

From concept to measurement: Advancing resilience analysis in small ruminant farming systems

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The 77th EAAP Annual Meeting

Session. “European resilient livestock farming systems in a
continuously changing world”

CENTRO DE INVESTIGACIÓN Y TECNOLOGÍA
AGROALIMENTARIA DE ARAGÓN

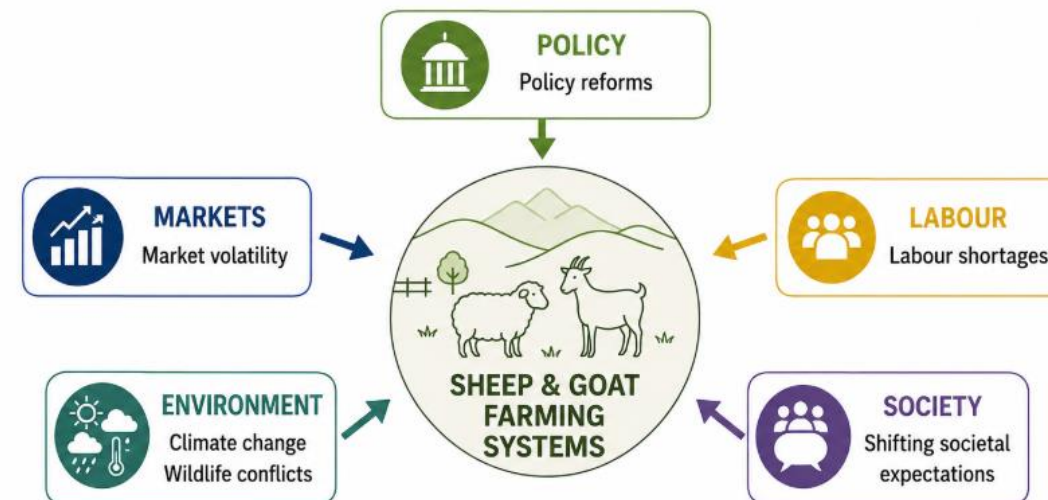
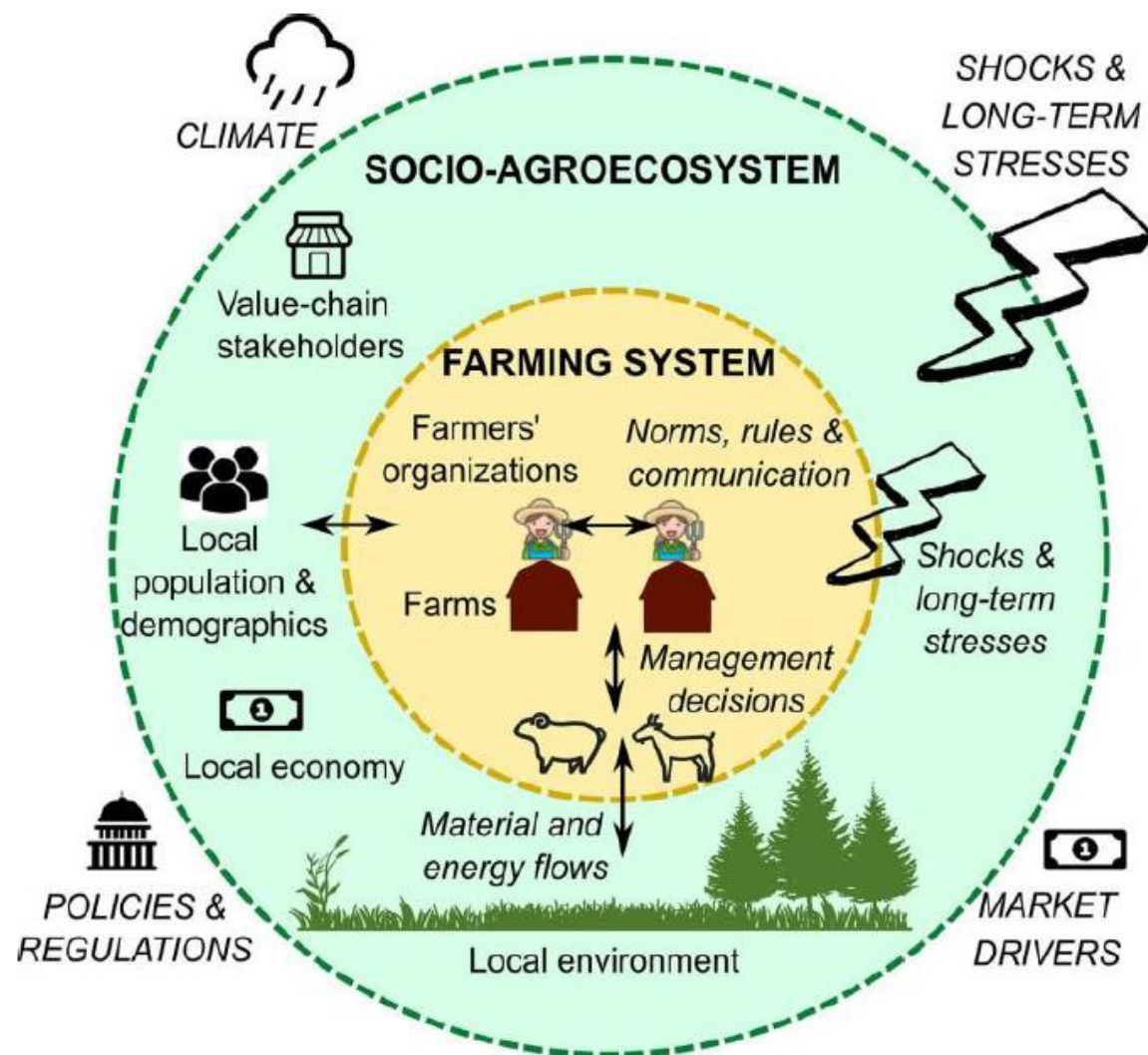


Talk index



- 1) Small Ruminant Farming Systems as socioecological systems in decline
- 2) Resilience conceptualization
- 3) Resilience quantification and analysis; examples of frameworks and studies
- 4) Take-home messages

Farming systems; a socioecological systems



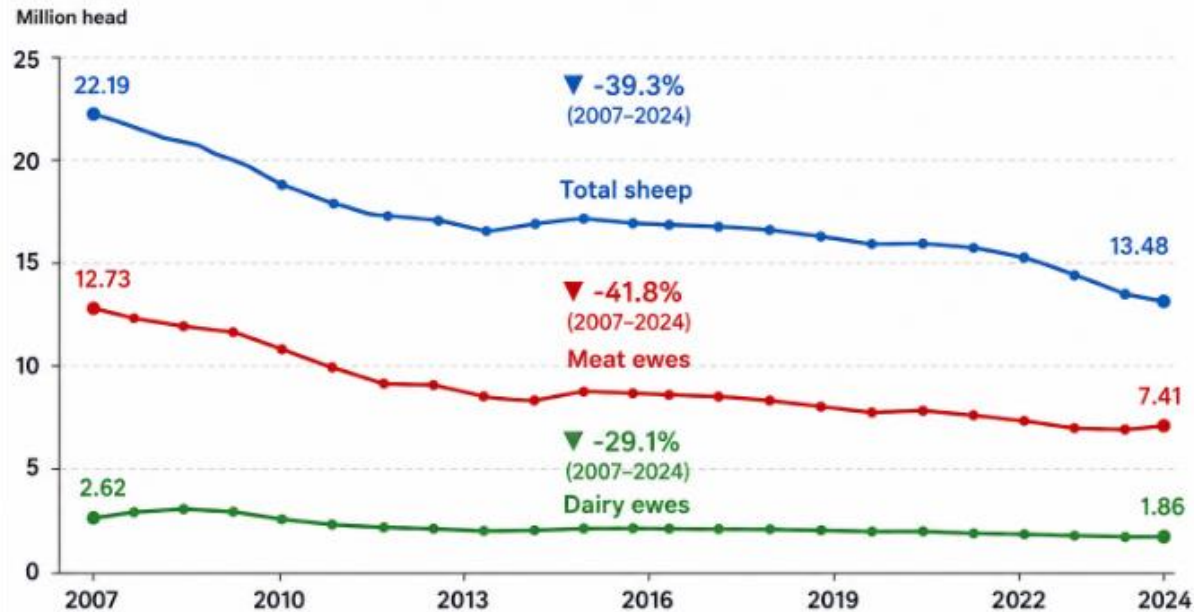
Accelerating and overlapping pressures are **reshaping the conditions for farm viability**.



The case of Spain; a long-term crisis

SHEEP POPULATION IN SPAIN

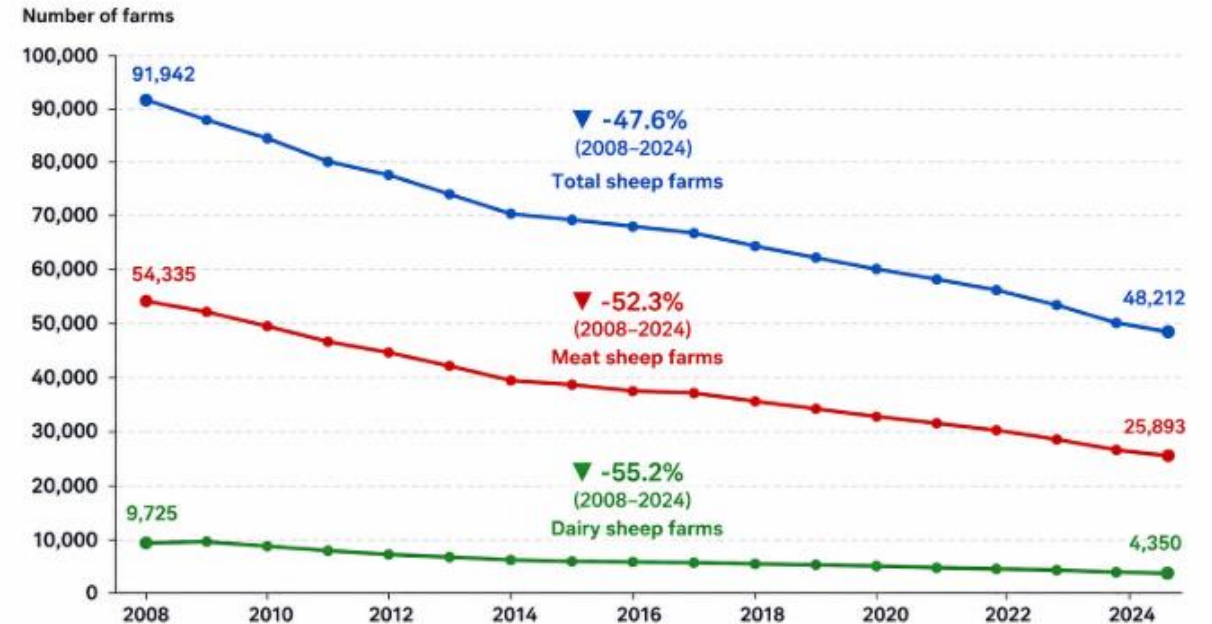
Total sheep, meat ewes and dairy ewes (2007–2024)



Source: MAPA (Ministerio de Agricultura, Pesca y Alimentación). Encuestas Ganaderas.
Latest data: 2024 (provisional).

SHEEP FARMS IN SPAIN

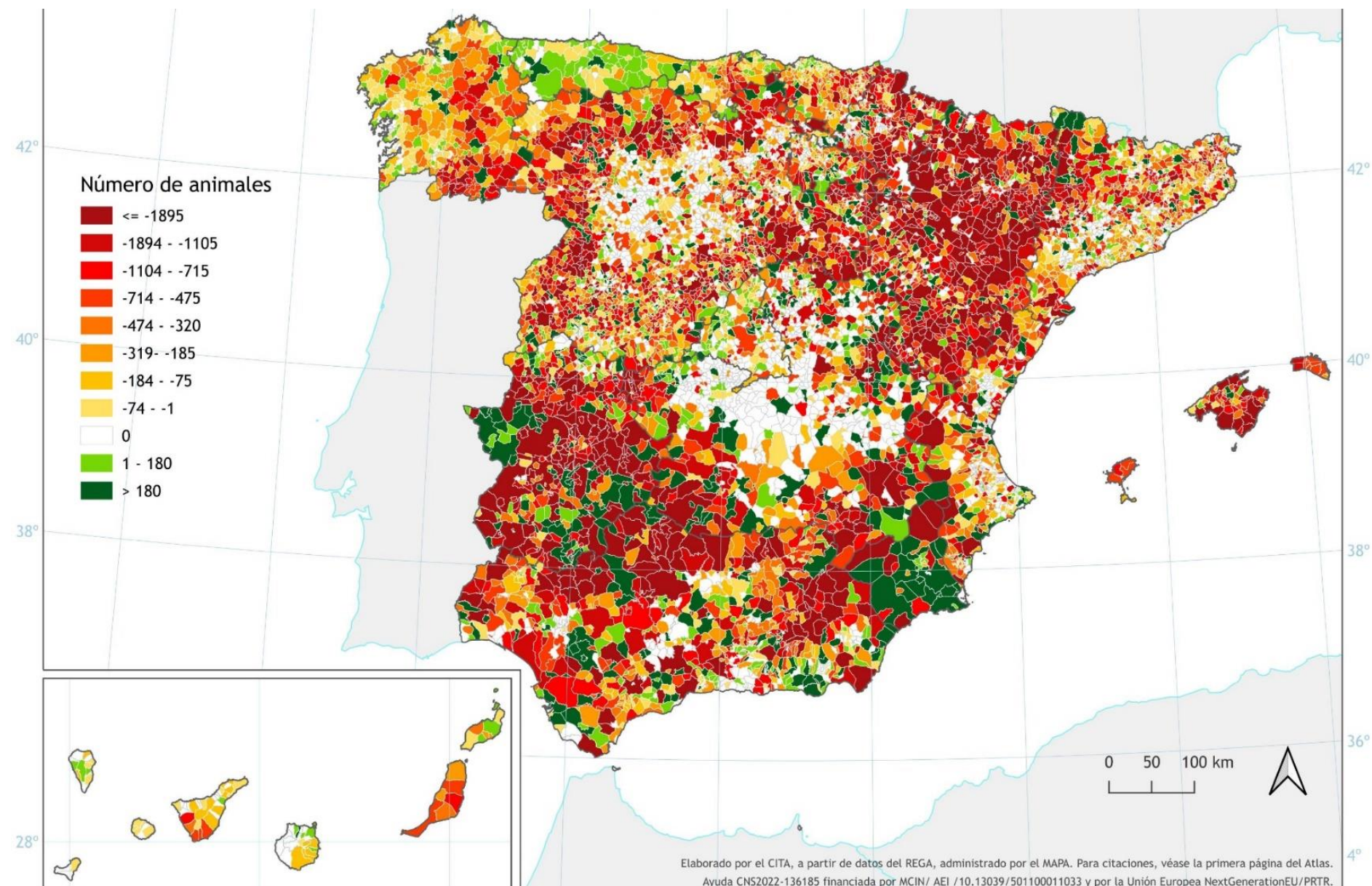
Total sheep farms, meat sheep farms and dairy sheep farms (2008–2024)



Source: MAPA (Ministerio de Agricultura, Pesca y Alimentación). SITRAN (Registro General de Explotaciones Ganaderas).
Latest data: 2024 (provisional).

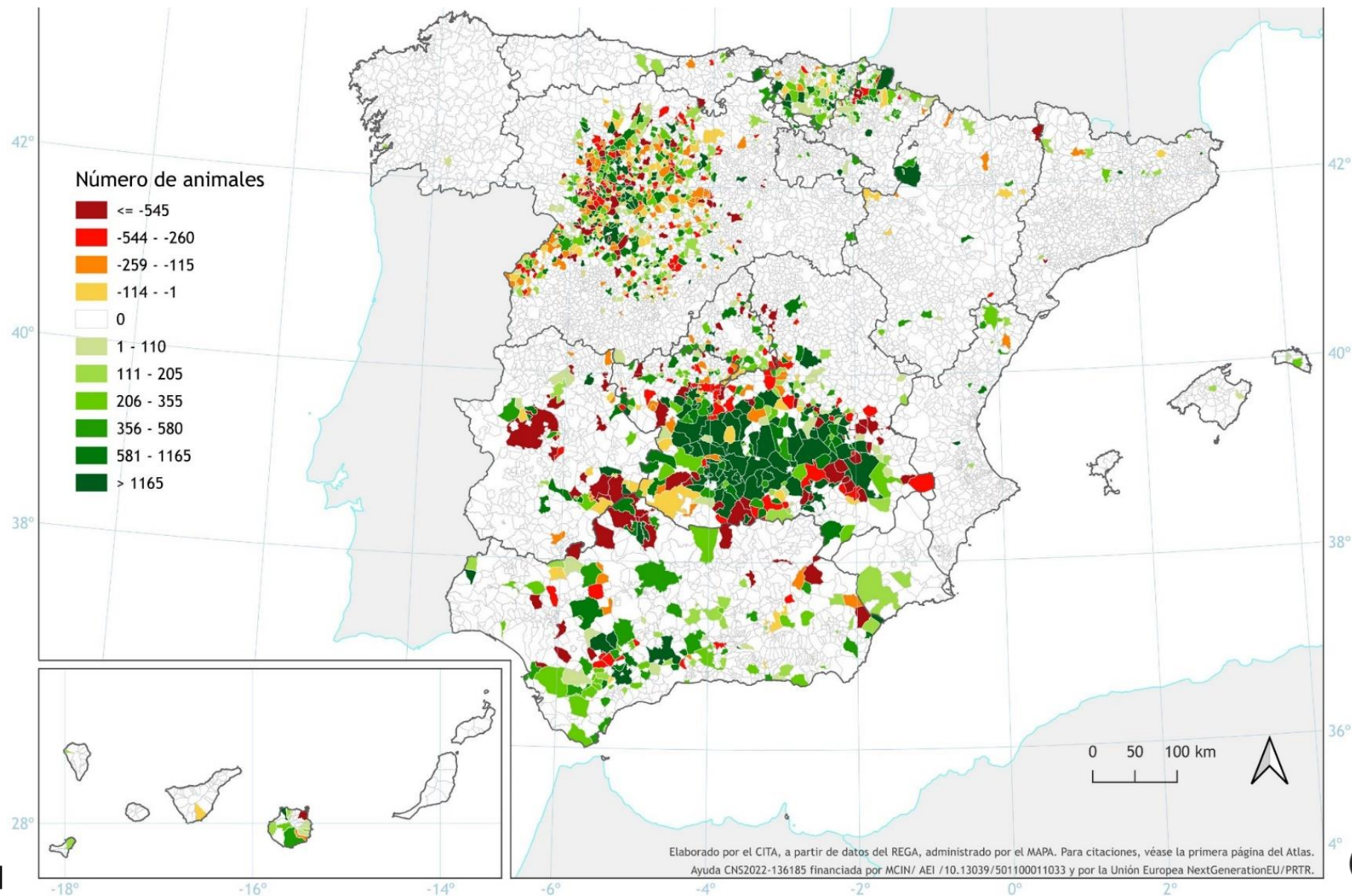


Evolution of the municipal meat sheep population (2007–2021)





Evolution of the municipal dairy sheep population (2007–2021)





Resilience at the centre of policy agendas



Strengthening resilience is at the heart of
national and international policy agendas...
such as the CAP

**REGULATION (EU) 2021/2115 OF THE EUROPEAN
PARLIAMENT AND OF THE COUNCIL**

of 2 December 2021

**establishing rules on support for strategic plans to be drawn up by
Member States under the common agricultural policy (CAP
Strategic Plans) and financed by the European Agricultural
Guarantee Fund (EAGF) and by the European Agricultural Fund
for Rural Development (EAFRD) and repealing Regulations (EU)
No 1305/2013 and (EU) No 1307/2013**

Article 5

General objectives

- (a) to foster a smart, competitive, **resilient** and diversified agricultural sector ensuring long-term food security;

Article 6

Specific objectives

1. The achievement of the general objectives shall be pursued through the following specific objectives:

- (a) to support viable farm income and **resilience** of the agricultural sector across the Union in order to enhance long-term food security and agricultural diversity as well as to ensure the economic sustainability of agricultural production in the Union;



Resilience at the centre of the Academy



Google Académico

resilience

Artículos

Aproximadamente 6.890.000 resultados (0,15 s)

Cualquier momento

Desde 2026

Desde 2025

Desde 2022

Intervalo
específico...

Ordenar por
relevancia

Ordenar por fecha

What is **resilience**?

[H Herrman](#), [DE Stewart](#)... - The Canadian ..., 2011 - journals.sagepub.com

... growing study of **resilience**. Our paper reviews the definitions of **resilience** and the range of ... 2010 to identify key papers considering the definitions of **resilience** and related concepts. ...

☆ Guardar Citar Citado por 2800 Artículos relacionados Las 10 versiones

Understanding **resilience**

[G Wu](#), [A Feder](#), [H Cohen](#), [JJ Kim](#), [S Calderon](#)... - Frontiers in behavioral ..., 2013 - frontiersin.org

... in mediating **resilience** are also discussed. The growing understanding of **resilience** factors will ... interventions for enhancing **resilience** and mitigating the untoward consequences. ...

☆ Guardar Citar Citado por 1448 Artículos relacionados Las 19 versiones



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sustainability

Artículos

Aproximadamente 5.530.000 resultados (0,06 s)



A brief history of the evolution of “resilience” concept

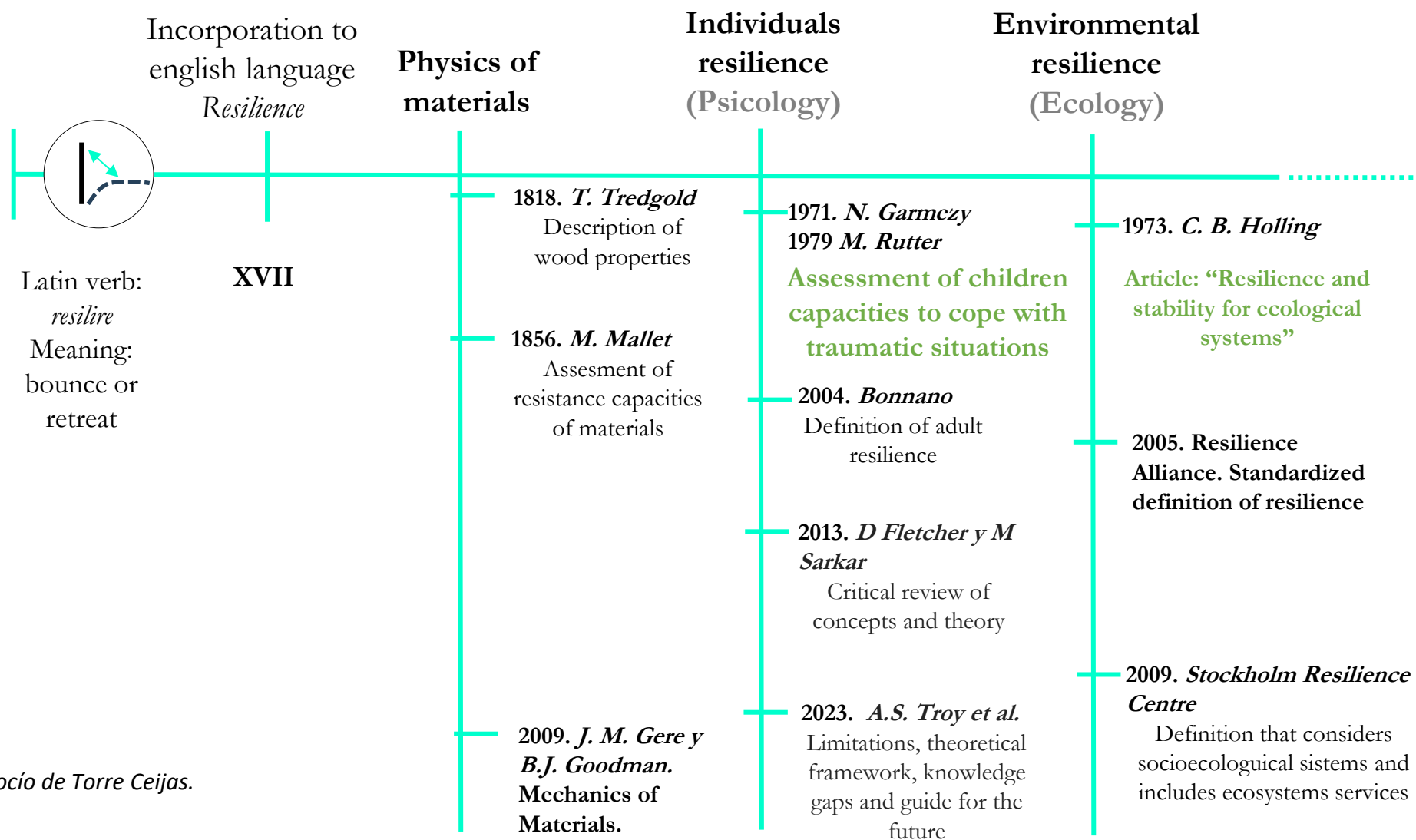


Figure made by Rocío de Torre Ceijas.

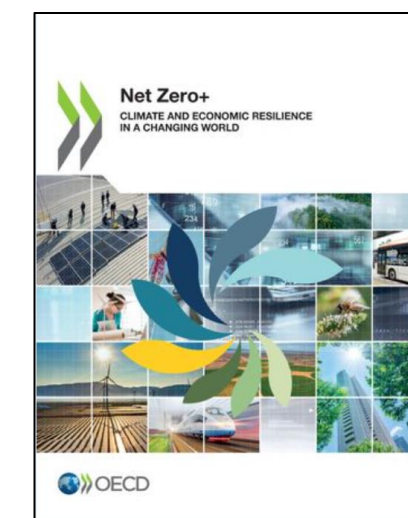
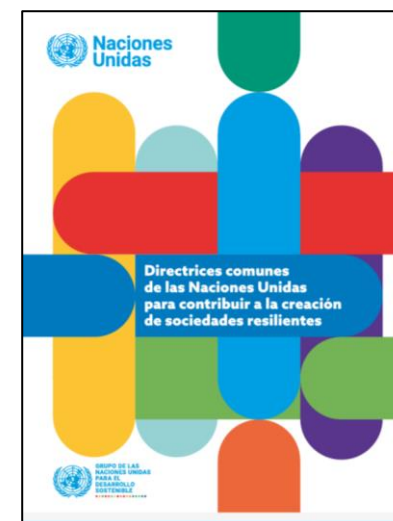
A brief history of the evolution of “resilience” concept

Community resilience (Sociology)	Organizations resilience (Economy and business)	Resilience in Policy (Policy strategies and programmes)
-------------------------------------	--	--

90's
Models of sustainable livelihoods

1990. *Tobin*
2000. *Adger*
Sociology and human geography.

2003. Hamel y Välikangas
The Quest for Resilience
Successful organizations evolve as resilient ecosystems to adapt to external changes

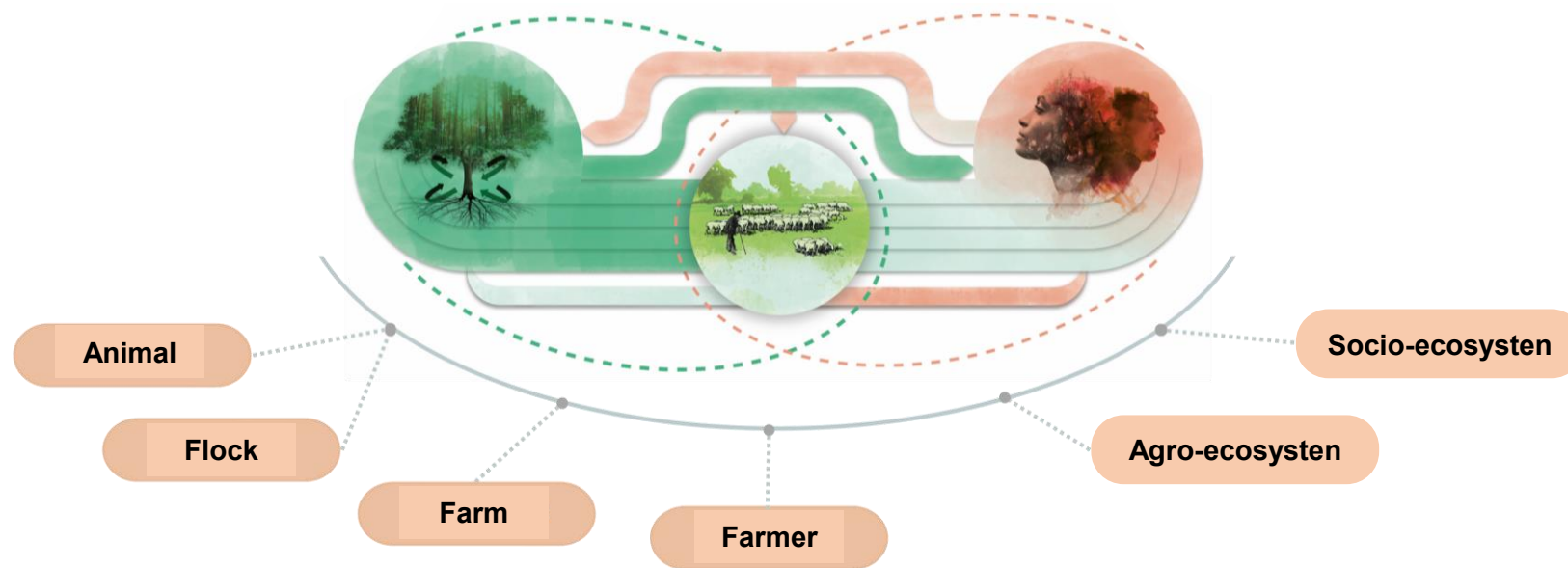




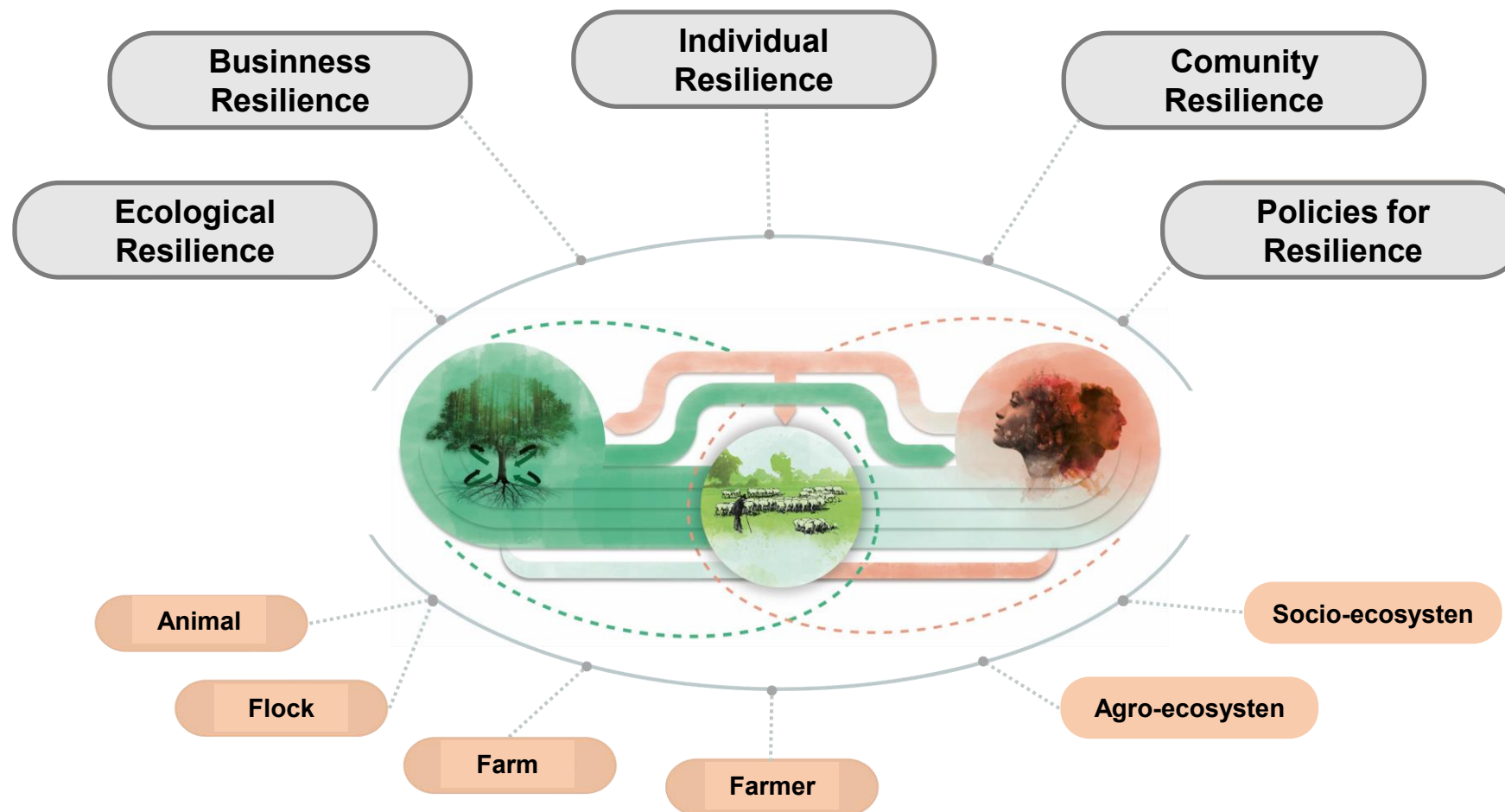
Key resilience concepts

- **Different approaches/definitions** with common features:
 - Responding to events and disturbances of different kinds
 - Positive response and capacity to absorb and recover
- **Continuous change and dynamism**
- **Uncertainty**
 - We do not know where we are heading

Resilience concept in farming systems



Resilience concept in livestock farming systems



Challenges for resilience analysis

- Resilience is (almost always) **latent** property
- **Measuring** resilience is key for practical aspects
- ¿How do we **approach it**?
 - ¿Assesment of characteristic to predict future events?
 - ¿Objective indicators?
 - ¿Subjective indicators?
 - ¿Participative approaches?
- ¿How far we **simplify**?
- Analitical **framework** depends of the objectives and data available



The five “what” questions to frame the analysis of resilience





Our approach to the study of small ruminant systems



<https://socialecologicalagrolab.com/>

- Strong “farming systems” perspective
- Farmers and sector stakeholder at the centre
- Multi/inter disciplinary and participative research
- Case studies
- Resilience Alliance SES framework

An approach to the study of resilience of a system

“Capacity to ensure the delivery of **system functions** in the face of increasingly complex and **cumulative economic, social, environmental and institutional shocks and stresses**, through capacities for **robustness, adaptability and transformability**” *Meuwissen et al., 2019*



Farm as the analitical unit

Analysing the **present** time

Measure the features that relate to resilience (indicators):

- Subjective
- Objective
- ...



Looking at the **past**

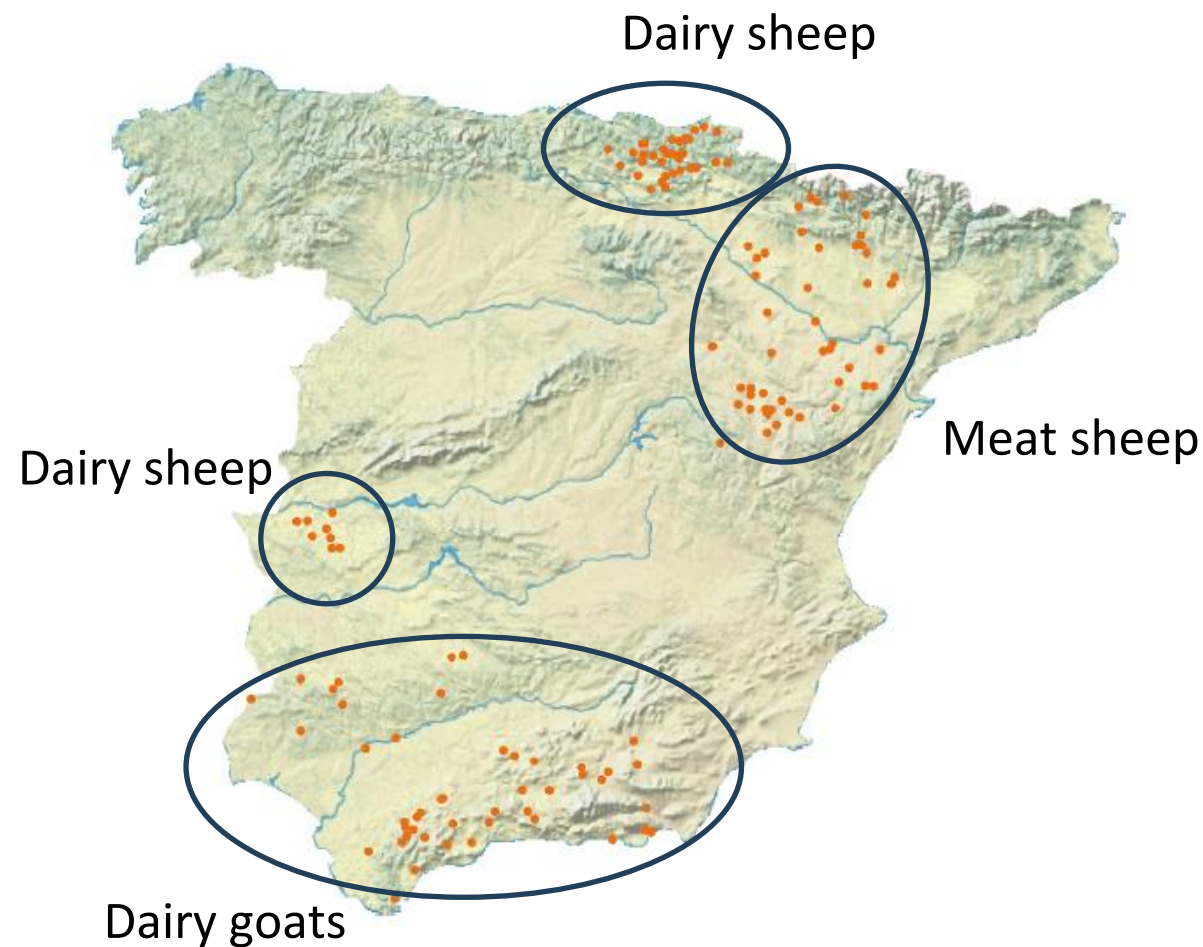
Analyse the behaviour of a system:

- Economics
- Social
- Production
- ...



Material and methods

- **Face-to-face surveys** to 160 farmers in four case areas
- **Interviews**
- **Workshops** in case study areas
- Technical-economic (public) **databases**
- **Farm resilience assessment:** Structural Equations Modelling, composite indexes development, dynamic modelling and econometric analysis



Bringing theoretical frameworks down to farms: Attributes, principles and capacities

How do farm and farmer attributes explain perceived resilience?

Alicia Prat-Benhamou ^{a,b,*}, Alberto Bernués ^{a,b}, Paula Gaspar ^c, Joseba Lizarralde ^d, Juan Manuel Mancilla-Leytón ^{e,f}, Nerea Mandaluniz ^d, Yolanda Mena ^g, Bárbara Soriano ^h, Daniel Ondé ⁱ, Daniel Martín-Collado ^{a,b}

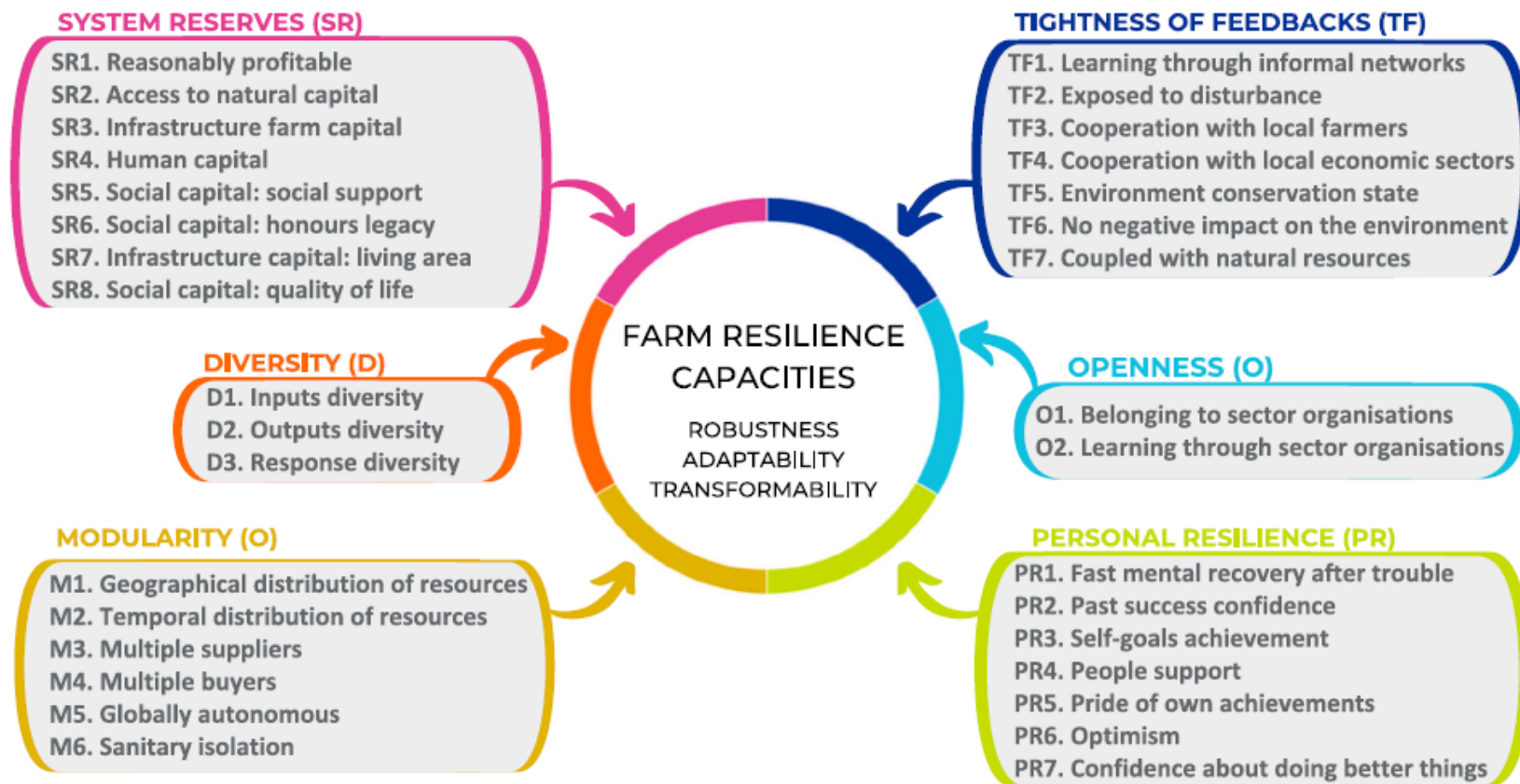


Fig. 2. Graphical representation of the conceptual framework. Resilience principles are System reserves (SR), Diversity (D), Modularity (M), Openness (O), Tightness of feedbacks (TF) and Personal resilience (PR). The attributes classified in each principle are coded with the principle's abbreviation and a serial number in grey boxes. Attributes are assigned to each principle based on Paas et al. (2021a), Darnhofer (2021) and the authors' expertise.

How do farm and farmer attributes explain perceived resilience?

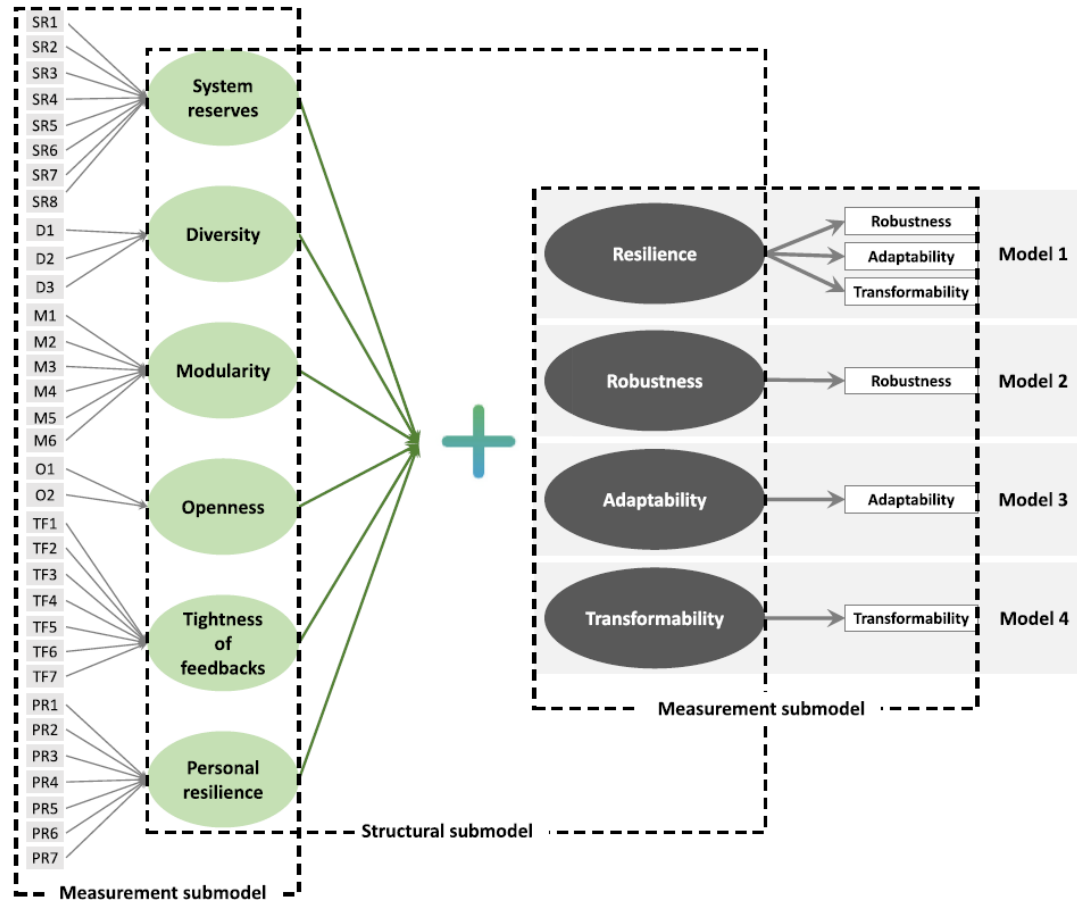
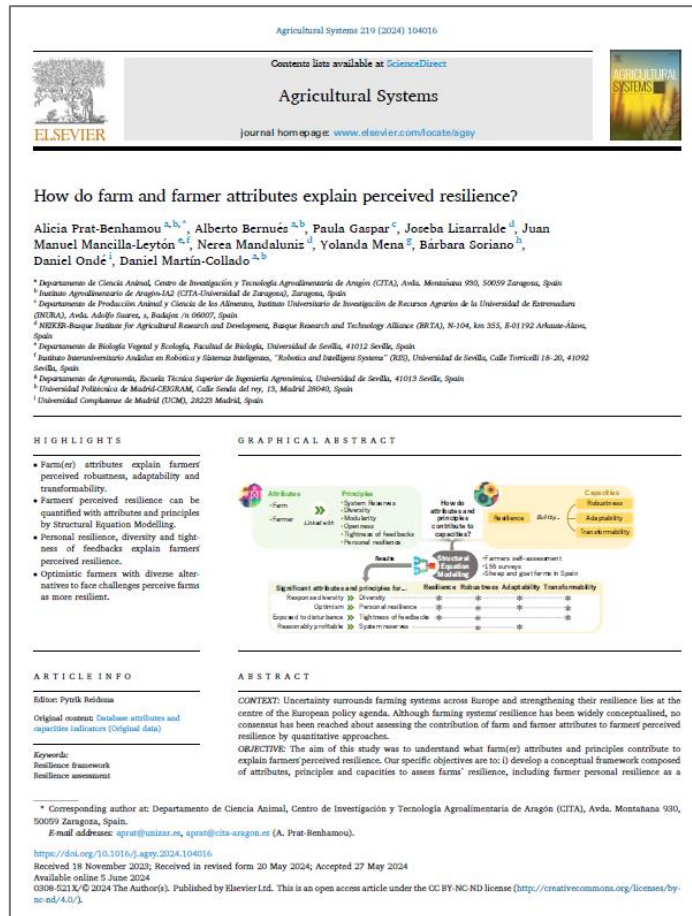


Fig. 1. Rationale of the theoretical framework.

Subjective indicators using Liker scale questions: e.g.
 “My farm is profitable enough to earn a living”,
 “My farm has multiple resource suppliers”
 “My work as a farmer allows me good quality of life”

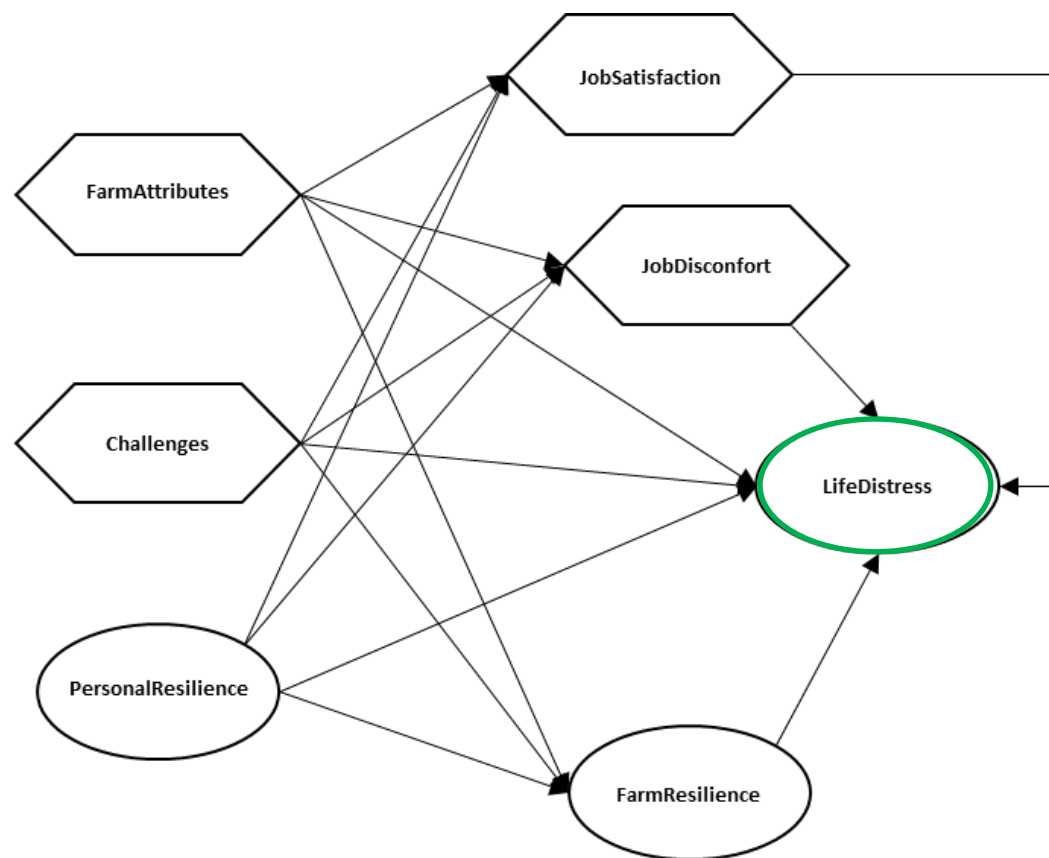
How do farm and farmer attributes explain perceived resilience?



- Results**
- Structural Equation Modelling**
- Farmers self-assessment
 - 156 surveys
 - Sheep and goat farms in Spain
- | Significant attributes and principles for... | Resilience | Robustness | Adaptability | Transformability |
|--|------------|------------|--------------|------------------|
| Response diversity >> Diversity | * | * | * | * |
| Optimism >> Personal resilience | * | * | * | * |
| Exposed to disturbance >> Tightness of feedbacks | * | * | * | * |
| Reasonably profitable >> System reserves | | * | * | |
- Resilience is influenced not only by farm assets, but also by farmers' personal capacities and experiences: personal resilience, diversity and tightness of feedbacks are the main principles
 - Our study also highlights the importance of farm profitability, social support and access to infrastructure in the areas where farmers live.
 - Access to natural capital and product diversity have a negative effect on perceived adaptive capacity; the complexity of farm management and product diversification could make farmers less adaptable to changing conditions.



Expanding the study of resilience in socio-ecological systems: the role of farmer psychological (personal) resilience in livestock farms



Job Satisfaction Statements

I am proud of my work as a livestock farmer.

I feel fulfilled as a livestock farmer.

My work as a livestock farmer makes me feel important.

Job Discomfort Statements

The type of work I do as a livestock farmer frustrates me.

The daily workload I should be doing as a livestock farmer is always more than I can handle.

I didn't achieve the goals I set for myself when I started as a livestock farmer.

Life distress statements

Little interest or little pleasure in doing things

Tired or low on energy

Lack of appetite or excessive appetite

Feeling bad about yourself

With a feeling of nervousness, anxiety, or being on edge

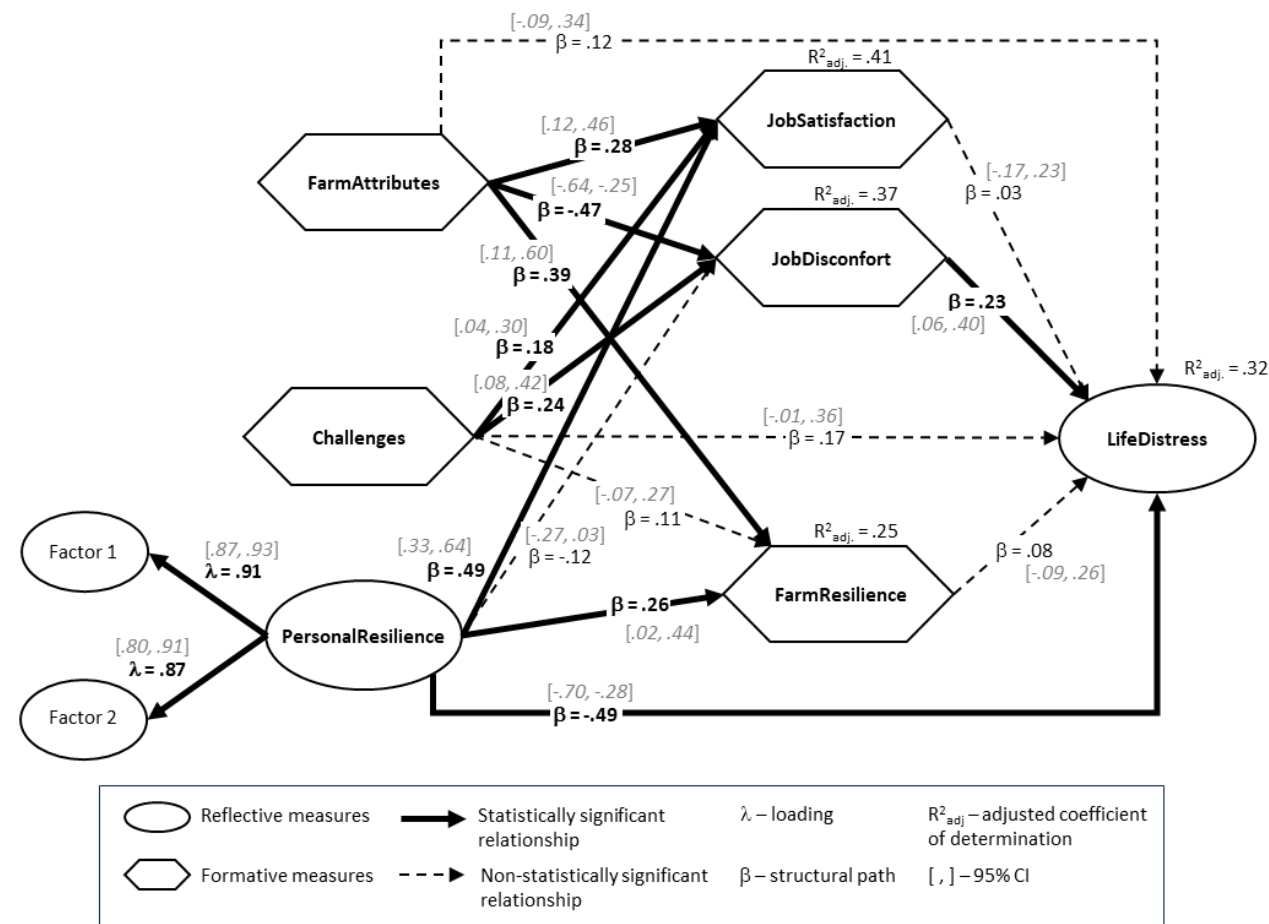
With excessive worry about different things or situations

Easily angered, irritable

With fear, as if something bad might happen

Submitted to

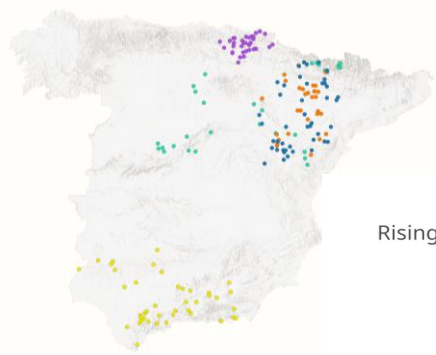
Expanding the study of resilience in socio-ecological systems: the role of farmer psychological (personal) resilience in livestock farms



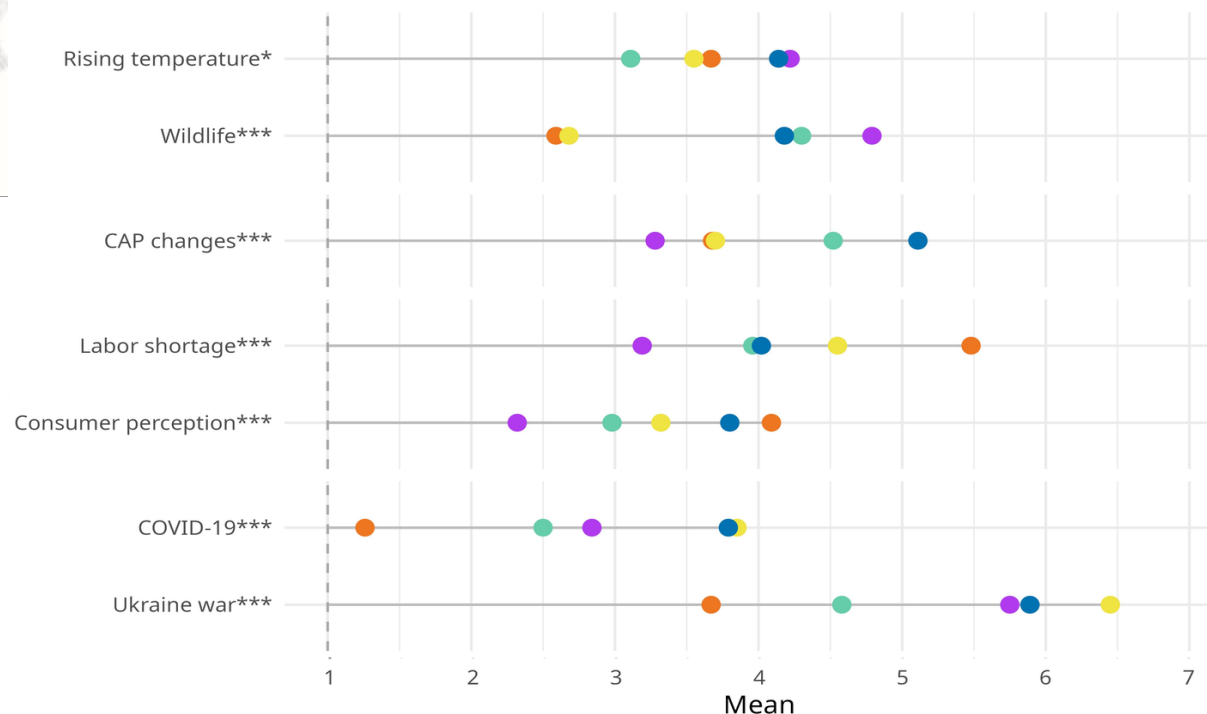
- Among the three primary variables analyzed, only personal resilience showed a statistical direct effect on life distress.
- External challenges and suboptimal farm attributes increase job-related stress (job discomfort), which subsequently impact life distress.
- No direct association was found between farm resilience and life distress, farm's capacity to cope with adversity does not necessarily influence the level of perceived life distress.



A comparative analysis of resilience of livestock systems at different levels of intensification



241 farms



● Pig ● Dairy goat ● Dairy sheep ● Meat sheep ● Beef cattle



Wildlife: higher in extensive
lowest in dairy goat



CAP reform: most critical for
meat sheep

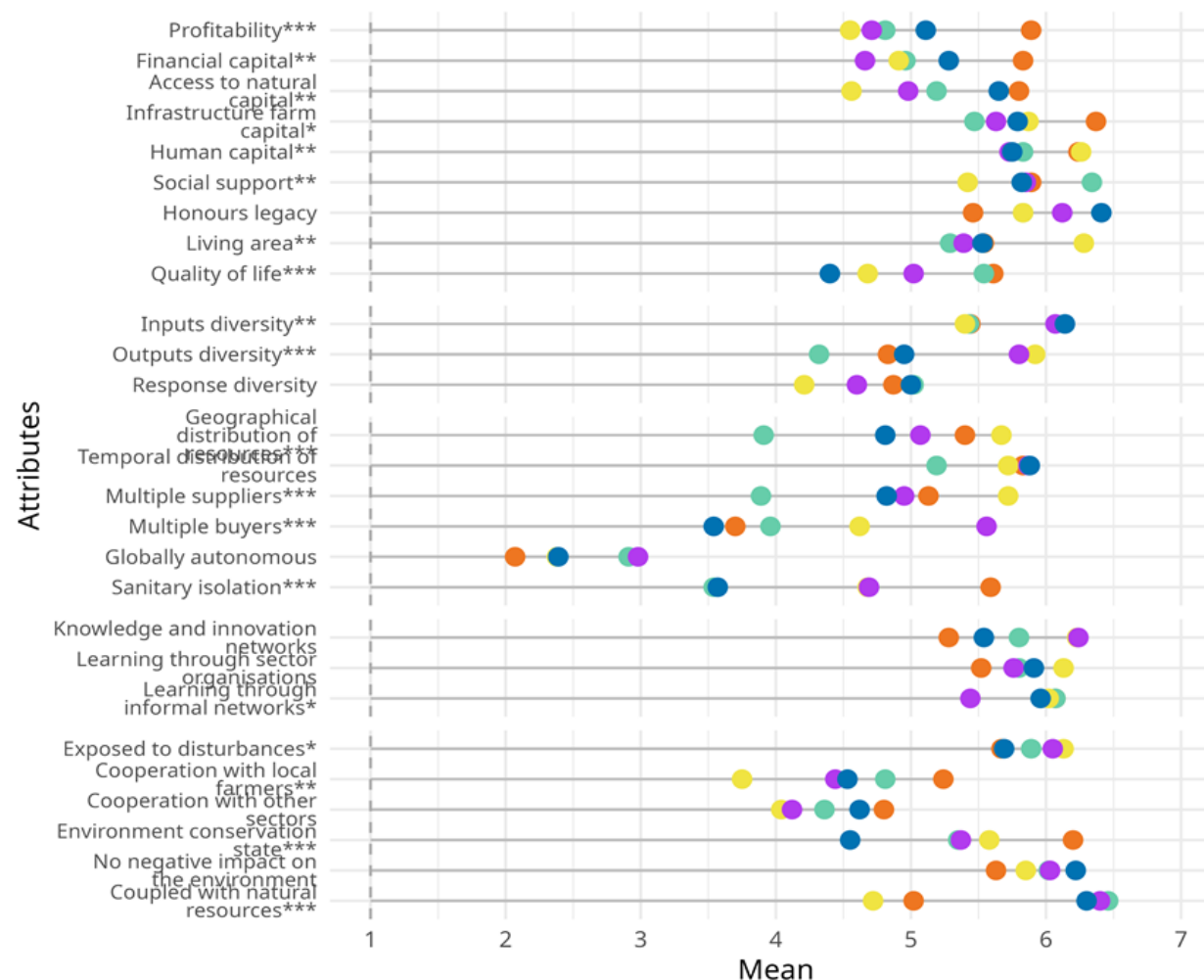


Labor shortage: most critical for
pig



Ukraine war: most severe
challenge overall, highest in small
ruminants (pig least affected)

A comparative analysis of resilience of livestock systems at different levels of intensification



Pig: highest profitability, financial capital and sanitary isolation



Dairy sheep: most diversified market channels (multiple buyers)



Beef cattle: fewest suppliers and most geographically concentrated resources



Grazing systems: strongest coupling with natural resources



A comparative analysis of resilience of livestock systems at different levels of intensification



A comparative analysis of resilience of livestock systems at different levels of intensification

Maria Vittoria Castori¹, Marizna Y. R. Couto², Alicia Prat-Benhamou², Alberto Bernués Ja², Clara Díaz³, Nerea Mandahuri², Yolanda Mená⁴, María Rivasés Moñuc⁴, Roberto Ruiz⁵, Daniel Martín-Collado²

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Abstract

Livestock farming systems across Europe face a wide range of environmental, economic, social and institutional challenges. Because these systems differ substantially in their structure and organization, resilience is expected to be built through different combinations of farm attributes, yet comparative evidence on how resilience varies across heterogeneous livestock systems remains limited. This study compares perceived resilience across five Spanish livestock farming systems (pig, dairy goat, dairy sheep, meat sheep and beef cattle) representing a broad production intensity gradient. Using a structured questionnaire administered to 241 farmers, we assessed 27 resilience attributes grouped under the five principles of system reserves, diversity, modularity, openness and tightness of feedbacks, together with farmers' perceived difficulty in coping with nine environmental, economic, social, institutional and sanitary challenges. Pig systems reported higher profitability, financial capital and infrastructural farm capital, as well as higher sanitary isolation, whereas grazing-based systems showed stronger coupling with natural resources but lower modularity. Perceived challenges varied across farming systems: pig farmers reported greater difficulty with sanitary challenges and labor shortages, whereas grazing-based systems generally reported greater difficulty with wildlife-related pressures and CAP changes. Overall, the results suggest that resilience is built in different ways across farming systems, reflecting their contrasting structural, organizational and socioecological contexts. Resilience-oriented policies should therefore account for these different configurations rather than promote a single optimal production model.

- Resilience of livestock farming systems is built through **different configurations of attributes** that reflect different structural, organizational and socioecological conditions.
- Results from **balancing** independent, complementary, and sometimes competing, **attributes** within specific farming contexts.
- Characteristics that strengthen resilience to one type of challenge may simultaneously increase vulnerability to another.
- **Production intensity** emerged as an important explanatory **dimension** of these resilience configurations.
- **Production orientation** (milk vs meat) and **value-chain organization** also shaped how resilience was configured



A practical approach to assess the resilience attributes of livestock farms



A practical approach to assess the resilience attributes of livestock farms

A. Prat-Benhamou^{a,b,*}, M.P.M. Meuwissen^c, T. Slijper^d, A. Bernués^{a,b}, P. Gaspar-García^e, J. Lizarralde^f, J.M. Mancilla-Leytón^g, N. Mandaluniz^f, Y. Mena^h, B. Sorianoⁱ, D. Martín-Collado^{a,b}



Step 1

Identification of resilience attributes

Resilience attributes (21)

Step 2

Operationalisation of resilience attributes

Farm indicators (85)

Step 3

Data collection

Survey **144** Workshop **21**

Step 4

Aggregation

Attribute scores

Attribute weights

Weighted sum

Overall resilience score

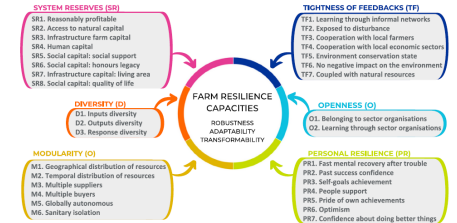


Fig. 2. Graphical representation of the conceptual framework. Resilience principles are System reserves (SR), Diversity (D), Modularity (M), Openness (O), Tightness of feedbacks (TF) and Personal resilience (PR). The attributes classified in each principle are coded with the principle's abbreviation and a serial number in grey boxes. Attributes are assigned to each principle based on Prat et al. (2021a), Trnkašević (2021) and the authors' expertise.



A practical approach to assess the resilience attributes of livestock farms



Principles (5)

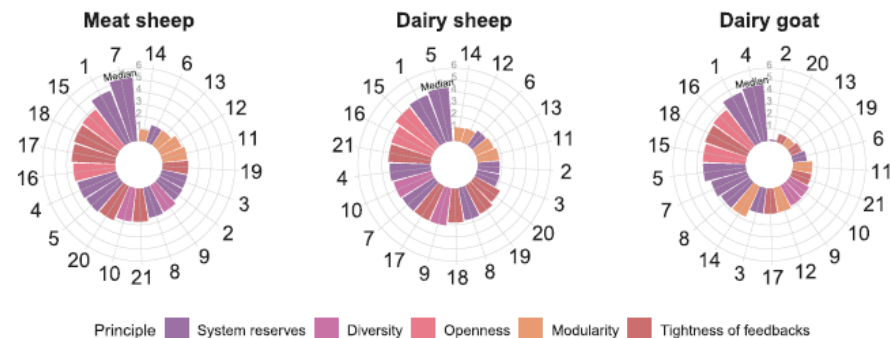
Attributes (21)

Indicators (85)

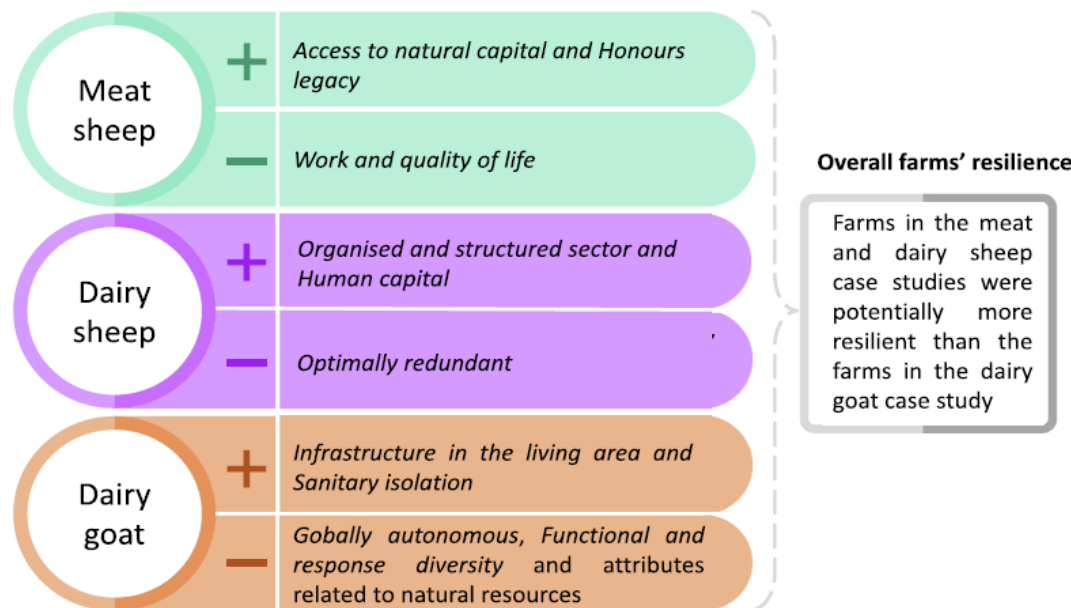
System reserves	Financial capital	• Percentage of family members working units • Farm succession secured
	Access to natural capital	
	Farm infrastructure	
	Infrastructure of the living area	
	Human capital	
	Social support	
Diversity	Honors legacy	• The possibility of selling the products directly to the consumer • Absence of legal obligations that prevent switching buyers
	Work and life quality	
	Functional diversity	
Modularity	Response diversity	
	Spatial and temporal heterogeneity	
	Optimally redundant	
	Globally autonomous	
Openness	Sanitary isolation	
	Organized and structured sector	
	Knowledge and innovation networks	
Tightness of feedbacks	Exposed to disturbances	
	Organizations feedback	
	Locally interdependent	
	Ecologically self-regulated	
	Coupled with natural capital	



A practical approach to assess the resilience attributes of livestock farms

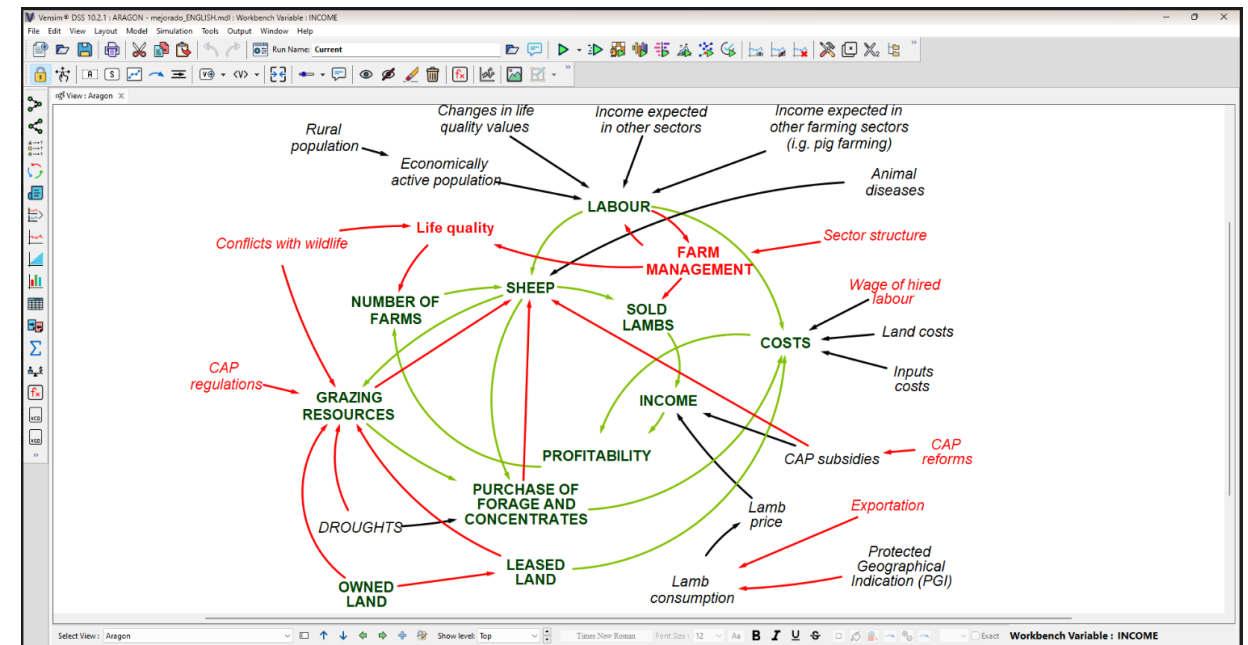


Status of the resilience attributes



Explaining the decline of Mediterranean meat sheep farming through system dynamics modelling

- Disentangle the relationships between the components of complex systems to understand their behavior over time.
- Three steps: 1) development and validation of a conceptual model; participative approach.
2) development and validation of quantitative models; public and sectorial databases
3) exploring future scenarios.



Modelling the system

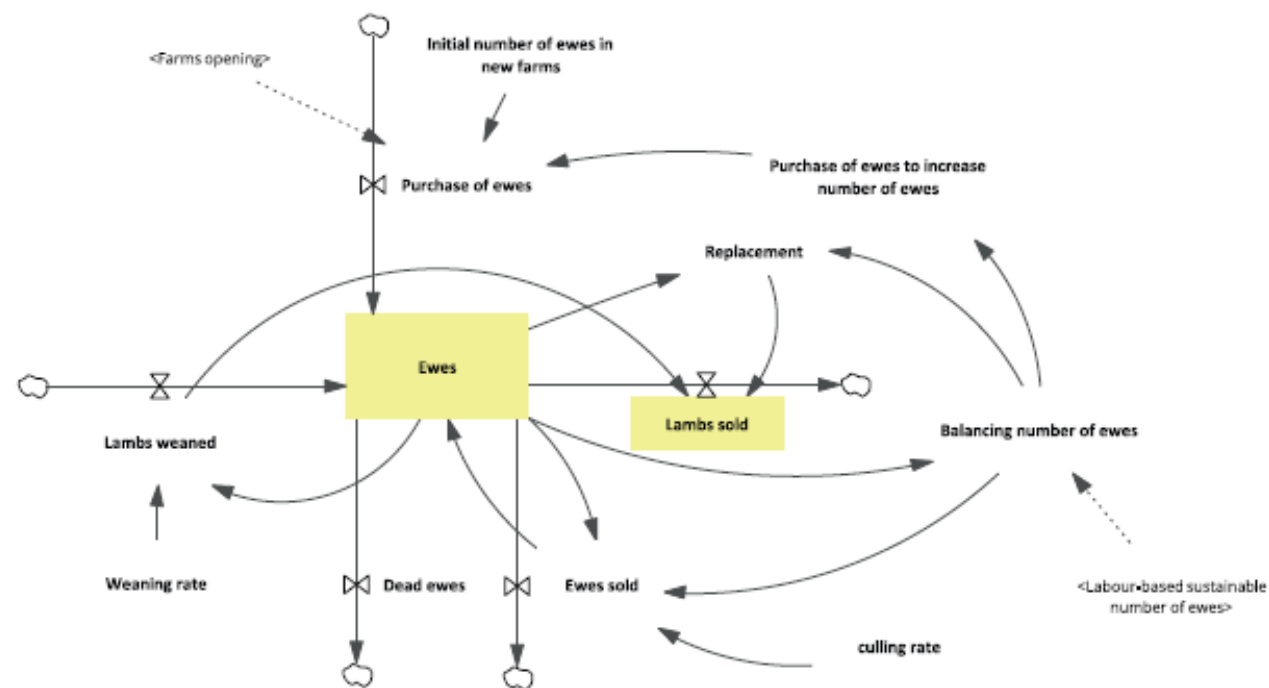
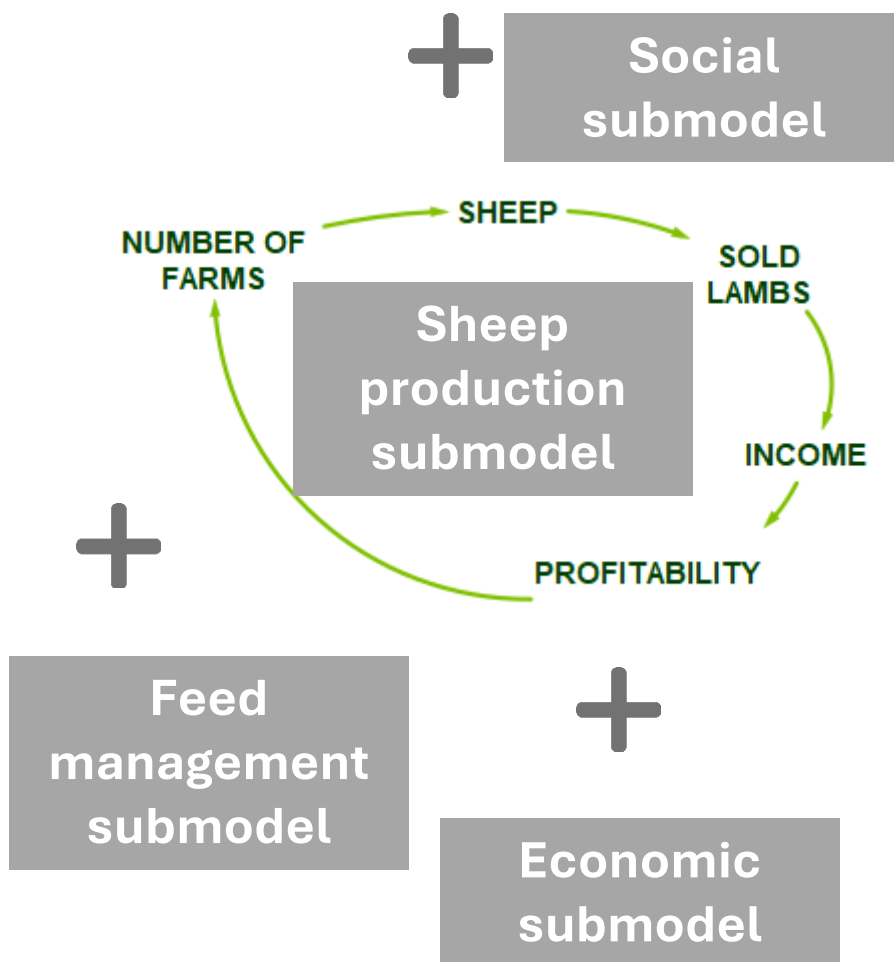


Fig. 1. Simplified version of the sheep production submodel. Variables within "<>" and followed by dashed lines are described in other submodel sections.

Modelling the system: economic submodel

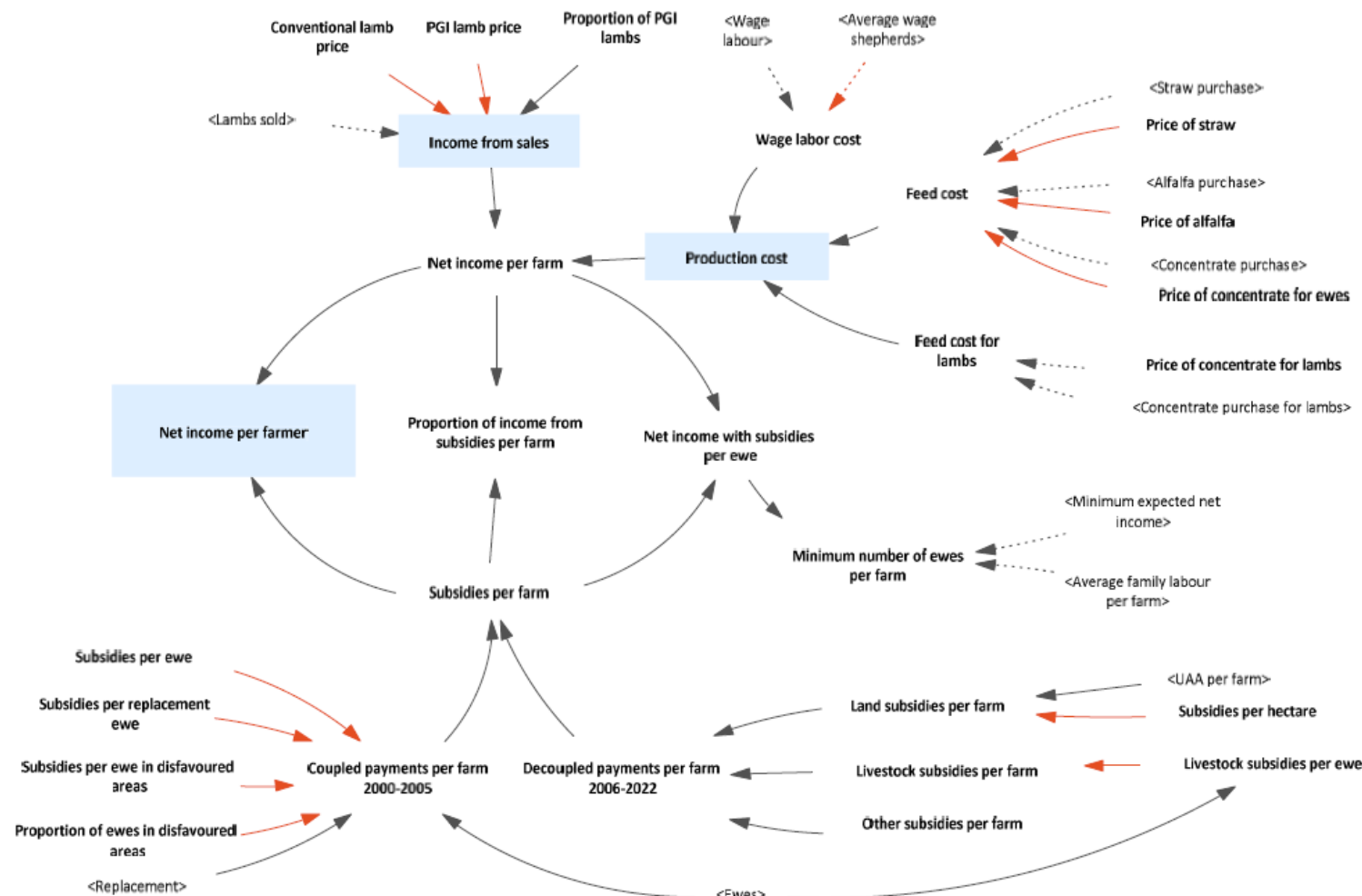
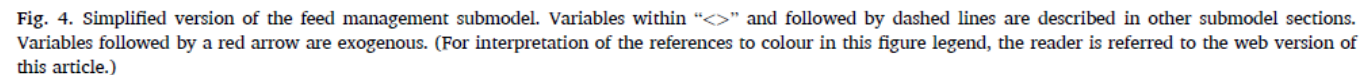


Fig. 3. Simplified version of the economic submodel. Variables within "<>" and followed by dashed lines are described in other submodel sections. Variables followed by a red arrow are exogenous. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)



Explaining the decline of Mediterranean meat sheep farming through system dynamics modelling



KPIs over time

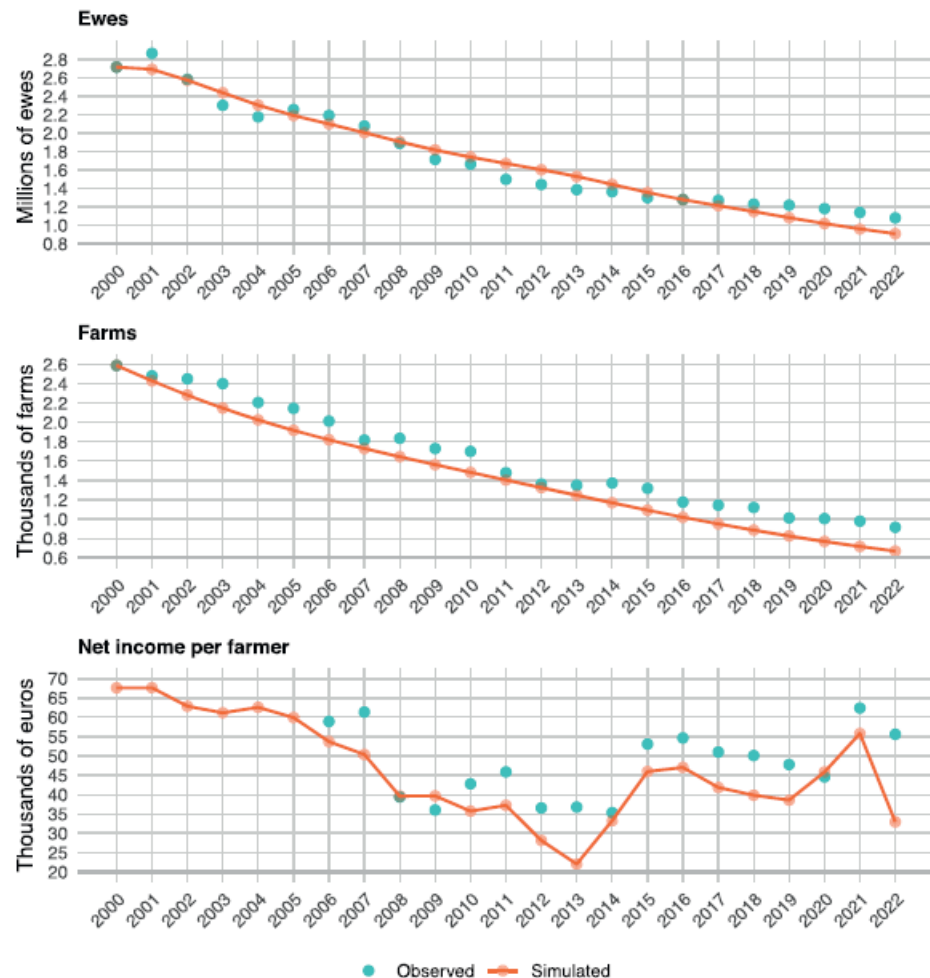


Fig. 5. Evolution of the Key Performance indicators (KPIs) over time (years 2000 to 2022). Observed data corresponds to real values over time according to data sources described in Supplementary Material 2, and simulated data corresponds to model outputs.

Simulation name	Farms		
	End time	Mean	SD
Equal quality of life	9.1	0.1	-4.9
Initial attractiveness of rural areas	1.0	0.1	-0.3
No subsidies for young	-2.2	-0.2	0.6
All labour needed available	8.1	3.8	-3.1
No subsidies	-100.0	-38.7	63.4
Initial lamb prices	19.2	4.1	-7.9
Average lamb prices	-4.5	-4.3	0.1
No quality differentiation	-3.5	-0.6	1.7
Initial input prices	13.1	2.3	-5.2
Average inputs prices	-16.1	-8.6	4.5
Normal precipitation	0.7	0.2	-0.6
No increase in UAA	-15.2	-2.4	6.6
No mountain pastures	-20.8	-14.0	6.6

	Ewes			Net income per farmer	
	End time	Mean	SD	Mean	SD
	9.1	0.2	-6.1	-0.1	0.1
	1.0	0.1	-0.4	0.0	0.0
	-2.2	-0.2	0.8	0.0	0.0
	52.9	30.0	1.1	8.5	27.1
	-100.0	-40.8	82.6	-71.0	2.5
	19.1	4.4	-10.3	27.3	-33.5
	-4.5	-4.4	0.6	1.0	-31.1
	-3.5	-0.7	2.1	-7.4	4.8
	12.3	2.7	-5.7	22.4	-31.5
	-16.9	-8.7	7.4	-14.8	-28.3
	-0.7	0.9	-2.3	0.4	-3.2
	-27.4	-6.9	16.6	-21.9	52.2
	-64.8	-69.3	-35.2	1.2	208.5



Explaining the decline of Mediterranean meat sheep farming through system dynamics modelling



- Together with economic drivers, social drivers drove the decline in the number of farms and sheep.
- Lack of generational renewal, which was a consequence of poor quality of life, largely driven by high workloads rather than low income, and low attractiveness of rural areas.
- The system would have collapsed without the subsidies of the Common Agricultural Policy.
- However, policies based on economic premiums have proven insufficient to reverse the declining trend in sheep and farm numbers.





Assessing resilience of small ruminant farms in Spain: A longitudinal analysis based on FADN



Small Ruminant Research 255 (2026) 107664



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Assessing resilience of small ruminant farms in Spain: A longitudinal analysis based on FADN

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JOURNAL ARTICLE

Quantifying the resilience of European farms using FADN

Thomas Slijper , Yann de Mey, P Marijn Poortvliet, Miranda P M Meuwissen

European Review of Agricultural Economics, Volume 49, Issue 1, January 2022, Pages 121–150, <https://doi.org/10.1093/erae/jbab042>

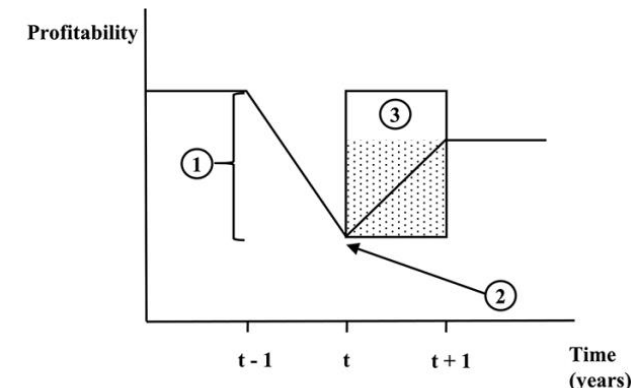


Table 1

Overview of the resilience capacity indicators. Positive “+” (negative “-”) directions indicate that higher (lower) values of an indicator imply higher (lower) levels of a resilience capacity. “+ / -” indicates that either a positive or negative change implies higher levels of a resilience capacity. Based on Slijper et al. (2022).

Resilience capacity	Resilience capacity indicator (indicator name)	Definition (change in variables)	Direction
Robustness	Resistance (<i>resistance</i>)	Decrease in profitability (%)	+
	Shock (<i>shock</i>)	Occurs if profitability decreases with at least 30 % (0–1)	-
	Recovery rate after 1 year (<i>recovery rate</i>)	Degree of recovery after 1 year. Expressed as a percentage of the decrease in profitability (%)	+
Adaptation	Livestock units per working unit (<i>labour</i>)	Change in livestock units (LU) per annual working unit (AWU) (Absolute terms)	+ / -
	Hectares per livestock unit (<i>land use</i>)	Change in hectares of utilised agricultural area (UAA) per livestock units (LU) (Absolute terms)	+ / -
Transformation	Feed ratio (<i>feed ratio</i>)	Change in the ratio on-farm to total feed costs (Absolute terms)	+ / -
	Organic (<i>organic</i>)	Conversion from conventional to organic farming or vice versa (0–1)	+
	Farm type (<i>farm type</i>)	Change in farm type* (0–1)	+
	On-farm transformation of products (<i>product transformation</i>)	Change to on-farm transformation of products or vice versa (0–1)	+

* Based on TF21 classification, which groups farm types according to livestock species and the mixed livestock-crop character of production systems.





Assessing resilience of small ruminant farms in Spain: A longitudinal analysis based on FADN

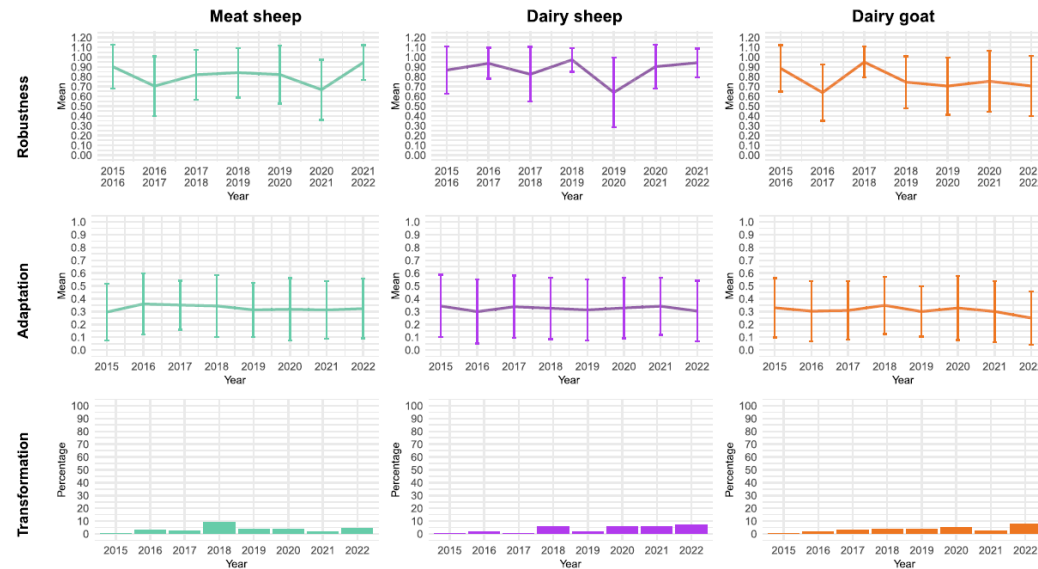


Fig. 1. Resilience capacities indicators over years in each case study.

Calculation
of capacity
values

Grouping of best
and worst
performers

Statistical
analysis of
probabilities

Elastic Net
binomial
regresions

Table 3

Descriptive statistics of the farm indicators for the period 2016–2022. As variables are not normally distributed, we present Quartile 1 / Median / Quartile 3.

Group	Variable	Meat sheep (N = 78)	Dairy sheep (N = 120)	Dairy goat (N = 81)
Management and structure	Herd size (LU)	54.61 / 77.61 / 132.50	34.25 / 46.14 / 61.07	28.36 / 47.97 / 82.15
	Land (ha)	59.24 / 107.22 / 182.38	32.05 / 52.08 / 75.54	23.00 / 69.00 / 185.00
	Owned land ratio	0.04 / 0.20 / 0.52	0.04 / 0.14 / 0.42	0.00 / 0.40 / 1.00
	Total labour (AWU)	1.00 / 1.05 / 2.00	1.00 / 2.00 / 2.00	1.08 / 1.41 / 2.00
	Family labour ratio	0.67 / 1.00 / 1.00	0.96 / 1.00 / 1.00	0.91 / 1.00 / 1.00
Productivity and efficiency	Family labour productivity (€/AWU)	14172.01 / 28899.04 / 57905.57	15194.03 / 26800.85 / 44148.28	11892.75 / 27850.83 / 52718.1
	Labour productivity (€/AWU)	16822.74 / 30780.27 / 50349.64	16742.87 / 27828.26 / 43178.41	12818.84 / 27134.95 / 49565.33
	Production efficiency	0.80 / 1.01 / 1.27	0.98 / 1.23 / 1.47	1.02 / 1.42 / 1.89
	Current subsidies / Income	0.29 / 0.36 / 0.46	0.11 / 0.18 / 0.27	0.07 / 0.11 / 0.18
Sources of income	Decoupled payments / Income	0.16 / 0.21 / 0.28	0.05 / 0.07 / 0.13	0.04 / 0.06 / 0.10
	Livestock payments / Income	0.06 / 0.08 / 0.10	0.02 / 0.04 / 0.06	0.00 / 0.02 / 0.04
	Rural payments / Income	0.02 / 0.04 / 0.08	0.02 / 0.05 / 0.07	0.00 / 0.01 / 0.03
	Other production / Income ^a	0.00 / 0.00 / 0.00	0.00 / 0.00 / 0.00	0.00 / 0.00 / 0.00



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- Small ruminant farming systems should strengthen adaptability and transformability
- High profitability and productivity increases robustness
- Higher availability of land per animal and higher proportion of feed produced in the farm favor adaptation





Take-home messages



- 1) Resilience should not be an empty term; needs clear definition, framework and system boundaries.
- 2) Different approaches with its strengths and limitations.
- 3) Complementarity and transdisciplinarity and participation
- 4) Social drivers of resilience are of central in small ruminants farming
- 5) There is not one only way of building resilience.
- 6) The challenge is general resilience, given uncertainly and complexity

THANK YOU!!!!



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