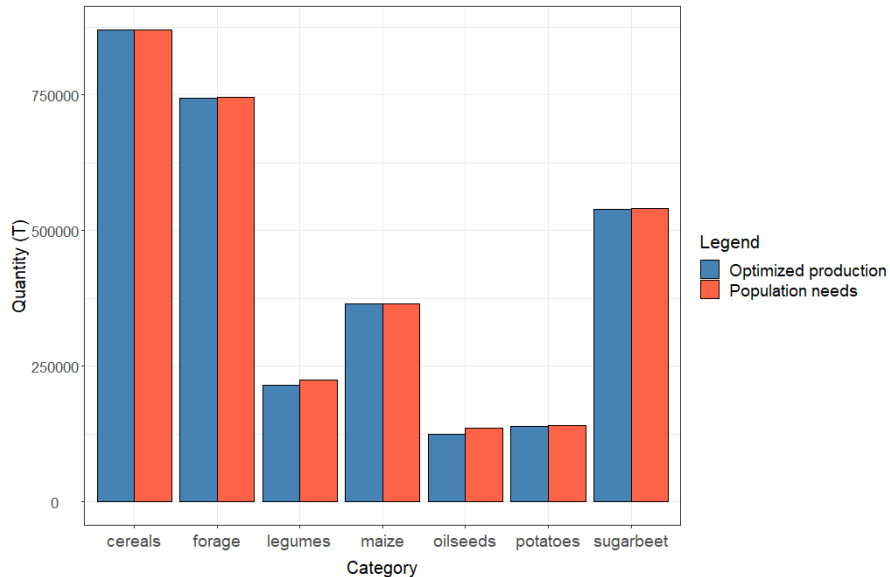
Sources : Poux & Aubert, 2018 ; Ponisio et al., 2015



Source : Gaudaré et al., 2021

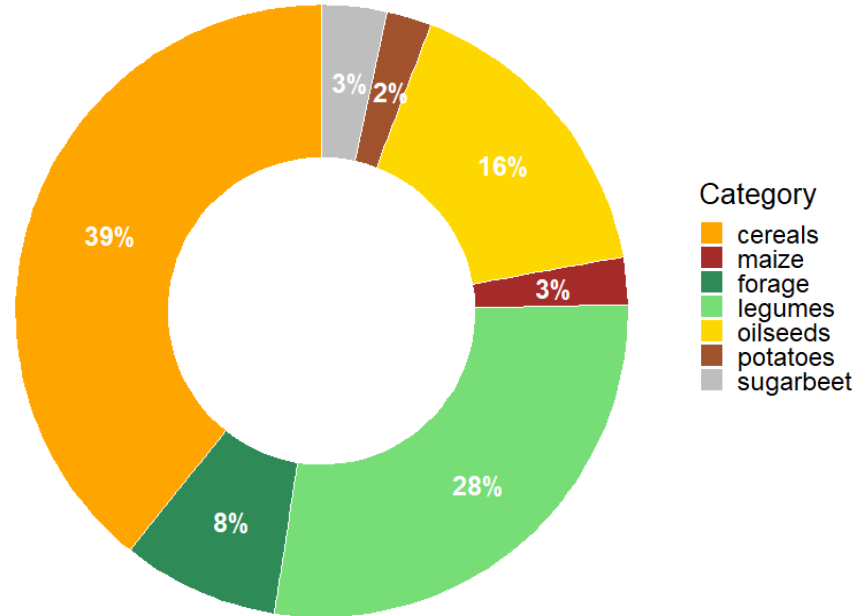
Development of an land use optimization algorithm

- Could we go « Organic » ? *In theory, we could !*



Development of an land use optimization algorithm

- For each region, we have a land use that can be converted in cropping system (CS)



Sandy-loam area



Mathieu Delandmeter PhD Thesis

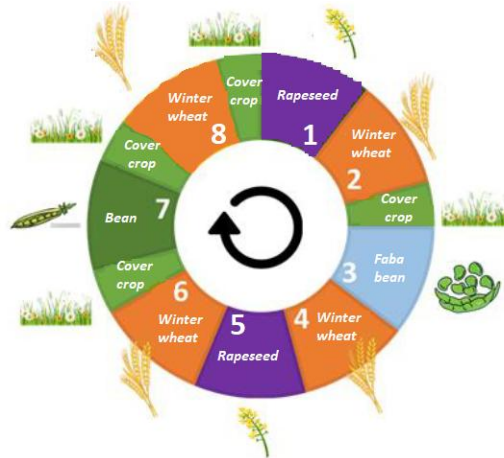
Assessing CC on innovative cropping systems

BACK TO THE FUTURE

EcoFoodSystem – Innovative cropping systems designed by GxABT



Business-as-usual (BAU)



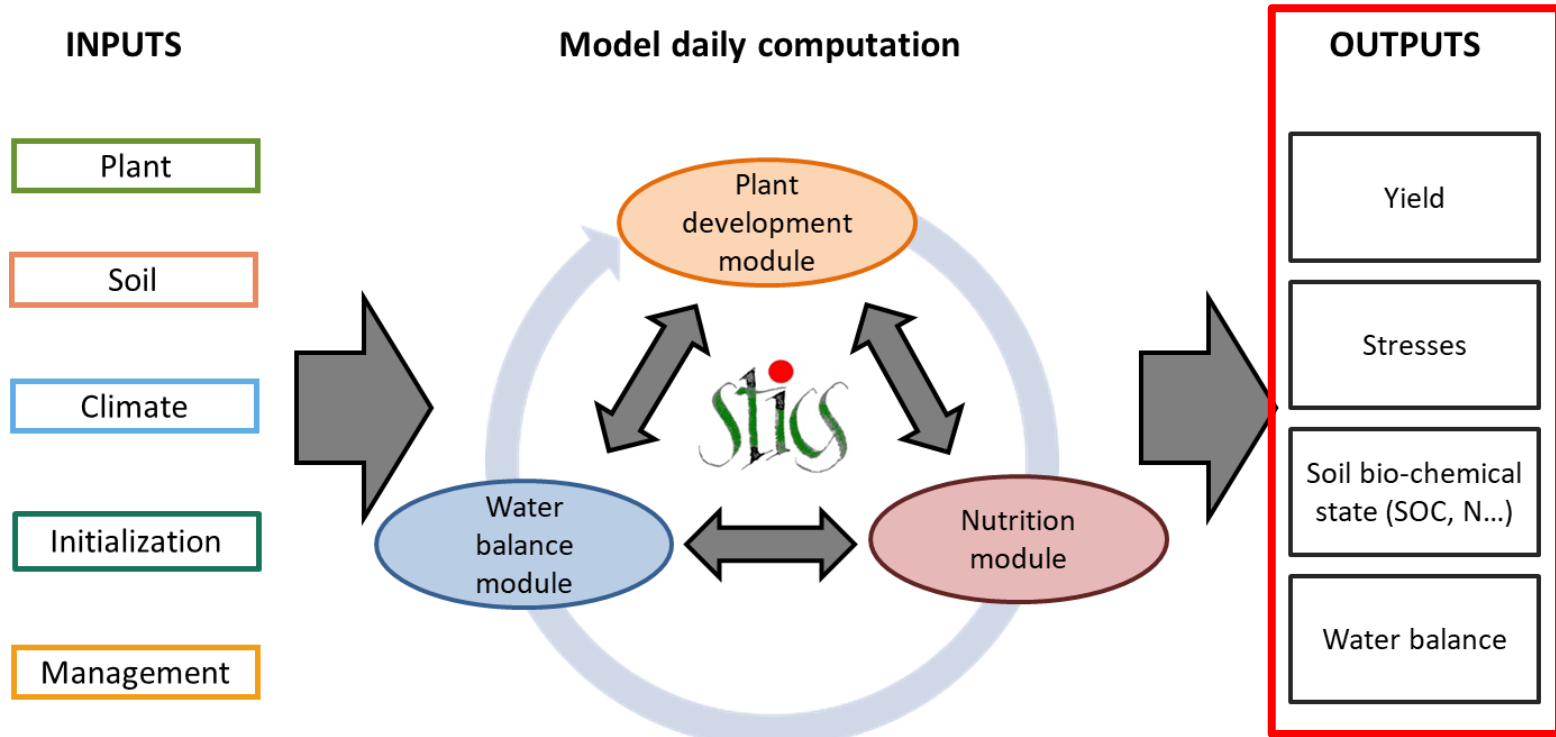
Vegan



Integrated Crop-Livestock (ICLS)

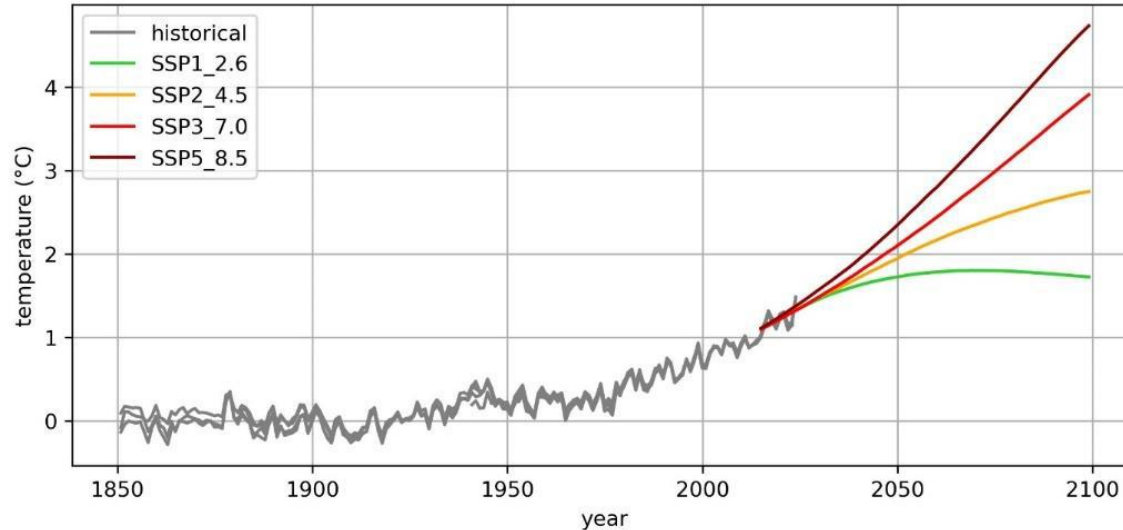
Soil crop modelling

→ Ecosystem Services (ESS)



- Sets of differential equation reproducing the behavior of Agroecosystems

Climate Change – The not-so-invisible threat

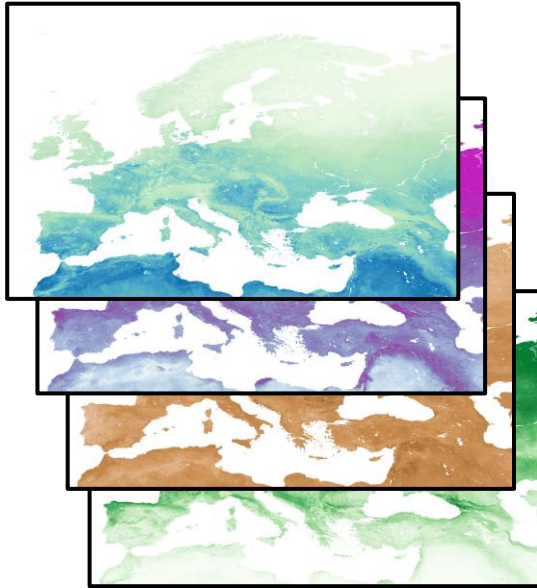


- Using GCM/RCM models (other digital tools !) to downscale climatic projections
 - ❖ MPI (German): average trend
 - ❖ MIROC (Japanese): better captures extremes (especially wet)
 - ❖ CMCC (Italian): better captures extreme droughts
 - ❖ ...

A unique modelling framework



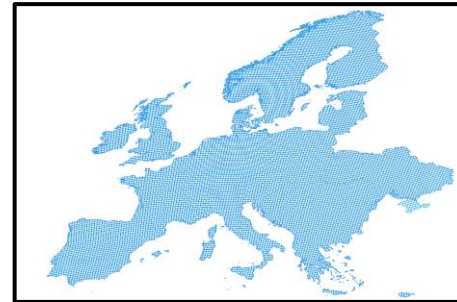
+2 millions soils profiles



5 soil layers
7 descriptors per layer



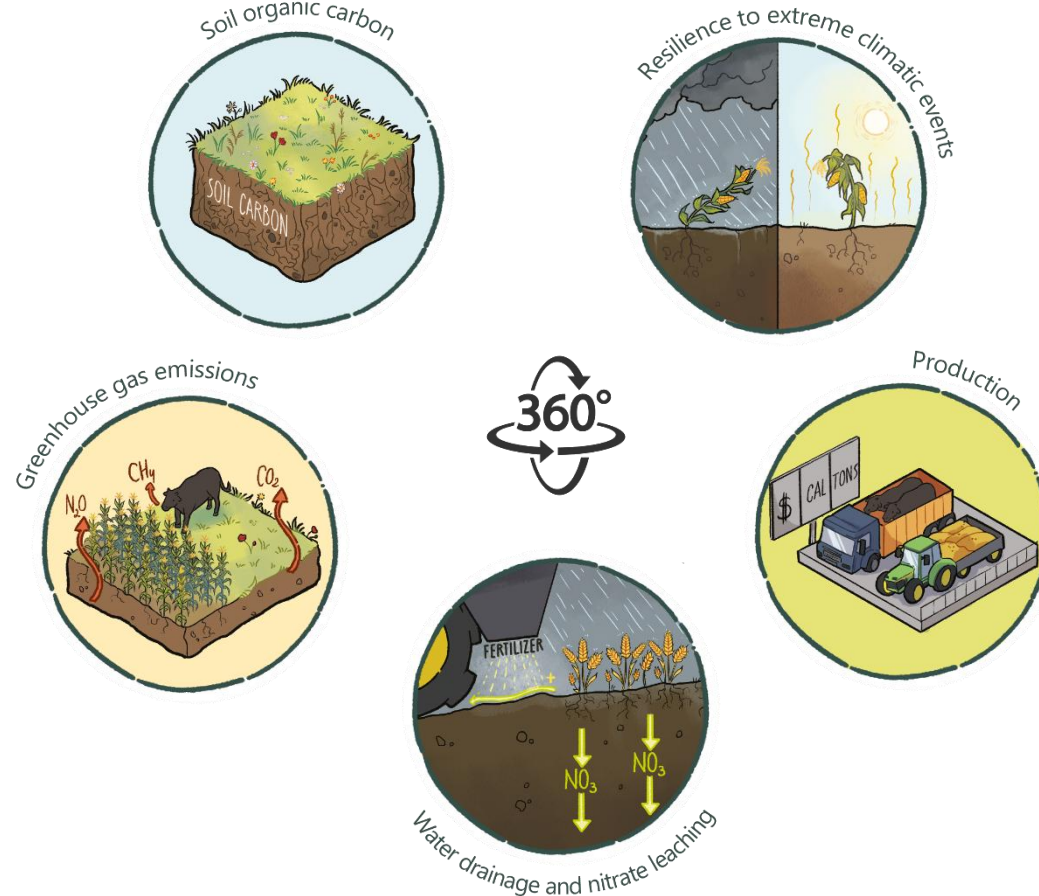
10.206 climatic tiles



Historic records (Agri4cast)
Future projections (RCP scenarios)

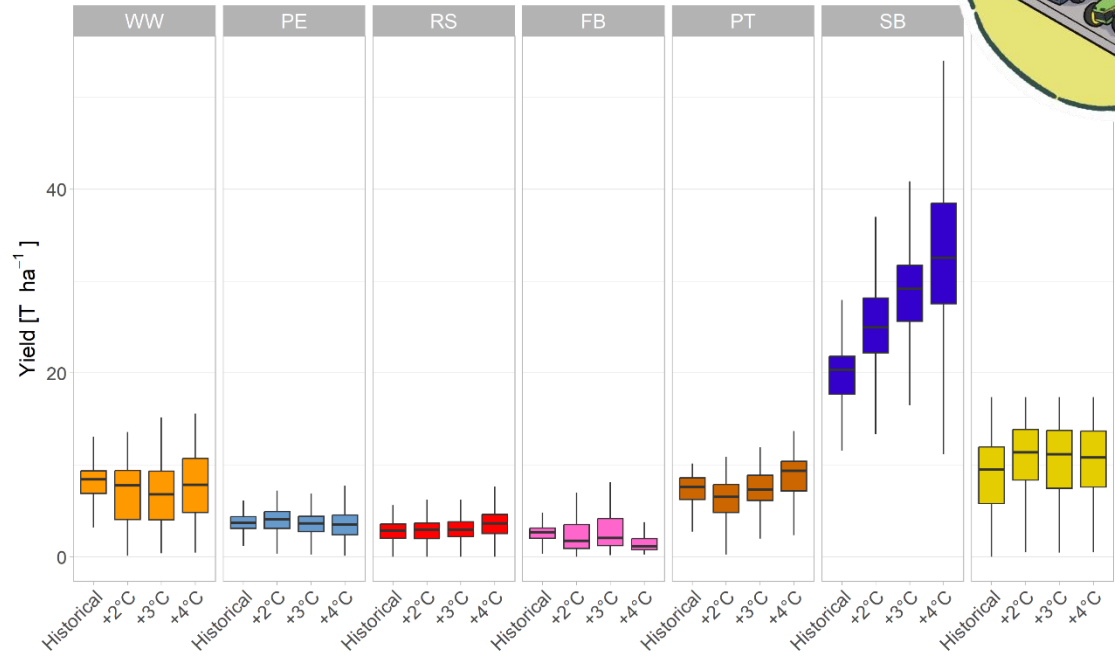
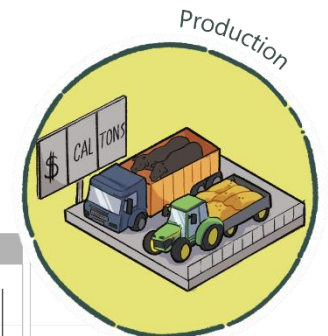


Multicriteria approach of agroecosystems functioning



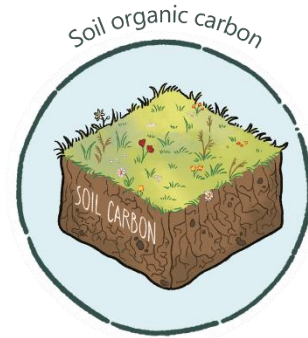
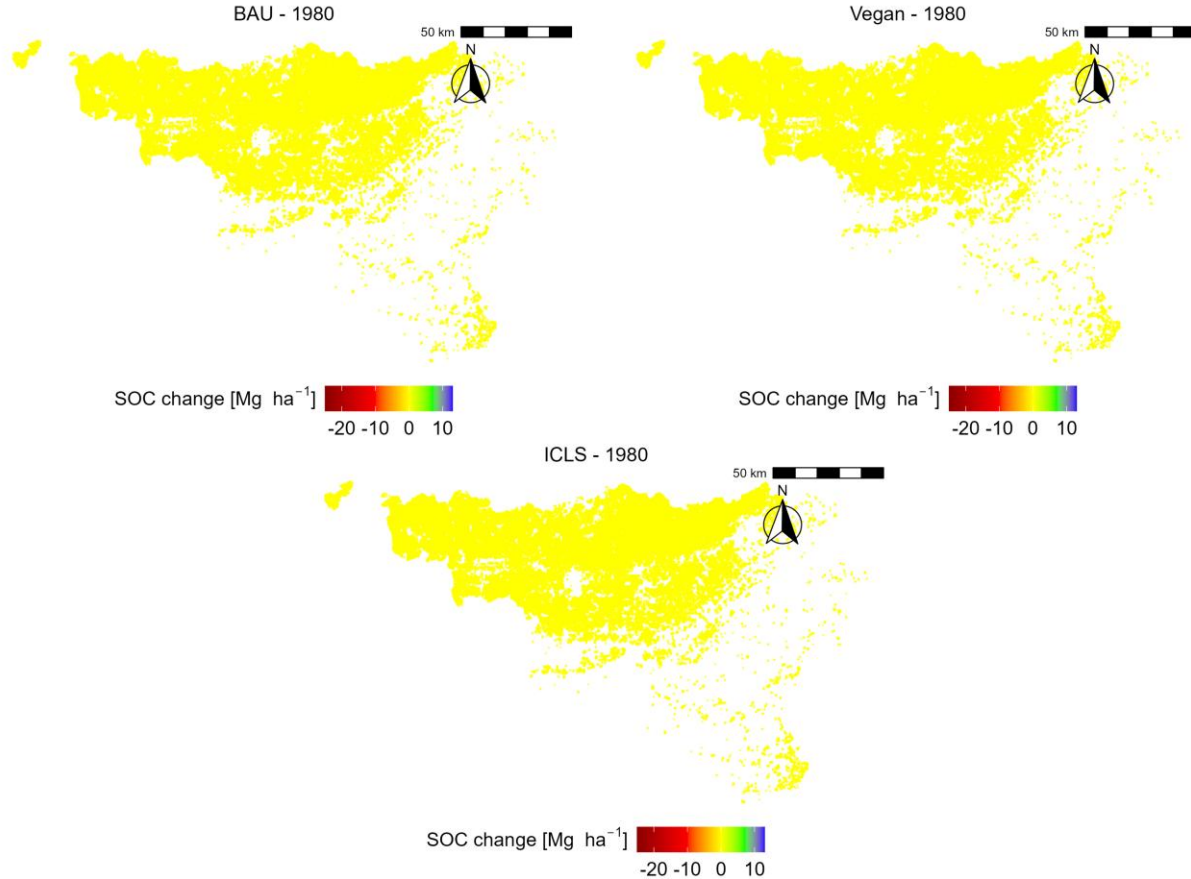
Crop production

- Assessment of :
 - Crop yield
 - Calory production
 - Monetary value
- Various patterns
 - Increase
 - Steady
 - Decrease
- Increase in yield variability

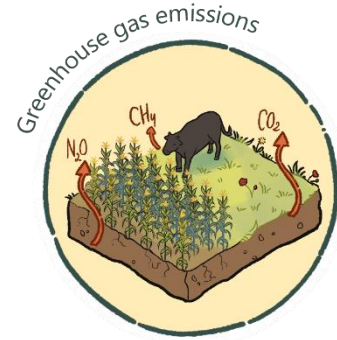
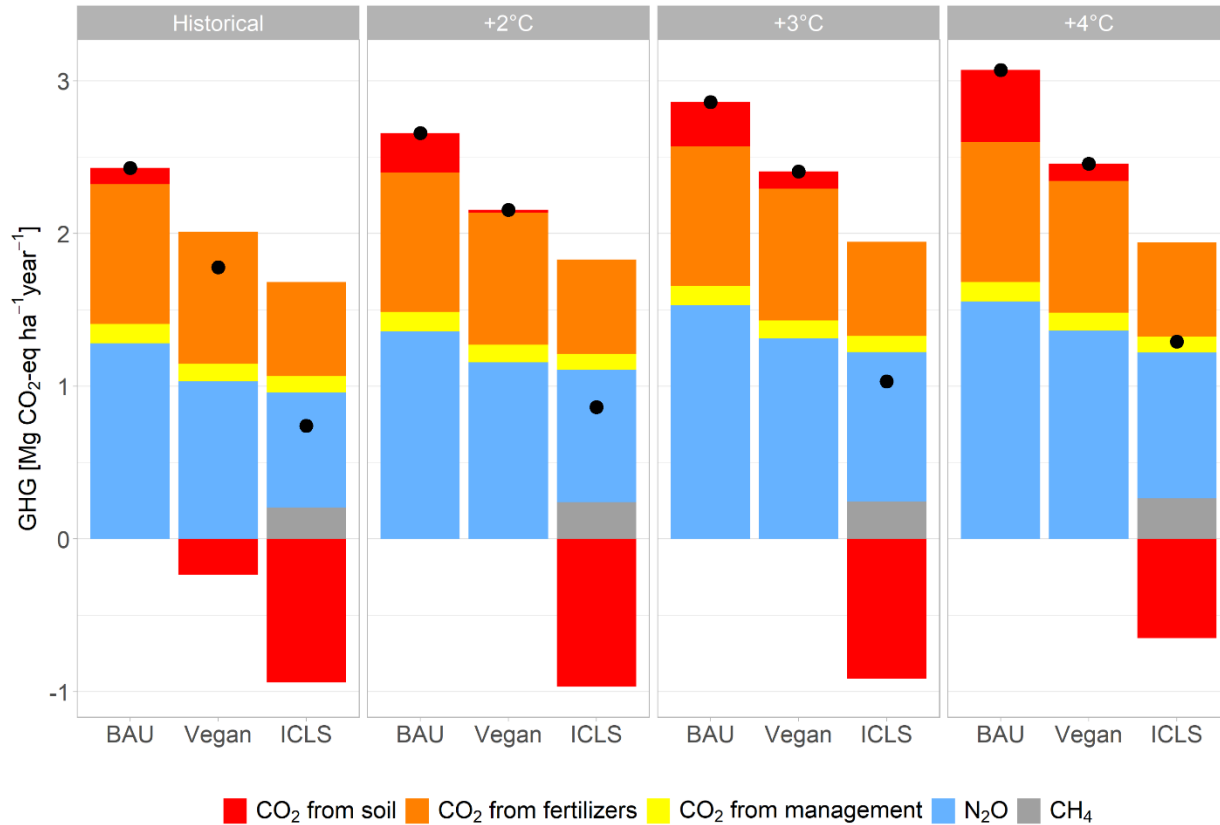


!/ Lower stability

Soil Organic Carbon (SOC) storage



Greenhouse gas emissions





Audrey Dejoncheere, Project Engineer



Cofinancé par
l'Union européenne



Wallonie

Assessing plant-based protein production sourcing

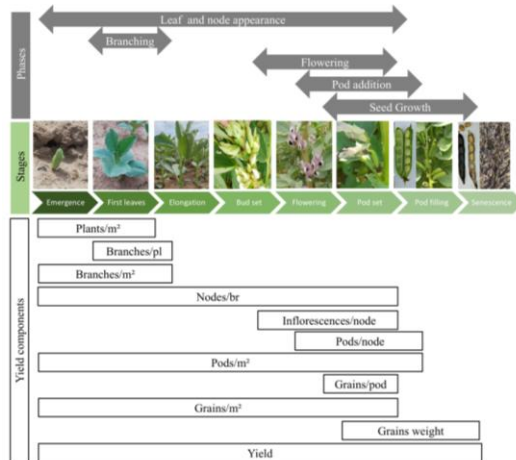
WAL'PROT



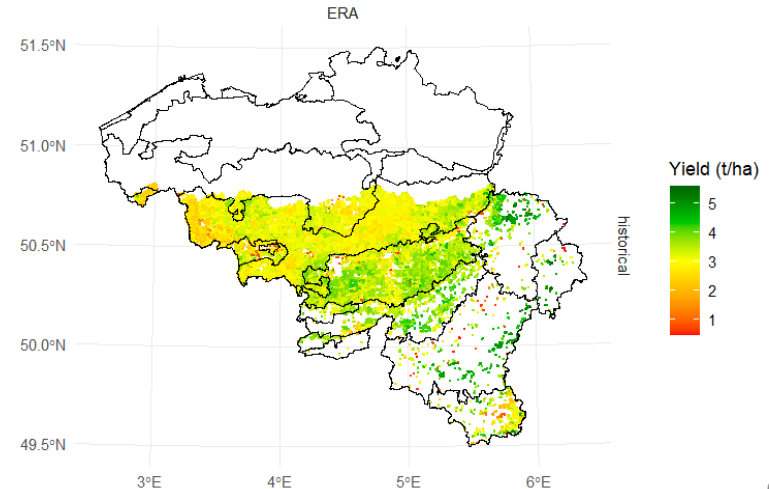
Poster teasing

- « Modeling the potential of legume crops to meet protein demand under climate change in Southern Belgium (Wallonia) »
- e.g. with Faba bean

From *in situ* experiments...



... to *in silico* environment

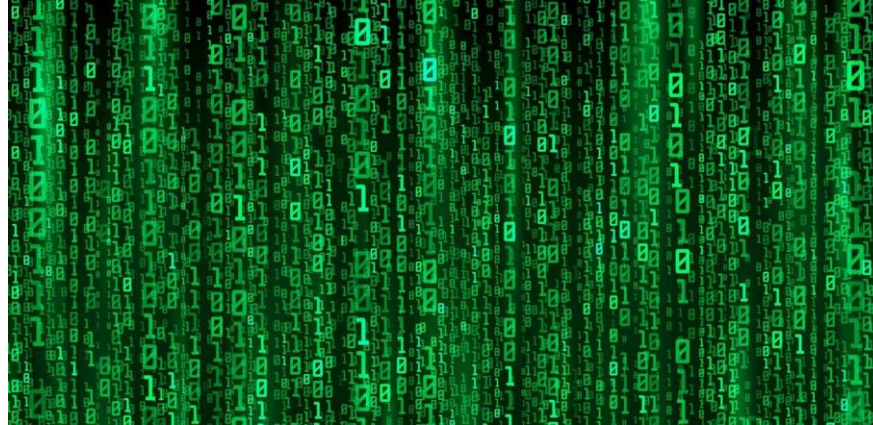


Conclusions

TAKE HOME MESSAGES

Take home messages

- Digital tools offer the potential to guide the ***agroecological transition***
- Soil-crop model are the most powerful tools to ***assess climate change impacts on ESS***
- There are efficient means to support the design of ***future-proof, resilient and sustainable CS***
- They need to be continuously challenged with real-life situation (new varieties, techniques, etc.)





Laura, Audrey, Anne-Sophie, Arthur, Mathieu, Tom, Pierre, Christophe, ...

A TEAM'S WORK

Thanks for your attention

? QUESTIONS ?