Farm resilience: assessment, drivers and policy-making

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Resilience of agricultural systems

Capacity of agricultural systems to **absorb**, **recover** from, and **adapt** to various types of **disturbances**, **stressors**, or **shocks**, while either maintaining or transforming their structure to **sustain continuously their identity and core functions**.

- Achieving a **resilient agricultural sector** is key to accomplishing **other relevant societal goals** such as food security, economic stability, social well-being, and environmental sustainability.
- Fostering the **resilience of agricultural systems** has become a **priority objective** in the international policy agenda.
- **Farms** are broadly recognized as the **essential operational units** within agricultural systems.
- The **policy objective** to enhance the resilience of the agricultural sector has been operationally translated into **instruments** aiming at strengthening **resilience at the farm level**.
- In order to **design and implement policy instruments** fostering farm resilience **efficiently**, it is necessary to quantitatively **assess the resilience** of these operational units, accounting that this **complex** concept entails several **dimensions or capacities.**

Resilience of farms

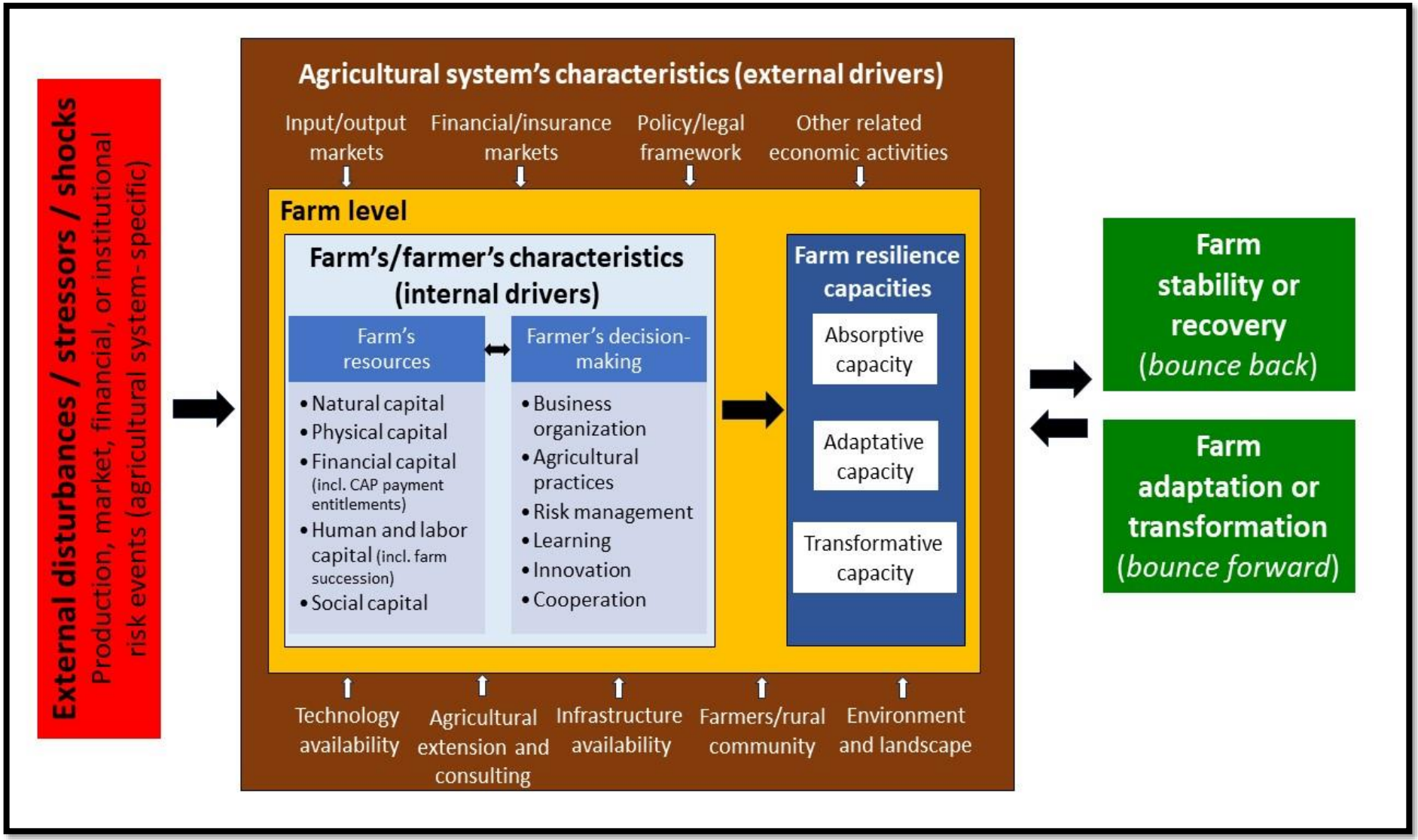
The ability to **cope with external disturbances** (e.g., market shocks or extreme weather events) while maintaining **farms' main functions** (i.e., the provision of **private and public goods** and services) over time.

External resilience drivers

- Input/output markets
- Financial and insurance markets
- Policy and legal frameworks
- Technology availability
- …

Internal resilience drivers

- Farm's resources
- Farmer's decision-making


External disturbances / stressors / shocks
Production, market, financial, or institutional risk events (agricultural system-specific)
Agricultural system's characteristics (external drivers)
Input/output markets
Financial/insurance markets
Policy/legal framework
Other related economic activities
Farm level
Farm's/farmer's characteristics (internal drivers)
Farm's resources
Natural capital
Physical capital
Financial capital (incl. CAP payment entitlements)
Human and labor capital (incl. farm succession)
Social capital
Farmer's decision-making
Business organization
Agricultural practices
Risk management
Learning
Innovation
Cooperation
Farm resilience capacities
Absorptive capacity
Adaptative capacity
Transformative capacity
Technology availability
Agricultural extension and consulting
Infrastructure availability
Farmers/rural community
Environment and landscape
Farm stability or recovery (bounce back)
Farm adaptation or transformation (bounce forward)

Objectives

- To propose a **framework** for the assessment of farm resilience based on **base and composite indicators of robustness, adaptability, and transformability**.
- To illustrate the proposed framework using the **Spanish herbaceous crops** agricultural systems as a case study.

Source of information: RECAN

- **RECAN** (Spanish brand of the FADN) as source of microeconomic data at the farm level.
- **Microdata** from **TF 15** (cereals, oilseeds and protein crops)**, TF 16** (general field cropping) **and TF 20** (horticulture) at the **national level.**
- Panel sample of **1255 farms** for the period **2009-2021**.

Economic performance indicators (ECOIND)

Indicator (ACRONYM)	Formula	Units
Land productivity (LAND_PR)	$\frac{\text{Total output}}{\text{Utilsed Agricultural Area}}$	€/ha
Return On Assets (ROA)	$\frac{\text{EBIT}}{\text{Total assets}}$	%
Economic viability (VIABILITY)	$\frac{\text{FNI}}{OC_{Land} + OC_{Labor} + OC_{Capital}}$	Dimensionless

Robustness indicators

Indicator (ACRONYM)	Formula	Units	Effect on resilience
Relative semideviation (RSD)	$\frac{\frac{1}{T}\sqrt{\sum_{t=1}^{t=T}\left[min\left(0, ECOIND_{i,t} - \mu_{ECOIND_i}\right)\right]^2}}{\mu_{ECOIND_i}}$	%	-
Beta parameter (β)	$\frac{cov(ECOIND_i, ECOIND_{fs})}{var(ECOIND_i)}$	#	-
Resistance rate (RS)	$\sum_{t=2}^{t=T} max\left(0, \frac{ECOIND_{i,t-1} - ECOIND_{i,t}}{ECOIND_{i,t-1}}\right)$	%	-
Frequency of economic disruptions (FED)	Number of **>= 30% decreases** in the farm economic performance indicator	1-13	-
Recovery rate (RC)	$\begin{cases} 1 & \text{if } ECOIND_{i,t} \text{ or } ECOIND_{i,t+1} \geq ECOIND_{i,t-1} \\ \frac{ECOIND_{i,t+1} - ECOIND_{i,t}}{ECOIND_{i,t-1} - ECOIND_{i,t}} & \text{if } ECOIND_{i,t-1} > ECOIND_{i,t} < ECOIND_{i,t+1} \\ 0 & \text{if } ECOIND_{i,t-1} > ECOIND_{i,t} \geq ECOIND_{i,t+1} \end{cases}$	%	+

Adaptability indicators

Indicator (ACRONYM)	Formula	Units	Effect on resilience
Flexibility of economic structure (FES)	$\frac{1}{T-1}\sum_{t=2}^{t=T}\left\|\frac{ASSETS_{i,t} - ASSETS_{i,t-1}}{ASSETS_{i,t-1}}\right\|$	%	+
Flexibility of production intensity (FPI)	$\frac{1}{T-1}\sum_{t=2}^{t=T}\left\|\frac{FCE_{i,t} - FCE_{i,t-1}}{FCE_{i,t-1}}\right\|$	%	+
Flexibility of labor input (FLI)	$\frac{1}{T-1}\sum_{t=2}^{t=T}\left\|\frac{LI_{i,t} - LI_{i,t-1}}{LI_{i,t-1}}\right\|$	%	+
Flexibility of outsourcing (FOUTS)	$\frac{1}{T-1}\sum_{t=2}^{t=T}\left\|\frac{OUTS_{i,t} - OUTS_{i,t-1}}{OUTS_{i,t-1}}\right\|$	%	+
Crop mix divergence index (CMDI)	$\frac{1}{T-1}\sum_{t=2}^{t=T}\sqrt{\sum_{c=1}^{c=C}\left[p_{c,t-1} - p_{c,t}\right]^2}$	%	+

Farm transformability

Productive transformations	Units
Rainfed – irrigated farming	0-1
Conventional – organic farming	0-1
50% change in farmland size	0-1
100% change in capital invested in farming activities	0-1

Business transformations	Units
Change in the type of farming (TF)	0-1
Engagement in other gainful activities (OGA)	0-1

Transformability indicators

- **Six binary logistic regressions** were fitted to detect the **transformative capacity** of each farm in the sample (both transformed and not transformed during the period) **regarding each farm transformation** considered.

$$\underset{\text{(1=transformed, 0=not transformed)}}{\widehat{TRANSF_k}} = \frac{1}{1 + e^{-(\beta_0 + \beta_1 DRIV_1 + \beta_2 DRIV_2 + \ldots + \beta_N DRIV_N + \varepsilon)}}$$

- The **outcomes estimated** by each logistic model for each farm represents a **proxy indicator** of their transformative **capacity regarding farm transformation *k***, measured on a 0-1 scale (lowest to highest capacity). A set of **24 drivers** were considered, related to **farms' resources** and **farmers' decision-making**.

Composite indicators

Resilience capacity	Normalization method	Weighting procedure	Aggregation method	Composite indicator (units)
Robustness	Min-max	Principal Component Analysis (PCA)	Additive	$ROB_i^{LAND\_PR}$, ROB_i^{ROA}, and $ROB_i^{VIABILITY}$ [0-1]
Adaptability	Min-max	PCA	Additive	$ADAPT_i$ [0-1]
Transformability	-	PCA	Additive	$TRANSF_i$ [0-1]
Overall resilience	-	**PCA**	**Additive**	$\boldsymbol{RES_i}$ **[0-1]**

Robustness indicator	Min	1st quartile	Median	3rd quartile	Max
RSD_LAND_PR	1,98%	4,38%	5,84%	7,40%	12,75%
BETA_LAND_PR	-1,10	0,02	0,32	0,96	10,59
RS_LAND_PR	21,8%	70,1%	98,3%	135,4%	250,4%
FED_LAND_PR	0	0	1	2	5
RC_LAND_PR	470%	793%	885%	951%	1100%
RSD_ROA	3,37%	7,70%	10,33%	13,66%	52,86%
BETA_ROA	-3,21	-0,21	0,60	1,64	7,86
RS_ROA	84%	171%	249%	777%	11513%
FED_ROA	0	2	4	5	11
RC_ROA	364%	715%	807%	900%	1080%
RSD_VIABILITY	3,24%	7,97%	10,98%	14,66%	75,27%
BETA_VIABILITY	-3,63	0,01	0,70	1,80	7,67
RS_VIABILITY	85%	182%	272%	877%	14551%
FED_VIABILITY	0	3	4	5	10
RC_VIABILITY	355%	732%	819%	900%	1100%

Adaptability indicator	Min	1st quartile	Median	3rd quartile	Max
FES	**1,4%**	5,7%	**9,0%**	13,5%	**45,3%**
FPI	**7,0%**	20,5%	**25,9%**	33,5%	**74,1%**
FLI	**0,3%**	10,5%	**18,1%**	25,5%	**66,2%**
FOUTS	**0,0%**	20,1%	**31,1%**	43,9%	**84,0%**
CMDI	**0,0%**	11,2%	**20,9%**	31,6%	**83,9%**

Productive transformations	% Farms
Rainfed – irrigated farming	31,1%
Conventional – organic farming	4,4%
50% change in farmland size	38,6%
100% change in capital invested in farming activities	41,7%

Business transformations	% Farms
Change in the type of farming (TF)	24,4%
Engagement in other gainful activities (OGA)	1,2%

Composite indicators

Indicator	Min	1st quartile	Median	3rd quartile	Max
ROB_LAND_PR	**0,23**	0,61	**0,71**	0,78	**0,94**
ROB_ROA	**0,37**	0,66	**0,72**	0,77	**0,90**
ROB_VIABILITY	**0,27**	0,69	**0,74**	0,79	**0,91**
ADAPT	**0,07**	0,21	**0,27**	0,33	**0,62**
TRANSF	**0,07**	0,18	**0,23**	0,29	**0,59**
RES	**0,35**	0,50	**0,54**	0,56	**0,67**

- The proposed **framework** is useful for the **comprehensive assessment of resilience capacities** at the farm level, allowing to support more **efficient agricultural policy-making**.
- **Spanish herbaceous crops** agricultural system is “half-resilient”, since it shows a **high robustness capacity**, but relatively **low values for adaptability and transformability** indicators.
- **Further analysis of trade-offs and synergies** both within the **three resilience capacities** and between each capacity and **farm economic performance indicators**.
- Need to **relate the results** with a wide **set of resilience drivers** in order to support a **better design and implementation of policy instruments** fostering **farm resilience** efficiently.

THANKS FOR THE ATTENTION!

Any comments and suggestions are welcome

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