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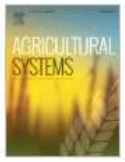

Outcomes arising after a Senior Researcher Mobility Grant from the Ministry of Universities of Spain (PRX21/00146)

Circularity and livestock diversity: Pathways to sustainability in intensive pig farming regions

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Presentation outline

- Context
- Study region and goals
- Scenarios compared and Methodology
- Key Results
- Conclusions and Policy implications

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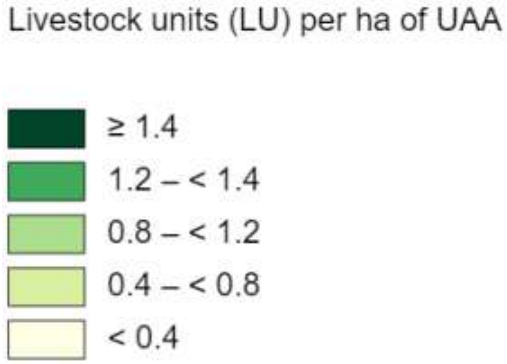
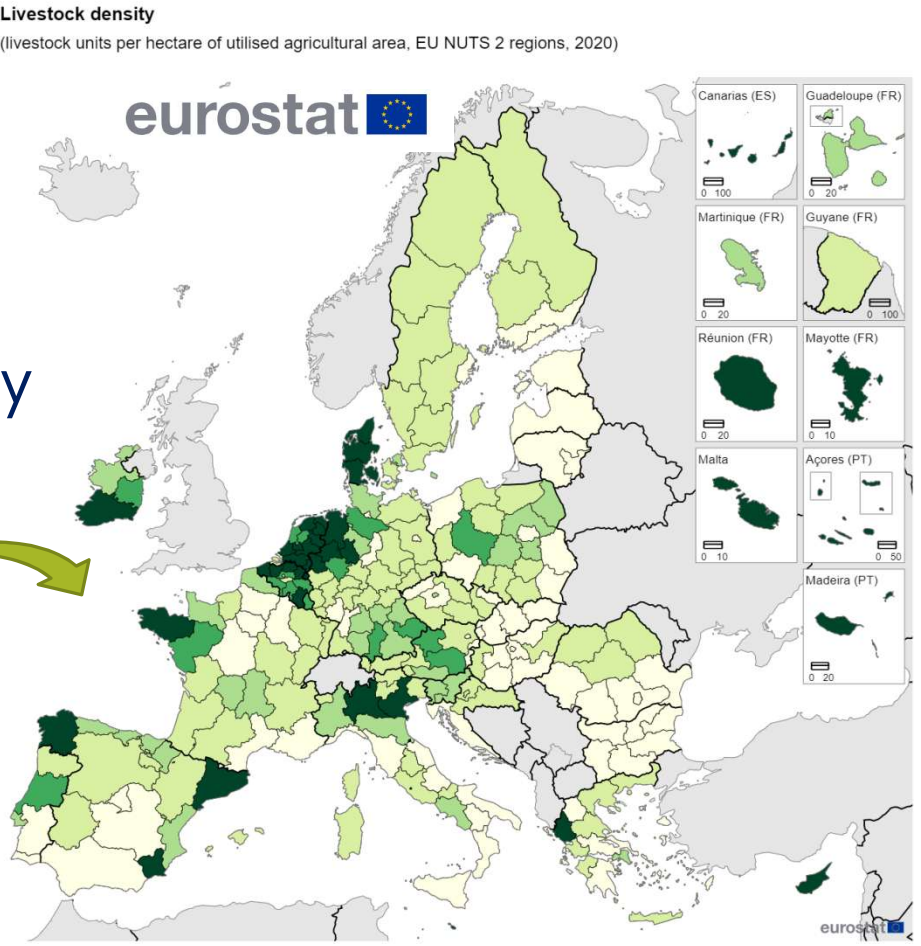
Context

- Strong **dependence on imported feed ingredients** to support intensive livestock.
- **Crop and livestock** systems in many EU areas are **disconnected**.

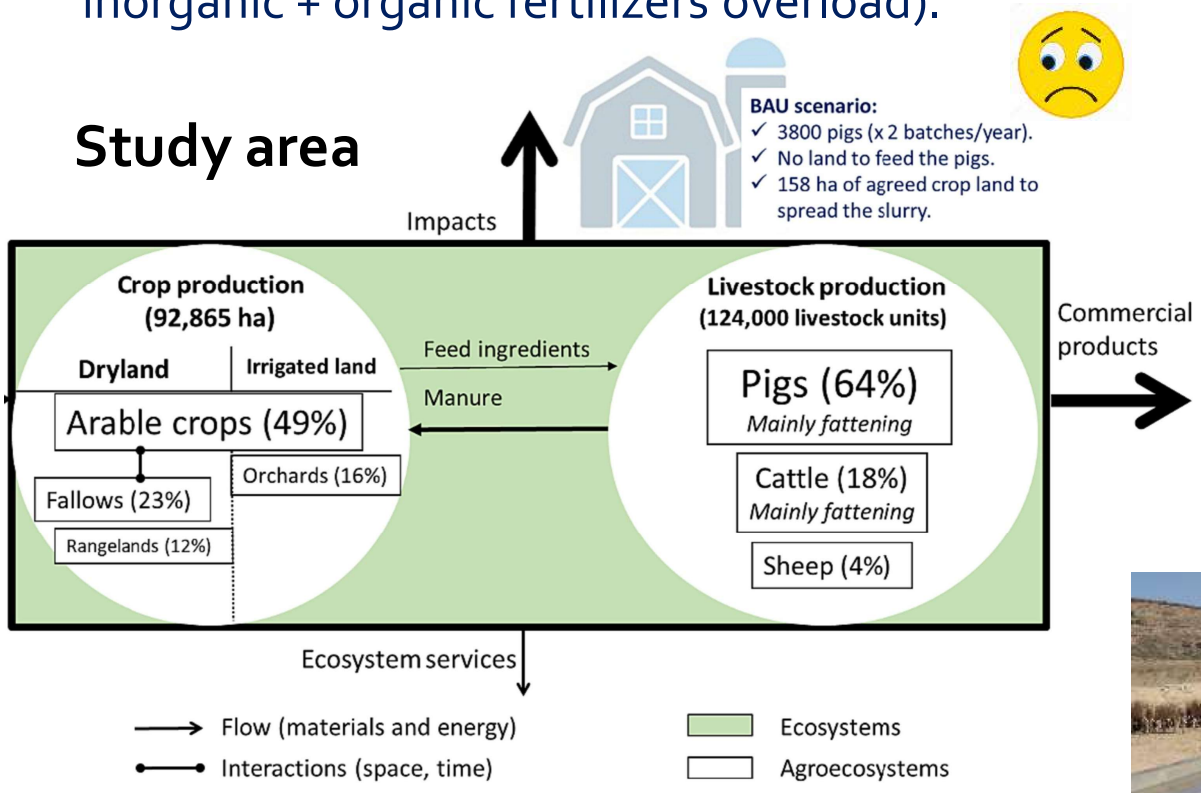


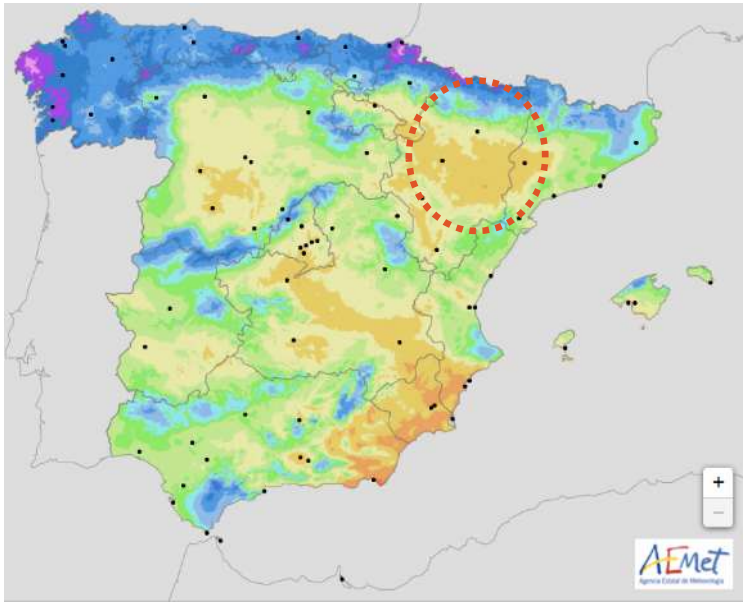


Land use challenges in Semiarid areas in Spain

- **Water scarcity** and **high air temperatures.**
- **Nutrient load risk** on some drainage areas (due to inorganic + organic fertilizers overload).

Study area





Objective

To evaluate through a multicriteria tool grid whether increasing **feed circularity**, and reintroducing sheep as **complementary livestock** could improve **sustainability** in a pig dominated region with two **dietary crude protein** level scenarios.

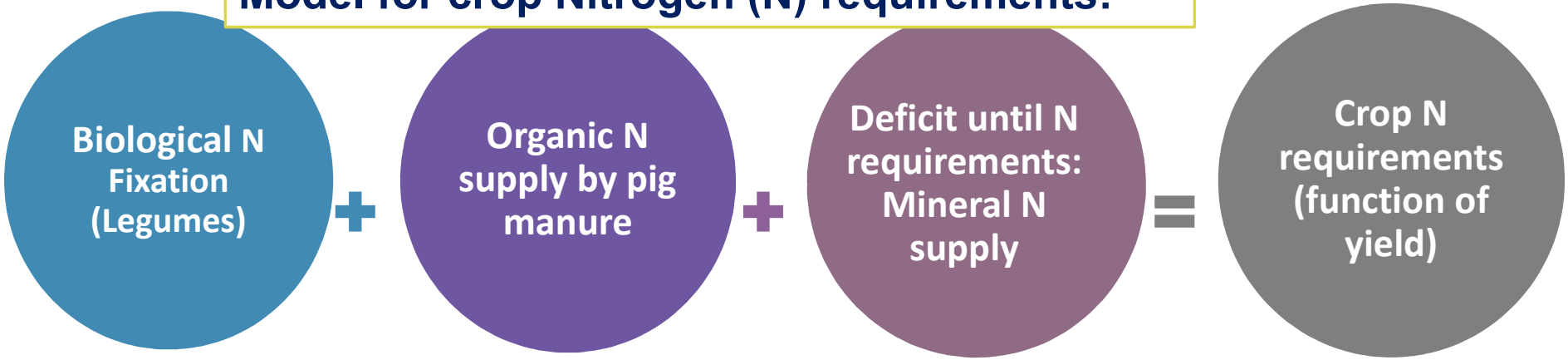
Methods: multicriteria evaluation of sustainability (1/2)

Criteria	Indicator considered
Economics	Economic pay-off as a result of circular pig feeding (most decrease of feed cost under low and high market feed price scenarios) (€/pig)
	Cover crop pay-off (€/ewe in high carrying capacity farm) to support mixed farming with sheep production
Temporal diversity of landscape mosaic	Surface of land dedicated to major crop (ha)
	Surface of land dedicated to legumes (reducing mineral fertilizer dependence) (ha)
Spatial diversity of landscape mosaic	Mean field size per crop type (ha)
	Number of crops for animal feeding (diversification-rotation) (number)
Livestock diversity	Sheep number that could be introduced in the region of study to recycle crop residues and prevent fire risks trough rangeland grazing.

Methods: multicriteria evaluation of sustainability (2/2)

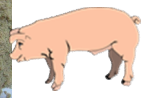
Criteria	Indicator considered
Nitrogen cycling	Nitrogen input dependence (Purchased N inputs / Sold N outputs)
	Farm-gate nitrogen balance (kg N/ha)
	Livestock saturation index=(∑organic N availability - ∑organic N allowance) x 100/ ∑ organic N allowance (Aragon Government)
Feed-food competition	Land productivity (kg sold total protein/land area)
	Amount of rice bran (**local food by-product**) used per pig as a proxy of food-waste recycling (kg rice bran/pig).

Model for crop Nitrogen (N) requirements:



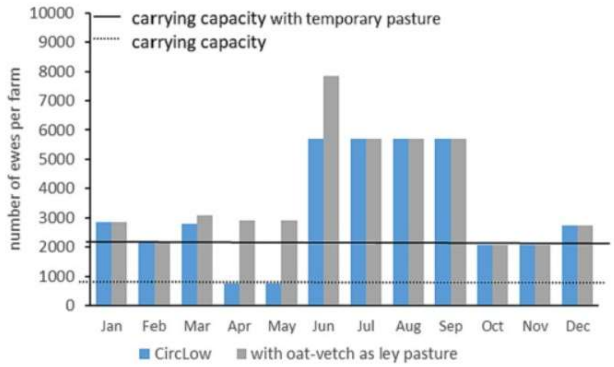
Methods: mixed regional farming with different circular diets for pigs and sheep to balance agroecosystem impacts and services

1. Circular feed for pigs



	Cereal grains			Legumes			Other oilseeds	x → Lucerne not available for feed			
				Maize / Sorghum							
				Rice							
				Sunflower							
				Soyabean							
Barley / Rye / Wheat											
Rapeseed											
Field pea / Fababeans											
Lucerne for grazing	x	x	x	Lucerne for hay-making					x	x	x
January	February	March	April	May	June	July	August	September	October	November	Desember

2. Grazing calendar for sheep based on **crop residues** used to feed the pigs and grazing resources as fallows and **rangeland pastures**

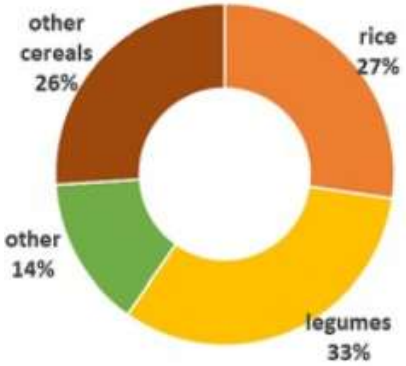


January	February	March	April	May	June	July	August	September	October	November	Desember
						winter cereal residues					
						pulse crop residues					
						rapeseed residues					
maize residues											maize residues
									sunflower residues		
									soyabean residues		
		rangeland pastures							rangeland pastures		
		oat-vetch as ley pasture									
Lucerne pasture											

+Lucerne and green vetch-oat as pastures in fallow land

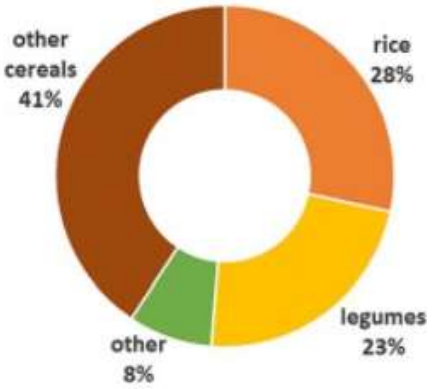
Key Results: Circularity and biodiversity

(717 ha)
Circ High CP Low AA



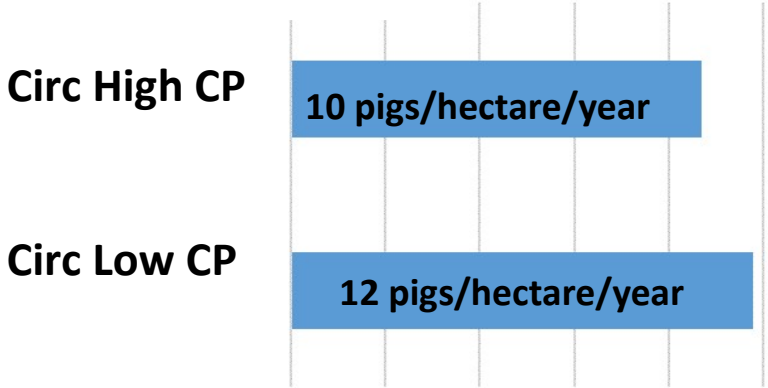
3 Summer crops
7 Winter crops

(648 ha)
Circ Low CP High AA



4 Summer crops
7 Winter crops

Pig farm type 3,800 stocks



Slurry application:

158 ha **124 ha**

Crop N requirements met by organic N from pigs

40% **37%**

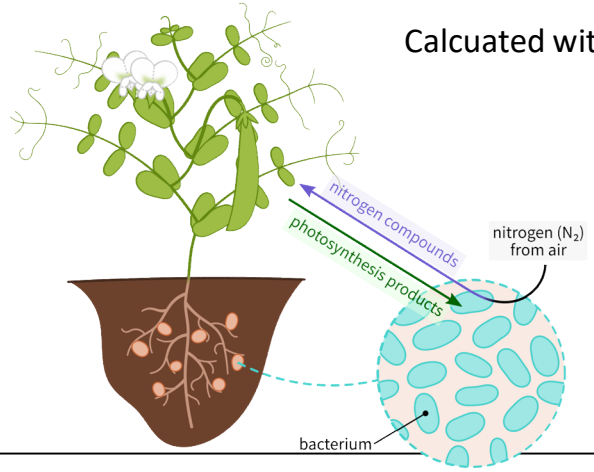
↑ Crop biodiversity: ↑ Pollinator actions and ↓ Mineral N dependency (↑ Legumes)

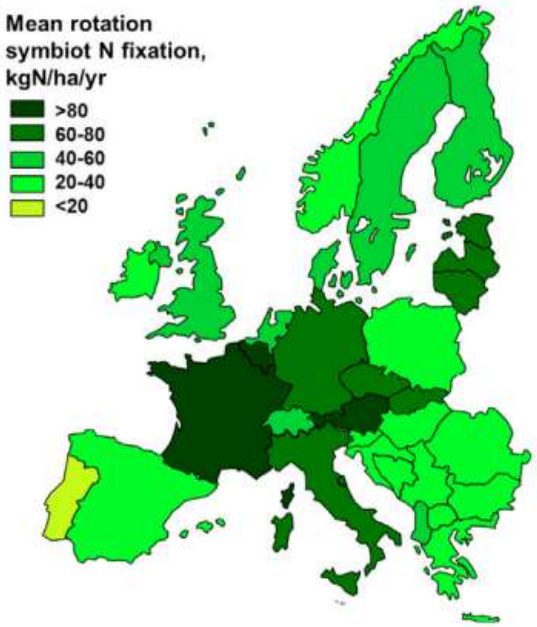
Key Results: Circularity ↑ N inputs

Biological N fixation (BNF) by crops used for feeding pigs in study area

	BNF in **dryland** (kg N/ha)	BNF in **irrigation** (kg N/ha)
Beans	23	63
Soybean	-	72
Peas	48	73
Luzerne	139	311

Calcuated with Anglade et al. (2015) equati



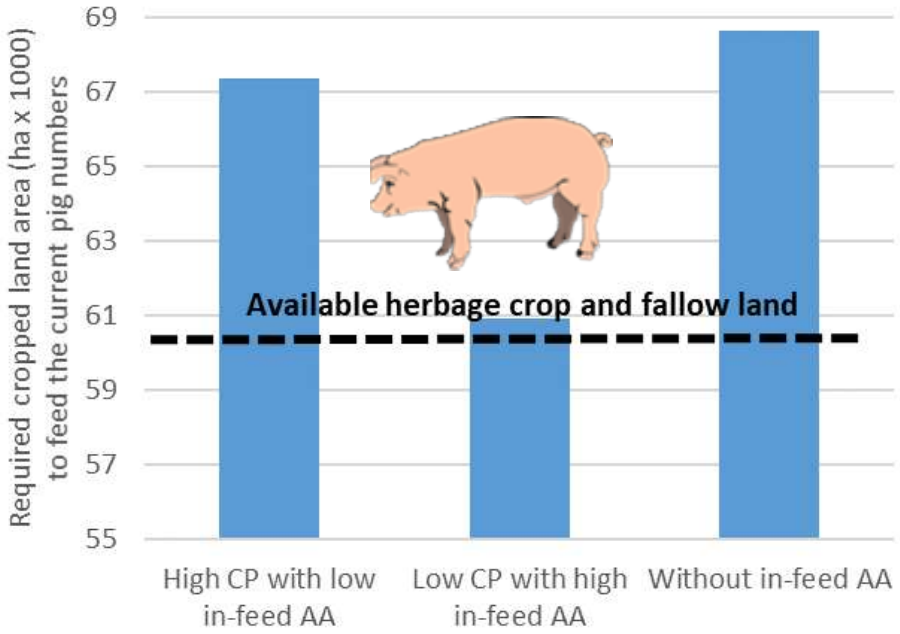


Billen et al. (2021)

The greater the crop yield due to photosynthetic activity, the greater the BNF capacity by Rhizobium-legume simbiosis.

Key Results: Circularity

Required crop land area to feed the current pig stocked in the region of study according to dietary crude protein (CP) strategy



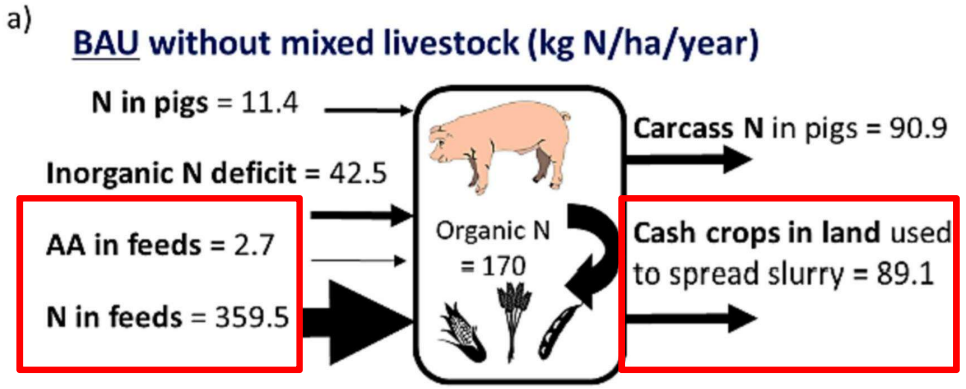
Reintroduction of complementary niche sheep can counteract the decrease in land protein productivity when feeding pigs with circular feeds

Key Results: Nitrogen flows

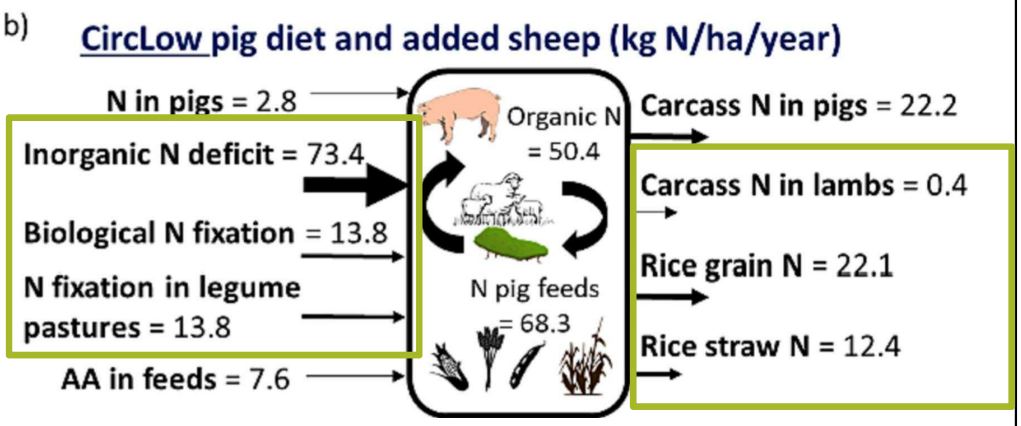
N surplus, N use efficiency (NUE), N dependence, Land productivity

(a) pig farming system with outsourced feed (Business-as-usual, BAU)

(b) circular pig farming with low dietary CP and using rice bran for feed and mixed sheep using crop residues and fallow land



NUE (Noutputs/Ninputs)= 0.43



NUE=0.51

Conclusions and Policy Implications

- This tool may **evaluate trade-offs** among **economic performance, crop landscape mosaic, livestock diversity, N cycling and feed-food competition,** according to feeding scenarios.

- To stand with **the available regional crop land area**, the implementation of feed circularity in areas with high livestock density requires **the use of low CP pig diets supplemented with a high level of in-feed AA**, otherwise the sizes of livestock populations in the future may be challenged.

- To avoid a reduction in overall **protein productivity**, the **reintroduction of sheep** may be a **mitigation strategy** which consume feed with low opportunity costs. These changes would greatly **improve N cycling** and overall sustainability.

Merci beaucoup de votre attention!