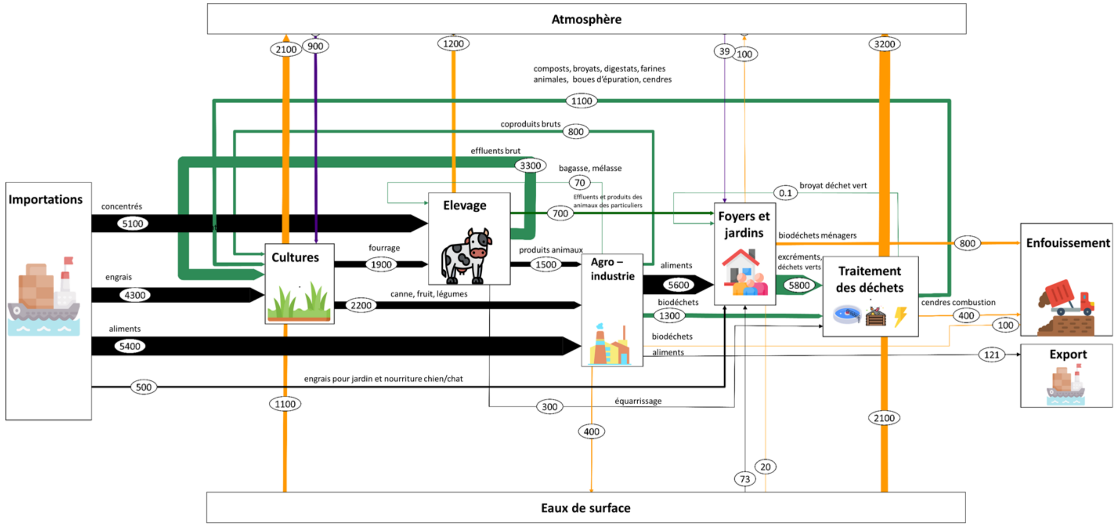
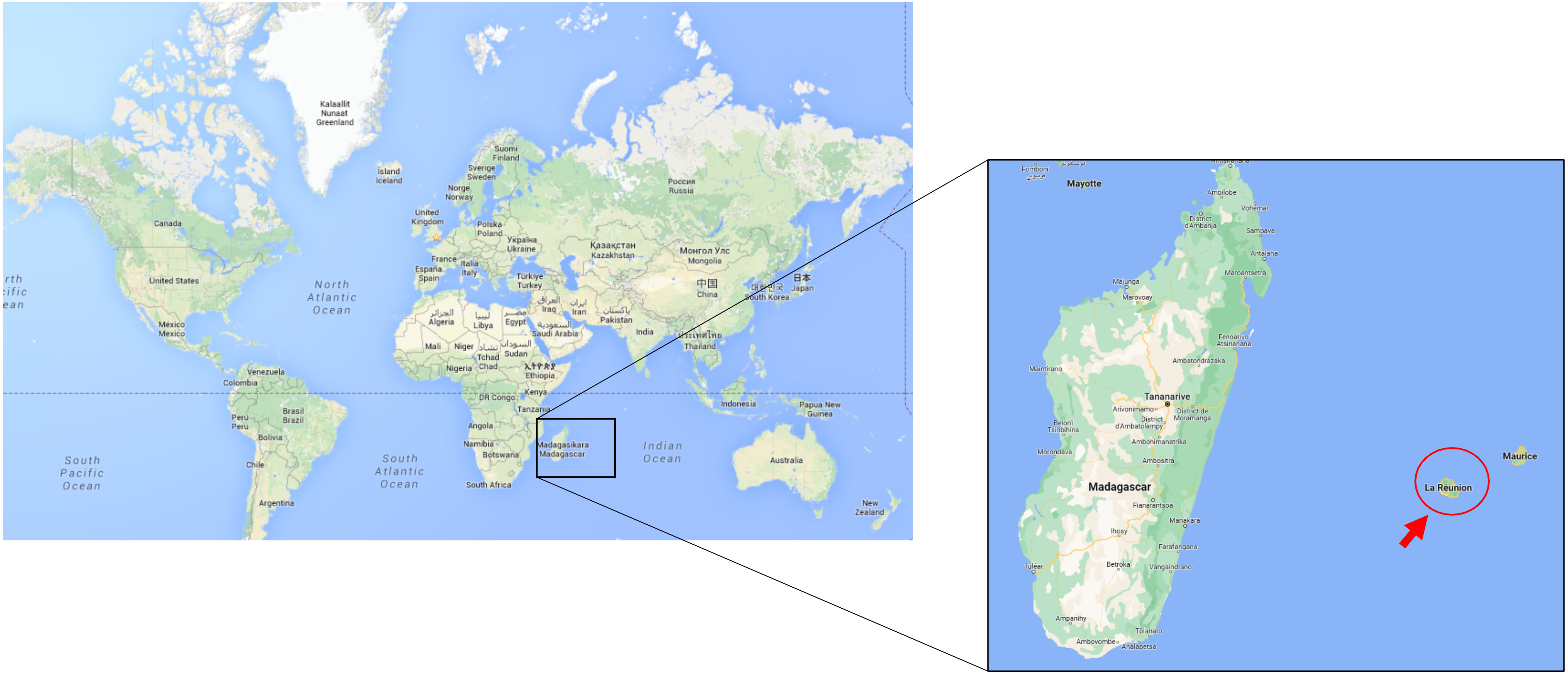
Role of livestock in the nutrient and carbon metabolism of the agri-food system of a tropical island

Alvanitakis M., Kleinpeter V., Vigne M., Benoist A., Vayssières J.



Study area : a French tropical Island, Reunion Island



Study area : a French tropical Island, Reunion Island

- 56% of the cultivated area is sugarcane
- 25% of the cultivated aera is grassland

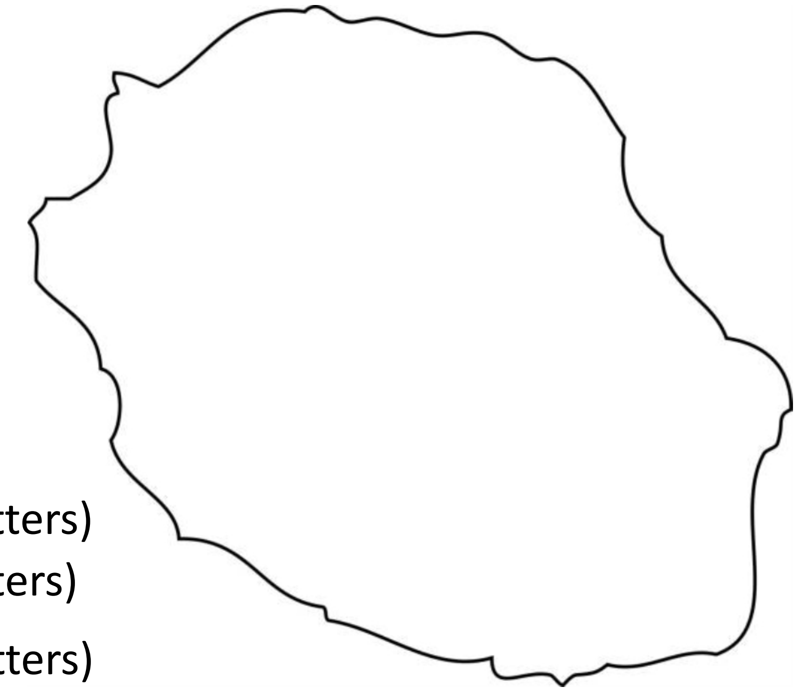
Study area : a French tropical Island, Reunion Island

A diversity of livestock farming system

Study area : a French tropical Island, Reunion Island

Reunion Island is a **nutrient sink**

Big imports



Fertilizers (35 000 tons fresh matters)
Food (415 000 tons of fresh matters)

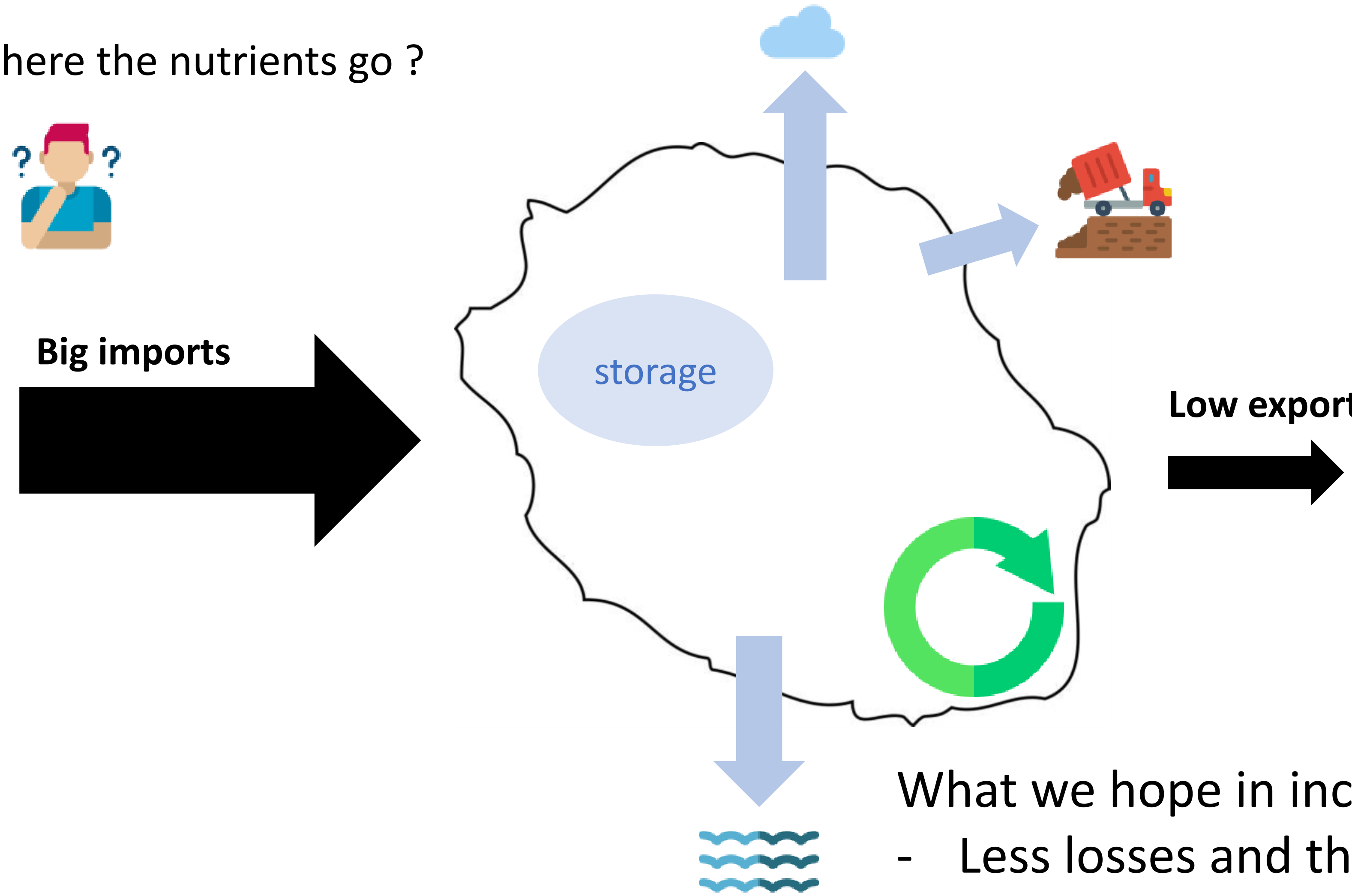
Feeds (220 000 tons of fresh matters)

Low exports

Sugar (175 000 tons of fresh matters)
Fruits and vegetables (3 500 tons of fresh matters)

Study area : a French tropical Island, Reunion Island

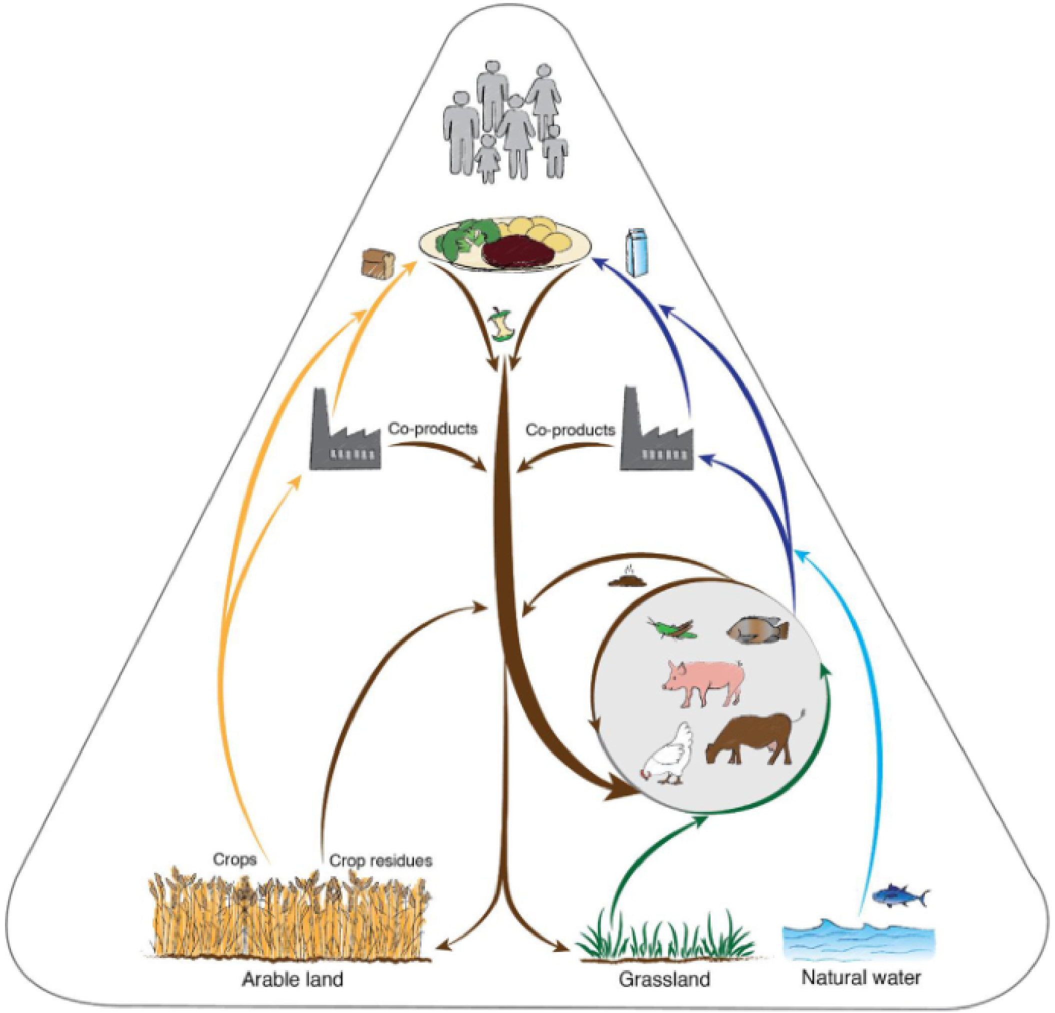
Where the nutrients go ?



What we hope in increasing circularity :

- Less losses and thus less imports
- More return of organic carbon to soils

Livestock: A potential hub of nutrient and carbon circularity in territories



(Van Zanten et al, 2019)

Livestock can consume products un-edible by humans



Livestock can provide co-products to other sectors

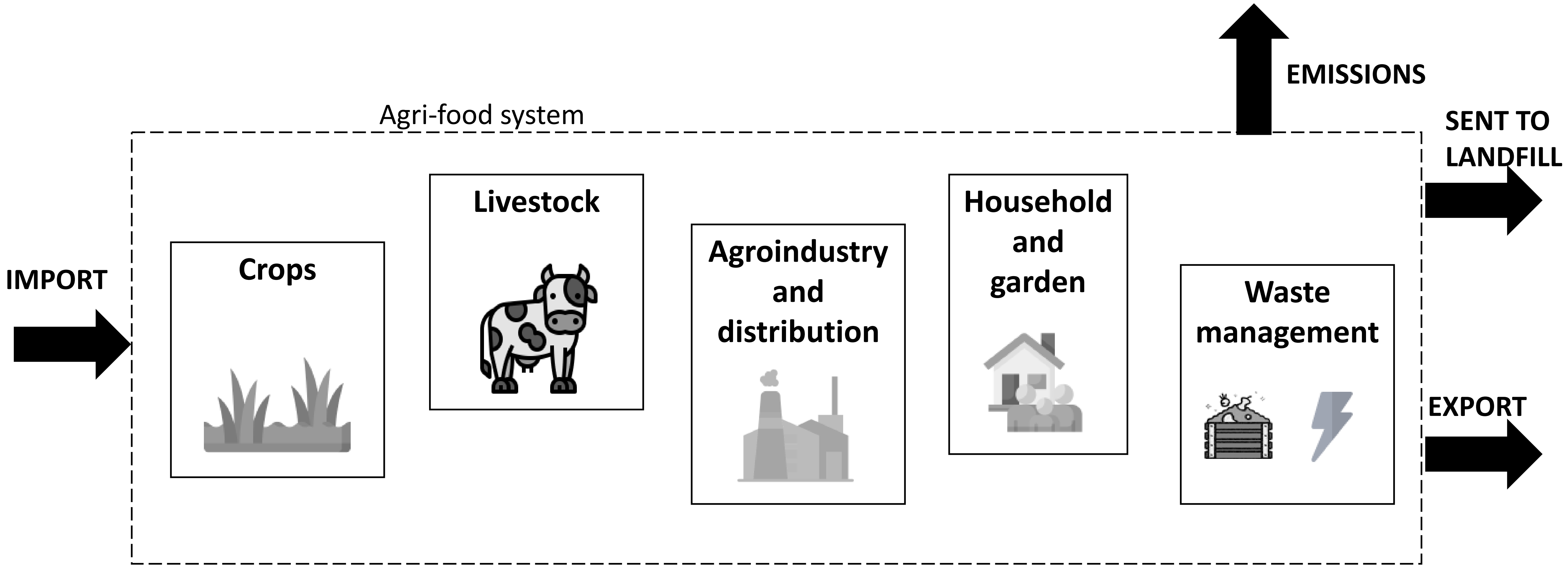


Study objectives

1- Describe the existing circularity of nutrients and carbon on Reunion Island

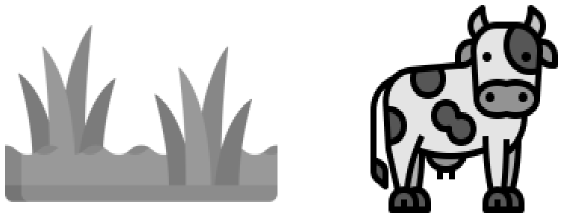
2- Identify technical levers around livestock to increase the territory’s nutrient self-sufficiency and the return of carbon to soils.

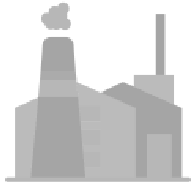
Method : Substance flow analysis of N, P, C on the agri-food system

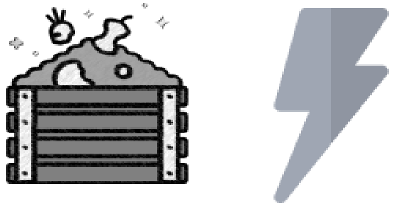


Method: Quantify flows

Use data from statistical basis and local data-base to quantify raw material flow







Customs data → Fertilizers and feed imports
AGRESTE → Crops/Pasture area, livestock numbers
Agricultural cooperatives → Ruminant rations, yields, fertilization practices

Customs Data → Imports and exports of food
GEREP → Tonnages of buried waste
INSEE → Food consumption per capita

Regional Waste Management Plan
Food waste produced
Green waste produced
Office de l'eau → Wastewater produced

Regional Waste Management Plan → Volumes of waste treated and type of treatment (combustion, buried, compost, anaerobic digestion ..)

Then we apply a N, P and C content

Method: Quantify flows

Collect data on waste recycling by survey of stakeholders, agro-industrials, platform owners.

- 40 stackholder surveyed
- 107 different biomasses identified

Restitution day

Quantified flows

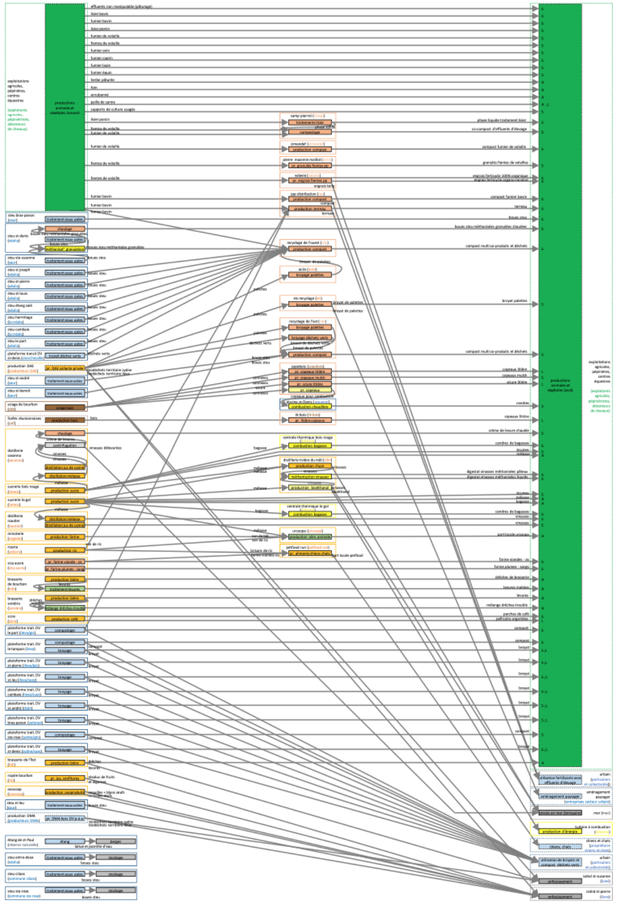


Figure 12 : inventaire des flux de biomasses locales valorisées ou valorisables en agriculture

(Kleinpeter et al, 2020)

Method: Quantify flows

Use models and emissions factors to quantify emissions.

Local emissions factors → **(Poultney, 2021):** Local experimentation on nitrogen emissions in sugarcane

Generic models →

(IPCC, 2018): C and N emissions during enteric fermentation and effluent management.

(Bolinder, 2007): Aerial and root carbon residues.

(Justes et al, 2009): Humification of residues and organic materials.

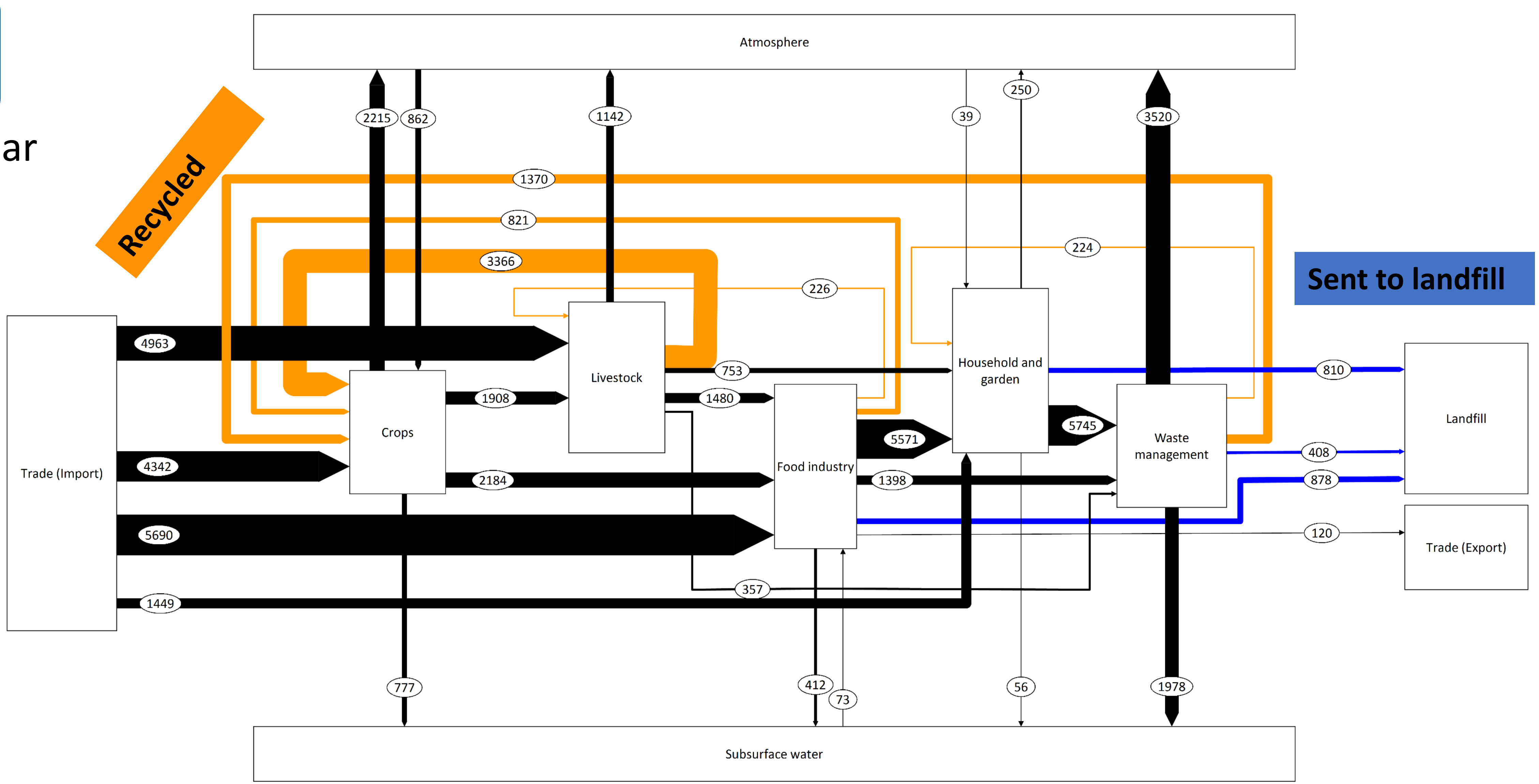
(Huang et al, 2022): C and N emissions during composting.

When we don't know, we use mass balance

A high recycling of nutrient

$$\text{Recycling index} = \frac{\text{recycled flows of secondary products}}{\text{total flows of secondary products}} = \mathbf{85\%}$$

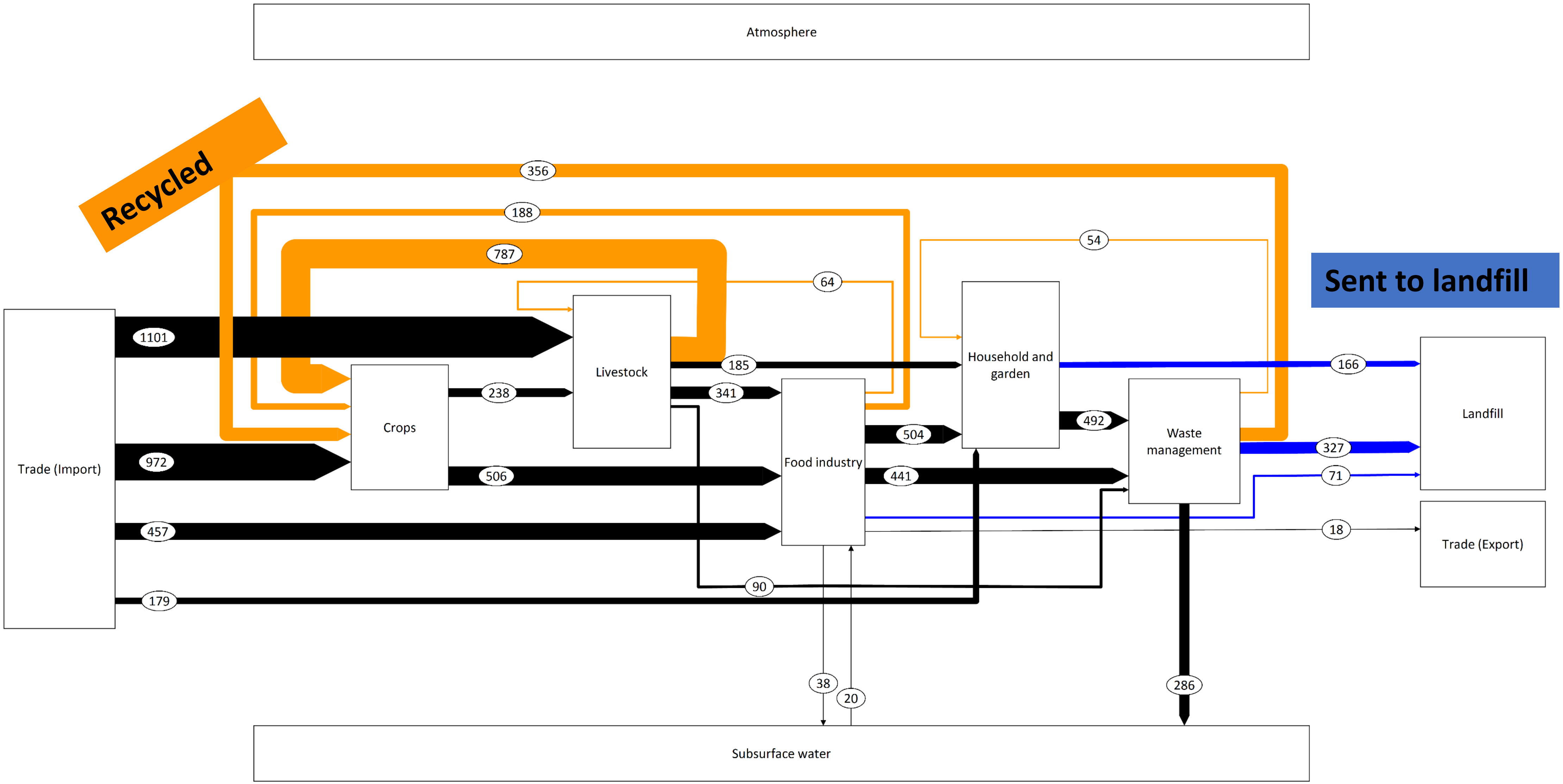
TN/year flows



A high recycling of nutrient

$$\text{Recycling index} = \frac{\text{recycled flows of secondary products}}{\text{total flows of secondary products}} = \mathbf{83\%}$$

TP/year flows



Limited amount of un-used organic coproducts

Amounts in tons/year

N : 700 t P : 160 t C : 10400 t	Food wastes from household
N : 800 t P : 70 t C : 8000 t	Food wastes from distribution
N : 400 t P : 200 t C : 4600 t	Slaughter-house waste (C2-C3)
P : 114 t	Scories from bagasse combustion
N : 50 t P : 5 t C : 3000 t	Green wastes
N : 20 t P : 4 t C : 200 t	Unknow (quantified by mass balance on the industry sector)

Limited amount of un-used organic coproducts Can be mainly be recycled toward crops

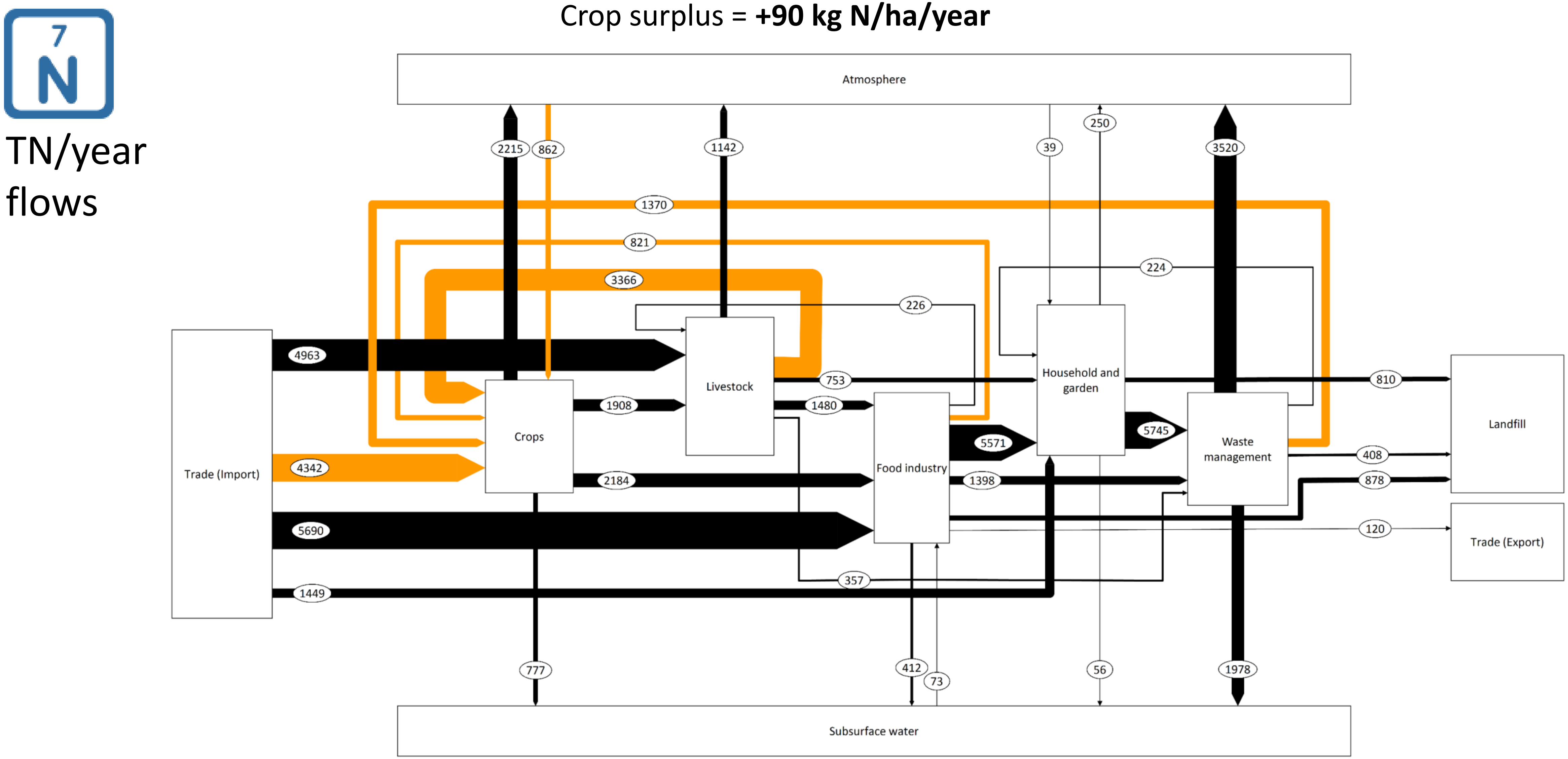
Amounts in tons/year

N : 700 t P : 160 t C : 10400 t	Food wastes from household	Composting
N : 800 t P : 70 t C : 8000 t	Food wastes from distribution	Composting
N : 400 t P : 200 t C : 4600 t	Slaughter-house waste (C2-C3)	Anaerobic digestion of C2 wastes (moderate risk wastes) and spread digestates on crops
P : 114 t	Scories from bagasse combustion	
N : 50 t P : 5 t C : 3000 t	Green wastes	Co-composting with manure
N : 20 t P : 4 t C : 200 t	Unknow (quantified by mass balance on the industry sector)	

Crop sector is already saturated by nutrient

Nitrogen use efficiency of crop sector = used outpouts/ inputs = **38%**
Crop surplus = **+90 kg N/ha/year**

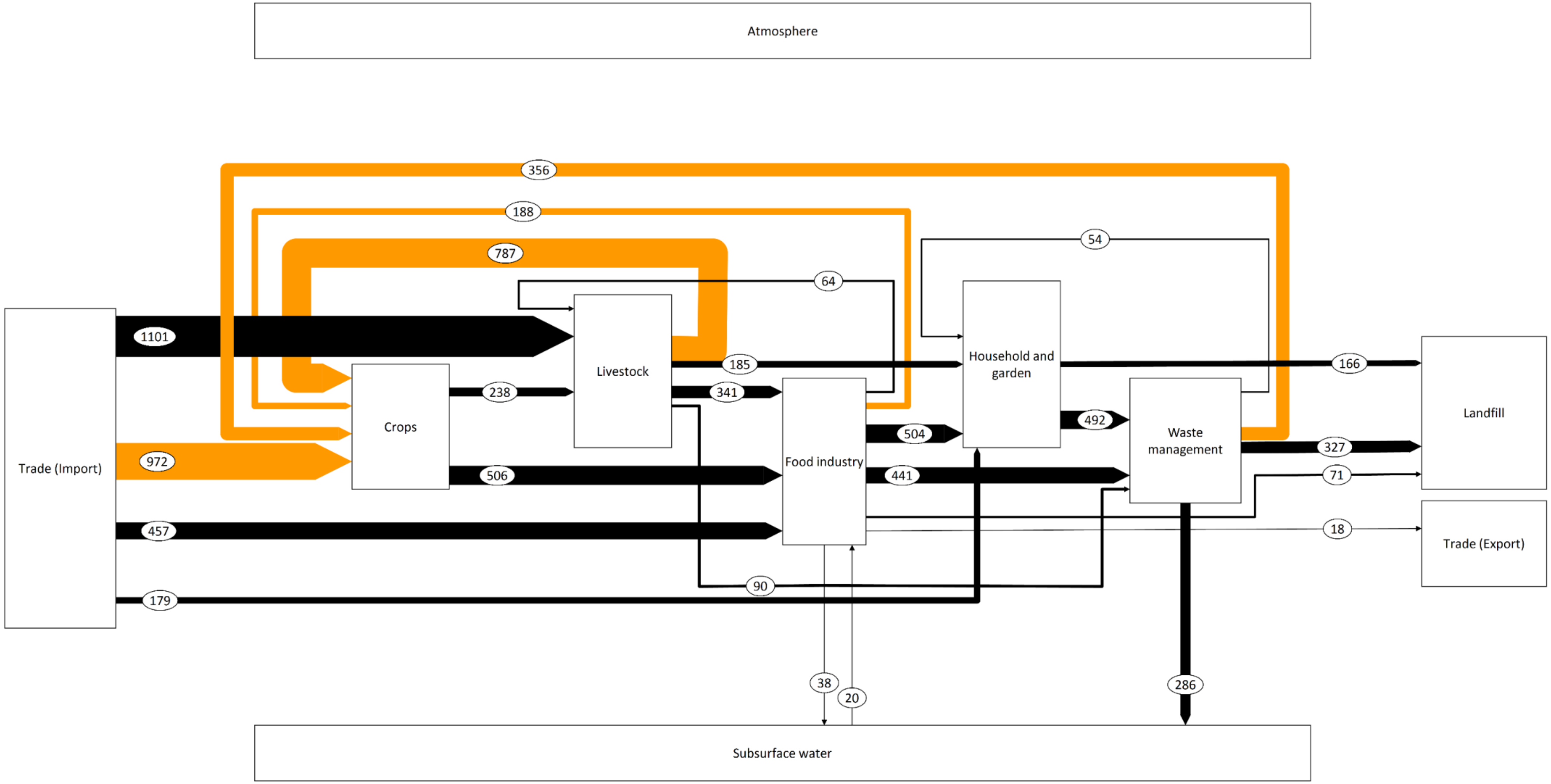
TN/year flows



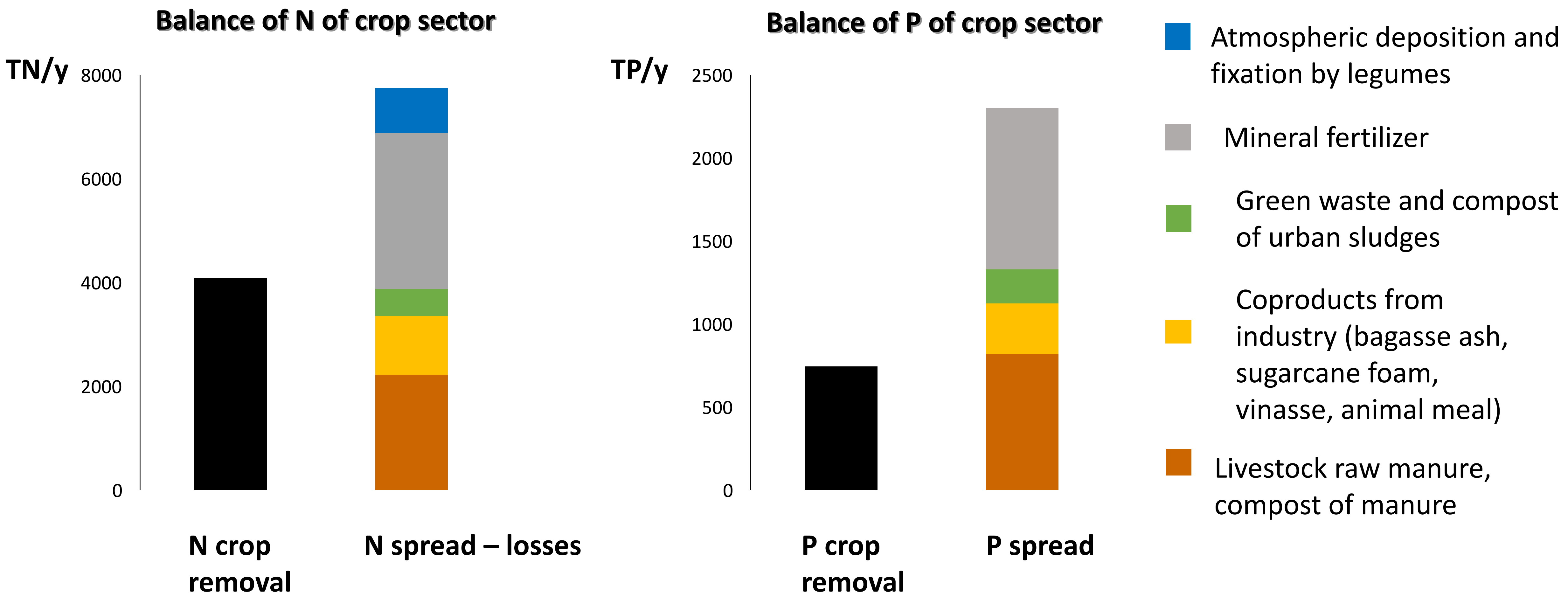
Crop sector is already saturated by nutrient

TP/year flows

Phosphorus use efficiency of crop sector = used outpouts/inputs = **32 %**
Crop surplus = **+40 kg P/ha/year**

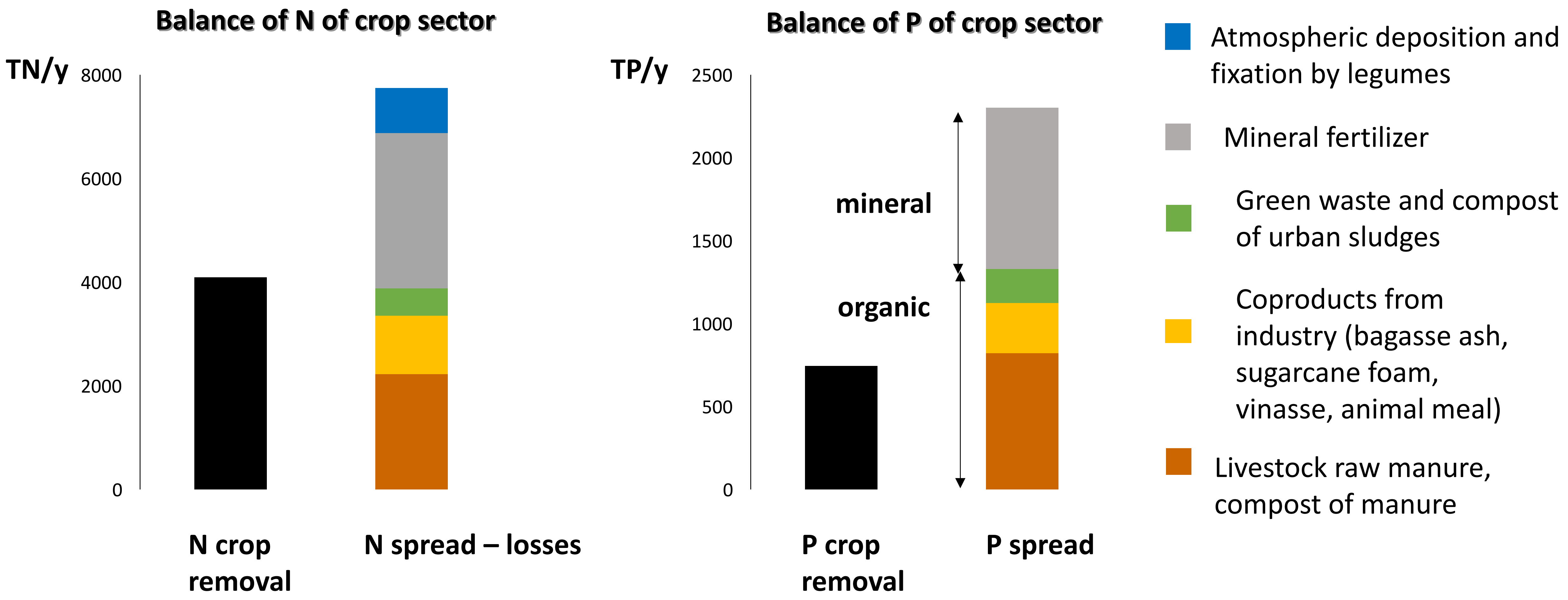


A low substitution of mineral fertilizers by available organic matters



A low substitution of mineral fertilizers by available organic matters

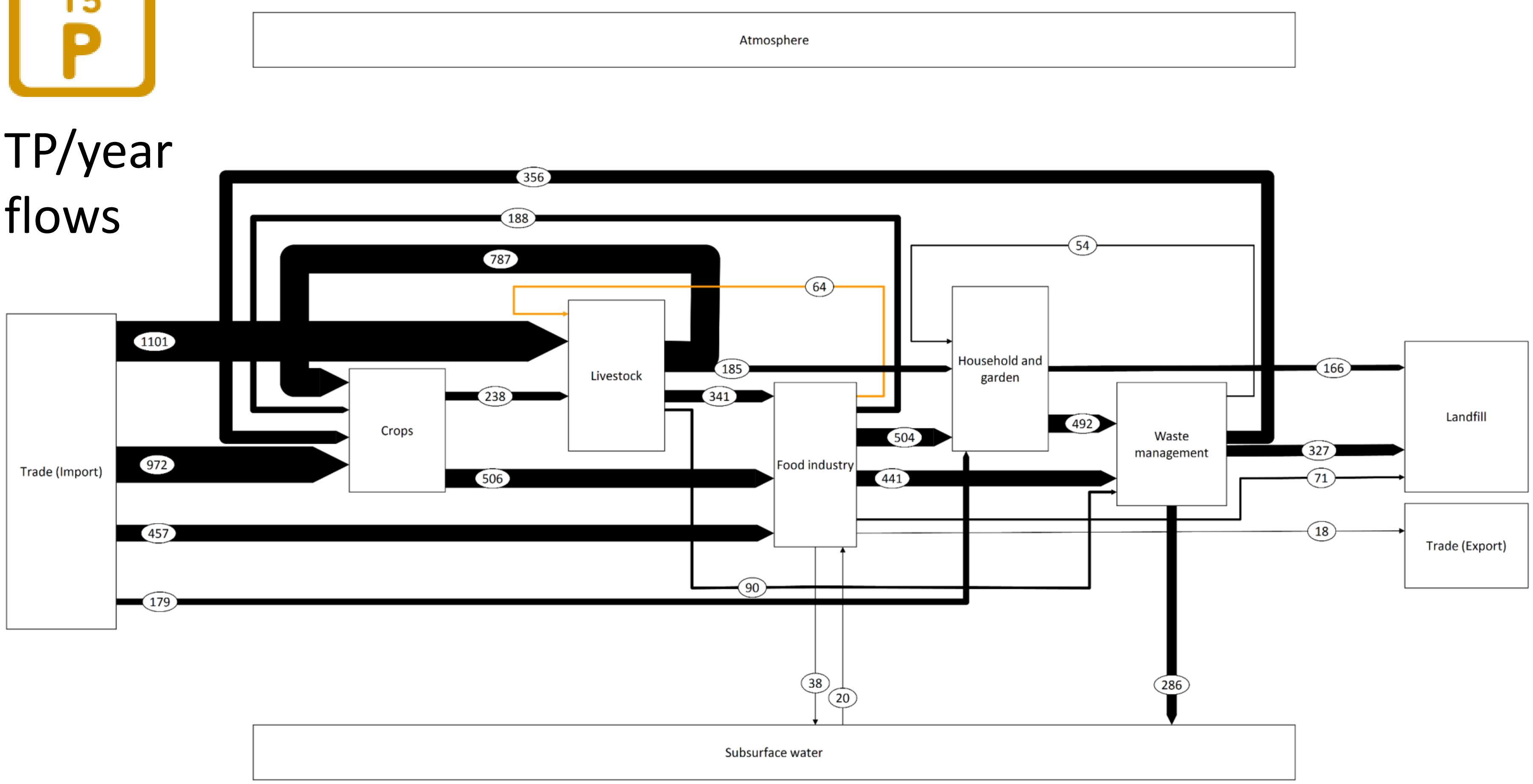
We still import mineral P despite having a supply of organic P already exceeding 1.7x the export of the P by crops



Livestock recycle huge volume of local coproducts, but with a low nutrient content

FM = fresh matters

TP/year flows



5000 tons of FM
Sugar-cane straw

4900 tons of FM
Wheat bran

4800 tons of FM
Sugar-cane molasses

4700 tons of FM
Brewery draff

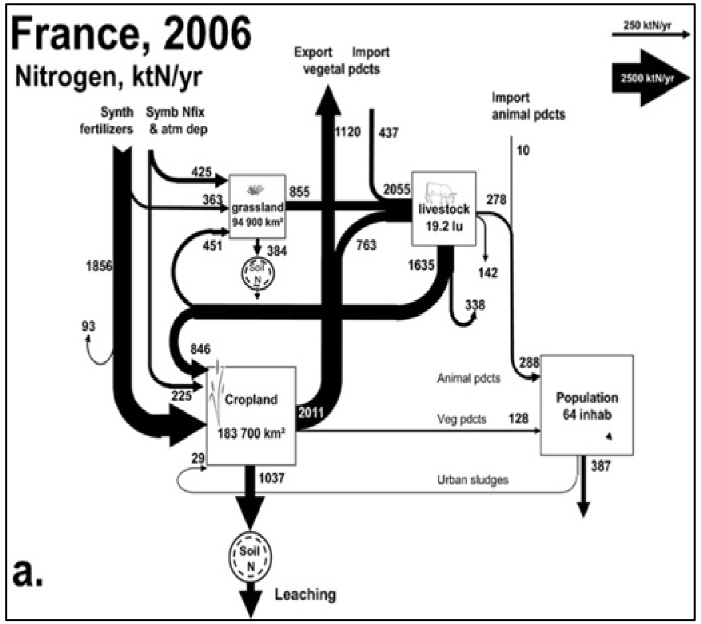
4000 tons of FM
Sugar-cane bagasse

400 tons of FM
Rice bran

Livestock sector is dependant

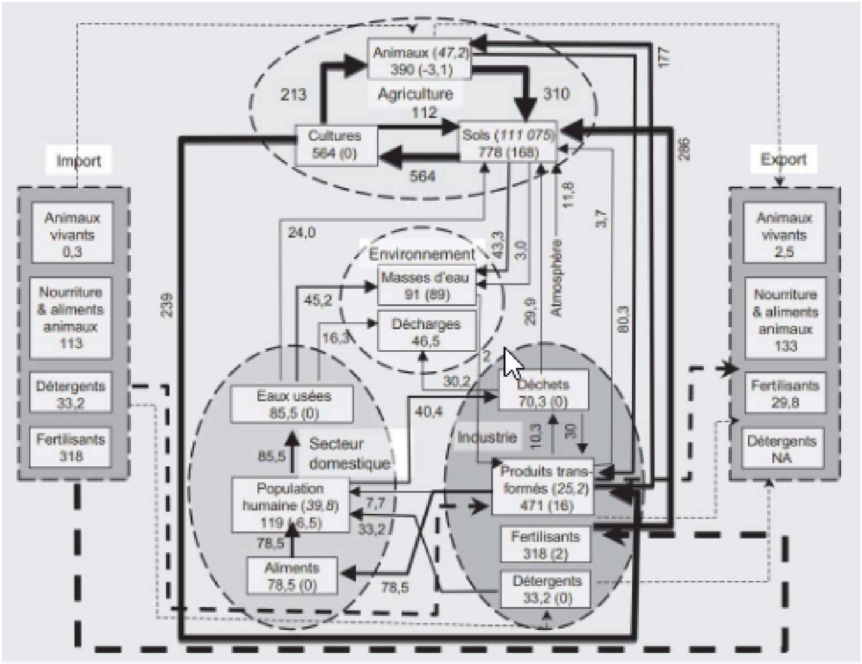
On Réunion Island, only 27% of N and 17% of P consumed by animals come from local production

Against 78% of N in mainland France



(Le Noë, 2016)

Against 55% of P in mainland France



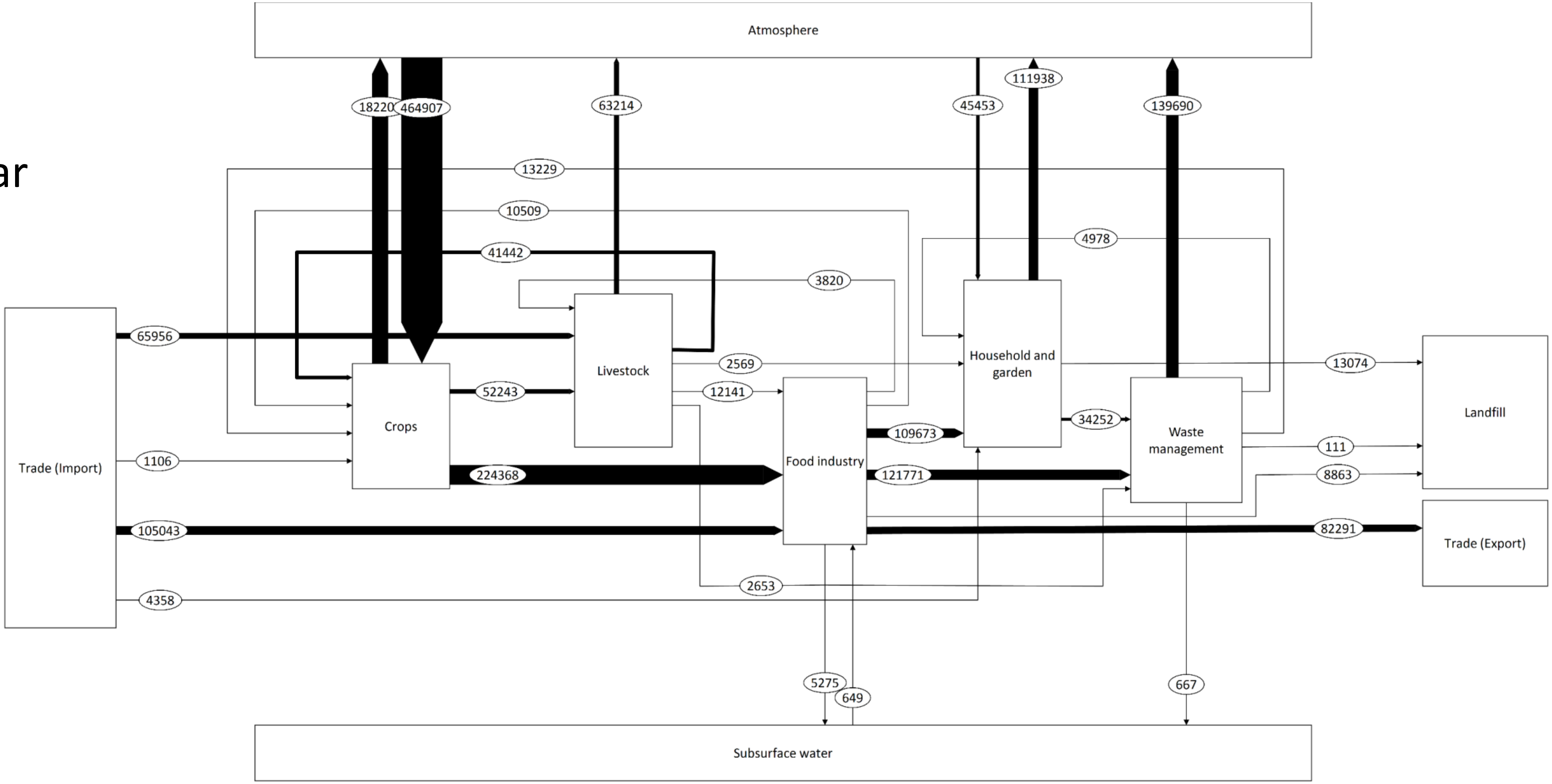
(Pellerin et Nesme, 2015)

Return of carbon to soils

Efficient carbon return = inputs of organic carbon to crops * humification coefficient

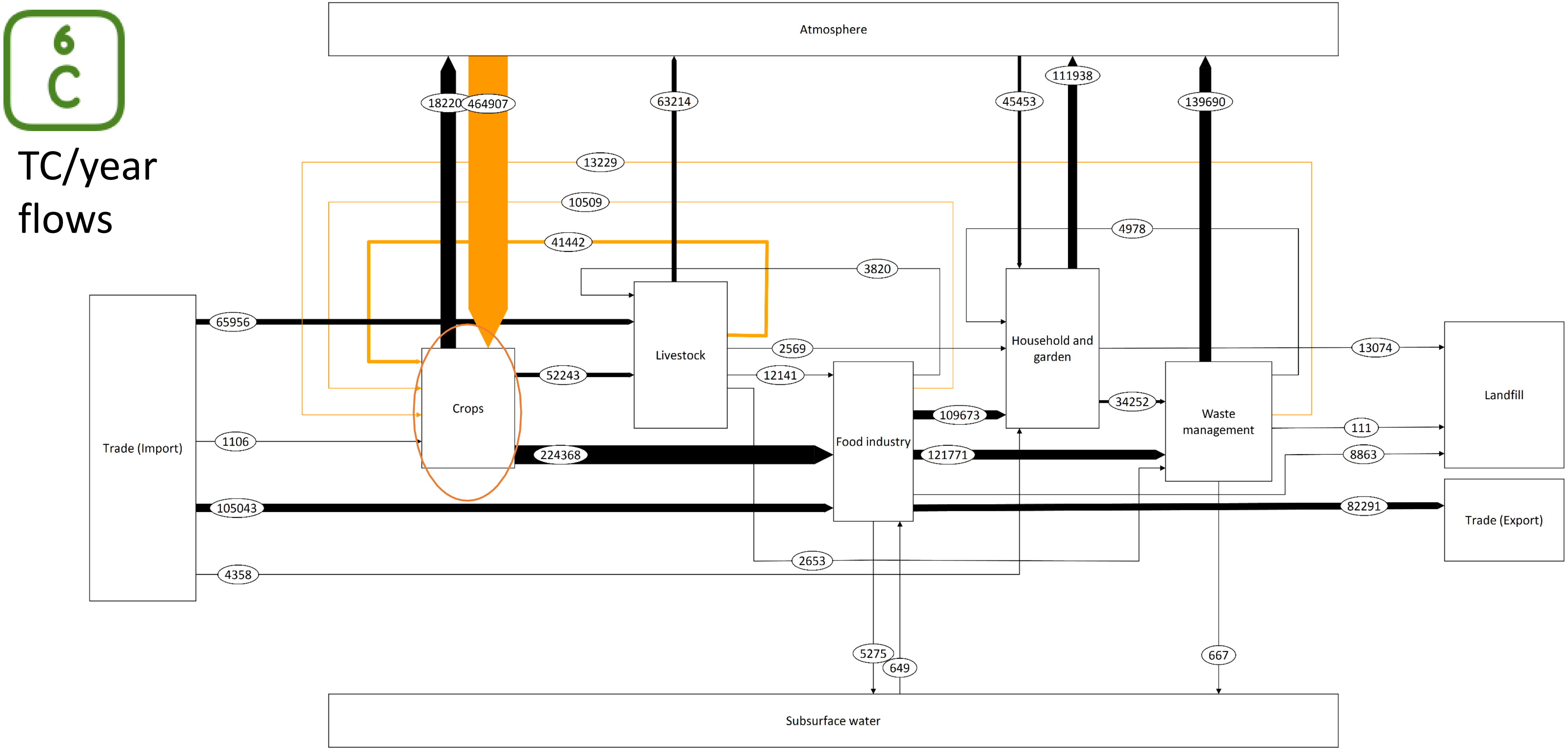
(Justes et al, 2009)

TC/year
flows



Return of carbon to soils is driven by crop productivity and bagasse combustion

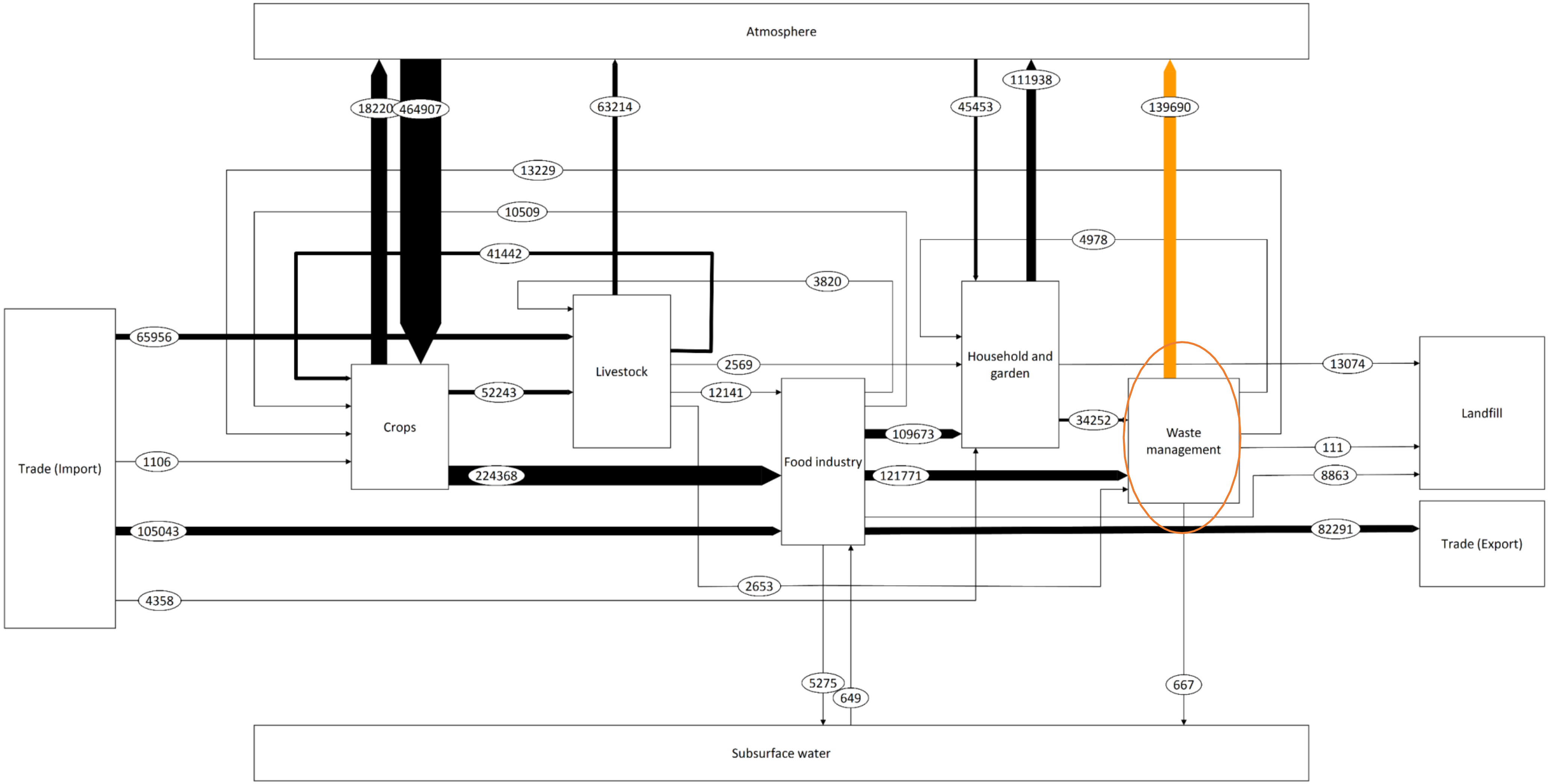
50% of efficient carbon return comes from sugar-cane residues
Only 10% of efficient carbon return comes from grassland residues



Return of carbon to soils is driven by crop productivity and bagasse combustion

TC/year flows

27% of carbon losses come from sugarcane bagasse combustion for energy



Conclusion

1- Describe the existing circularity of nutrients and carbon on Reunion Island :

- A high recycling of biomasses, mainly toward crops.
- But this recycling is inefficient due to the low substitution of mineral fertilizers.
- A low recycling toward livestock, which is dependent on imports
- A limited amount of un-used co-products, mainly recyclable toward crops that are already over-fertilized
- A return of carbon to soil driven by crop productivity and bagasse combustion

Conclusion

2- Identify technical levers around livestock to increase the territory's nutrient self-sufficiency and the return of carbon to soils.

Levers aimed at **a bigger return of nutrients to crops** will have little benefits on nutrient self-sufficiency because crops are already over-fertilized.

→ e.g. co-composting manure with buried green waste, slaughterhouse waste recycling toward crops, reduction of N losses at barn or at field

The most effective lever to increase nutrient self-sufficiency seems

- **to adjust mineral fertilizer supply according to crop needs and manure already spread**
  → understand why farmers don't substitute mineral fertilizers.
- to **increase grassland productivity** in the absence of other coproducts available for animal feed.

Livestock could increase return of carbon to soil :

- by valorize green waste buried or unused slaughter-house wastes but the amounts are limited.
- by increasing grassland productivity and thus plant residues.

Next step : Testing territorial scenarios and their effects on flow reorganization

THANK YOU FOR YOUR ATTENTION