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POUR LE DÉVELOPPEMENT RURAL. L'EUROPE INVESTIT DANS LES ZONES RURALES



SYNERGY: a bio economic model assessing the economic and environmental impacts of increased regional protein self-sufficiency

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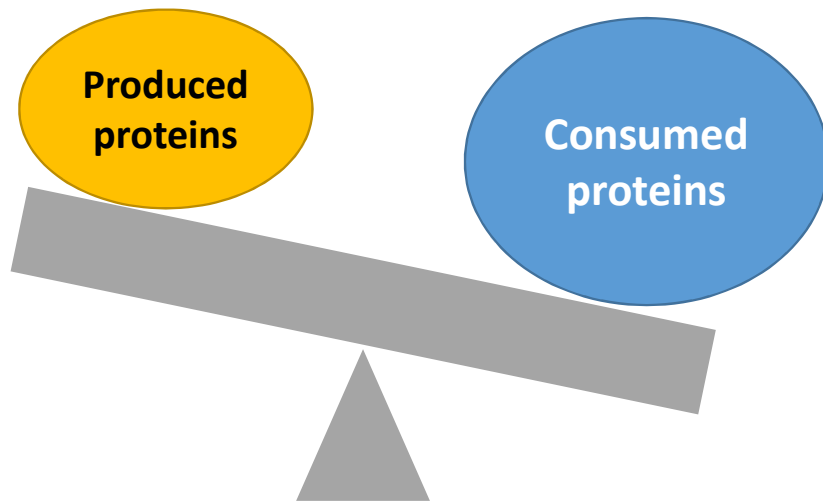
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Introduction - Context

Protein self-sufficiency



Protein self-sufficiency in feed is not reached



Imports of soybean meal
from the Americas



Security of supply
Deforestation
Use of GMOs

Introduction- Context

The CAP aims at increasing legume production



Protein-rich crops



Lower annual gross margins



Nitrogen fixation



Yields seen as more variable



Biodiversity improved



Spreading of organic fertilizers prohibited

Introduction - Objective

Objective

Assess the impacts of increased protein self-sufficiency through the production of legumes at the regional level

Economic + environmental impacts



Implementation of a bio-economic model

Introduction – State of Art

Bio-economic models



Assess **both economic and environmental impacts** by integrating biological and economic processes



Prospective analysis of agricultural practices not introduced at large scale yet (Jacquet et al., 2011)

Bio-economic models on legume development : Reckling et al., 2016; Schläfke et al., 2014; Mahmood et al., 2017



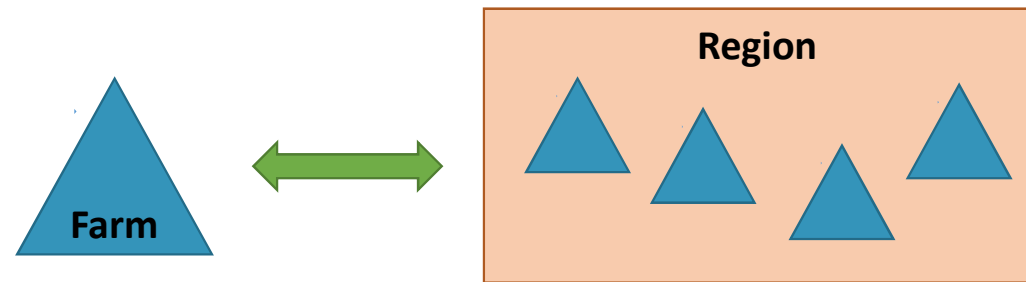
Take into account **the decision-making process** at the farm scale



Fail to **aggregate impacts** at higher scales (e.g., region, country)

Introduction – State of Art

Hybrid bio-economic models (Britz et al., 2012)



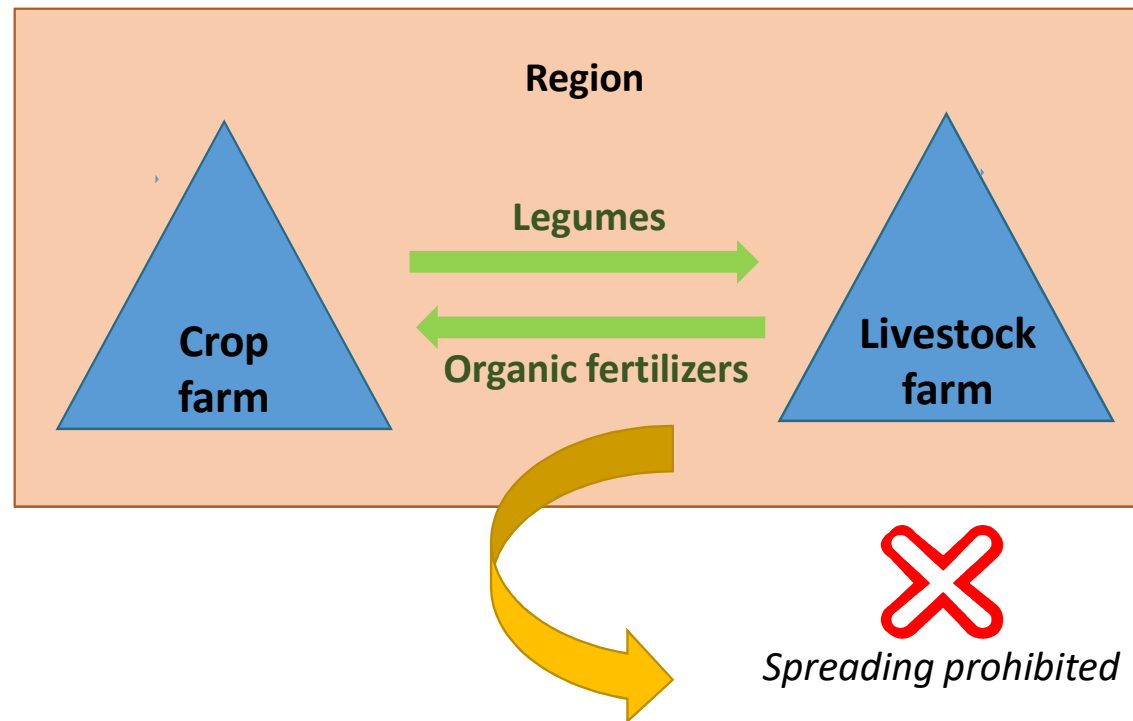
Hybrid bio-economic models : Galko and Jayet, 2011; Gocht et al., 2017, Chopin et al., 2015



No hybrid bio-economic model on legume production (only partially)

Introduction – Hypothesis

New lever : Crop livestock integration beyond the farm level



Hypothesis :

Complementarity between specialized crop farms and livestock farms can increase protein self-sufficiency while having positive economic and environmental impacts at the regional level.

Outline

1. Introduction

2. Method

3. Case-study

4. Results

5. Discussion & conclusion

Method : SYNERGY model

SYNERGY bio economic model

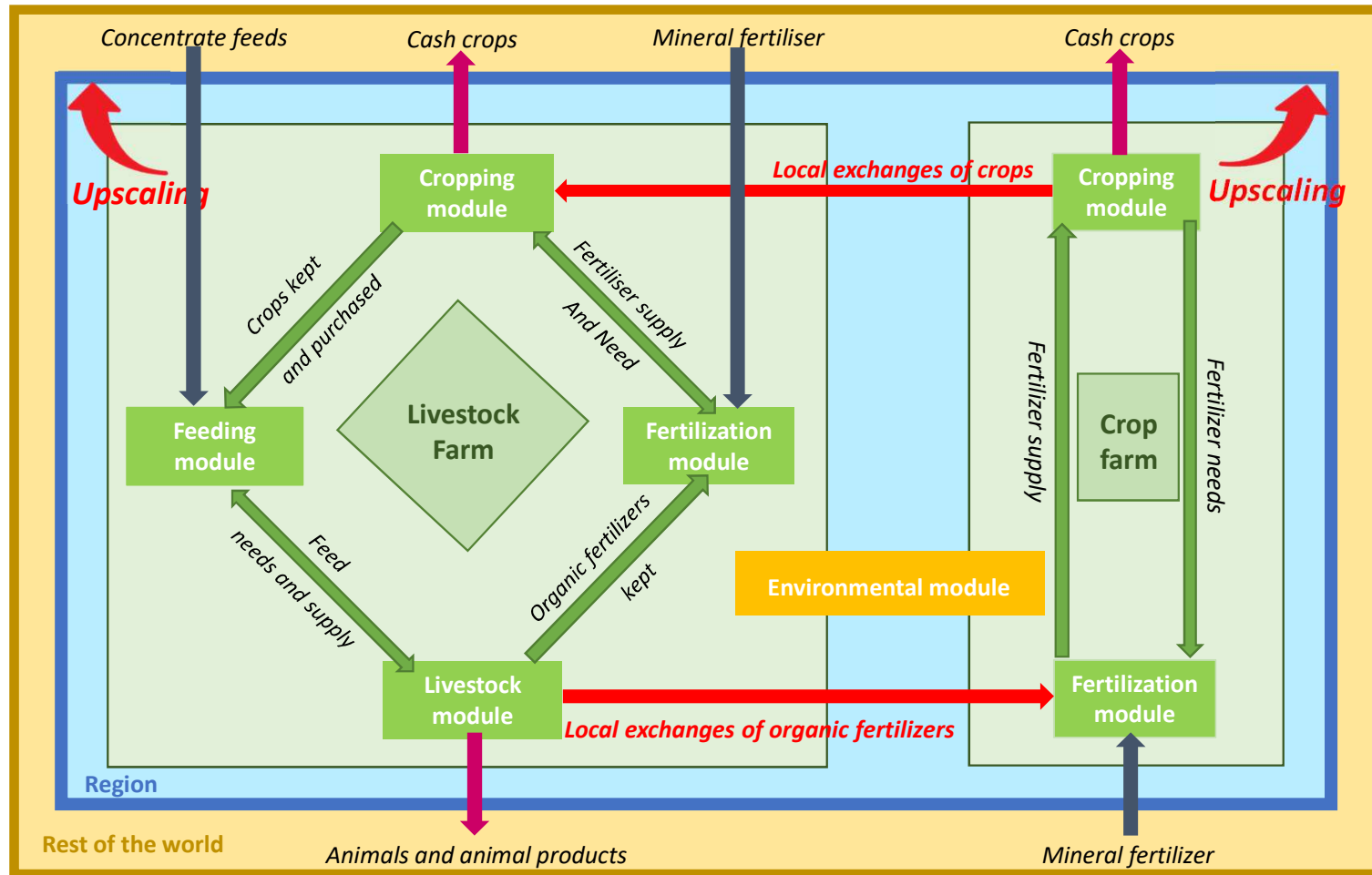
3 main characteristics:

- ✓ **Hybrid model** implemented at farm scale and then, aggregated at the regional level
- ✓ **various types** of farms, technologies and pedological and climatic conditions
- ✓ **exchanges** of crops and organic fertilizers between farms

3 main types of outputs, at the farm and the region scales:

- ✓ assessment of **protein self-sufficiency** in animal feed => self-sufficiency in total nitrogenous matter
- ✓ **economic** assessment => incomes
- ✓ **environmental** assessment => nitrogen related indicators SyNE and SyNB (*Godinot et al. 2014*)

Method : SYNERGY model



(Jouan, Carof, and Ridier 2017)

Method : Main functions

Objectif function :

$$\text{MAX } E(U) = \sum_f \sum_s E(R_{f,s}) - \Phi_{f,s} \sum_f \sum_s (Z_{f,s}^+ + Z_{f,s}^-), \quad (1)$$

Incomes :

$$\text{Profit}_{f,m,s} = \sum_c [(SL_{c,f,s} + SW_{c,f,s})Ps_c - (BL_{c,f,s} + BW_{c,f,s})Pb_c - Q_{c,f,s}COST_c], \quad (2)$$

f	farm	$SL_{c,f,s}; SW_{c,f,s}$	commodities sold on local market; on world market
s	territory	$BL_{c,f,s}; BW_{c,f,s}$	commodities bought on local market; on world market
$R_{f,s}$	incomes	$Ps_c; Pb_c$	selling price ; buying price
$\Phi_{f,s}$	Risk-aversion coefficient	$COST_c$	cost of production
$Q_{c,f,s}$	quantity produced		
$Z_{f,s}^+; Z_{f,s}^-$	positive and negative variations of incomes		

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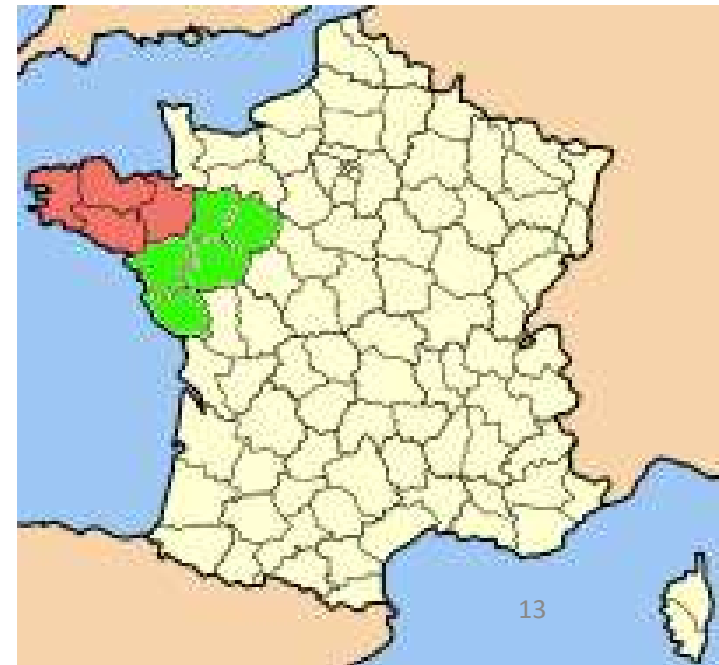
Case study : the region

Region of western France

Two NUTS sub-regions: Pays de la Loire and Brittany

Animal productions are significant:

- ✓ Mainly animal production in the Northern part
- ✓ More crop production in the Southern part



Case study : diversity of farms and technologies

Dairy farms

- ✓ 5 types of dairy farms
- ✓ 6 types of rations with :
 - Soybean meal
 - Rapeseed meal
 - Pea
 - Faba bean
 - Dehydrated alfalfa
 - Associated pasture with clover

=> 60 rations

Crops

Pig farms

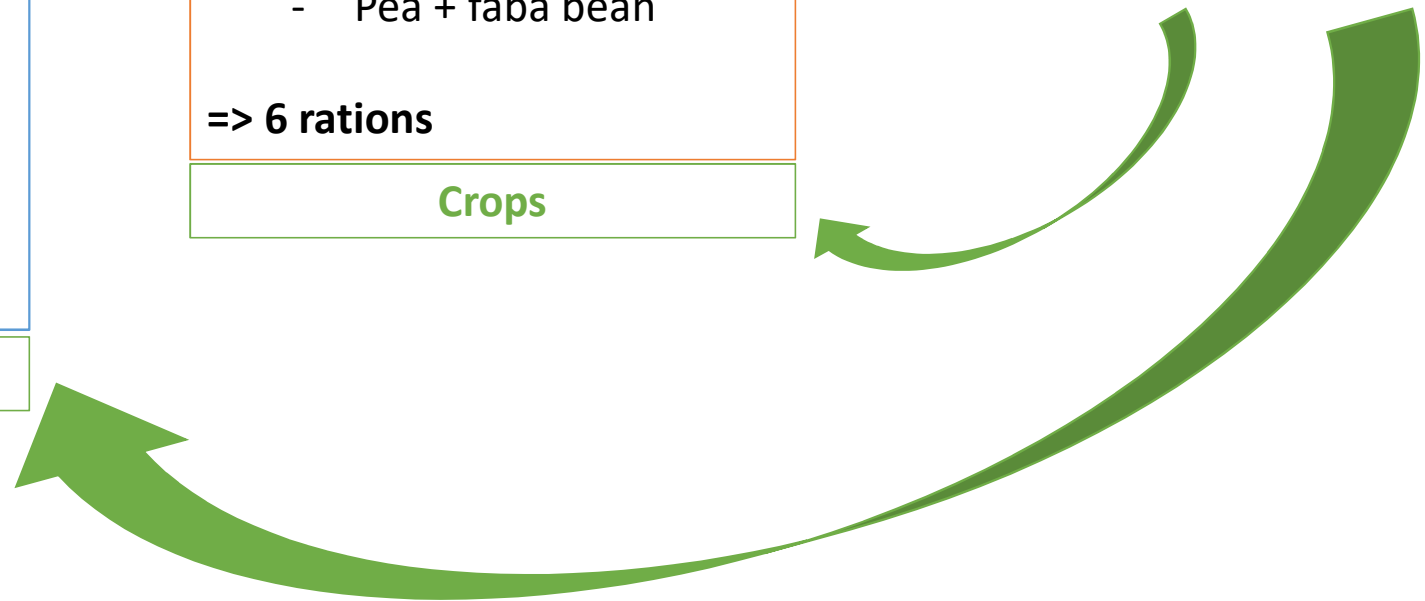
- ✓ 1 type of pig farm
- ✓ 3 types of rations with :
 - Soybean meal
 - Rapeseed meal
 - Pea + faba bean

=> 6 rations

Crops

Crop farm

- ✓ 1 type of crop farm
 - ✓ 11 crops
- => 36 rotations



Case study : scenarios

3 scenarios implemented

Baseline scenario

Scenarios with local exchanges

Local exchanges between farms are possible + price differential from 0% to 25% between crops bought on local and on world market

Scenarios with local exchanges + GMO-free certification :

GMO-free certification for animal commodities produced with legumes or rapeseed is set up in addition to local exchanges => certified commodities are sold 6% more expensive

Outline

1. Introduction

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4. Preliminary results

5. Discussion & conclusion

Evaluation of the SYNERGY model

Percentage of absolute or relative deviation between the observed levels of production and the simulated levels

- Calibration of the SYNERGY model is satisfying
- Only small issues on pastures and grain corn

Results

Comparison of “baseline” scenario and scenario “with local exchanges”

	B	SC_E0
Milk produced	102 405 482 hl	-4%
Pig produced	14 756 681	+30%
Legume area	140 495 ha	-4%
Protein self-sufficiency	59%	-2%
Incomes	1690 €/ha	+10%
SyNB	42	+1
SyNE	0,71	+0,02

Results

Comparison of “baseline” scenario and scenario “with local exchanges and price differentiation”

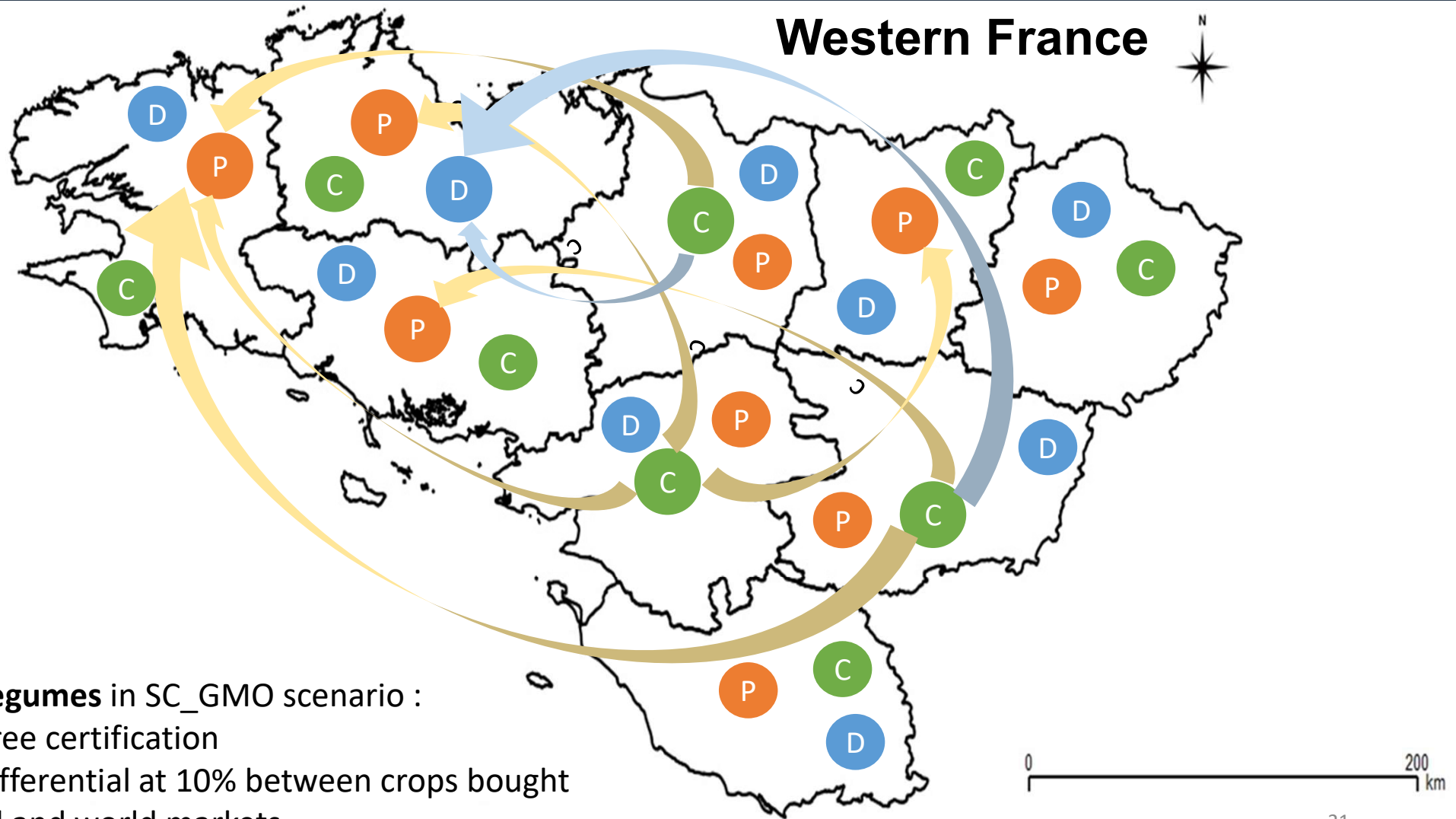
	B	SC_E0	SC_E10
Milk produced	102 405 482 hl	-4%	-8%
Pig produced	14 756 681	+30%	+58%
Legume area	140 495 ha	-4%	+20%
Protein self-sufficiency	59%	-2%	+2%
Incomes	1690 €/ha	+10%	+10%
SyNB	42	+1	-1
SyNE	0,71	+0,02	+0

Results

Comparison of “baseline” scenario and scenario “with local exchanges and GMO-free certification”

	B	SC_E0	SC_E10	SC_GMO
Milk produced	102 405 482 hl	-4%	-8%	-2%
Pig produced	14 756 681	+30%	+58%	+58%
Legume area	140 495 ha	-4%	+20%	+192%
Protein self-sufficiency	59%	-2%	+2%	+5%
Incomes	1690 €/ha	+10%	+10%	+16%
SyNB	42	+1	-1	+3
SyNE	0,71	+0,02	+0	-0,03

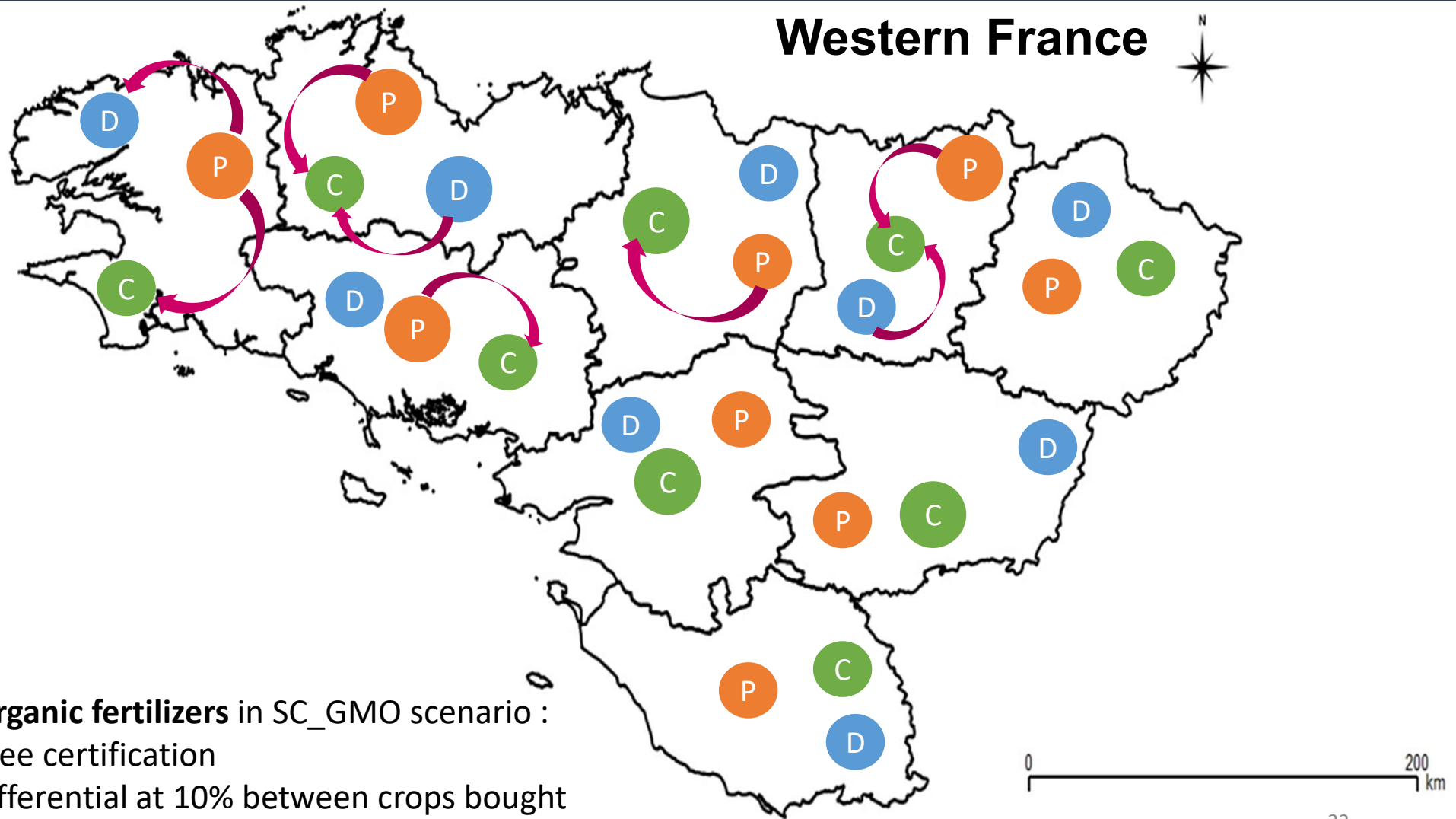
Results



Exchanges of legumes in SC_GMO scenario :

- GMO-free certification
- price differential at 10% between crops bought on local and world markets

Results



Exchanges of organic fertilizers in SC_GMO scenario :

- GMO-free certification
- price differential at 10% between crops bought on local and world markets

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Results

Main conclusions

	B	SC_E0	SC_E10	SC_GMO
Milk produced	102 405 482 hl	-4%	-8%	-2%
Pig produced	14 756 681	+30%	+58%	+58%
Legume area	140 495 ha	-4%	+20%	+192%
Protein self-sufficiency	59%	-2%	+2%	+5%
Incomes	1690 €/ha	+10%	+10%	+16%
SyNB	42	+1	-1	+3
SyNE	0,71	+0,02	+0	-0,03

Discussion & conclusion

Preliminary results at regional scale => only trends

Local exchanges of crops or organic fertilizers can increase legume production, and thus protein self-sufficiency, provided that costs of transaction and transport are lower on local markets.

This increase does not go along with an improvement in environmental indicators

But, it is unlikely that such exchanges take place without local intermediaries such as cooperatives

More research is thus needed to understand the vertical relationships between farmers and cooperatives, in particular when added value in animal feed is created (GMO-free).

Thank you for your attention
