

# Reconnecting cropping and livestock operations to enhance circularity and avoid ecological collapse

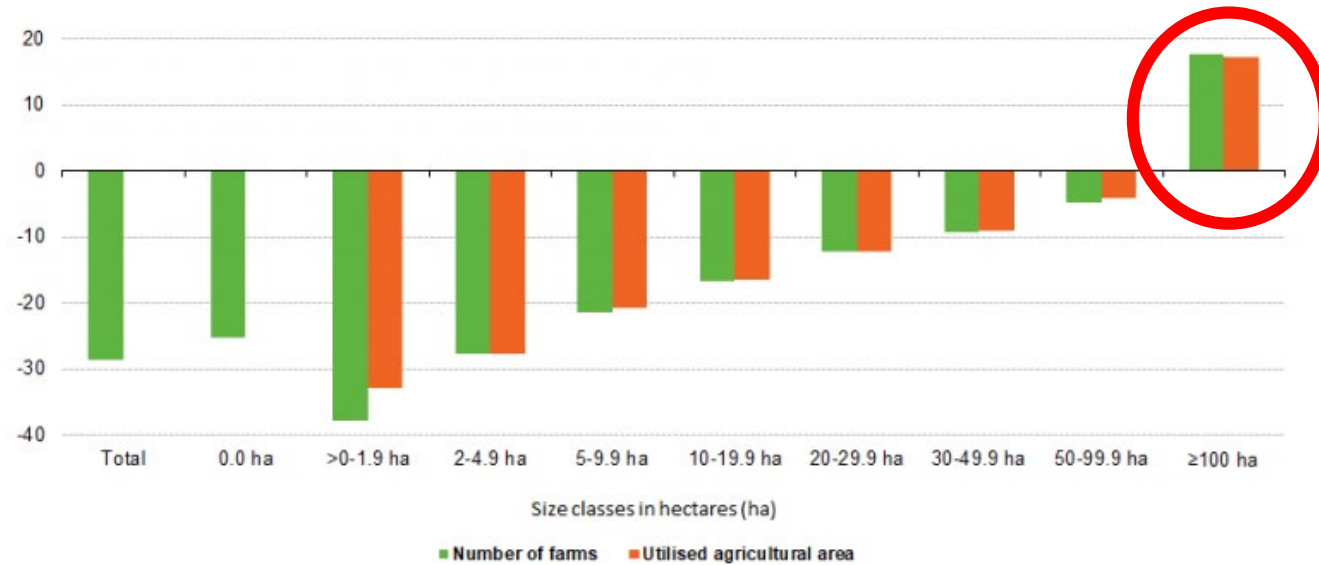
Guillaume Martin  
and

Alan J. Franzluebbers



# Farm size growing in advanced economies

Change in the number of farms and utilised agricultural area by size class, EU-28, 2005–2016 (%)



→ Only the share of the largest farms grows



Note: Although the strongest decreases were recorded for the smallest size classes, the precise rates themselves may also reflect changes in survey thresholds. Furthermore, the EU-28 figure for 2005 includes 2007 data for Croatia. By definition, the size class of farms with 0 hectare of utilised agricultural area has no change in area. The change of 0.2 % in EU-28 total utilised agricultural area during the period 2005-2016 is not missing from this figure but due to its small size it is hardly visible.

Source: Eurostat (online data code: ef\_m\_farmleg)

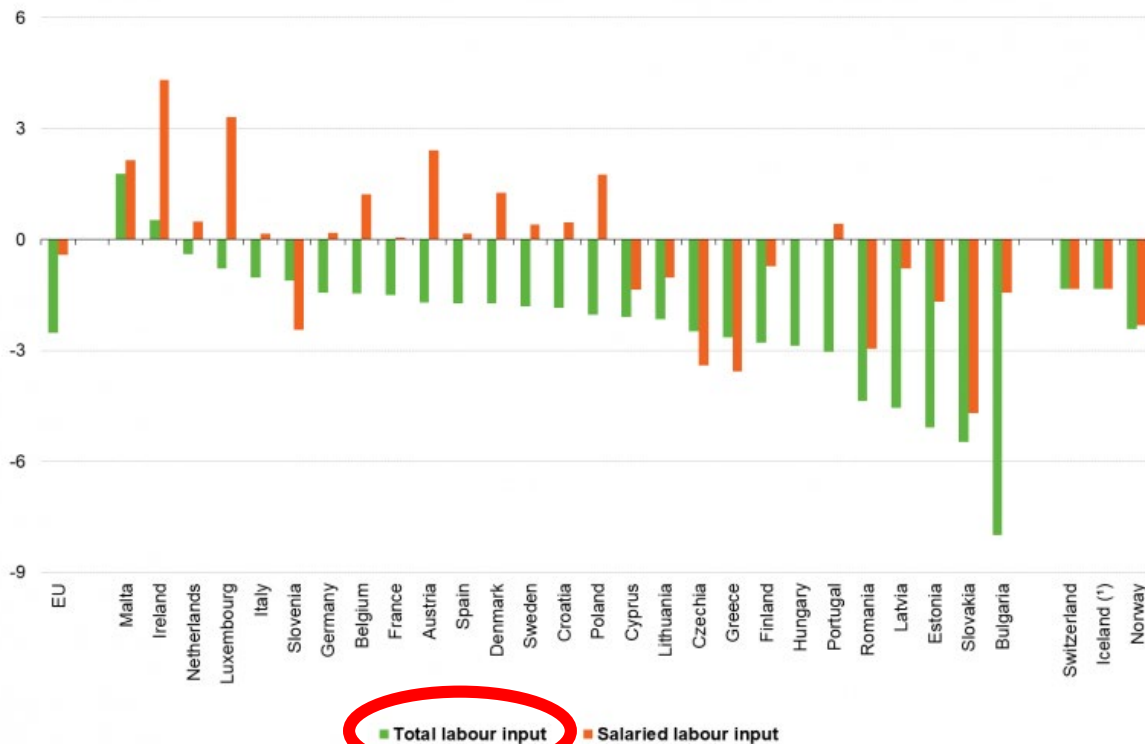
eurostat

100 000 farms lost in France over 2010-2020!  
(over a total of 490 000 farms in 2010)



# With fewer farm workers

**Agricultural labour input**  
(%, average annual rate of change, 2005-2020)

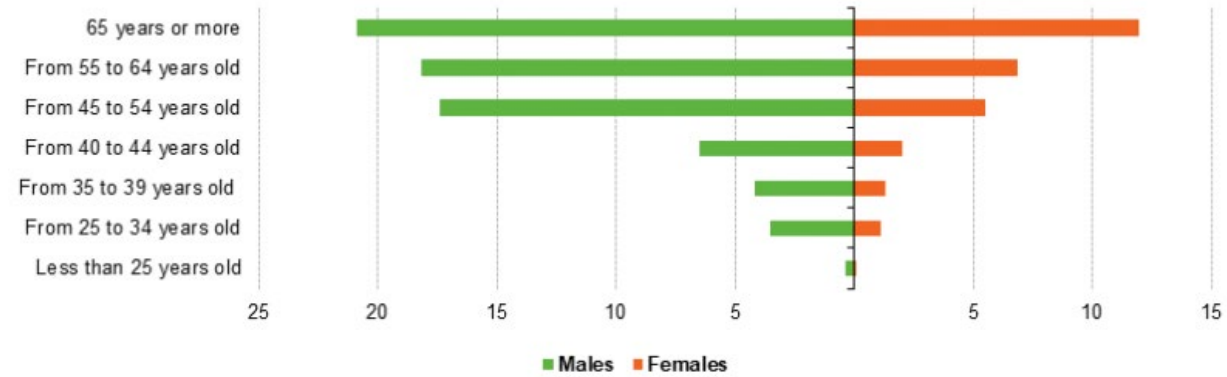


(\*) 2010-2019.  
Source: Eurostat (online data code: aact\_all02)

eurostat

**58% of farmers are at least 55 years of age**

**Age classes of farm managers, by gender, EU-28, 2016**  
(% of all farm managers)



Source: Eurostat (online data code: ef\_m\_farmang)

eurostat

➔ Increasing labor productivity to mitigate the decrease in farm workers

+1.9%/year in the French beef sector

Animal (2019), 13-5, pp 1063-1073 © The Animal Consortium 2018  
doi:10.1017/S1757173118002574

animal



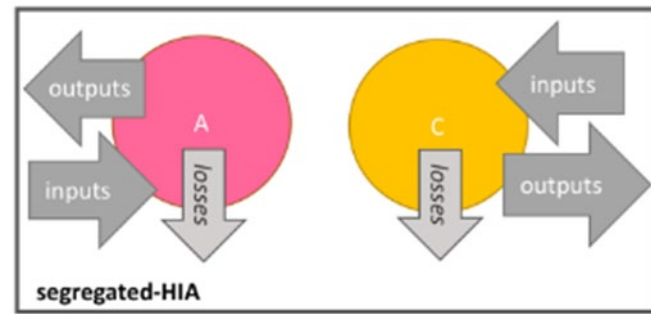
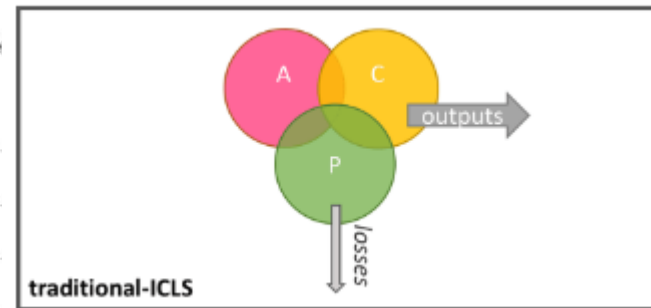
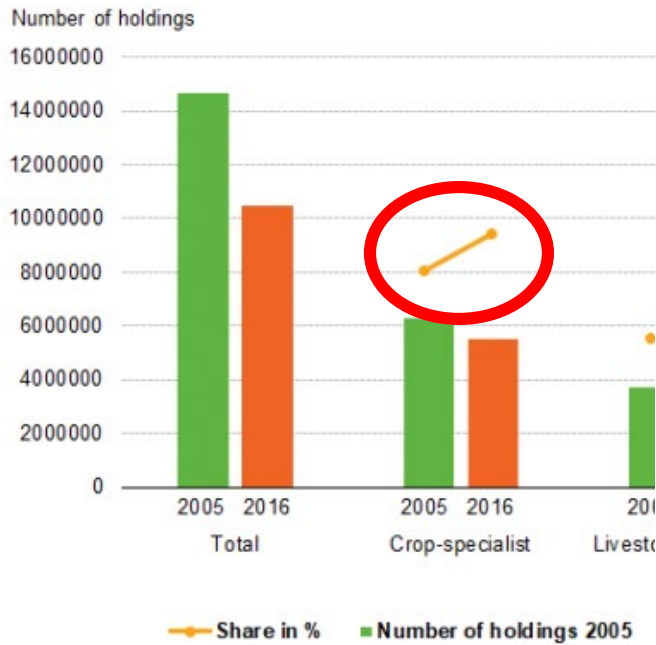
Generation and distribution of productivity gains in beef cattle farming: Who are the winners and losers between 1980 and 2015?

P. Veysset<sup>1</sup>, M. Lherm<sup>1</sup>, J. P. Boussemart<sup>2</sup> and P. Natier<sup>2</sup>



# The simplest avenue (1): farm specialization and intensification

Specialisation of agricultural holdings, change between



Copyright © 2020 by the author(s). Published here under license by the Resilience Alliance.  
 Garrett, R. D., J. Ryschawy, L. W. Bell, O. Cortner, J. Ferreira, A. V. N. Garik, J. D. B. Gil, L. Klerkx, M. Moraine, C. A. Peterson, J. C. dos Reis, and J. F. Valentim. 2020. Drivers of decoupling and recoupling of crop and livestock systems at farm and territorial scales. *Ecology and Society* 25(1):24. <https://doi.org/10.5751/ES-11412-250124>



Source: Eurostat (online data code: ef\_m\_farmleg)

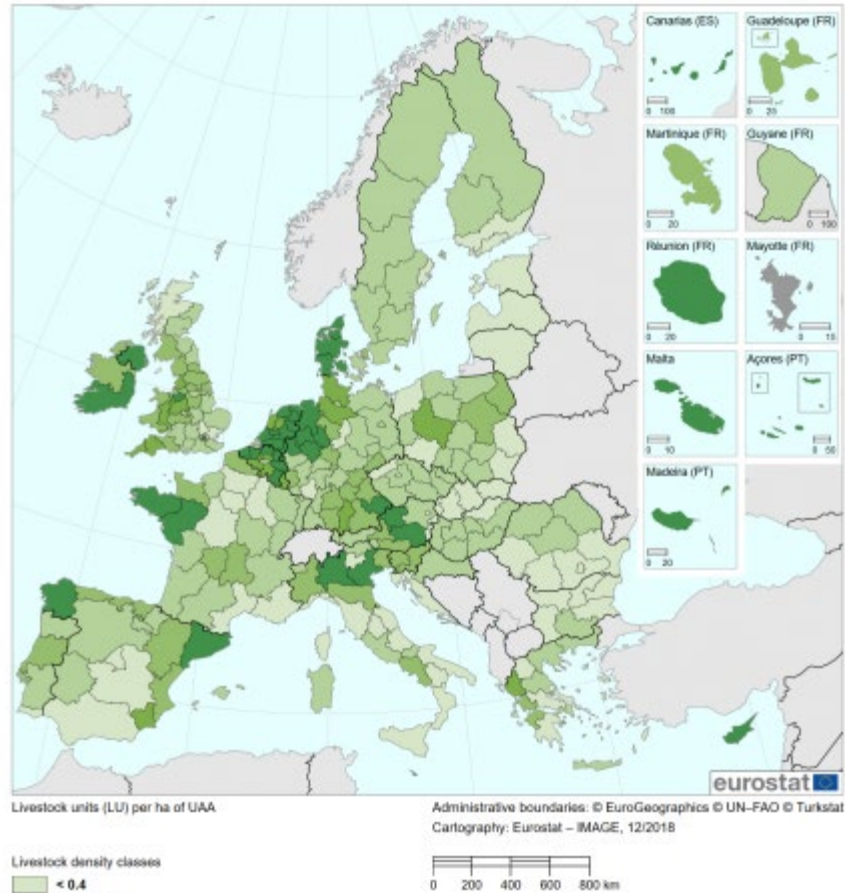


↗ fertilizers and pesticides **D** ↗ feed inputs and drugs



# The simplest avenue (2): regional specialization

Map 1: Livestock density by NUTS 2 regions, EU-28, 2016  
(Livestock units per hectare of utilised agricultural area)

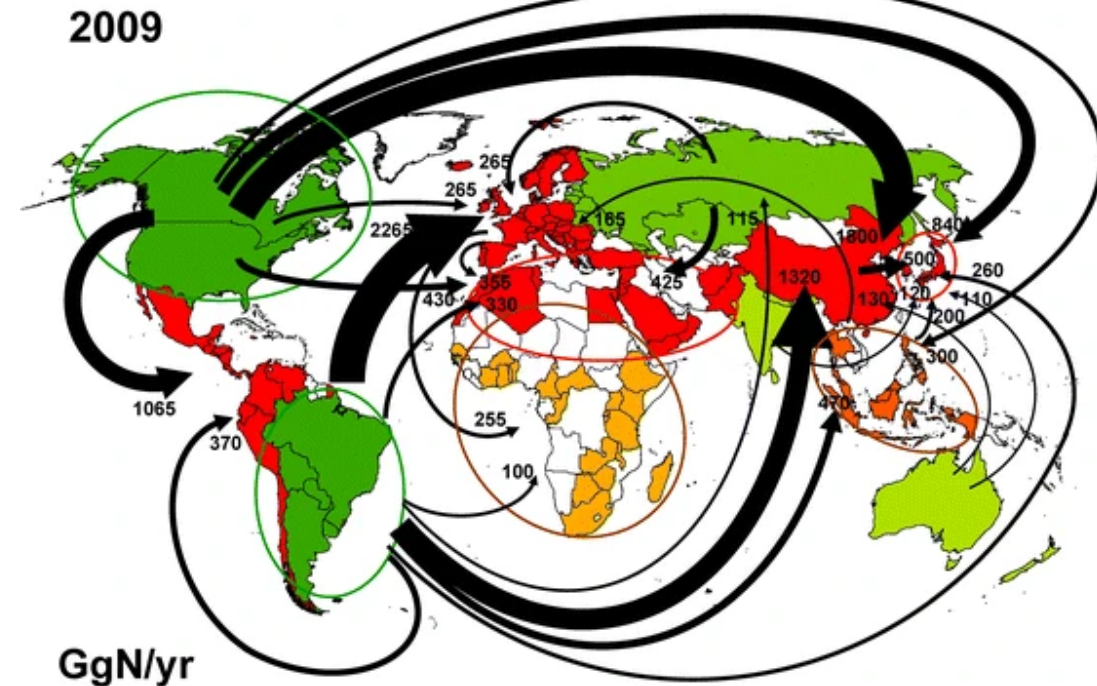
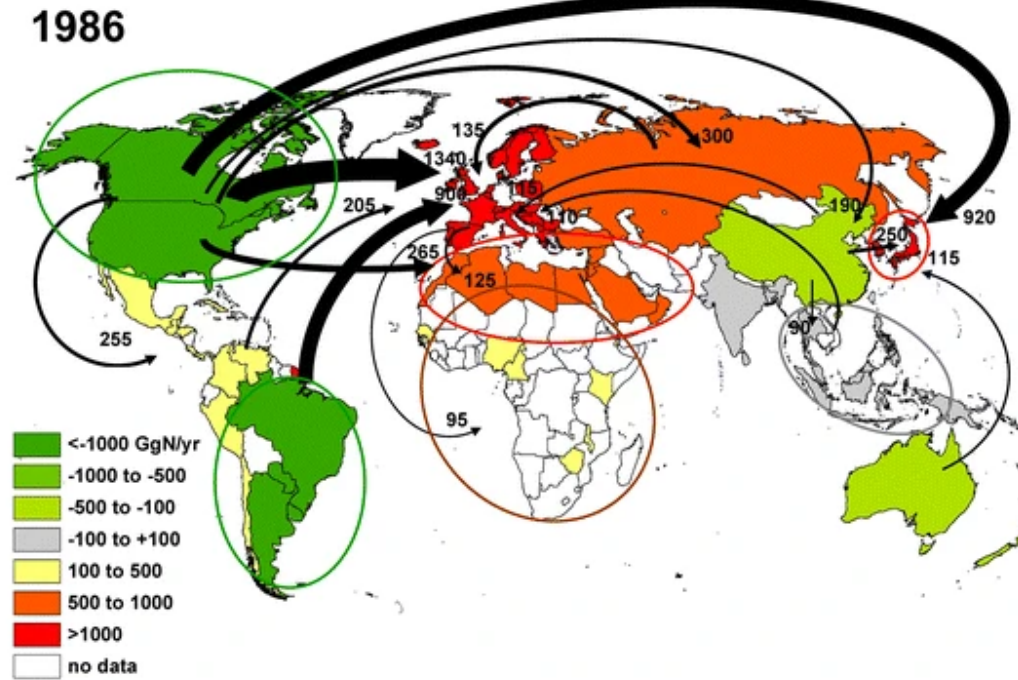


# Agriculture embedded in international trade

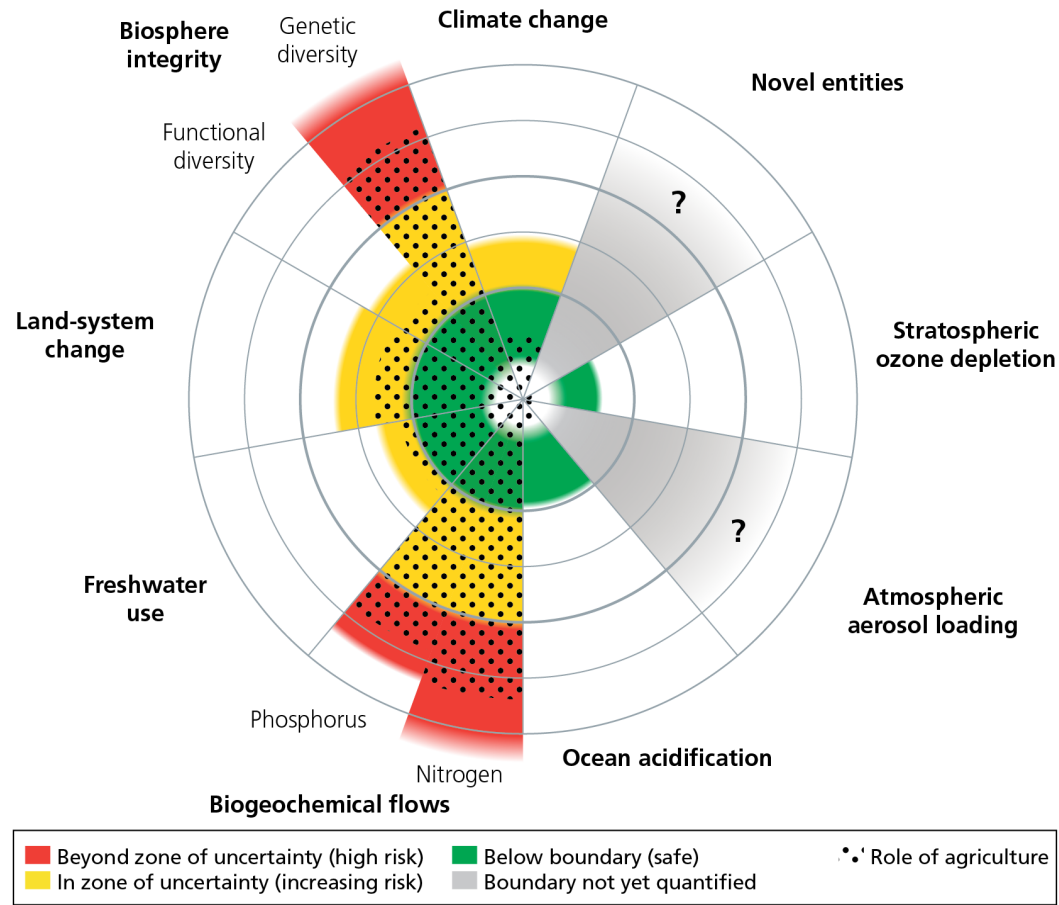
Biogeochemistry (2014) 118:225–241  
DOI 10.1007/s10533-013-9923-4

## Food and feed trade as a driver in the global nitrogen cycle: 50-year trends

Luis Lassaletta · Gilles Billen · Bruna Grizzetti ·  
Josette Garnier · Allison M. Leach ·  
James N. Galloway



# Agriculture as a major driver of environmental burdens



Part of society calls for more sustainable agricultural models



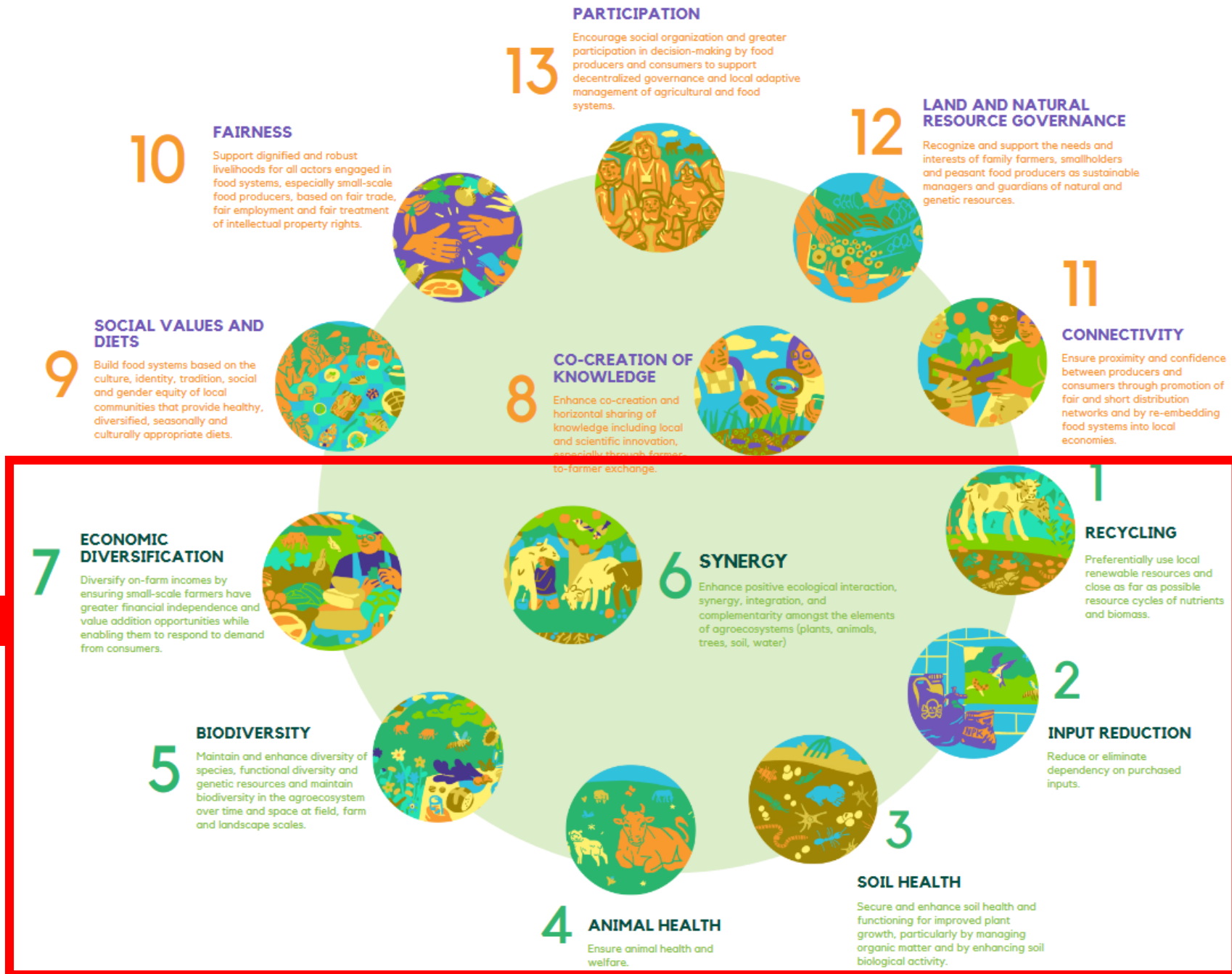
# Agroecology as an alternative

FOOD SYSTEM

AGR

COSYSTEM

Integrated crop-pasture-livestock farming as a an ideal model





# An old recipe with new technologies

Pietro Di Crescenzi (1233-1321)  
*Opus ruralium commodorum*



Availability of seeds for a large diversity of crops, pastures and cover crops

Novel machinery to allow e.g. relay cropping and direct sowing

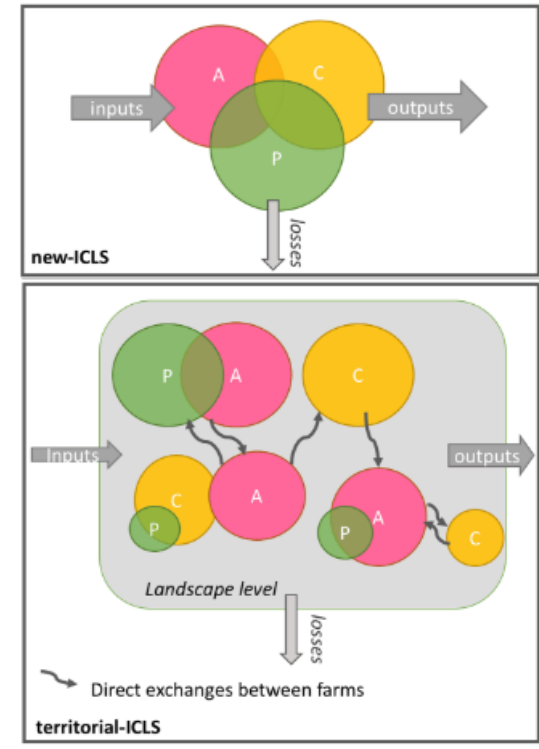
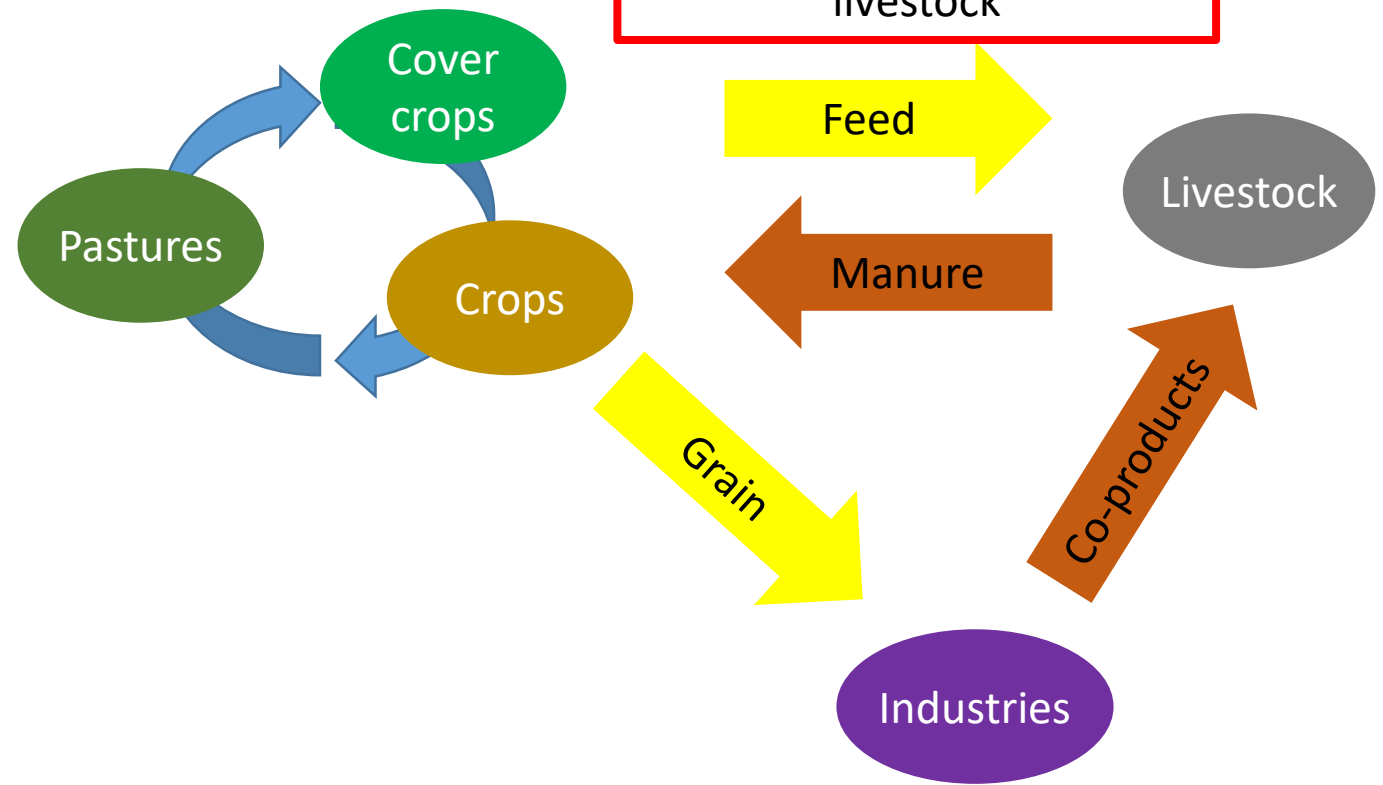


Novel equipment to allow e.g. mobile fencing for cover crop grazing

# Integrated crop-pasture-livestock systems

Introduction of pastures and cover crops in crop rotations

Coupling between plant and livestock



Coupling between crop, pasture and livestock at all levels:

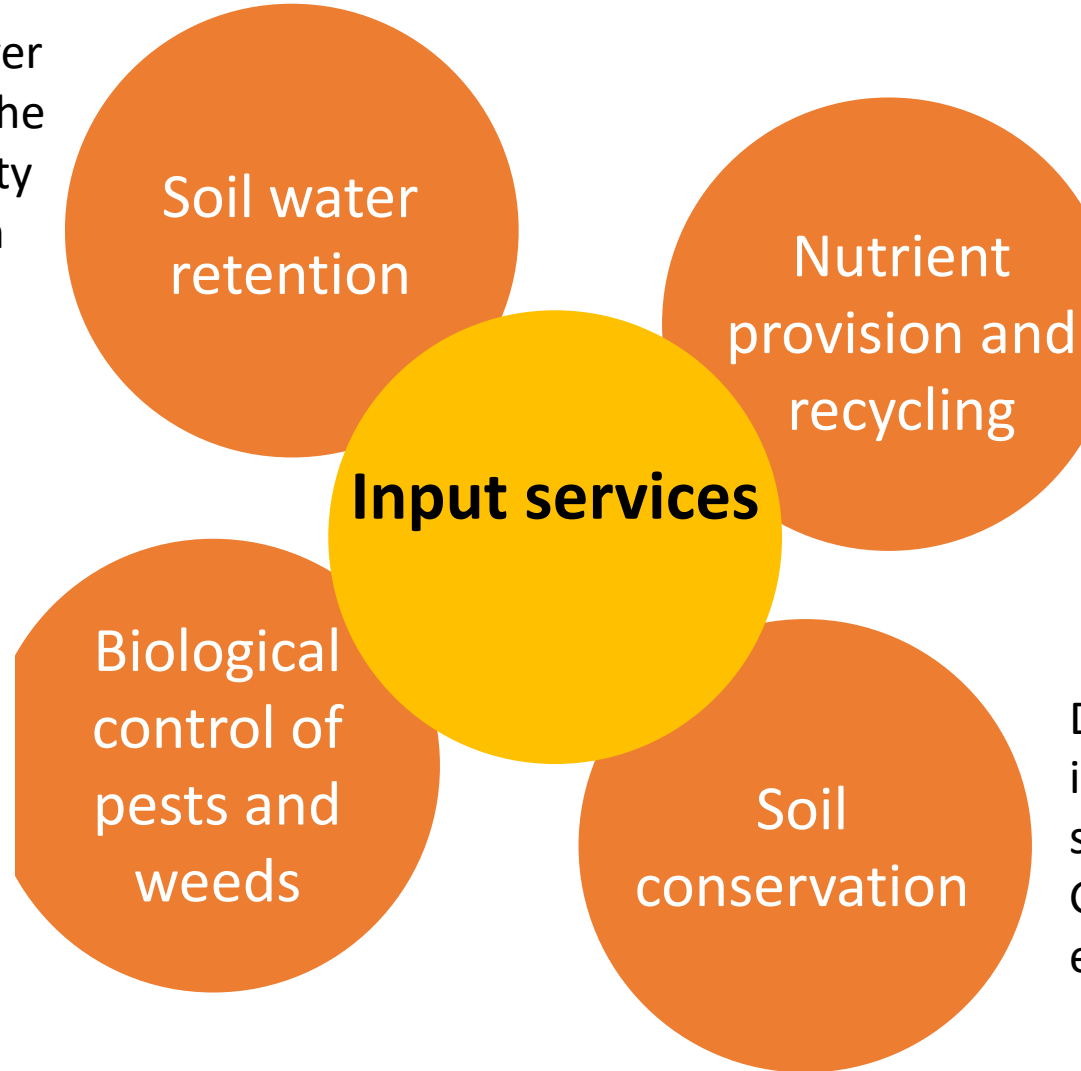
- the field → biogeochemical processes
- the farm → matter flows
- the landscape → ecosystem processes
- the region → coordination among farms and with agrofood industries



# Input services provided by ley pastures and cover crops in crop rotations

SOM stored during the pasture/cover crop period and dead roots left in the soil increase available water capacity and water infiltration and retention (Zhao et al. 2013)

Unfavorable growth conditions for weeds (Meiss et al. 2010): competition, regular disturbance... Cropping systems integrating ley pastures generally have lower pesticides inputs (Lechenet 2017)



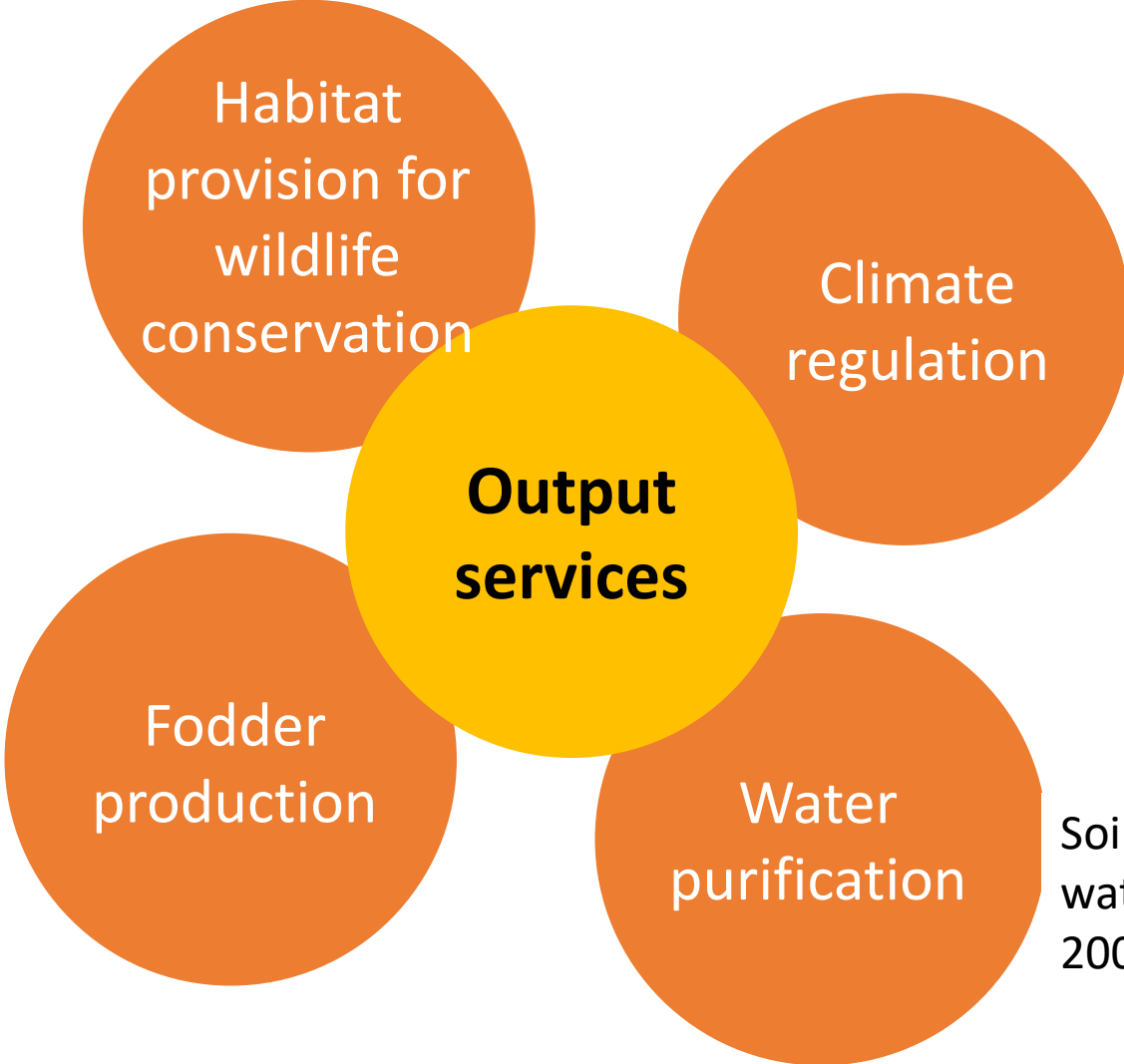
High C and N inputs via grass and legume species respectively (Ledgard, 1989)

As stocking rate increases, C–N decoupling by animals can offset the C–N coupling capacity of the soil-plant system, leading to NO<sub>3</sub> leaching and N<sub>2</sub>O emissions (Vertès et al. 2008)

Decreasing soil disturbance and increasing C input greatly improve soil structure (Franzluebbers and Gastal 2018) and reduce soil erosion (Gyssels et al. 2005)

Photo credits: <http://traceandsave.com/why-diversify-your-pastures/>

# Output services provided by ley pastures and cover crops in crop rotations



Since the rate of C storage decreases with increasing C stock (Minasny et al. 2017), ley pastures are expected to be able to store C more than permanent grasslands (Pellerin et al. 2019).

Soil cover reducing risks for deep water contamination (Ledgard et al. 2009)

Photo credits: <http://traceandsave.com/why-diversify-your-pastures/>



# Output services provided by ley pastures and cover crops in crop rotations

Vital role in maintaining biodiversity by providing over-wintering sites, food resources, etc. (Tscharntke et al. 2005)

Unclear to date whether reintroduction of ley pastures to intensive arable-crop areas may have similar impacts

Habitat provision for wildlife conservation

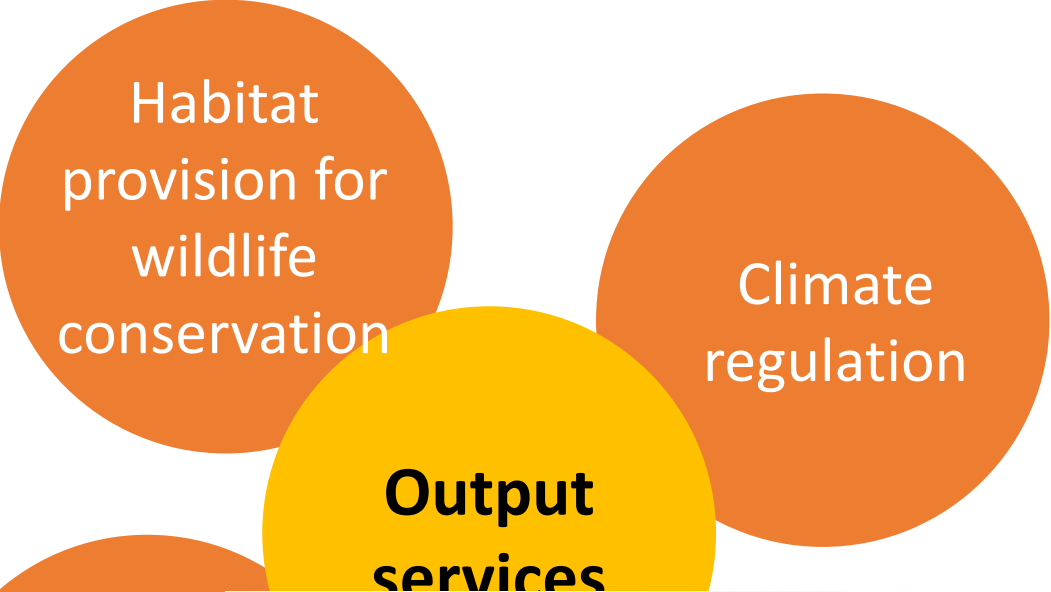


**Output services**

Fodder production

Water purification

# Output services provided by ley pastures and cover crops in crop rotations



Widely recognized service in terms of quantity and quality of forage



NOM DE LA PRESENTATION

# Output services provided by ley pastures and cover crops in crop rotations

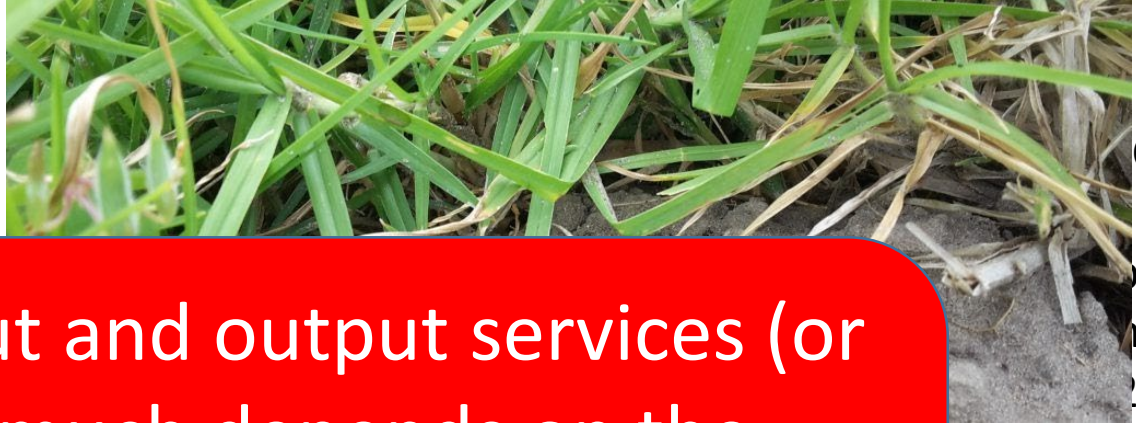
Vital role in maintaining biodiversity by providing over-wintering sites, food resources, etc. (Tscharrntke et al. 2005)

Unclear to date whether reintroduction of ley pastures in intensive arable-crop areas has similar impacts

**Achievement of input and output services (or disservices) very much depends on the management practices implemented e.g.**

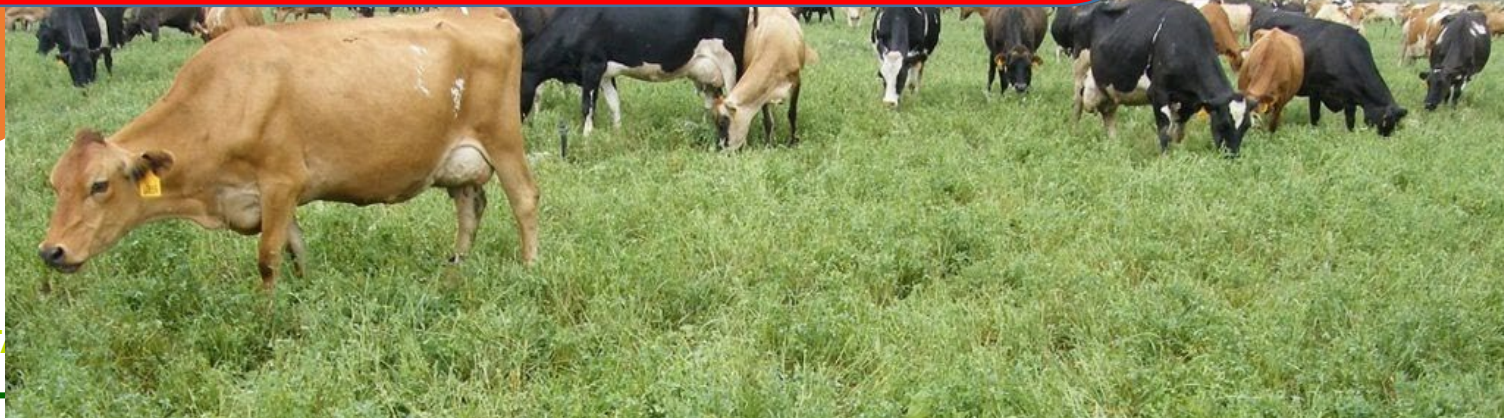
- An appropriate stocking rate at grazing
- A relevant combination of plant species

Habitat provision for

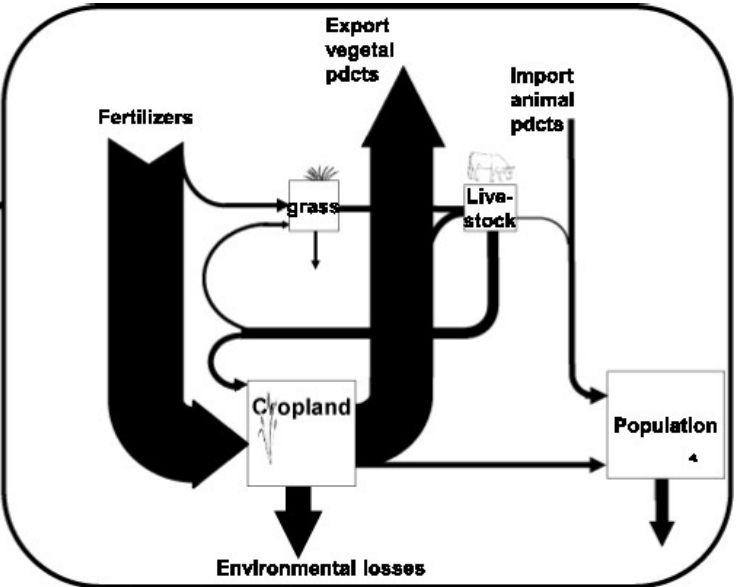
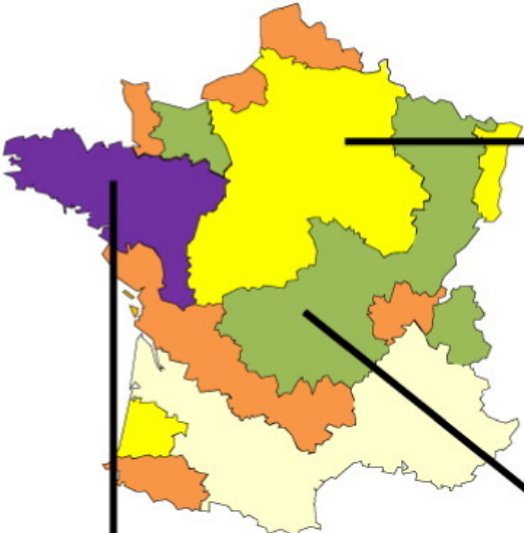


C stock  
be able  
manent  
(2019).

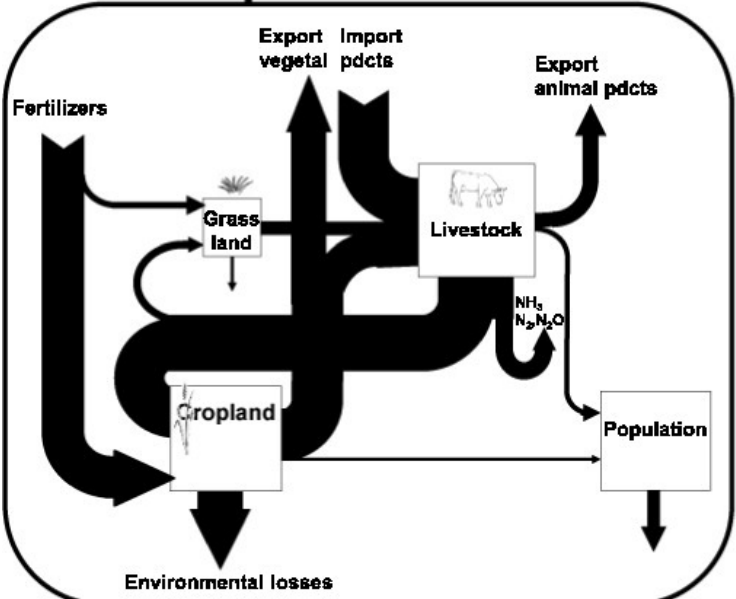
Widely recognized in terms of quantity and quality of forage



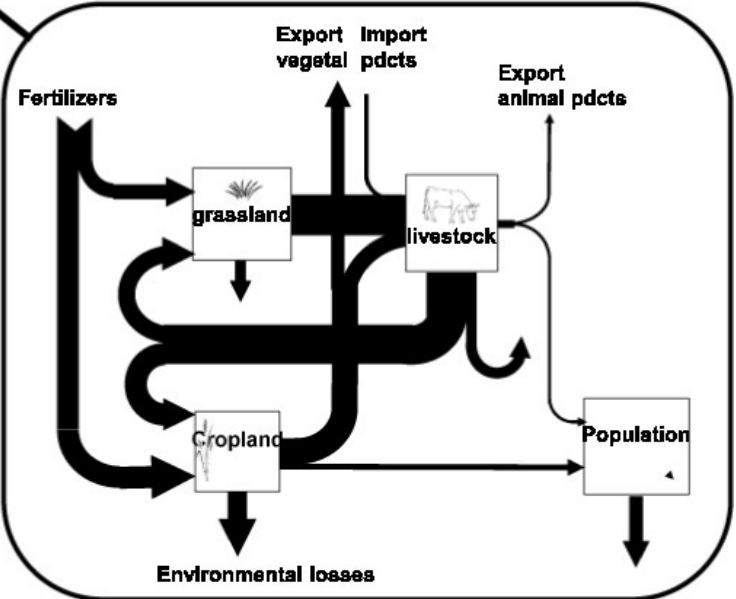
# Impact of coupling crop, pasture and livestock in the farms on nutrient cycling



**Specialized cropping systems**



**Specialized livestock systems**



**Extensive mixed crop-livestock systems**

Contents lists available at ScienceDirect

Science of the Total Environment

ELSEVIER

journal homepage: [www.elsevier.com/locate/scitotenv](http://www.elsevier.com/locate/scitotenv)

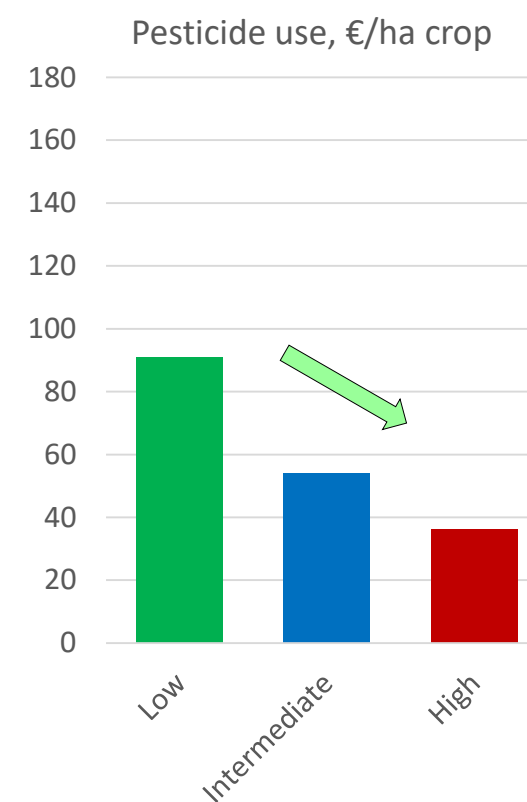
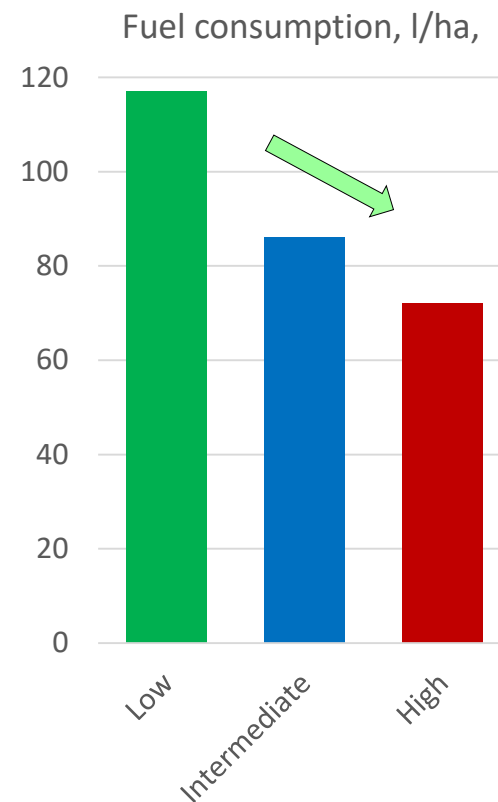
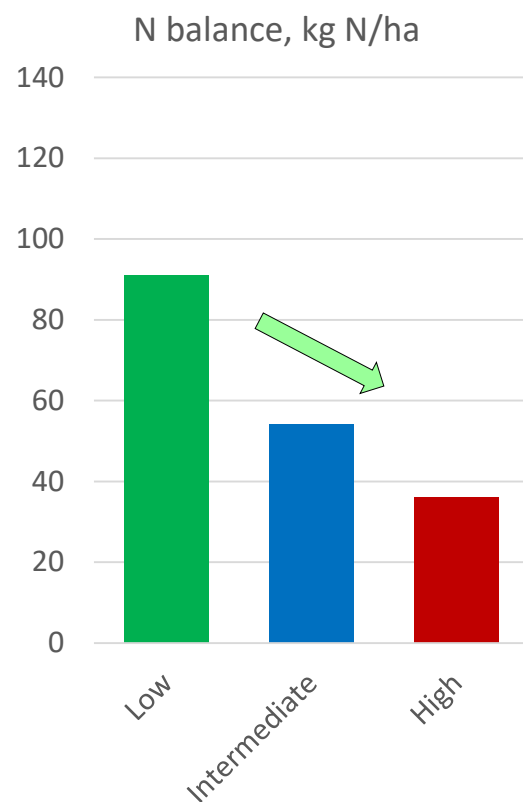
How the structure of agro-food systems shapes nitrogen, phosphorus, and carbon fluxes: The generalized representation of agro-food system applied at the regional scale in France

Julia Le Noë \*, Gilles Billen, Josette Garnier





# Coupling for better environmental impacts



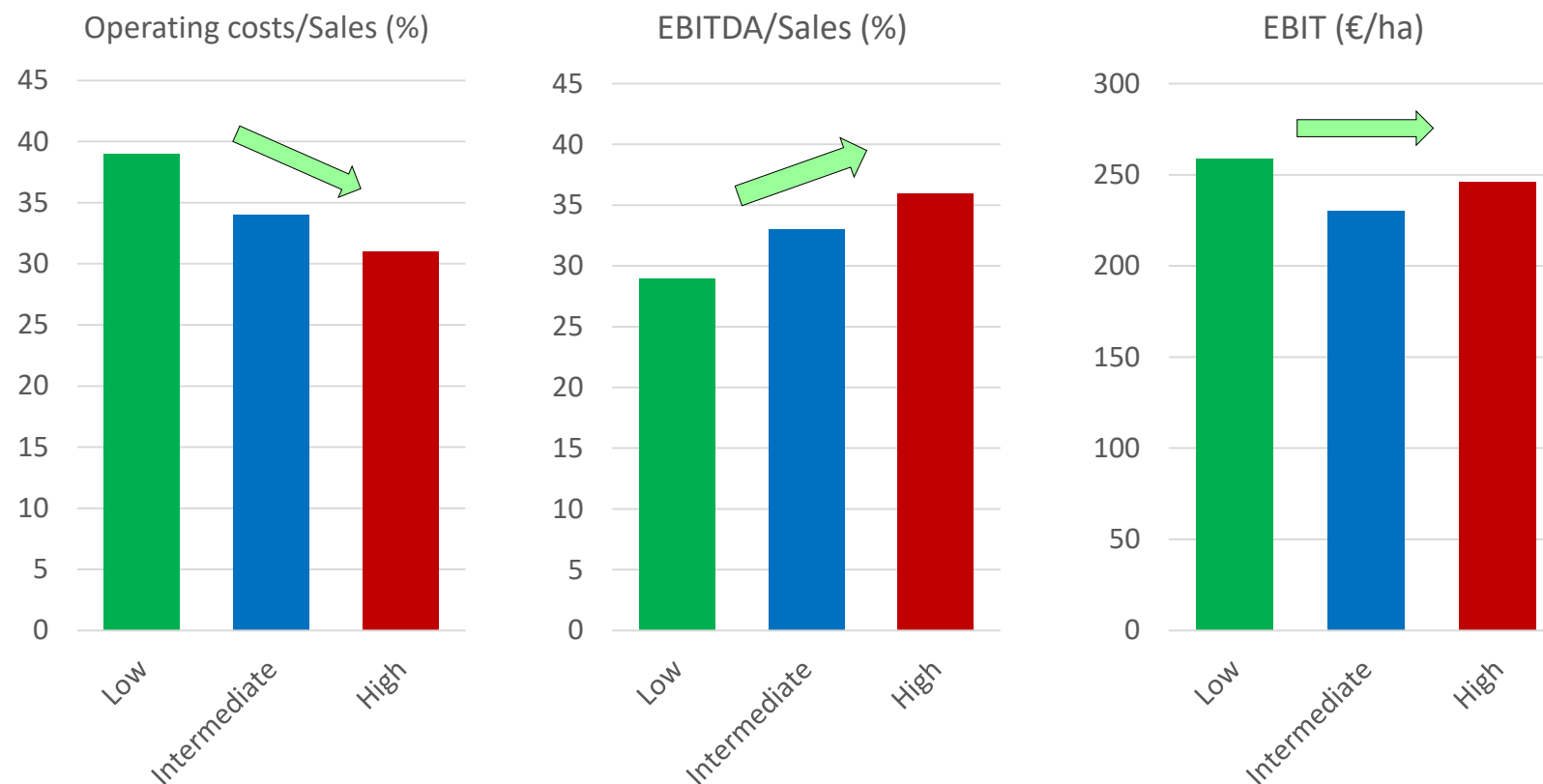
Integration among crop,  
pasture and livestock

Sample of 1190 French farms over 2011-2013

©Pierre Mischler, Institut de l'Élevage



# Coupling for better economic performances



Integration among crop,  
pasture and livestock

Sample of 1190 French farms over 2011-2013

©Pierre Mischler, Institut de l'Élevage



# Coupling at the farm level is not always possible

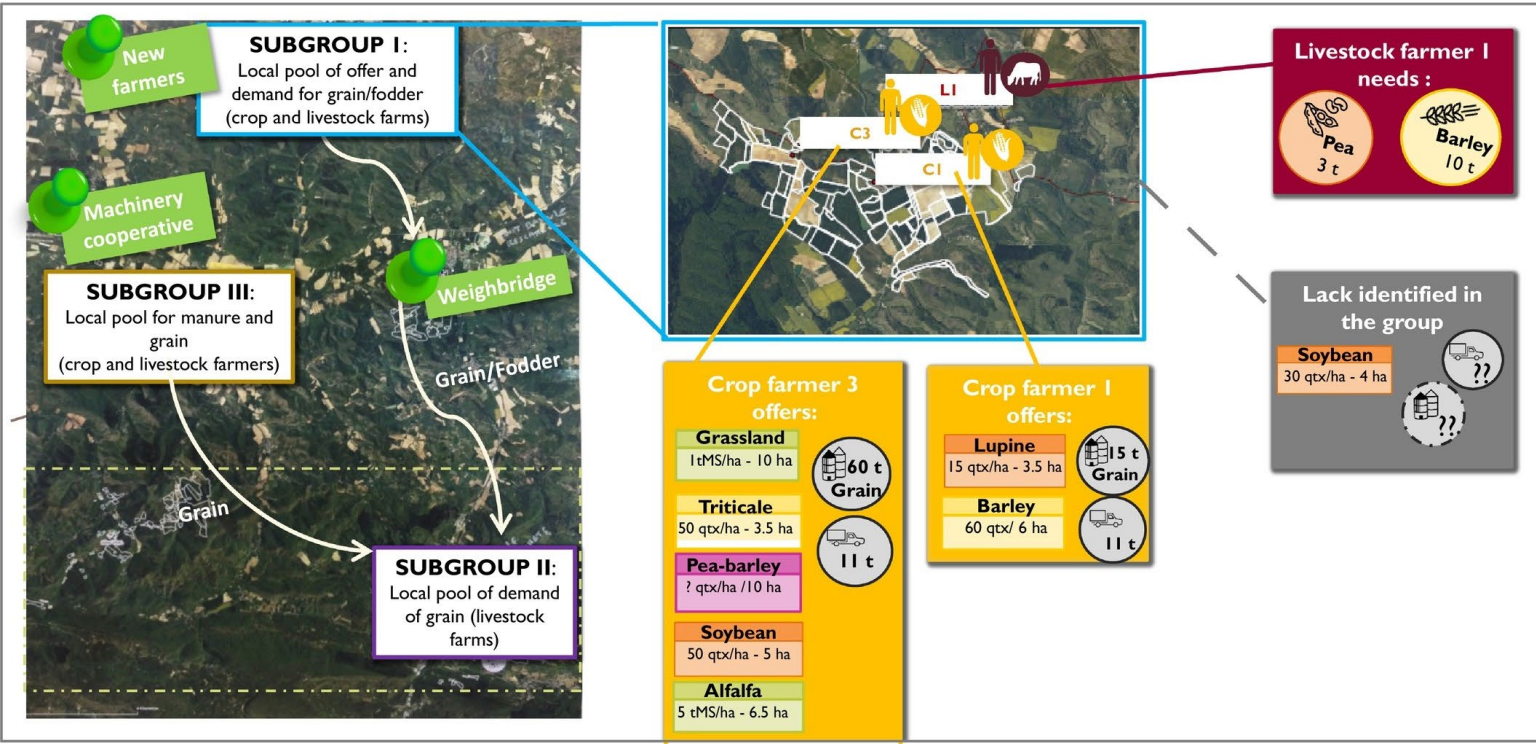
Lack and cost of infrastructures



Lack of knowledge and skills



# Towards coordination among farms?



- Multiple types of transaction costs for information gathering, collective decision-making, implementation and monitoring
- Reducing these costs remains a challenge
- A first set of factors identified e.g.
  - Coordination by third-party entities
  - Presence of social networks
  - Spatial proximity of farms

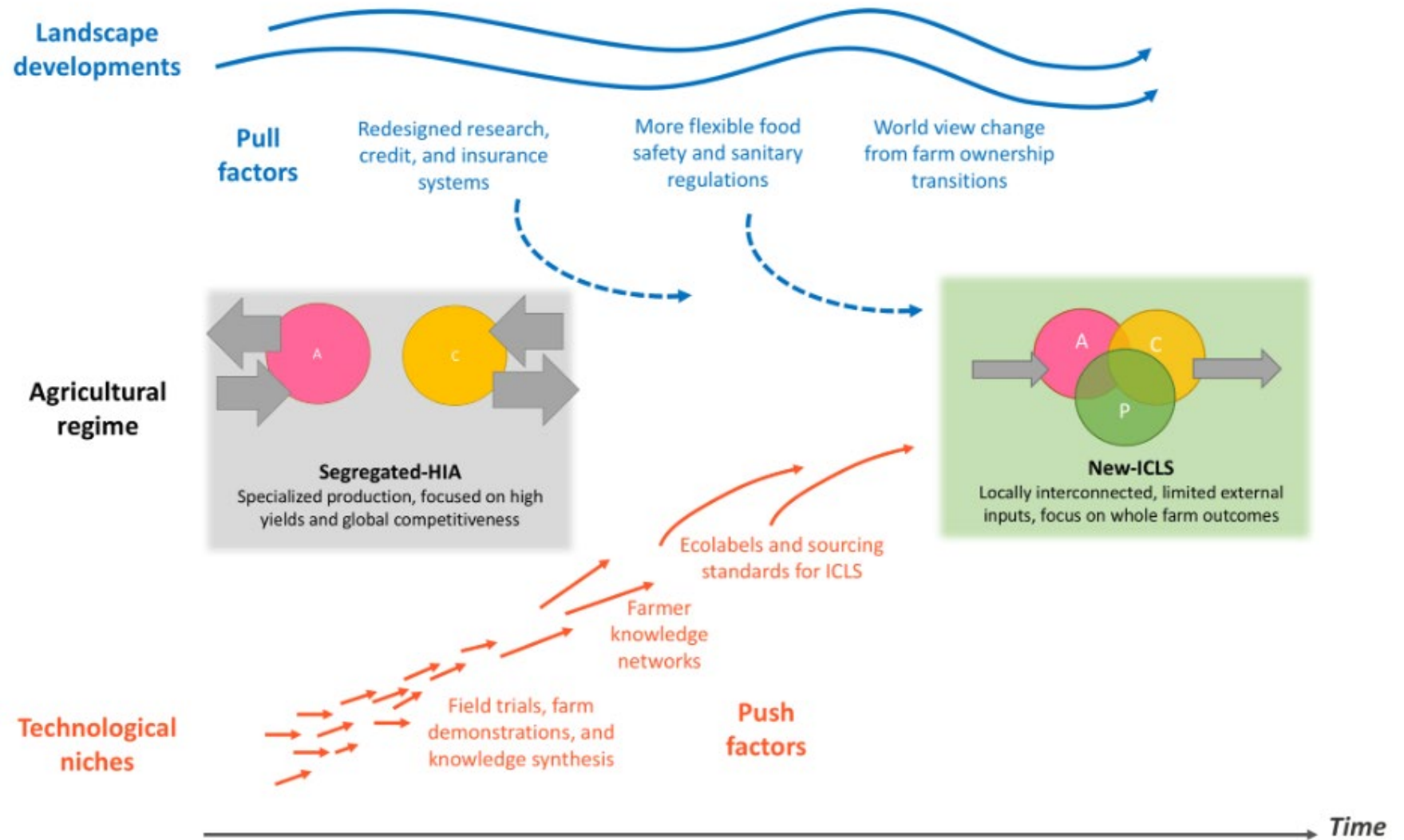
# Conclusions

Integrated crop-pasture-livestock farming is a response to today's crises

...But how to return to this historical, yet improved approach now that specialization has enormous momentum?



# Disrupting the agricultural regime for the reemergence of crop-pasture-livestock systems



Copyright © 2020 by the author(s). Published here under license by the Resilience Alliance.

Garrett, R. D., J. Ryschawy, L. W. Bell, O. Cortner, J. Ferreira, A. V. N. Garik, J. D. B. Gil, L. Klerkx, M. Moraine, C. A. Peterson, J. C. dos Reis, and J. F. Valentim. 2020. Drivers of decoupling and recoupling of crop and livestock systems at farm and territorial scales. *Ecology and Society* 25(1):24. <https://doi.org/10.5751/ES-11412-250124>

