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A multi-stakeholder participatory study identifies the priorities for the sustainability of the small ruminants farming sector in Europe

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ABSTRACT

The European small ruminants (i.e. sheep and goats) farming sector (**ESRS**) provides economic, social and environmental benefits to society, but is also one of the most vulnerable livestock sectors in Europe. This sector has diverse livestock species, breeds, production systems and products, which makes difficult to have a clear vision of its challenges through using conventional analyses. A multi-stakeholder and multi-step approach, including 90 surveys, was used to identify and assess the main challenges for the sustainability of the ESRS to prioritize actions. These challenges and actions were identified by ESRS experts including farmers, cooperatives, breeding associations, advisers and researchers of six EU countries and Turkey. From the 30 identified challenges, the most relevant were economy-related challenges such as 'uncertainty of meat and milk prices', 'volatility of commodity prices', 'low farm income', 'high subsidy dependency' and 'uncertainty in future changes in subsidies' resulting in 'a sector not attractive to young farmers'. Most of these challenges were beyond the farmer's control and perceived as difficult to address. Challenges were prioritized using an index, calculated by multiplying the relevance and the feasibility to address measures. The identified challenges had a similar priority index across the whole sector with small differences across livestock species (sheep vs goats), type of products (meat vs dairy) and intensification levels (intensive vs semi-intensive vs extensive). The priorities were different, however, between socio-geographical regions (Southern vs Central Europe). Some of the top prioritized challenges were linked to aspects related to the production systems ('low promotion of local breeds' and 'slow adaptability of high producing breeds') and market practices ('unfair trade/lack of traceability'). The majority of the priority challenges, however, were associated with a deficient knowledge or training at farm level ('poor business management training', 'lack of professionalization', 'slow adoption of innovations'), academia ('researchers do not address real problems') and society as a whole ('low consumer education in local products', 'low social knowledge about farming', 'poor recognition of farming public services'). Thus, improved collaboration among the different stakeholders across the food chain with special implication of farmers, associations of producers, academia and governments is needed to facilitate knowledge exchange and capacity building. These actions can contribute to make ESRS economically more sustainable and to adapt the production systems and policy to the current and future societal needs in a more region-contextualized framework.

Implications

The challenges that may compromise the sustainability of the European small ruminants sector were identified using a multi-stakeholder participatory approach. Economy-related challenges were perceived as highly relevant, but out of the farmer's control. The challenges that were identified as priority based on their relevance and feasibility to be addressed were 1) enhancing consumer and social awareness, 2) farmer's capacity building, 3) promoting local breeds and 4) re-focusing research priorities. It was also noted that effective collaboration and knowledge transfer across the different stakeholders involved in this sector are critical to address these challenges.

Introduction

The European small ruminants (i.e. sheep and goats) farming sector (**ESRS**) contributes to many of the Sustainable Development Goals described by the United Nations (Animal Task Force [**ATF**], 2019). This sector produces 6% of meat and 3% of milk production in the European

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Union (**EU**) representing an important share of the total livestock production in some European countries such as UK, Spain, Italy, France and Greece (Food and Agriculutre Organization of the United Nations [**FAOSTAT**], 2020). The ESRS supports 1.5 million farmers, plus members of the food chain, and provides economic and social cohesion for the most disadvantaged and depopulated rural areas (ATF, 2019). Furthermore, this sector delivers multiple environmental services such as wildfire prevention through grazing in dry regions during the hot summer season, naturalization of marginal areas and maintenance of landscape and biodiversity (Rook et al., 2004). All these ecosystem services, along with the quality of their products and ways of living in rural areas, contribute to the cultural heritage of many EU countries (Parente and Bovolenta, 2012).

Despite the importance of ESRS, it is one of the most vulnerable livestock sectors in Europe (Pulina et al., 2018). In recent decades, the ESRS suffered a steady decrease in animals and farms (mostly sheep) because of economic and structural difficulties (FAOSTAT, 2020). One key driver has been the constant decline in sheep and goat meat demand derived from changes in the consumers' habits. Young consumers living in urban areas prefer fast and easy-to-make recipes and diets with less fat and less red meat (Montossi et al., 2013; Mandolesi et al., 2020). Moreover, the ageing farmers population and the lack of new entrants provide little hope to the future of the ESRS (Pulina et al., 2018), unless the main constraints of the sector are identified and successfully addressed. Given the complexity of the ESRS, it is exposed to many challenges that are interconnected and apply to different levels (i.e. farm, regions, countries and EU). This means that farmers and stakeholders often have limited control over these challenges (Castel et al., 2011). Also, the diversity of livestock, products and level of intensification in the ESRS within and across countries makes the challenges and the identification of feasible solutions difficult (Ruiz-Morales et al., 2019).

Farm sustainability encompasses economic, social, cultural and environmental aspects (Lebacq et al., 2013). Views and perceptions of relevant players need to be considered to achieve significant outputs when analysing complex and multi-level systems. This requires multi-way interaction and co-production of knowledge between researchers, decision-makers and other beneficiaries of science (Francis and Goodman, 2010). In the case of the ESRS, farmers and industry views are critical for any analysis. Multi-stakeholder and participatory approaches are commonly used to integrate all existing views to identify and frame problems and solutions in socio-ecosystems in farming systems (Thiele et al., 2011; Martin-Collado et al., 2013).

In this context, we carried out a wide international multi-stakeholder study to provide a broad vision and new insights about current and future challenges that compromise the sustainability of the ESRS. This work was part of the H2020 iSAGE project 'Innovation for Sustainable Sheep and Goats in Europe' (www.isage.eu) which aimed to enhance the sustainability, competitiveness and resilience of the ESRS through collaboration between industry and academia. Specifically, the objectives of this study were 1) to identify the main challenges affecting the ESRS sustainability, 2) to assess whether these challenges are common across the production systems and 3) to prioritize the challenges according to both their relevance and the feasibility to be addressed. The results of this study can help the different members of the food chain and policy makers to prioritize the effort when addressing the main constraints of the ESRS.

Material and methods

Multi-stakeholder participatory approach

This study used an international multi-stakeholder and multi-step participatory process as previously validated in similar studies (Thiele et al., 2011; Martin-Collado et al., 2013). All 34 partners participating in iSAGE were involved in every phase of the process (Supplementary Table S1). Partners included farmers' groups and cooperatives, breeding associations, National livestock associations, governmental research institutions and universities from six EU countries and Turkey (Table 1). These partners ensured the identified challenges were relevant to the real situation on the ground of the ESRS. The countries represented by the iSAGE industry partners group collectively accounted for 80% of the European sheep and 85% of the European goat censuses (EUROSTAT, 2018). The multi-stakeholder participatory approach included seven steps (Fig. 1): 1) definition of the framework, 2) identification of challenges, 3) shortlisting of challenges, 4) assessment of the relevance of challenges, 5) assessment of the feasibility to address the challenge, 6) prioritization of challenges and 7) identification of the stakeholders needed to take action.

Step 1. Definition of the analysis framework

The framework defined the boundaries of the analysis and aimed to analyse the challenges of ESRS through the central role that farmers have in the development of the sector. SWOT analysis is a widely used tool to explore the Strengths, Weaknesses, Opportunities and Threats of an organization with the final aim of adjusting its internal behaviour with the surrounding environment (Martin-Collado et al., 2013). Following the SWOT principles, challenges were divided into internal and external. Internal challenges (or weaknesses) were mostly controlled by the farmer, and external challenges (or threats) were mostly beyond the farmer's control such as environment and market factors.

Steps 2 and 3. Identification and shortlisting of challenges

Challenges were identified using two consecutive steps. First, a preliminary list of challenges was prepared from a review of EU reports on 'The current situation and future prospects for the sheep and goat sector in the EU' [2017/2117(INI)], 'The future of the sheep meat and goat meat sectors in Europe' (IP/B/AGRI/IC/2007_043), 'The role of agriculture in rural development today' [Ares (2011) 1350301] and on iSAGE Deliverable 1.1 (www.isage.eu). Farmers' views were included in the process using semi-structured interviews of 47 sheep and goat farmers across 6 countries (Finland, France, Greece, Italy, Spain and UK). The interviews covered three general topics: 1) local and environmental changes affecting farm sustainability, 2) strengths, weaknesses, opportunities and threats and 3) future priorities for the development of ESRS.

Second, the soundness and completeness of the preliminary list of challenges were discussed by 45 iSAGE experts representing all project partners in a workshop in Bilbao, Spain. During the workshop, attendees were randomly distributed in three groups with similar representation of researchers, ESRS experts and organizations of farmers. The main outputs were shared in a closing debate and a final list of challenges was discussed and agreed.

Steps 4 and 5. Assessment of challenge relevance and feasibility to address

This phase involved an online survey of 90 ESRS experts. This expert panel included representatives of all iSAGE partners plus the members of the National Advisory Committees of the seven countries participating in the project (Table 1). The National Advisory Committees were established at the beginning of iSAGE project and members were selected on the basis of having a wide knowledge in national and regional sector policy and practice relevant to the industries in their countries. The proportion of experts from each country was approximately equivalent to the country contribution to the European small ruminants census, with more representing sheep than goats, but having a similar representation the intensive, semi-intensive and extensive production systems. The group of experts included farmers groups ($n = 14$, including farmers, cooperatives, meat producers and cheese producing companies), breeding associations ($n = 14$, including technicians and farm advisers), researchers ($n = 35$, including experts on nutrition, production systems, genetics, health, reproduction, climate change and consumer behaviour) and National Advisory Committees ($n = 27$, including experts from agriculture departments, veterinarians and coordinators of R&D programs). The survey included three questions

Table 1
Summary of the organizations and experts involved in the European project 'Innovation for the sustainable sheep and goat production in Europe' (iSAGE).

	Total	France	Finland	Greece	Italy	Spain	Turkey	UK
iSAGE institutions								
Farmers groups/cooperatives	10	1		2		5	1	1
Breeding associations	10	1	1		2	2	2	2
Research institutions	14	2	1	3	1	3	2	2
Experts (no. of individuals)								
Farmers groups/cooperatives	14	3		2		7	1	1
Breeding associations	14	1		1	2	6	2	2
Research institutions	35	8	1	6	3	13	1	3
National Advisory Committees	27	2		9	1	10	4	1

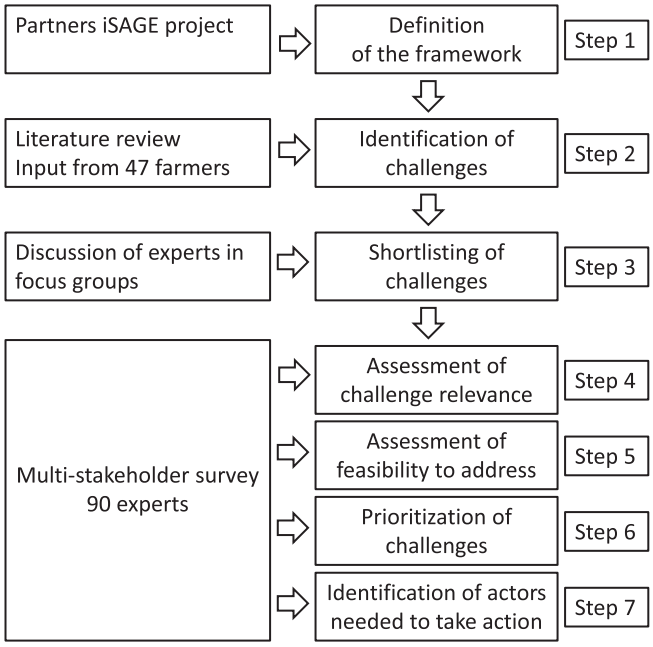

Fig. 1. Flux diagram describing the multi-stakeholder and multi-step participatory approach used to identify and prioritize the challenges for the European small ruminants sector.

assessing experts' views on 1) the Relevance (R), 2) the Feasibility (F) to address each challenge and 3) the main stakeholder(s) that should be involved in addressing the challenges. Participants scored the relevance and feasibility to address the challenges using a scale for the Relevance (being 1 very low and 5 very high) and the Feasibility question (being 1 very difficult and 5 very easy).

Steps 6 and 7. Challenge prioritization and identification of the actors needed to take action

Challenges were prioritized using a priority index (**PI**) calculated by multiplying the relevance and the feasibility for each challenge. Then, participants indicated which stakeholders would have to act to address each challenge from the following list: 1) government, 2) associations of producers, 3) farmers, 4) consumers, 5) retailers, 6) academia and 7) processing industry. Participants could select as many stakeholders as they considered necessary with the subsequent weight dilution as the number of choices increased.

Statistical analyses

Data distribution, regarding to challenge relevance, feasibility to address and PI, was assessed using the Shapiro–Wilk test resulting on a non-normal distribution (summary statistics in Supplementary Table S2). Therefore, pair-wise contrasts were performed for each challenge using the Kruskal–Wallis non-parametric ANOVA with H adjusted for ties to evaluate the following factors: type of product [dairy ($n = 61$) vs meat ($n = 29$)], livestock species [sheep ($n = 60$) vs goats ($n = 30$)], production system [intensive ($n = 25$) vs semi-intensive ($n = 31$) vs extensive ($n = 34$)] and geographical region [Southern ($n = 69$) vs Central Europe ($n = 21$)]. Southern Europe was represented by Spain, Italy, Greece and Turkey, whereas Central Europe was represented by France, UK and Finland. To compare challenges in terms of relevance, feasibility to address and PI, a repeated measures mixed-model was performed considering the answers from each stakeholder as repeats. When significant effects were detected, means were compared by Fisher's protected LSD test. Effects were declared significant at $P < 0.05$. All statistical analyses were conducted using SPSS software (IBM Corp., Version 21.0, NY, USA).

European research priorities for the small ruminants sector

A final analysis compared the priorities identified in the present study with the EU research programs related to ESRS. Funding programs were found by searching the European Commission website (www.cordis.europa.eu) limiting the search to projects funded through the Framework Program 7 (FP7) and Horizon 2020 (H2020). These programs represent the main EU research funding over the last decade. The keyword combination for small ruminants was ('sheep' OR 'goat*' OR 'small ruminant*'). A similar search was done for the cattle sector (keywords: 'cow*' OR 'cattle' OR 'large ruminant*') that was used as a control. All projects identified were classified according to the thematic area based on the 'Domain of Application' described in the EU website. The same approach was used to search for publications in Web of Sciences. All the research publications published in the last 10 years were considered with the following keyword combinations in the title 'technology OR innovation', 'health OR welfare' and 'environment* OR climate change' along with the keywords described before to define the ruminant typologies.

Results

Identification and grouping of challenges

A total of 30 challenges were identified by the multi-stakeholder participatory approach (Table 2). The 13 internal challenges identified were classified into four categories ('Farmer level', 'Farming system', 'Sector level' and 'Overarching'), and the 17 external challenges were assigned into 6 categories ('Production factors', 'Environment', 'Market', 'Society', 'Policy' and 'Science').

Relevance of challenges

Despite the large range of variation observed across stakeholders (values from 1 to 5) in their perception of the relevance for each challenge (Supplementary Table S2), a moderate variation was observed

Table 2
Final list of the challenges identified for the European small ruminant sector (i.e. sheep and goats). Internal and external challenges are grouped in categories.

Internal challenges	External challenges
Farmer level	Factors of production
Poor business management training	Difficult access to capital/poor income
Lack of professionalization	Limited access to land
Slow adoption of technology and innovations	Environment
Farming system	Climate change threats
Low promotion of local breeds	Wildlife conflicts
Low integration of livestock and agriculture	Market
Low adaptability of high productive breeds	Uncertainty of meat and milk prices
Sector level	Volatility of commodity prices
Not attractive to young farmers	Unfair trade/lack of traceability
Low cooperation between farmers	Market monopolized
Sector fragmentation/lack of integration	Society
Low female involvement	Low social knowledge about farming
Overarching	Low consumer education in local products
High subsidy dependency	Farmer role unrecognized by society
Low competitiveness	Poor recognition of farming public services
Parasites and infectious diseases	Low consumer demand
	Policy
	Uncertainty in future changes in subsidies
	EU policy without scientific evidence
	Environmental policy against intensification
	Science
	Researchers do not address real problems

on the average relevance across challenges (average 2.80–4.28). Significant differences were observed between challenges for their perceived relevance ($P < 0.001$, Table 3). All challenges, except 'parasites and infectious diseases', had scores above 3, indicating a medium-to-high relevance. Eight out of the top 10 challenges were external and four out of the five most relevant challenges were related to economy.

The average relevance of internal challenges was the same for sheep and goats and productions systems but differed across geographical regions and type of products. The average relevance of external challenges only differed across farming systems. Overall, internal challenges were perceived as more relevant in Southern Europe and in the dairy sector while external challenges were perceived as more relevant in extensive than in intensive or semi-intensive systems.

The dairy systems were perceived to be more affected by internal challenges related to the structure of the sector (e.g. 'sector fragmentation' and 'low cooperation between farmers') and the farming system (e.g. 'low promotion of local breeds', 'low integration of livestock and agriculture' and 'low adaptability of high producing breeds' or 'slow adoption of innovations'). Experts from dairy systems also perceived higher relevance for 'low social knowledge about farming', 'low consumer education in local products', 'lack of traceability' and 'climate change threats', whereas the 'low consumer demand' was perceived as more relevant for meat production.

There was a similar overall perception of relevance for the external challenges across types of animal product (meat or milk). Sheep production was perceived to be more affected than goat production by 'high subsidy dependency', 'low female involvement', 'volatility of commodity prices' and 'low consumer demand, whereas goat production systems perceived higher relevance for 'low integration of livestock and agriculture', 'slow adoption of innovations', 'climate change threats' and 'limited access to land'. The average relevance of the external challenges decreased as the system's intensification increased. In particular, internal challenges such as 'low competitiveness' and 'low female involvement' and external challenges such as 'unfair trade/lack of traceability', 'climate change threats', 'poor recognition of farming public services', 'limited access to land' and 'wildlife conflicts' were perceived as more relevant in extensive and semi-extensive than in intensive production systems. The perception of relevance of many internal challenges was higher in Southern than Central Europe ($P < 0.001$), and in particular, 'lack of professionalization', 'slow adoption of innovations', 'sector fragmentation', 'low promotion of local breeds' and 'low adaptability of high producing breeds'.

Feasibility to address challenges

The perception of the feasibility to address the challenges showed a large range of variation across stakeholders (values from 1 to 5, Supplementary Table S2), whereas the average variation across challenges varied from 1.70 to 3.01. None of the 30 challenges investigated were perceived as easy or very easy to address (Fig. 2) but significant differences were noted across challenges on the feasibility to be addressed ($P < 0.001$, Supplementary Table S3). The challenge 'researchers do not address real problems' was perceived as the easiest to address (score 3), whereas most challenges had a score between 2 and 3, indicating a medium–high difficulty for being addressed. Five external challenges were considered as very difficult to address (score below 2), most of them being external challenges related to market factors (e.g. 'volatility of commodity prices', 'uncertainty of meat and milk prices' and 'market monopolized'), as well as 'low farm income' and 'climate change threats'. The challenge 'not attractive to young farmers' was perceived as not only the most relevant internal challenge but also the most difficult to address. Contrary, addressing internal challenges related to farming practices ('parasite and infectious diseases', 'low adaptability of high productive breeds', 'low promotion of local breeds', 'poor business management training', 'slow adoption of technology' and 'lack of professionalization') and addressing external challenges related to education and sciences ('researchers do not address real problems', 'low consumer education in local products', 'environmental policy against intensification', 'low social knowledge about farming' and 'EU policy without scientific evidence') were perceived as more feasible. Overall, type of product, livestock species and level of intensification had minor effect on the overall perception of the feasibility to address the challenges. Most external challenges were perceived easier to address in Southern than in Central Europe.

Prioritization of challenges

The PI values for some challenges showed the maximum potential range of variation (from 1 to 25, Supplementary Table S2), but the average PI for each challenge showed a smaller variation (from 6.28 to 10.91) indicating that the most relevant challenges tended to be difficult to

Table 3
Relevance of the challenges for the European small ruminants sector across type of products, species, production systems and regions.

Challenges	Group	Relevance[1]			Product		P	Species		P	Production system[2]			P	Region		P
		Rank	Mean	SE	Dairy	Meat		Sheep	Goat		Int.	Semi.	Ext.		South	Central	
Internal challenges			3.50	0.52	3.6	3.3	***	3.4	3.6		3.3	3.6	3.5		3.6	3.2	***
Not attractive to young farmers	Sector	4	4.05^{jklm}	1.08	4.1	3.9		4.1	4.0		3.9	4.3	4.0		3.9	4.5	*
High subsidy dependency	Overarching	5	4.03^{jklm}	1.01	4.1	3.9		4.2	3.7	*	3.8	4.2	4.1		4.0	4.0	
Low cooperation between farmers	Sector	13	3.59^{defgh}	1.17	3.8	3.1	*	3.5	3.8		3.6	3.6	3.6		3.7	3.1	*
Low promotion of local breeds	Farming	15	3.57^{defgh}	1.35	3.7	3.2	*	3.5	3.7		3.4	3.9	3.5		3.9	2.6	***
Poor business management training	Farmer	16	3.53^{defg}	0.86	3.6	3.4		3.5	3.7		3.4	3.7	3.4		3.6	3.2	*
Low competitiveness	Overarching	17	3.53^{defg}	0.99	3.5	3.7		3.6	3.4		3.2^{a}	3.9^{b}	3.4^{a}	*	3.6	3.4	
Sector fragmentation/lack of integration	Sector	19	3.51^{def}	1.09	3.7	3.0	**	3.4	3.8		3.6	3.6	3.3		3.7	3.0	**
Lack of professionalization	Farmer	20	3.48^{def}	0.89	3.5	3.3		3.4	3.6		3.5	3.5	3.4		3.7	2.7	***
Low integration of livestock and agriculture	Farming	21	3.42^{cde}	0.85	3.6	3.0	***	3.2	3.9	***	3.4	3.4	3.5		3.5	3.1	
Slow adoption of innovations	Farmer	22	3.40^{cde}	1.04	3.6	3.0	*	3.2	3.8	*	3.5	3.5	3.3		3.6	2.7	***
Low adaptability of high productive breeds	Farming	27	3.14^{bc}	1.14	3.3	2.8	*	3.0	3.4		3.0	3.2	3.2		3.4	2.4	**
Low female involvement	Sector	28	3.13^{bc}	1.12	3.1	3.2		3.4	2.7	**	2.8^{a}	3.5^{b}	3.1^{ab}	*	3.3	2.5	*
Parasites and infectious diseases	Overarching	30	2.80^{a}	1.14	2.7	3.0		2.8	2.8		2.4^{a}	2.6^{a}	3.3^{b}	**	2.5	3.8	***
External challenges			3.70	0.48	3.7	3.6		3.7	3.6		3.5^{a}	3.6^{ab}	3.8^{b}	*	3.6	3.8	
Uncertainty of meat and milk prices	Market	1	4.28^{m}	0.76	4.3	4.2		4.4	4.1		4.5	4.3	4.1		4.3	4.2	
Volatility of commodity prices	Market	2	4.11^{lm}	0.85	4.0	4.3		4.3	3.8	*	4.2	4.2	4.0		4.0	4.5	*
Low farm income/difficult access to capital	Factor of production	3	4.08^{klm}	1.06	4.0	4.2		4.1	4.1		4.0	4.0	4.2		4.1	4.1	
Uncertainty in future changes in subsidies	Policy	6	3.97^{ijkl}	0.97	4.1	3.8		4.0	3.9		3.6^{a}	4.3^{b}	4.0^{ab}	*	4.0	3.9	
Low social knowledge about farming	Society	7	3.84^{hijkl}	1.02	4.0	3.6	*	3.9	3.8		3.7	3.7	4.1		3.7	4.2	
Low consumer education in local products	Society	8	3.81^{ghijk}	0.91	4.0	3.3	**	3.8	3.9		3.9	3.7	3.8		3.9	3.5	
Unfair trade/lack of traceability	Market	9	3.76^{fghij}	1.06	3.9	3.4	*	3.7	4.0		3.8^{ab}	3.3^{a}	4.2^{b}	**	3.8	3.5	
Climate change threats	Environment	10	3.73^{fghi}	0.95	3.9	3.4	*	3.6	4.0	*	3.5^{a}	3.6^{a}	4.1^{b}	*	3.7	3.9	
Farmer role unrecognized by society	Society	11	3.68^{efghi}	1.08	3.8	3.4		3.8	3.5		3.5	3.7	3.8		3.6	4.0	
Poor recognition of farming public services	Society	12	3.62^{defgh}	0.96	3.7	3.5		3.6	3.6		3.2^{a}	3.7^{b}	3.9^{b}	*	3.5	4.1	**
Market monopolized	Market	14	3.58^{defgh}	0.84	3.6	3.5		3.6	3.6		3.6	3.4	3.8		3.5	3.9	
Limited access to land	Factor of production	18	3.52^{defg}	1.22	3.5	3.5		3.3	3.9	*	3.0^{a}	3.3^{a}	4.2^{b}	***	3.5	3.5	
Low consumer demand	Society	23	3.39^{bcde}	1.25	3.0	4.1	***	3.6	2.9	**	3.0	3.7	3.4		3.3	3.5	
EU policy without scientific evidence	Policy	24	3.32^{bcd}	1.05	3.4	3.1		3.4	3.1		3.2	3.4	3.3		3.3	3.3	
Environmental policy against intensification	Policy	25	3.16^{bc}	1.17	3.3	2.9		3.1	3.3		3.4	3.0	3.1		3.1	3.2	
Researchers do not address real problems	Sciences	26	3.15^{bc}	1.14	3.2	3.1		3.0	3.4		2.8	3.3	3.2		3.2	2.9	
Wildlife conflicts	Environment	29	3.10^{b}	1.37	3.0	3.3		3.3	2.7		2.1^{a}	3.2^{b}	3.8^{c}	***	3.0	3.5	
Total challenges			3.60	0.41	3.6	3.4	*	3.60	3.6		3.4^{a}	3.6^{ab}	3.7^{b}	*	3.6	3.5	

[a–c] For the production system, means within the same row with different superscript differ at $P < 0.05$.
[1] Relevance was based on a 1–5 scale. Within this column, means with different superscript differ at $P < 0.05$.
[2] Abreviations: Int., intensive; Semi., Semi-intensive; Ext., Extensive; *** $P < 0.001$; ** $P < 0.01$; * $P < 0.05$.

address and vice-versa (Fig. 2). Moreover, significant differences were noted across challenges for their PI ($P < 0.001$, Table 4). The top 10 priority challenges had equal representation between internal and external categories. Most of them were related to low awareness/training at different levels such as farm, consumers, researchers and society as a whole. On the contrary, the lowest PI values corresponded to four external challenges about 'climate change threats', 'market monopolized' and 'wildlife conflicts'. The PI of challenges differed between geographical regions while just minor differences were found across production systems, type of products and animal species. Southern Europe had higher PI values for several internal and external challenges mostly related to the sector's structure and insufficient farmer and consumer awareness, while Central Europe had higher PI for 'parasite and infectious diseases'.

Identification of the stakeholders that need to take action

The combined participation of several stakeholders (2.8 on average) was perceived to be required to address the internal challenges (Table 5). Among them, the highest percentage of influence was attributed to farmers (27%), associations of producers (26%) and governments (23%), followed by academia (14%), while minor involvement (<5%) was needed from the processing industry, consumers and retailers. An average of 3.2 stakeholders was needed to address the external challenges: the government was considered the most responsible to address them (31%), followed by association of producers (16%), farmers (15%), academia (12%), processing industry (11%), retailers (8%) and consumers (8%). However, some challenges required the involvement of specific stakeholders such as the processing industry for 'low education in local products' and 'lack of traceability', academia and consumers for 'low social knowledge about farming', 'poor recognition of farming public services' and 'researcher do not address real problems'. Across the 30 identified challenges, it was perceived that farmers only compiled an average of 20% of the total responsibility/capacity to address the challenges concerning farm sustainability, whereas the remaining 80% would involve external stakeholders.

European research priorities for the small ruminants sector

A total of 332 EU-funded research projects directly or indirectly connected with the ruminant sector were identified (Fig. 3). One-third

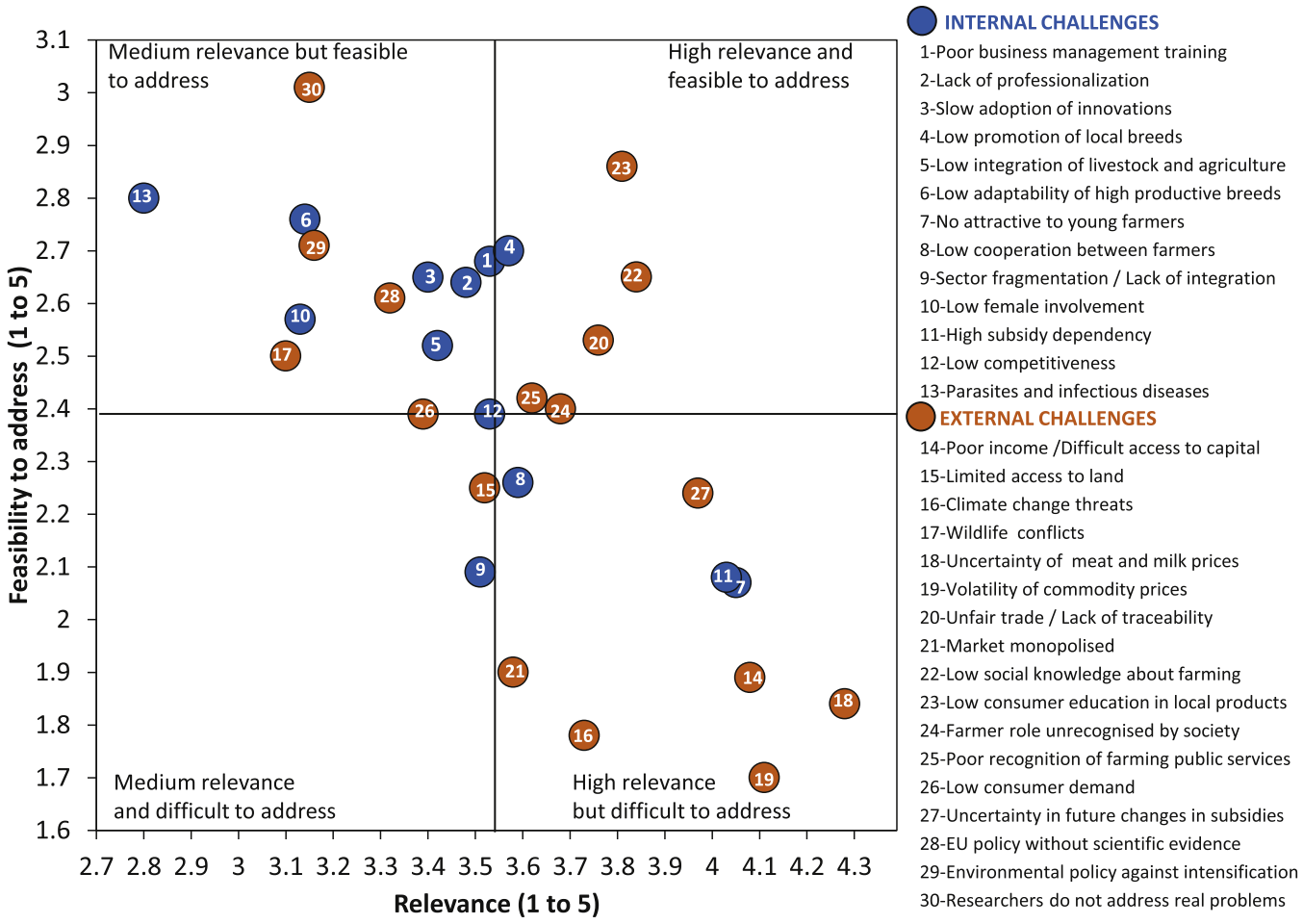

Fig. 2. Plot ilustrating the relationship between the relevance and the feasibility to adress the challenges identified for the European small ruminants farming sector. Quadrants are delimited by the means from each axis.

(35%) were related to research in small ruminants and two-thirds to cattle. Within the small ruminants related projects, two research areas, 'Health' and 'Climate Change and Environment' represented 60% of the total projects with very few contributions in other research areas such as 'Food and Natural Resources' (9%), 'Industrial Technologies' (8%) or 'Fundamental Research' (7%). On the contrary, projects related to cattle had a more even distribution across the different research areas with similar proportion of 'Health' (16%), 'Climate Change and Environment' (19%), 'Food and Natural Resources' (20%) and substantial figures for 'Industrial Technologies' (11%), 'Fundamental Research' (9%) or 'Energy' (6%). Similar results were observed when the number of research publications was investigated (75 468 in the last 10 years worldwide), 37% of them included studies in small ruminants and 67% in cattle. Within the publications related to small ruminants, only 83 included the words 'technology OR innovations' in their title, whereas 311 included 'health OR welfare' and 305 'climate change OR environment'.

Discussion

Collaborative multi-stakeholder process

Our study involved a wide stakeholder platform including sheep and goats farmers, breeding associations, cooperatives, advisers, meat producers, cheese producing companies, representatives of national governments within Agriculture departments from seven countries, international farming training organizations and academics specialized in nutrition, genetics, health, reproduction management, climate change and consumers behaviour. These stakeholders prioritized challenges using a multi-step process which gave opportunity to identify needs for capacity building, knowledge gaps and research (Thiele et al., 2011; Drago-Severson and Blum-DeStefano, 2018). Working in heterogeneous and informal groups revealed disparity of perspectives among stakeholders about the current and future trends in the ESRS and the implications of potential adaptation measures. Despite the diversity of stakeholders involved in this study, there was an even representation from the different farm typologies and socio-cultural/regional contexts to have a balanced vision of the ESRS. This approach ensured that most relevant economic, social, environmental, policy and technical attributes were considered (Paraskevopoulou et al., 2020). Previous analyses of ESRS include the perception of individual stakeholders such as European Commission reports, academic studies focusing on a range of specific issues such as consumer preferences (Montossi et al., 2013), dairy products market (Pulina et al., 2018; Ruiz-Morales et al., 2019), technical-economic performances (Castel et al., 2011; Mena et al., 2017) or describing the sector situation within specific countries (Sossidou et al., 2013). The present study is one of the first international multi-stakeholder participatory diagnoses of the problems and giving particular attention to the views of farmers and farming-related institutions. This exercise is an example of 'a structured communicative process of linking scientists with selected stakeholders that are relevant for the research problem at hand' (Welp et al., 2006).

Table 4
Priorities of the challenges for the European small ruminants sector across type of products, species, production systems and regions.

Challenges	Group	Priority Index[1]			Product		P	Species		P	Production system[2]			P	Region		P
		Rank	Mean	SE	Dairy	Meat		Sheep	Goat		Int.	Semi.	Ext.		South	Central	
Internal challenges			8.30	1.62	8.5	8.1		8.4	8.2		8.5	8.5	8.1		8.6	7.4	**
Low promotion of local breeds	Farming	2	10.04^{mn}	3.77	10.5	9.2		9.8	10.6		9.7	10.4	9.9		10.2	9.3	
Poor business management training	Farm	4	9.52^{klm}	2.48	9.4	9.9		9.5	9.5		10.3	9.8	8.7		9.8	8.6	
Lack of professionalization	Farm	7	9.08^{jkl}	3.32	9.1	9.1		9.1	9.1		9.8^{b}	9.5^{ab}	8.2^{a}	*	9.7	7.2	**
Slow adoption of innovations	Farm	8	8.86^{ijkl}	3.38	9.3	7.9		8.6	9.4		9.3	9.0	8.4		9.4	7.0	***
Low adaptability of high productive breeds	Farming	9	8.74^{hijk}	3.80	9.0	8.2		8.8	8.5		9.2	9.0	8.1		9.1	7.5	
Low competitiveness	Overarching	13	8.37^{fghij}	3.23	8.3	8.4		8.2	8.6		8.2	8.4	8.5		8.7	7.4	*
Low integration livestock and agriculture	Farming	14	8.36^{fghij}	4.22	8.4	8.2		8.2	8.7		9.0	7.9	8.3		8.7	7.4	*
High subsidy dependency	Overarching	15	8.24^{efghij}	2.64	8.2	8.4		8.7	7.2	**	8.2	8.4	8.2		8.3	8.2	
Low cooperation between farmers	Sector	18	7.85^{cdefgh}	3.07	8.2	7.1		7.8	8.0		8.7	7.9	7.2		7.8	7.8	
Not attractive to young farmers	Sector	20	7.75^{cdef}	2.63	7.9	7.4		8.0	7.2		7.5	8.0	7.7		8.1	6.8	
Low female involvement	Sector	24	7.44^{bcde}	2.50	7.3	7.8		7.9	6.6		6.9	7.9	7.5		7.6	6.9	
Parasites and infectious diseases	Overarching	25	7.18^{abcd}	3.65	6.9	7.7		7.2	7.1		6.9	7.0	7.5		6.8	8.3	*
Sector fragmentation/lack of integration	Sector	26	7.01^{abc}	3.25	7.4	6.1		7.0	6.9		7.1	7.2	6.7		7.4	5.6	*
External challenges			8.20	1.77	8.5	7.5	*	8.0	8.4		8.0	8.1	8.4		8.5	6.9	***
Low consumer education in local products	Society	1	10.91^{n}	4.28	12.1	8.4	***	10.1	12.5	**	10.8	10.3	11.5		11.5	8.9	**
Low social knowledge about farming	Society	3	9.74^{lm}	3.36	10.3	8.7		9.4	10.4		9.4	9.6	10.1		10.3	8.0	**
Researchers do not address real problems	Sciences	5	9.37^{klm}	3.52	9.5	9.0		9.2	9.8		8.5	9.9	9.6		9.7	8.2	
Unfair trade/lack of traceability	Market	6	9.32^{klm}	4.11	10.0	8.0	*	8.8	10.4		9.9	9.3	8.9		10.1	6.7	**
Poor recognition of farming public services	Society	10	8.72^{hijk}	3.05	9.1	7.9		8.7	8.8		8.1	8.3	9.5		8.8	8.4	
Uncertainty in future changes in subsidies	Policy	11	8.70^{ghijk}	3.07	8.2	6.9		7.9	7.6		8.2	7.3	7.9		8.2	6.3	
Farmer role unrecognized by society	Society	12	8.66^{ghijk}	4.15	9.6	6.8	**	8.3	9.5		8.2	8.6	9.1		9.4	6.3	**
EU policy without scientific evidence	Policy	16	$8.16^{defghij}$	2.85	8.5	7.3		8.3	7.8		8.1	8.6	7.7		8.7	6.5	**
Environmental policy against intensification	Policy	17	8.10^{defghi}	2.92	8.1	8.2		8.0	8.3		8.7	8.0	7.7		8.1	8.1	
Uncertainty of meat and milk prices	Market	19	7.78^{cdefg}	4.04	8.2	6.9		7.9	7.6		8.2	7.3	7.9		8.2	6.3	
Low consumer demand	Society	21	7.53^{bcdef}	3.11	7.7	7.2		7.1	8.6	*	6.2	7.8	8.3		8.0	5.9	*
Low farm income/difficult access to capital	Factor of production	22	7.51^{bcdef}	3.28	7.3	7.9		7.5	7.5		7.6	7.7	7.3		7.7	6.8	
Limited access to land	Factor of production	23	7.50^{bcdef}	3.41	7.5	7.4		7.2	8.1		7.8	6.6	8.0		7.6	7.0	
Volatility of commodity prices	Market	27	6.83^{ab}	3.38	7.0	6.4		7.1	6.3		7.1	6.2	7.2		7.2	5.7	*
Wildlife conflicts	Environment	28	6.80^{ab}	3.08	7.1	6.3		6.7	7.1		6.2	7.2	6.8		7.0	5.8	
Market monopolized	Market	29	6.76^{ab}	3.54	6.8	6.6		6.7	6.9		6.6	6.4	7.2		6.9	6.2	
Climate change threats	Environment	30	6.28^{a}	2.64	6.4	6.1		6.3	6.3		5.8	6.6	6.4		6.7	5.0	*
Total challenges			8.20	1.49	8.5	7.8		8.2	8.3		8.2	8.3	8.2		8.6	7.1	***

[a,b] For the production system, means within the same row with different superscript differ at $P < 0.05$.
[1] The Priority Index for each challenge was calculated as the product of its relevance (1–5 scale) and its ease to be addressed (1–5 scale). Within this column, means with different superscript differ at $P < 0.05$.
[2] Abreviations: Int., intensive; Semi., Semi-intensive; Ext., Extensive; *** $P < 0.001$; ** $P < 0.01$; * $P < 0.05$.

Relevance of the challenges

The challenges perceived as most relevant for the sustainability of ESRS were mainly linked to external economic aspects. These challenges are mostly beyond the control of farmers and farmers' institutions, since only 20% of the influence was assigned to the farmers. This situation reflects the weak position of farmers to deal with the most critical challenges for the ESRS sustainability. Therefore, different stakeholders, especially governmental institutions and retailers, need to be involved in strategic decisions.

The volatility and uncertainly of inputs and commodity prices were identified as relevant challenges for the sustainability of ESRS. While some variation in prices is considered to be normal in well-functioning markets, volatility becomes problematic when price fluctuations are large and unpredictable. The ESRS deals with higher price volatility levels than other livestock sectors because of three main factors: 1) meat and dairy products from small ruminants have variable and seasonal demand (e.g. peaks of consumption in Easter, Sacrifice Festivals and Christmas). Alternatively, production cycles are long and cannot be adapted easily causing short-term volatility. 2) The small ruminants sector is sensitive to natural factors such as adverse weather conditions and plant and animal diseases, and seasonal changes in the animal's physiology make output uncertain across the year (Montossi et al., 2013). 3) Following World Trade Organization agreement, EU agricultural sectors are more open to global markets and hence more vulnerable to international macro-economic changes such as food, feeds and oil prices or currency exchange rates (Westhoek et al., 2011). One recent example of macro-volatility was the COVID-19 pandemic that caused major market disruptions in the ESRS because the closure of the hospitality sector, which is considered the main selling point for small ruminants products. Moreover, the lower rates received by the farmers did not lead to reduced shelf prices and ultimately higher demand as previously reported (Ben-Kaabia and Gil, 2007).

Because of these economics constraints, the production costs in many European farms are higher than the total revenue (up to 52% in dairy sheep), making them highly dependent on EU Common Agricultural Policy (**CAP**) subsidies (Pulina et al., 2018). Our study revealed that market volatility was perceived as more relevant for the sheep than for the goat sector, possibly because it has higher seasonality in the offer-demand market. In this sense, there are mixed views about how to deal with market volatility in the European livestock sector (Moraine et al., 2014). Since its establishment in 1962, the EU CAP sought to stabilize markets and ensure a fair standard of living through market interventions measures. Over time, however, CAP reforms (1992, 2003, 2009, 2013 and 2020) have gradually reduced market interventions towards a more open market to increase farm incomes.

Table 5
Priorities and the expected inputs (in %) from each stakeholder to address the challenges for the European small ruminants sector.

Stakeholders	PI Rank	N° actors	Government	Farmers	Associations producers	Academia	Processing industry	Consumers	Retailers
Internal challenges		2.8	$24^{d} \pm 7$	$27^{e} \pm 8$	$26^{de} \pm 9$	$13^{c} \pm 8$	$6^{b} \pm 4$	$3^{a} \pm 3$	$2^{a} \pm 2$
Low promotion of local breeds	2	2.5	$27^{c} \pm 12$	$27^{c} \pm 16$	$23^{bc} \pm 14$	$22^{b} \pm 23$	$0^{a} \pm 0$	$1^{a} \pm 6$	$0^{a} \pm 0$
Poor business management training	4	3.0	$29^{c} \pm 28$	$25^{c} \pm 21$	$25^{c} \pm 21$	$12^{b} \pm 19$	$5^{ab} \pm 10$	$2^{a} \pm 7$	$2^{a} \pm 7$
Lack of professionalization	7	3.5	$28^{d} \pm 12$	$21^{c} \pm 17$	$28^{d} \pm 12$	$17^{c} \pm 15$	$6^{b} \pm 11$	$0^{a} \pm 0$	$0^{a} \pm 3$
Slow adoption of innovations	8	3.4	$21^{bc} \pm 19$	$27^{d} \pm 15$	$26^{cd} \pm 15$	$19^{b} \pm 19$	$6^{a} \pm 11$	$1^{a} \pm 3$	$1^{a} \pm 4$
Low adaptability of high productive breeds	9	1.9	$15^{b} \pm 18$	$24^{c} \pm 19$	$24^{c} \pm 22$	$34^{d} \pm 33$	$2^{a} \pm 9$	$0^{a} \pm 0$	$0^{a} \pm 3$
Low competitiveness	13	3.9	$16^{b} \pm 18$	$24^{c} \pm 16$	$16^{b} \pm 14$	$7^{a} \pm 11$	$16^{b} \pm 13$	$7^{a} \pm 11$	$14^{b} \pm 14$
Low integration of livestock and agriculture	14	2.7	$32^{d} \pm 27$	$26^{cd} \pm 21$	$21^{bc} \pm 17$	$15^{b} \pm 21$	$2^{a} \pm 8$	$3^{a} \pm 9$	$1^{a} \pm 5$
High subsidy dependency	15	2.8	$43^{d} \pm 33$	$20^{c} \pm 18$	$20^{c} \pm 18$	$4^{ab} \pm 8$	$3^{ab} \pm 8$	$8^{b} \pm 13$	$1^{a} \pm 6$
Low cooperation between farmers	18	2.0	7b ± 14	$49^{d} \pm 16$	$40^{c} \pm 17$	$1^{a} \pm 7$	$1^{a} \pm 5$	$0^{a} \pm 0$	$1^{a} \pm 4$
Not attractive to young farmers	20	3.4	$28^{bc} \pm 21$	$23^{b} \pm 22$	$30^{c} \pm 26$	$6^{a} \pm 10$	$5^{a} \pm 10$	$6^{a} \pm 10$	$2^{a} \pm 5$
Low female involvement	24	1.9	$31^{b} \pm 27$	$29^{b} \pm 25$	$28^{b} \pm 19$	$7^{a} \pm 15$	$1^{a} \pm 8$	$3^{a} \pm 16$	$0^{a} \pm 0$
Parasites and infectious diseases	25	2.2	$15^{b} \pm 21$	$33^{d} \pm 26$	$22^{c} \pm 19$	$29^{cd} \pm 23$	$0^{a} \pm 3$	$1^{a} \pm 4$	$0^{a} \pm 0$
Sector fragmentation/lack of integration	26	3.3	$10^{b} \pm 13$	$26^{d} \pm 20$	$30^{d} \pm 18$	$4^{a} \pm 9$	$20^{c} \pm 17$	$2^{a} \pm 5$	$7^{ab} \pm 10$
External challenges		3.2	$30^{d} \pm 9$	$15^{c} \pm 8$	$16^{c} \pm 7$	$12^{b} \pm 6$	$11^{b} \pm 6$	$8^{a} \pm 4$	$8^{a} \pm 4$
Low consumer education in local products	1	3.4	$29^{c} \pm 20$	$7^{a} \pm 11$	$22^{c} \pm 28$	$10^{ab} \pm 16$	$14^{b} \pm 14$	$10^{ab} \pm 13$	$8^{ab} \pm 13$
Low social knowledge about farming	3	4.1	$21^{cd} \pm 19$	$12^{ab} \pm 10$	$23^{d} \pm 28$	$17^{bcd} \pm 19$	$6^{a} \pm 9$	$15^{bc} \pm 14$	$7^{a} \pm 8$
Researchers do not address real problems	5	2.8	$20^{b} \pm 22$	$19^{b} \pm 30$	$20^{b} \pm 18$	$33^{c} \pm 22$	$5^{a} \pm 12$	$2^{a} \pm 6$	$2^{a} \pm 6$
Unfair trade/lack of traceability	6	3.6	$23^{d} \pm 24$	$12^{bc} \pm 15$	$17^{bcd} \pm 16$	$4^{a} \pm 8$	$19^{cd} \pm 26$	$10^{ab} \pm 13$	$15^{bc} \pm 13$
Poor recognition of public services of farming	10	3.2	$36^{d} \pm 27$	$20^{c} \pm 20$	$13^{b} \pm 13$	$11^{b} \pm 12$	$3^{a} \pm 7$	$15^{bc} \pm 18$	$2^{a} \pm 6$
Uncertainty in future changes in subsidies	11	2.6	$48^{e} \pm 28$	$18^{d} \pm 19$	$14^{cd} \pm 16$	$10^{bc} \pm 15$	$3^{a} \pm 7$	$6^{ab} \pm 11$	$1^{a} \pm 5$
Farmer role unrecognized by society	12	4.7	$19^{c} \pm 12$	$19^{c} \pm 15$	$18^{c} \pm 14$	$11^{ab} \pm 12$	$9^{a} \pm 10$	$16^{bc} \pm 21$	$8^{a} \pm 9$
EU policy without scientific evidence	16	1.6	$50^{d} \pm 26$	$2^{a} \pm 7$	$16^{b} \pm 16$	$31^{c} \pm 18$	$0^{a} \pm 0$	$1^{a} \pm 4$	$0^{a} \pm 0$
Environmental policy against intensification	17	2.3	$44^{d} \pm 32$	$13^{bc} \pm 16$	$18^{c} \pm 17$	$17^{c} \pm 23$	$6^{ab} \pm 14$	$1^{a} \pm 8$	$1^{a} \pm 4$
Uncertainty of meat and milk prices	19	4.0	$19^{c} \pm 21$	$13^{b} \pm 12$	$12^{b} \pm 12$	$3^{a} \pm 8$	$25^{d} \pm 19$	$8^{ab} \pm 12$	$21^{cd} \pm 13$
Low consumer demand	21	3.9	$7^{a} \pm 12$	$9^{a} \pm 11$	$11^{a} \pm 11$	$8^{a} \pm 12$	$21^{b} \pm 12$	$22^{b} \pm 14$	$22^{b} \pm 12$
Low farm income/difficult access to capital	22	3.3	$33^{c} \pm 25$	$16^{b} \pm 15$	$15^{b} \pm 20$	$7^{a} \pm 14$	$13^{ab} \pm 12$	$6^{a} \pm 16$	$10^{ab} \pm 12$
Limited access to land	23	2.2	$55^{c} \pm 31$	$21^{b} \pm 21$	$19^{b} \pm 18$	$5^{a} \pm 17$	$0^{a} \pm 0$	$0^{a} \pm 0$	$0^{a} \pm 0$
Volatility of commodity prices	27	3.5	$28^{c} \pm 29$	$13^{b} \pm 13$	$9^{b} \pm 12$	$1^{a} \pm 5$	$27^{c} \pm 15$	$8^{ab} \pm 13$	$14^{b} \pm 15$
Wildlife conflicts	28	2.3	$39^{d} \pm 33$	$29^{c} \pm 32$	$13^{b} \pm 14$	$12^{b} \pm 19$	$0^{a} \pm 0$	$6^{ab} \pm 10$	$0^{a} \pm 3$
Market monopolized	29	3.1	$26^{d} \pm 24$	$12^{bc} \pm 14$	$13^{c} \pm 14$	$2^{a} \pm 6$	$20^{d} \pm 17$	$6^{ab} \pm 11$	$21^{d} \pm 22$
Climate change threats	30	3.2	$28^{e} \pm 29$	$20^{cd} \pm 24$	$15^{bc} \pm 14$	$25^{de} \pm 23$	$9^{ab} \pm 13$	$2^{a} \pm 5$	$2^{a} \pm 5$
Total challenges		3.0	$27^{e} \pm 7$	$20^{d} \pm 7$	$20^{d} \pm 7$	$12^{c} \pm 7$	$9^{b} \pm 5$	$6^{a} \pm 3$	$6^{a} \pm 3$

[a–e] Means within a row with different superscript differ at $P < 0.05$; PI, priority index.

The current CAP still aims to compensate farmers for the negative effects of price volatility through direct payments; moreover, EU Rural Development Programs support risk management tools to farmers.

This EU policy has created a subsidy dependent sector and, according to some authors, has reduced innovation and adaptation capacity which are key for long-term farm sustainability (De Rancourt et al., 2006; Busch et al., 2018). We found that 'high subsidy dependency' was perceived as the fifth most relevant challenge, being more important for sheep than for goat systems, whereas the 'uncertainty in future changes in subsidies' was perceived as higher in relevance for extensive than for intensive systems, which might indirectly reflect a higher subsidy dependency. In line with our findings, different studies have shown that

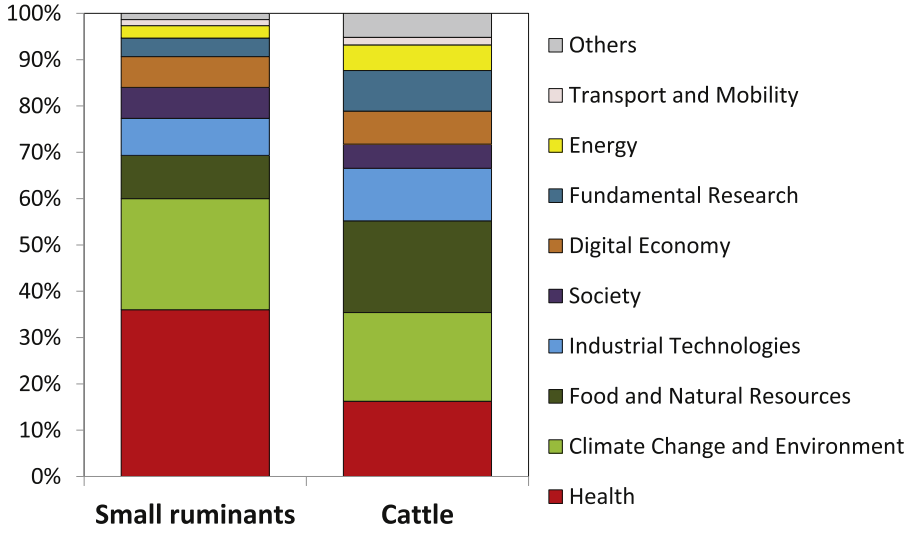

Fig. 3. Distribution of the number of EU project (FP7 and H2020) across the different research areas for small ruminants ($n = 117$) and cattle ($n = 215$).

subsidies can represent 6% of the total incomes in intensive dairy goat farms (Pulina et al., 2018) and up to 70% in extensive meat sheep (Hennessy and Moran, 2015).

Additionally, according to Farm Accountancy Data Network (FADN) (2017), the average EU agricultural income per family work unit is lower for specialized sheep and goat-rearing (€12 900) compared to beef cattle (€14 400), dairy cows (€22 900) and monogastrics farms (€49 000). These low income and high labour requirements make ESRS unappealing to young farmers, as noted in our study. As a result, the challenge 'sector not attractive to young farmers' was perceived as not only the most relevant external challenge but also the most difficult to address, possibly because it represents the consequence of multiple factors that should be addressed in first instance. Our study showed that low farmers' income and job attractiveness were perceived as equally relevant across all ESRS production typologies representing common and significant problems that compromise the viability of the entire sector for the next generation.

Feasibility to address challenges

Several authors (De Rancourt et al., 2006; Castel et al., 2010; Castel et al., 2011; Montossi et al., 2013; Pulina et al., 2018) proposed different strategies to tackle the economic challenges of the sheep and goat sectors such as: 1) increasing farm size and intensification, 2) decreasing seasonality of production, 3) implementing new technologies in reproduction, management and breeding strategies, 4) promoting feed self-sufficiency, 5) promoting cooperatives and relationships between farmers and food industries and 6) improving product diversification and differentiation. Most of these strategies focus on the economic and technical aspects of farming, and our findings agreed with these studies on the high relevance of economic challenges.

Our study revealed a substantial variability in the perceived feasibility to address the identified challenges. Therefore, our priority assessment, which also included the feasibility of addressing the challenges, found that many of the most relevant challenges were external. This makes it difficult to address since they are intimately linked to the low flexibility of the traditional production systems (De Rancourt et al., 2006) and market idiosyncrasy (Ben-Kaabia and Gil, 2007). Our study also revealed that these issues are perceived as more challenging to address in Southern than Central Europe. This could be due to higher feeding costs derived from a lower availability of perennial pastures, insufficient sector structure (e.g. not so developed cooperative organizational systems and farmers associations) and market idiosyncrasy (e.g. asymmetric price transmission thought the food chain) in Southern Europe (De Rancourt et al., 2006; Ben-Kaabia and Gil, 2007; Mena et al., 2017; Ruiz-Morales et al., 2019).

Several internal challenges were perceived as non-difficult to address ('parasite and infectious diseases', 'low adaptability of high productive breeds', 'low promotion of local breeds', 'poor business management training', 'slow adoption of innovations' and 'lack of professionalization'). Solving these challenges was likely perceived as more achievable as they rely on the successful implementation of technology and innovations, health treatments, disease surveillance, appropriate breeding programmes and farmer training initiatives. It has been described that the successful implementation of these strategies can improve farm productivity and sustainability, offering career opportunities for young people (Pulina et al., 2018). Furthermore, several external challenges related to education and sciences were also considered achievable such as 'researchers do not address real problems', 'low consumer education in local products', 'environmental policy against intensification' and 'low social knowledge about farming'. These observations justify the need to consider, not only the relevance but also the feasibility to address the challenges during the prioritization process. Considering both the relevance and feasibility to address the challenges, this study identified a number of prioritized challenges that could be grouped in four areas as follows.

Enhancing consumer and social awareness

Our analysis showed that several aspects related to consumer and society knowledge on sheep and goat farming (i.e. 'low consumer education in local products', 'low social knowledge about farming' and 'poor recognition of public services of farming') are of great importance for the ESRS. These results point out the existing miscommunication between rural and urban societies and the different perceptions on the production systems and food attributes (Mceachern and Seaman, 2005). Our study also revealed that this lack of knowledge is more relevant in Southern than in Central Europe and for dairy than meat systems, possibly because of higher product diversification (e.g. cheese, yogurt, meat) in comparison to meat production systems (De Rancourt et al., 2006).

Previous SWOT analyses have also identified similar external challenges for the ESRS because of declining consumption of animal products, and ruminant products in particular, even if they may have been produced and transformed in a sustainable manner (Pulina et al., 2018; Ruiz-Morales et al., 2019). This might indicate that societal knowledge on the ways that ruminant foods are produced is poor (Montossi et al., 2013). Consumers prefer local or national products because they are considered fresher, tastier and of better quality (Chambers et al., 2007). However, consumers also prefer cheaper options which are often imported products and affect the market of local sheep and goat products (Chambers et al., 2007; Montossi et al., 2013). Product diversification and commercialization of easy-to-cook foods (e.g. pre-cooked recipes, new meat cuts and dairy products) along with marketing campaigns can, to some extent, stimulate consumption of small ruminants products (Mandolesi et al., 2020). However, providing more information to consumers about animal rearing conditions, feeding and animal welfare, previous to lamb consumption, positively influenced consumer acceptability, contributing to improved satisfaction of their expectations (Napolitano et al., 2007; Font i Furnols et al., 2011). As a result, product information about high standards of animal welfare or more 'natural' production systems is starting to be used as a marketing strategy (Blokhuis et al., 2013). In our study, the assessment of stakeholders that should take action in addressing the reduced consumer demand and social awareness in local products included governments, association of producers and consumers themselves.

In recent years, social awareness about how food is produced has increased livestock farming (Blokhuis et al., 2013). After a systematic review of 80 publications, Clark et al. (2016) reported that the public is concerned about animal welfare in modern production systems with variations in relation to age, gender, education and familiarity with farming. As a result, consumers adopted self-justifications to avoid animal products (Busch and Spiller, 2018). This has led the ESRS to work on a cross-sectoral communication with the public in recent years in order to correct existing misconceptions about animal husbandry (Blokhuis et al., 2013). This information deficit-approach assumes that better knowledge within the public about farming will increase the acceptance of husbandry systems. Although such strategies may increase transparency with regard to animal farming, they have largely failed to increase acceptance for existing systems (Montossi et al., 2013). In some cases, such strategies provoke the opposite reactions and people can get even more critical towards livestock farming due to the new information they received (McNeill, 2014). Reasons may lie in different reference frames and values between experts and laypeople about farming.

The challenge 'poor recognition of public services of farming' was perceived as a more relevant and priority in extensive than in intensive production systems. Several studies indicate that sheep and goat semi-extensive and extensive farming systems provide multiple ecosystem services that improve environmental diversity, landscape conservation, fire prevention, carbon sequestration and employment in rural areas (Bernués et al., 2011; Sanderson et al., 2013; Rodríguez-Ortega et al., 2014; Herrero et al., 2015). These public services justify further EU public support for a 'Greening CAP' paying for ecosystem services

(Rodríguez-Ortega et al., 2018). However, our study showed that the role of ESRS for environmental and social services is not perceived equally across the society. Therefore, more collaboration between government, farmers and food industry would guarantee effective knowledge transfer through the food chain.

Farmer's capacity building

Insufficient sheep and goat farmer professionalization and farm modernization have often been identified as key weaknesses of the ESRS. Previous studies based on SWOT analyses (De Rancourt et al., 2006; Pulina et al., 2018), technical-economic indicators (Castel et al., 2011; Mena et al., 2017) and country-specific observations (Castel et al., 2010; Sossidou et al., 2013) highlighted that farmers need more capacity building beyond the farm gate through training, developing public advisory services, promoting innovation and modernization and better product commercialization. Our study reflected this situation and highlighted insufficient business management training, slow adoption of innovations on-farm and lack of professionalization. Our study also revealed that these challenges are a higher priority in intensive production systems from Southern Europe (mostly dairy), compared to the more extensive grazing system from Central Europe which are mostly devoted to sheep meat production.

This observation highlights the need to enhance specific skills such as artificial milk feeding, milking, insemination and product diversification in intensive dairy systems (Thornton, 2010) or pasture management and monitoring of technical-economic indicators in extensive systems (Castel et al., 2011). Our study revealed that improved farmer's skills is perceived as easy to solve and should be given high priority. This aspect can even be considered as an opportunity if farmers, associations of producers, governments and academia work together to develop comprehensive training programs tailored at a regional level to address the needs of local farmers and new entrants (Ruiz-Morales et al., 2019). Programs that build farmer capacity developed by regional governments and technical courses promoted by farmers associations and cooperatives could aid to address this problem by encouraging the innovation uptake by the farmers. For example, recently and as part of the iSAGE project, we have shown that implementation of smart-farming technology based on individual animal data minimizes unproductive periods and assists farmers in their decision-making, increasing productivity in dairy goats farms (Belanche et al., 2019). These innovations promote a step change when farmers have sufficient knowledge beyond the farm gate for business management training and risks assessment based on the use of technical-economic indicators (Gaspar et al., 2008).

Promoting local breeds

Local breeds are a major component of animal farm biodiversity, despite the low census of some autochthonous breeds, which represents a weakness (Castel et al., 2010; Montossi et al., 2013; Ruiz-Morales et al., 2019). Adding value to local breeds contributes to their conservation. 'Low promotion of local breeds' and 'low adaptability of high producing breeds' were challenges perceived as moderately relevant, but were considered as two of the easiest to address through appropriate breeding programs (Martin-Collado et al., 2013) and therefore are considered a strategic priority.

Local dairy goat breeds are traditionally reared in semi-extensive systems using marginal territories (Pulina et al., 2018) and have a highly variable production (150 to 500 kg/lactation). Despite their improvement through recent breeding and management programs (Belanche et al., 2019), they are still far from foreign breeds (800–950 kg/lactation) such as Saanen or Alpine (Pulina et al., 2018). The dairy sheep industry is based on local breeds and crossbreeds raised under more intensive systems than dairy goats, but with increasing importance of foreign breeds such as Assaf and East Friesian (Pulina et al., 2018). As a result, the census of some local dairy breeds in Europe is a growing cause for concern. However, this change in the use of breeds is not always accompanied with improvements in feeding, sanitary programs, milking automation, reproduction intensification, management or genetic selection, aspects that can severely limit their productivity (Miller and Lu, 2019).

The European meat sheep sector is dominated by local rustic breeds (e.g. Merino, Rasa Aragonesa, Welsh Mountain or Scottish Blackface) which often produce branded local products (e.g. Ternasco de Aragon, Welsh lamb, Scottish lamb). However, the European sheep meat production has decreased by 34% in the last decade causing imports of lamb meat mostly from New Zealand and Australia (FAOSTAT, 2020). This, along with the substantial decrease in lamb consumption, has led to a crisis in the EU meat sheep sector (Montossi et al., 2013). Our study identified that both challenges ('low promotion of local breeds' and 'low adaptation of high producing breeds') were perceived as more relevant for the dairy than for the meat sector and in Southern than in Central Europe. These observations could be justified because dairy animals are more sensitive than meat animals to the environmental factors such as feed scarcity and heat stress typical from Southern European countries (Ramón et al., 2016).

To solve this situation, the European Commission allocates resources for the implementation of regional programs to promote local breeds. These resources are normally for breeding associations and farmers to subsidize some breeding programs costs such as milk controls or artificial inseminations to improve productivity (Ruiz-Morales et al., 2019). This investment has allowed substantial increase in productivity in some local breeds such as the Lacaune sheep in France or the Murciano-Granadina goats in Spain (Belanche et al., 2019). However, our study revealed that this financial support seems insufficient and requires a stronger collaboration between governments, farmers, producers and academia. A recent report from the European Parliament (A8-0064/2018) called on the Commission to take measures to step up support for the keeping and promoting further sheep and goat local breeds.

Re-focusing research priorities

Despite the multi-stakeholder process used in this study aimed to maximize the adherence between the identified challenges and the real situation of the ESRS, we are aware that the slight overrepresentation of research institutions in this process could magnify some of their concerns, such as 'researchers do not address real problems'. Our study identified this challenge as a priority across species, production systems, type of products and regions, mostly because it was perceived as the easiest to solve. Although in the last 10 years a total of 117 EU research projects have been funded to address different aspects related to small ruminants, along with 28 102 research publications worldwide, our study revealed that this sector has the perception that researchers do not satisfactorily deal with relevant issues at farm level. Most EU projects supporting the ESRS focused on two specific research areas ('health' and 'climate change and environment') which are aspects of great social concerns, but that as our multi-stakeholder survey revealed are not the priority for the ESRS. Similar overrepresentation of these two research areas in comparison with the area 'technology OR innovation' was also identified in the research publications related to small ruminants. On the contrary, cattle-related funded projects had a more even distribution across research areas and provided more support to areas such as 'food and natural resources' and 'industrial technologies'. These aspects are more focused on production elements that likely lead to improving farm profitability through innovations (Thornton, 2010). These findings show that in order to improve the ESRS perception on the usefulness of public research, which will likely facilitate their confidence on governmental agencies and their participation in research activities, the views from ESRS (including farmers, associations of producers, breeders and cooperatives) should be more effectively communicated to governments and funding agencies, so they can be incorporated into future research funding programs and agricultural policies (Blokhuis et al., 2013).

Conclusion

The proposed multi-stakeholder participatory analysis identified the ESRS main challenges. The challenges perceived as most relevant were related to economic aspects but were mostly beyond the farmer's control (external) and difficult to address. The implementation of a priority index facilitated the prioritization of challenges by considering the relevance and the feasibility to be addressed. The results of our study suggest that knowledge development at farm level (i.e. farmer's capacity building), consumers (i.e. increase consumer knowledge on food products), society (i.e. increasing social recognition of the ESRS role on delivering public services) and academia (i.e. increase applied research focused on key sector challenges) are the priorities. Promoting local breeds was also identified as a priority to preserve diversity and cultural heritage. Effective collaboration and knowledge transfer across the different stakeholders involved in the ESRS are needed to address these challenges. Moreover, the different perception across regions in Europe suggests that the upcoming policies should be more contextualized for different regions than they have been before.

Supplementary materials

Supplementary data to this article can be found online at https://doi.org/10.1016/j.animal.2020.100131.

Ethics approval

Surveys were anonymized.

Data and model availability statement

Data are available on request to the corresponding author.

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Declaration of interest

All authors declared no conflict of interest.

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