ESAAF

European Science Alliance
for Agriculture and Food

Strengthening Climate Resilience in European Livestock Systems

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CSIC Office Brussels

The Science of Livestock and Climate Change

Functioning and performance of livestock systems: mitigation and adaptation

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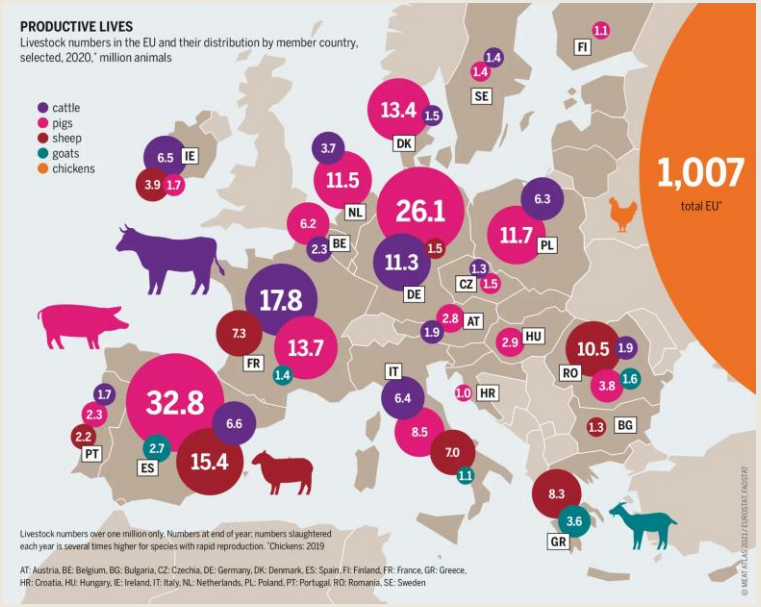
Climate change, a major challenge for livestock farming…

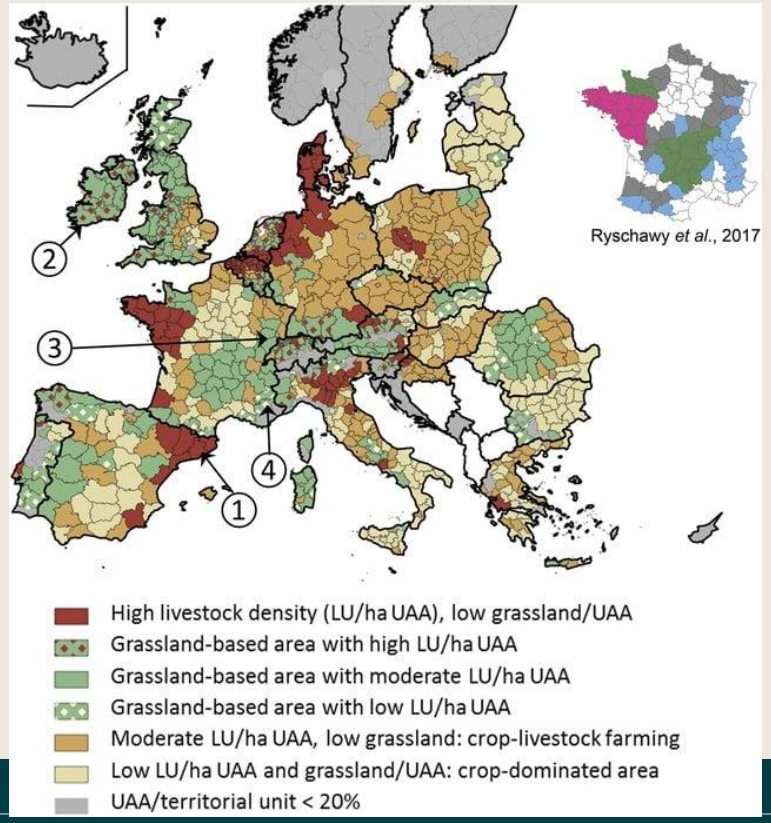
….that need science support

An important sector with a high diversity



Number of animals raised by European country
(Meat atlas, 2021)

Typology of European livestock production areas



based on Eurostat data 2010 at the NUTS3 (Nomenclature of Territorial Units for Statistics) level, or NUTS2 level for Germany, Belgium and the Netherlands
(reproduced from Hercule et al., 2017 and Dumont et al., 2017)

Livestock farming:

- A provider of **goods and services at different scales**
  - (Herrero et al., 2013; Dumont et al., 2019,
  - see also in particular *Beudou, 2017, Lauvie et al. 2018)*
- A key activity for **food sovereignty** *(Anderson et al., 2022)*

➔ A source of numerous **positive benefits**

➔ Facing climate change, livestock farming need support from science to

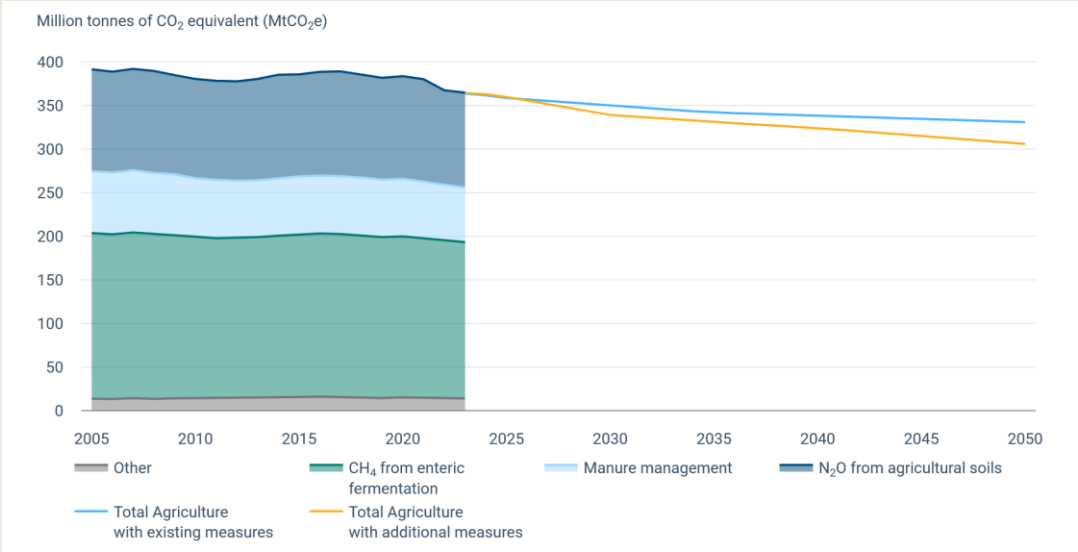
- **Evaluate its impacts**
- **Decrease its emissions**
- **Help it to adapt**

Contribution from livestock to the GHG emissions in Europe

- Livestock plays a significant role in the GHG emissions of agriculture. Half of them are enteric methane
- In Europe, agriculture is 10,8% of the total emissions estimated in CO2 equivalent in 2022 *(European Environment Agency)*
- In 2024, EU 27 is 5.95% of the total GHG of the world *(data from EDGAR report, 2025),* in a constant diminution from the 1990's

➔ A principle of accountability

EU agricultural emissions by source and projected emissions
(European environment agency)



Strengthen mitigation from livestock farming, drawing on research aimed at:

- **Evaluate the impacts of livestock farming on environment and especially on GHG**
  With multicriteria analysis… like life cycle assessment *(e.g. Roberts et al., 2010, Clausen et al., 2024, Duval-Dachary et al., 2024)*
  - the Agribalyse® data base, a free reference since 2013 (INRAE-ADEME & coll.) used by *e.g. Boros et al., 2026*
  - EcoAlim, a dataset of environmental impacts of feed ingredients *(Wilfart et al., 2016)*

- **Analyze the different types of levers, especially to decrease the enteric CH4** *(Gondret et al., 2026)*
  - Analyze how the rumen functions in order to guide its management
  - Select (directly or indirectly) animals that emit less methane
  - Manage ruminant feeding to reduce methane production

- **Analyze and strengthen capacity regarding the role of livestock farming in mitigation**
  - Carbon storage in pasture (permanent and temporary) *(Sharrow and Ismail, 2004; Klump et al., 2011…)*
  - Anaerobic digestion
    - see for technical option, for example, *Gerber et al., 2013*;
    - this solution needs to be put in perspective *(Malet et al., 2023)*

Warning! Mitigation efforts imply intensification of production ***(Gondret et al., 2026)***
that may conflict with other objectives (animal welfare, conservation of biodiversity…)

Adaptation of livestock farming : a huge challenge

- **Climate change is now noticeable.**
  - ➔ Changes in water regime and in vegetation in terms of spatial and temporal patterns:
    ex: advance in phenology, variation of plant communities…
    Observation made in surveys *(Karandish, et al., 2026)* or in devices as Alpages Sentinelles (since 2000) *(Deleglise et al., 2022)*
  - ➔ Increase of heat stress for animals
    ex: for dairy ewes, in La Fage experimental farm in 2022 and 2023, during the days with a moderated stress (THI >72),
    - increasing water consumption (+50% comparing to days with no stress)
    - decreasing milk production (between 9 and 15% less than days with no stress)
  - ➔ Emergence and Progression of Animal Infectious Diseases *(Lindgren et al., 2012; Semenza and Paz, 2021)*

- **Adaptation is ongoing, but diversely**
  - ➔ Adjustments for technical procedures, implying especially feed practices (and not often animals)
    ex: in lots of regions, hay harvesting must be brought forward *(Baumont and Maxin., 2026)*
  - ➔ Levers chosen for maintaining the level of production (most often) : purchase of feed…
  - ➔ Adaptation made differently depending on the stage of the farmers' career
    ex: an evidence for new farmers, not necessary for some farmers nearing retirement *(Allart et al., 2024; Loiodice, 2024)*
  - ➔ The type of levers differs depending on farm's location *(Allart et al., 2024; c)*
    ex: Natural resources, structuring in Mediterranean and mountain areas, crops and temporary pasture for lowland areas

Research is working for…

❖ Understanding what might happen

- With a projection of agro-climatic criteria at the global level, but also at the territorial level.
- In modelling the potential evolutions of feed resources *(see for example, in dairy cattle (Karandish et al., 2026))*
  And their consequences for production *(see for example, in pig (Renaudeau and Dourmad, 2022))*
- In understanding the effects of heat stress on animals performances (reproduction, level of production…)
  (Thornton et al., 2022; Vinet et al., 2024)

❖ Identifying / designing / co-designing different levers or ways to adapt

- **For feeding animals** *(Tracy et al., 2018)*

Ex: Modifying type of feed resources, grazing practices (with moderate defoliation, for example), but also mowing practices
Paying more attention to maintain and improve soil fertility

- **At the animal level** *(Cartwright et al., 2023)*
  With genetic selection (strategies for selecting animals with more thermotolerance, less sensitive to diseases…)
- **At the farm level**
  With a step-by step design in experimental farms … *(Coquil et al., 2014; Puech and Stark, 2023*
  By model-assisted co-designing *(Meynard et al., 2012; Sabatier et al., 2026)*
- **At the territorial level**
  by enhancing cooperation between farms and enhancing circularity *(Lurette et al., 2020; Stark et al., 2026)*

Warning! Adaptation and mitigation levers can be in opposition => A need of trade-offs

❖ Rethinking performances metrics *(Meuwissen et al., 2022; Magne et al., 2024; Prat-Benhamou et al., 2025)*

- Broaden the range of performance type to include resilience, autonomy as key performance factors
- Evaluate differently: using average, but also variance, and over a multi-year period

Coping with, and enhancing, diversity at different levels

- **A variety of regions facing different challenges under climatic change**

- **A variety of livestock production systems, in terms of**
  - their role/function in agroecological transition / sustainability
  - their adaptive capacity
  - their mitigation capacity

- **Several forms of livestock farming systems more adaptive AND more sustainable**

  Ex: agropastoral systems and diversified systems, *(Dedieu et al., 2025; Puech and Stark, 2023)*

  with a high adaptive capacity, developing
  - Sub-optimum performances and trade-offs for multifunctionality
  - Adaptive management
  - Buffering capacities
  - Diversity (of resources, of animals, of products)… and at territorial level

  but Climate Change also enhance their vulnerability

- **Other parts of the world, with more climatic hazards show the importance of**
  - Diversification *(Kiani et al., 2021)*
  - Autonomy and “ground contact” / link to the territorial resources and their sustainable management

  And the interaction between climate crisis and economic crisis *(e.g. Diaz-Solis et al., 2009)*

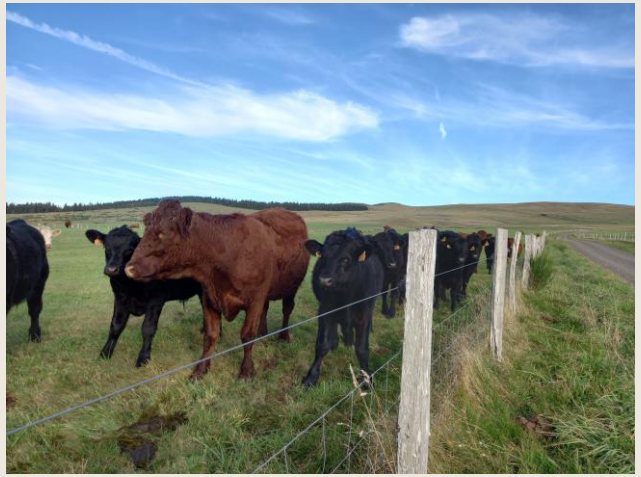
Under climate change, a systemic crisis, complexifying policies?

- Transformability of livestock farming for sustainable development is a main, difficult challenge alongside adaptability and robustness

- Currently, **adaptation AND mitigation** are structuring by **markets and downstream operators**
- **Policies** are fundamental at three levels: **European, national and territorial**
- **Extension services** but also the **agricultural education** could be ways to empower those transformations

  ➔ **Warning: the sociotechnical system could act as a lock-in**

- A need to support
  - **Together** mitigation AND adaptation issues -> **trade-offs**
  - **Innovations** (technical and organizational) **at the interface** between farms and downstream sectors
  - **Buffering capacity** in livestock farming systems
  - **Diversity of types of systems** and specificity of each territory
  - **Adaptive management** of livestock farming



Thanks for your attention

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