Centro de Estudios e Investigación para la Gestión de Riesgos Agrarios y Medioambientales

ESCUELA TÉCNICA SUPERIOR DE INGENIERÍA AGRONÓMICA, ALIMENTARIA Y DE BIOSISTEMAS

Resilience of extensive sheep farming systems in Spain: strategies and policy assessment

Tesis Doctoral

Daniele Bertolozzi Caredio Ingeniero Agronomo

Directores

Alberto Garrido Colmenero Dr. Ingeniero Agrónomo

Universidad Politécnica de Madrid

Isabel Bardají Azcárate Dr. Ingeniero Agrónomo

Universidad Politécnica de Madrid

Madrid, 2021

UNIVERSIDAD
POLITÉCNICA
DE MADRID

Tribunal nombrado por el Sr. Rector Magfco. de la Universidad Politécnica de Madrid, el día .... de .... de 2021

Presidente: ....

Vocal: ....

Vocal: ....

Vocal: ....

Secretario:...

Suplente:...

Suplente: ....

Realizado el acto de defensa y lectura de la Tesis el día ...... de .... de 2021 en la E.T.S.I./Facultad ....

Calificación ....

EL PRESIDENTE LOS VOCALES

EL SECRETARIO

A mia moglie Afsaneh,

ai miei genitori Emmi e Giovanni,

e a mia sorella Maddalena

ACKNOWLEDGMENTS

First and foremost, I am extremely grateful to my supervisors, Alberto and Isabel for their invaluable advice, continuous support, and patience during my PhD study. Their immense knowledge and plentiful experience have encouraged me in all the time of my academic research and daily life. They made me live with great serenity my PhD studies and my stay in Madrid. A special thanks to Isabel, who accepted me as an Erasmus student before my doctoral studies.

I would also like to thank Barbara for leading me into the SURE-Farm project, and for supporting me during my PhD thesis research. During these years, she helped me with great patience and kindness, not just for academic purposes, but also in my daily life. That is why I consider her as a guide and an example to follow.

I want to thank all people in CEIGRAM that, during my stay in Madrid, I considered as my family. Special thanks to Esperanza, Katerina and Begoña, pillars of CEIGRAM! And thanks to my friends Hamid, Andres, David, Caterina, Maritza, Omar, Jorrit, Adel, Sofia, Esteban, Nicolas and all those who shared with me a piece of their life. I will never forget this beautiful experience in CEIGRAM and what it meant to me.

I would like to thank all the members of the SURE-Farm project. This international experience has afforded me greater awareness, skills and goals. I much learned from all the project's partners, and for this, I am grateful.

Finally, I would like to express my gratitude to my wife, who supported me with extreme dedication over the last years, despite all the challenges. She was, and she is, the reason for all my goals, efforts and achievements.

SUMMARY

European extensive sheep farming is undergoing several challenges and negative trends, which are threatening the capacity of sheep systems to generate income and provide public/private goods/services. This is particularly evident in the marginal and rural areas of southern EU, affected by gradual depopulation, abandonment, and transitions to more intensive and specialized sectors. Concerns over the survival of extensive sheep farming are basically due to the wide range of ecosystem services and socio-economic functions delivered by sheep systems, above all in those marginal areas where other productive activities are unfeasible. In order to find new solutions to overcome existing challenges, and anticipate the emerging ones, novel comprehensive and multidisciplinary approaches to assess the farming systems' capacity to keep delivering their important functions are required. Within this broad scope, in recent years great importance has been attached to the resilience theory and its adaptations to agri-food systems. Most recent advances in resilience research in the EU have provided theoretical and analytical frameworks to assess the resilience of farming systems. Such approaches demonstrate remarkable potential, and worth being applied further.

The motivation of the PhD thesis is rooted into the urgent need to identify development trajectories and resilience paths that allow to conserve and boost the role played by extensive sheep farms in marginal areas of Spain, given the particular vulnerability of this sector. Sheep farms, in fact, are affected by several socio-economic, institutional and environmental challenges. Among the others, there is concern about the sharp reduction in lamb meat consumption, and the structural low profitability that is leading to transition to intensive productions, and the lack of workers and young successor willing to enter the sector. The main goal of the thesis, therefore, is to assess the strategies, management patterns, and policies that could potentially promote the capacity of extensive sheep farming systems to keep delivering their unreplaceable functions and services, in spite of the current and future challenges threatening the sector. To this end, the thesis research focuses on the case study of extensive sheep farms of Huesca, Aragón, Northeast Spain, with a minor incursion in the extensive beef farming of Sierra Guadarrama, Central Spain. In order to achieve the main goal, different aspects of extensive sheep farming system need to be investigated. These are addressed by five specific objectives: I) to identify the factors threatening intra-family farm succession and its characterizing phases; II) to identify the resilience attributes and capacities in alternative farm management patterns; III) to quantify the economic performance of alternative production strategies to cope with main economic risks; IV) to identify new ways through which risk management strategies may improve resilience; and V) to assess the impact of different policies on farms' resilience, and to highlight potential developments in the policy framework.

The PhD thesis methodology draws upon the most recent advances in resilience research in Europe, with special regard to the assessment framework provided by the H2020 SURE-Farm project[1], within which this thesis was developed. The thesis is based on a comprehensive and multidisciplinary methodology including multiple sources of data, and qualitative and

[1] https://www.surefarmproject.eu/

quantitative methods of analysis. The thesis investigation was carried out through four research studies, each targeting the first four research objectives, respectively. The fifth objective overarches the four studies. The first and the second research studies consist of a qualitative content analysis of 28 semi-structured interviews to farmers and their relatives. The third research study is based on an economic risk assessment including a farm profitability model and stochastic simulations, using national accountancy data and information from a survey of 60 farmers in Huesca. The fourth research study consists of a content analysis and coding of qualitative data from a focus group involving eight farming system's stakeholders in Huesca.

The PhD thesis results show that intra-family farm succession follows three key steps: the potentiality of succession, the successor's willingness to take over, and the effectiveness of succession. The willingness step was found to be the weakest step threatening the farm continuity in the sector, whereas the policy framework seems to be supporting almost exclusively the last step of effectiveness.

Along with the farm continuity, sheep farms in the region can follow four alternative development trajectories, namely extensification (more reliance on pasture-based), intensification (more stable-based), re-orientation (reduction of sheep and diversification), and conservation (farms' structure maintenance based on quality production). All patterns promote adaptability to some extent, but the patterns extensification and conservation mainly contribute to robustness to reinforce the original farms' structure, whereas the patterns re-orientation and intensification lead to transformations. There is clear distinction among resilience attributes determining transformative patterns like intensification and re-orientation, and those favouring the conservation or re-adjustment of traditional extensive management. The policy framework appears to drastically favour the transition towards more intensive or different productions.

Across the four farm trajectories, two main supply- and demand-oriented strategies seem promising: the increase of sheep prolificacy, and the use of protected geographical identification labels. The thesis findings highlight that feeding costs are the major source of risk, and that increased prolificacy has the greatest potential to mitigate this risk. In contrast, the quality labelling strategy shows scant performance, and appears to be more vulnerable to price variability.

The multi-stakeholder focus group indicated four main strategies to enhance resilience in the sector, i.e. 1) improving investment, financing capacity and insurance; 2) promoting lamb meat consumption (including bargaining power in value chain); 3) value extensive livestock contribution to environmental conservation and population retention; and 4) training and knowledge transfer. The stakeholders suggested manifold options to improve these strategies, which can be grouped into three main avenues: cooperation & marketing, the knowledge system, and the policy & financial tools.

This PhD thesis research provides a comprehensive and multifaceted analysis of the extensive sheep farming system dynamics in Huesca, and the different aspects that determine its resilience capacity, thus proving the efficacy of this resilience assessment approach. In addition, the thesis hints at ideas for future research in the case study area, mainly regarding the generational renewal and developments in the policy framework, as well as about the comparison with and generalization over other farming systems' resilience assessments.

RESUMEN

La ganadería ovina extensiva europea está atravesando tiempos en los que vive varios desafíos y tendencias negativas que amenazan la capacidad de los sistemas de ovino extensivo para generar ingresos y proporcionar bienes y servicios públicos / privados. Esto es particularmente evidente en aquellas zonas marginales y rurales del sur de la UE, afectadas por procesos graduales de despoblación, abandono y transiciones hacia sectores más intensivos y especializados. Las preocupaciones sobre la supervivencia de la ganadería extensiva de ovinos se deben básicamente a la amplia gama de servicios ecosistémicos y funciones socioeconómicas que brindan los sistemas de ovino, sobre todo en aquellas áreas marginales donde otras actividades productivas son inviables. Con el fin de encontrar nuevas soluciones para superar los desafíos existentes y anticipar los emergentes, se requieren enfoques novedosos, integrales y multidisciplinares para evaluar la capacidad de los sistemas agrícolas para seguir cumpliendo sus importantes funciones. En este ámbito, en los últimos años se ha otorgado gran importancia a la teoría de la resiliencia y sus adaptaciones a los sistemas agroalimentarios. Los avances más recientes en la investigación de la resiliencia en la UE han proporcionado marcos teóricos y analíticos para evaluar la resiliencia de los sistemas agrícolas. Estos enfoques demuestran un potencial notable de lograr hallazgos útiles, por lo que merecen ser aplicados.

La motivación de la tesis radica en la urgente necesidad de identificar trayectorias de desarrollo y caminos de resiliencia que permitan conservar e impulsar el papel que juegan las explotaciones extensivas de ovino en zonas marginales de España, dada la especial vulnerabilidad de este sector. El sector ovino, de hecho, se ve afectado por varios desafíos socioeconómicos, institucionales y ambientales. Entre otros, preocupa la fuerte reducción del consumo de carne de cordero, y la baja rentabilidad estructural que está llevando a la transición a producciones intensivas, y la falta de trabajadores y jóvenes sucesores dispuestos a ingresar al sector. El objetivo principal de la tesis, por lo tanto, es evaluar las estrategias, modelos de manejo y políticas que promuevan la capacidad de los sistemas de ganadería extensiva de ovino para seguir entregando sus funciones y servicios insustituibles, a pesar de los desafíos actuales y futuros que amenazan al sector. Para ello, la investigación de la tesis se centra en el estudio de caso de las explotaciones extensivas de ovino de Huesca, Aragón, noreste de España, con una pequeña incursión en la ganadería extensiva de vacuno de Sierra Guadarrama, en el Sistema Central. Para lograr el objetivo principal, es necesario investigar diferentes aspectos del sistema extensivo de cría de ovejas. Estos son abordados en cinco objetivos específicos: I) identificar los factores que amenazan la sucesión intrafamiliar y sus fases características; II) identificar los atributos y capacidades de resiliencia en modelos alternativos de gestión agrícola; III) cuantificar el potencial económico de estrategias de producción alternativas para hacer frente a los principales riesgos económicos; IV) identificar nuevas formas a través de las cuales las estrategias de gestión de riesgos pueden mejorar la resiliencia; y V) evaluar el impacto de las diferentes políticas en la resiliencia de las explotaciones y destacar los posibles desarrollos en el marco de políticas.

La metodología de la tesis se basa en los avances más recientes en la teoría de la resiliencia en Europa, con especial atención al marco de evaluación proporcionado por el proyecto SURE-

Farm[2], en el marco del cual se desarrolló esta tesis. La tesis se basa en una metodología integral y multidisciplinar que incluye múltiples fuentes de datos y métodos de análisis cualitativos y cuantitativos. La investigación de la tesis se llevó a cabo a través de cuatro estudios de investigación, cada uno de los cuales se centró en los primeros cuatro objetivos de investigación, respectivamente. El quinto objetivo es transversal a los cuatro estudios. El primero y el segundo estudio de investigación consiste en un análisis de contenido cualitativo de 28 entrevistas semiestructuradas a agricultores y sus familiares. El tercer estudio de investigación se basa en una evaluación de riesgo económico que incluye un modelo de rentabilidad agrícola y simulaciones estocásticas, utilizando datos de la Red contable de explotaciones nacionales e información de una encuesta a 60 agricultores en Huesca. El cuarto estudio de investigación consiste en un análisis de contenido y codificación de datos cualitativos de un grupo focal que involucra a ocho actores o grupos de interés del sistema agrícola en Huesca.

Los resultados de la tesis muestran que la sucesión agrícola intrafamiliar sigue tres pasos clave: la potencialidad de la sucesión, la voluntad del sucesor de asumir el control y la eficacia de la sucesión. Se descubrió que el paso de disposición es el paso más débil, amenazando la continuidad agrícola en el sector, mientras que el marco de política parece apoyar casi exclusivamente el último paso de eficacia.

Junto con la continuidad de la granja, las granjas de ovejas en la región pueden seguir cuatro trayectorias de desarrollo alternativas, a saber, extensificación (más dependencia de los pastos), intensificación (incremento en carga ganadera), reorientación (reducción de ovejas y diversificación) y conservación (mantenimiento de la estructura de las granjas basado en una producción de calidad). Todos los patrones estimulan la adaptabilidad hasta cierto punto, pero los patrones de extensión y conservación contribuyen principalmente a la robustez para reforzar la estructura de las granjas originales, mientras que los patrones de reorientación e intensificación conducen a transformaciones. Existe una clara distinción entre los atributos de resiliencia que determinan patrones transformadores como la intensificación y reorientación, y los que favorecen la conservación o reajuste del manejo extensivo tradicional. El marco de políticas parece favorecer drásticamente la transición hacia producciones más intensivas o diferentes.

En las cuatro trayectorias de las granjas, dos estrategias principales orientadas a la oferta y la demanda parecen prometedoras: el aumento de la prolificidad de ovejas y el uso de sellos de identificación geográfica protegidas. Los hallazgos de la tesis sugieren que los costes de alimentación son la principal fuente de riesgo y que una mayor prolificidad tiene el mayor potencial para mitigar este riesgo. Por el contrario, la estrategia de etiquetado con sellos de calidad muestra un rendimiento escaso y parece ser más vulnerable a la variabilidad de precios.

El grupo de enfoque de múltiples actores permitió destacar cuatro estrategias principales para mejorar la resiliencia en el sector: 1) aumentar la inversión, la capacidad de financiamiento y los seguros; 2) promover el consumo de carne de cordero (incluido el poder de negociación en

[2] https://www.surefarmproject.eu/

la cadena de valor); 3) valorar la contribución de la ganadería extensiva a la conservación del medio ambiente y la fijación de la población; y 4) formación y transferencia de conocimientos. Los actores sugirieron múltiples opciones para mejorar estas estrategias, que se pueden agrupar en tres vías principales: la cooperación y marketing, el sistema de conocimiento y las herramientas políticas y financieras.

Esta tesis proporciona un análisis integral y multifacético de la dinámica del sistema de ganadería extensiva ovina en Huesca, y los diferentes aspectos que determinan su capacidad de resiliencia, demostrando así la eficacia de este enfoque de evaluación de la resiliencia. Además, la tesis sugiere ideas para futuras investigaciones en el área de estudio de caso, principalmente sobre el relevo generacional y los desarrollos en el marco de políticas, así como sobre la comparación y generalización sobre las evaluaciones de resiliencia de otros sistemas agrícolas.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS

AKIS: Agricultural Knowledge and Innovation Systems

EC: European Commission

ECREA: Cost and Income Studies of Agricultural Holdings

ESPON: research programme of territorial development policies in Europe

EU: European Union

FADN: European Farm accountability Data Network

FAO: Food and Agriculture Organization

FEGA: Spanish Fund of Agricultural Guarantee

IFAD: International Fund for Agricultural Development

INE: Spanish National Statistical Institute

MAPA: Spanish Ministry of Agriculture

PGI: Protected Geographical Identification

RECAN: National Agricultural Accountability Network

SCAR: Standing Committee on Agricultural Research

SURE-Farm: Sustainable and Resilient EU Farming Systems (H2020 project)

1. PROBLEM STATEMENT AND MOTIVATION

1.1 EXTENSIVE SHEEP FARMING AND ITS FUNCTIONS

In the European Union (EU), extensive sheep farming accounted for approximately 87 million heads in 2017, of which about 19% were raised in Spain, which is the second largest producer in EU after the UK (considering that the Brexit was not effective yet). In 2013, the EU census included 850,000 sheep farms, employing 1.5 million people, representing about 7% of total agricultural employees. EU sheep farming is mainly oriented to meat production, delivering around 755,000 tonnes in 2016, for a total value of 5,300 million €. While sheep consumption is generally lower than other livestock meats, the EU is not self-sufficient (about 80% of consumer demand is satisfied), and still relies on import trade, mainly from New Zealand and Australia. In contrast, EU export accounts for about 10% of the total production, mainly shipped to Middle East and North Africa. Spain is the second exporter among EU countries, specialised mostly in live animals (Rossi, 2017; EC, 2019).

EU sheep farming, however, has shown declining trends over the last decades, which are likely to continue in the next years. The sheep census has declined by 16% between 2000 and 2016, whereas the production has decreased by 34% between 2005 and 2015 (Rossi, 2017). Though prices have remained rather stable over time (diminished 1.1% between 2010 and 2015), sheep consumption has decreased consistently across the EU (EP, 2008; Rossi, 2017). In line with the EU trends, Spain has shown a significant drop in the number of sheep farms, as well as in the annual lamb consumption, which decreased from 2.1 kg/capita in 2011 to 1.33 kg/capita in 2019 (MAPA, 2019). Future scenarios towards 2030 drawn by the European Commission (2019) confirm the negative trends. Sheep production in the EU is not expected to increase, and is likely to remain concentrated mainly in Spain (due to the Brexit, UK is not accounted). EU exports are expected to decline by 34% between 2019-2030, whereas projections for prices indicate a downward adjustment.

Extensive sheep farming systems are characterized by unique and intrinsic features, which make them diverse with respect to other livestock sectors, and more difficult to support and restructure. In the first place, extensive sheep farming is widely practiced in more marginal, often mountainous areas of Southern EU. About 80% of reared sheep are in less-favoured areas (LFA) (EP, 2008). Sheep farming, in fact, is likely to be practiced in those regions where other productive activities would be unfeasible (de Rancourt et al., 2006). In 2012, LFA covered the 35% of Utilized Agricultural Area (UAA) in the EU (approximately 61 million hectares in the EU-28), and about 34% in Spain. The use of grassland has been decreasing during the last decades, a source of environmental concern. In Spain, grassland has decreased by 15% in 2000s, leading to an increase in abandoned shrub and forest areas (Porqueddu et al., 2016).

Sheep farming shows a number of structural weaknesses, which are more pronounced than for other agricultural productions. In general, it is a low productive activity with low rates of innovation, and very labour-intensive. It requires specific skills (e.g. shepherd) which are not easily available in the labour market. Sheep farmers are older than in other sectors, and the share of young farmers is particularly low. There is poor organization of the sheep farms and industry, and average incomes are among the lowest in EU agriculture. Moreover, a remarkable set of regulations influence sheep farming, ranging from sanitary and transportation rules to Natural Reserves and Parks regulations (Rossi, 2017).

Also, sheep farms are strongly dependent on subsidies (EU Farm Economics Overview, 2018), meaning that any change in the policy framework has a major impact on the sector's survival (Soriano et al., 2018). An example is the decoupling of CAP payments in 2003, which led to important, consequential structural changes in the sector (de Rancourt et al., 2006). Not less importantly, the upcoming post-2020 CAP reform rises concerns and opportunities regarding the impact it may entail for sheep and livestock systems in the EU (Matthews, 2018).

Based on these weaknesses, concerns about the future of extensive sheep farming in Europe have grown (Morris, 2017). The reasons for such concerns are rooted in the irreplaceable environmental and social role that extensive sheep farms play by delivering a number of functions including public and private goods and services. Public goods/services are non-excludable and non-rivalrous (e.g. landscape), whereas private goods/services are excludable and rivalrous (e.g. food). For example, grazing livestock has been found to be beneficial for maintaining biodiversity (Bernués et al., 2005) and soil multifunctionality (Peco et al., 2017). Besides, grazing contributes to conserve habitat conditions and reduce pesticides and synthetic fertilizers (Kristensen et al., 2016), and to preserve cultural heritage and landscapes (Rodriguez-Ortega et al., 2014). In Aragón, Rodríguez-Ortega et al. (2018) highlight also the contribution of extensive livestock for wildfires prevention, carbon sequestration and quality production.

Previous research on extensive sheep farming in Huesca (Aragón, Spain) identified the main functions provided by extensive sheep farming (Spiegel et al., 2019; Reidsma et al., 2019), as reported in Table 1. Interestingly, results from these works are very similar to one another despite they were derived from different methods: farmer surveys and multi-stakeholder focus group. In the surveys, farmers were asked to assign 100 points between different functions, then the average perception between the surveyed farmers was calculated. Likewise, in the focus group, participants were asked to individually rank the perceived importance of functions by 100 points, than an average was measured. Basically, the main functions are the farm income, food supply, the animal welfare, and the maintenance of natural resources. Particular attention is paid to the significant ecosystem services delivered.

Spiegel et al. (2019) -based on surveys-	Reidsma et al. (2019) -based on focus groups-
Farm Income (42%)	Ensure sufficient farm income (40%)
Animal Welfare (17%)	Deliver quality food products (19%)
Food Supply (16%)	Ensure animal welfare (13%)
Natural Resources (9%)	Maintain natural resources (9%)
Work Conditions (5%)	Good working conditions (7%)
Protect biodiversity (5%)	Protect biodiversity (6%)

Table 1. The main functions provided by the extensive sheep farming system of Huesca. Own elaboration based on results from Reidsma et al. 2019, and Spiegel et al., 2019.

The constant decrease in sheep number and farms, as well as the implementation of different management patterns (e.g. intensification, Riedel et al., 2007), were found to be the driving phenomena of land abandonment and loss of ecosystem services delivered by the sector (Porqueddu et al., 2016). These dynamics appear to counteract the aims of EU institutions, which set outstanding goals for the future of livestock in the EU (Peyraud and MacLeod, 2020). In the current scenario, for example, the emerging management patterns applied to cope with the weaknesses of sheep farming put into question the sustainability of the sector. Abandonment of grassland, conversion to intensive sheep farming, and transition to other intensive livestock and crop productions (e.g. pig fattening, cereals) weaken the sector's capacity to deliver its characteristics socio-economic functions and ecosystem services.

The extensive sheep farms of southern EU, thus, merit receiving special attention from both institutions and research. With this regard, the European Commission (Peyraud and MacLeod, 2020) draws major trajectories to be explored in order to ensure the economic, environmental and social sustainability of livestock farming. These include the consideration of a large range of goods and services to be provided (rather than single commodity productions), as well as stronger agro-ecological approaches and faster adoption of innovative technologies. In order to enhance the extensive sheep farming systems, and to boost their unreplaceable functions, greater effort should be made to explore effective paths of development, and novel approaches are needed to explore new opportunities.

1.2 CURRENT AND FUTURE CHALLENGES

Figure 1 shows the main economic and structural trends of the sheep sector in Huesca, Aragón, Northeaster Spain. Between 2013 and 2019, in Huesca (Eurostat classification NUTS 3), the number of farms has decreased by 24%, whereas the number of heads has diminished by 13%. At regional level (Aragón, NUTS 2), the number of farms has decreased by 25% between 2013 and 2019, whereas the number of heads has decreased by 40% in the period 2006-2018. Similar trends are shown by sheep production under the protected geographical identification, for which the number of slaughtered lambs is stable (around 223,000 heads per annum), but the number of farms producing under label have diminished by 33% in the period 2008-2017. The conventional lamb prices have been stable over the last 15 years, but the prices under the

Protected Geographical Identification (PGI) label '*Ternasco de Aragón*' are generally higher and slightly increased. On the other hand, specific livestock costs per livestock unit have been increasing between 2004-2018 (by 23%), while the coupled subsidies per livestock unit have decreased consistently in the same period (by 54%).

In spite of the potential benefits of extensive sheep farming, several social, economic, institutional, and environmental challenges, materializing on both local and global scales, are threatening the capacity of the sector to generate income and deliver private and public goods and/or services (Dubeuf et al., 2016; Chartier and Cronin, 2017; Komarek et al., 2020; Ruiz et al., 2020). This is evident especially in the Mediterranean regions of Southern EU where there is overall socio-economic impoverishment (Giannakis and Bruggeman, 2015; Zagata and Sutherland, 2015). Among the challenges emerging at a larger scale stand the impact of climate change (Scocco et al., 2016), changes in the policy framework (Matthews, 2018) and market liberalization (Ferrari et al., 2021), and the weak generational renewal affecting several EU regions (Zagata and Sutherland, 2015). The challenges faced in extensive sheep farming system of Huesca, Aragón, were analysed in former investigations (Spiegel et al., 2019; Soriano et al., 2020). These investigations were part of the SURE-Farm project, and were carried out sequentially based on two alternative methodologies: respectively, survey of farmers and multi-stakeholders focus group. This thesis, therefore, has drawn upon this evidence and findings. The identified challenges are in line with those of sheep production in various EU regions.

The institutional challenges are relevant in the case study area (Spiegel et al., 2019; Soriano et al., 2020). Since the decoupling of direct payments in 2003, CAP aids to sheep farmers have been reduced and turn asymmetric, meaning that farmers who shifted to different productions still receive aids based on past sheep activities. The current policy framework emphasizes the competition of extensive sheep farmers with more intensive sectors, such as pig and calf fattening. As most of public subsidies are based on farmed area, there has been an increasing competition for land, that is a crucial resource for extensive sheep farming. Often, many pastures that would be exploited by farmers are not eligible for receiving decoupled payments, which are an important source of income for sheep farmers. Furthermore, there is plenty of regulations constraining the farmers' capacity to carry on their business. These includes sanitary norms, urban regulations, and rules to access and graze in Natural Reserves and Parks. In addition, it is important to mention that sheep farms income in the EU is strongly supported by public subsidies (EU Farm Economics Overview, 2018). This makes sheep farming strongly dependent on changes and developments in the policy framework (de Rancourt et al., 2006; Matthews, 2018; Soriano et al., 2018). Likewise, international markets liberalization, and the consequential increase in market competition, cast doubts on the effective capacity of sheep farms to go through the challenge at present (Ramírez-López et al., 2020).

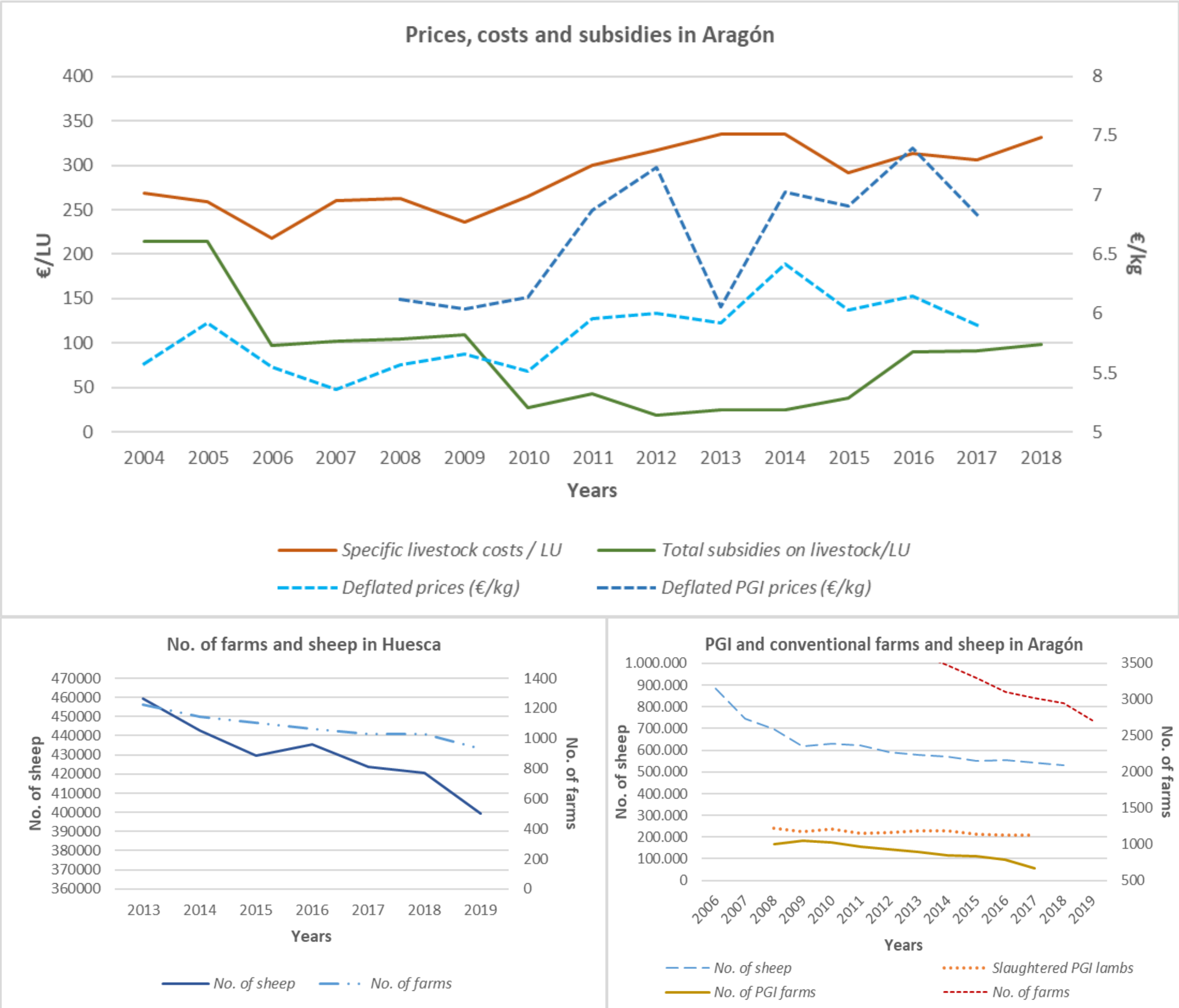


Figure 1. Trends of the sheep sector in Aragón and Huesca. Own elaboration.

Data on number of farms and heads in Huesca and Aragón are derived from the regional livestock statistics (Estadisticas Ganaderas – Gobierno de Aragón[3]), whereas accountability data on livestock costs and subsidies are based on the European Farm Accountancy Data Network[4] (FADN). Data on prices, PGI farms and slaughtered heads are provided by the Spanish Ministry of Agriculture (MAPA, 2020a; MAPA, 2020b, MAPA, 2020c).

On the social side, concerns on rural depopulation, low availability of workers, lack of intergenerational renewal, and low quality of life of sheep farmers are obstacles to attract younger farmers and their families. The sector's decline has brought about deep social changes over the last decades in rural and farming communities. The continuous and persistent phenomenon of rural depopulation affects large territories, threatening the survival of the social fabric (Cramer et al., 2008; JRC, 2013; ESPON, 2018). The interconnected phenomena of land abandonment and depopulation are related to the unwillingness of young adults to succeed in farming (Zagata and Sutherland, 2015; Conway et al., 2017), above all in those

[3] https://www.aragon.es/-/estadisticas-ganaderas
[4] https://ec.europa.eu/agriculture/rica/database/database_en.cfm

marginal and less-productive areas where agriculture is central to maintain the rural population (MacDonald et al., 2000; Hinojosa et al., 2016). The decline of farm succession is a crucial concern for the future of European farming (Anguaiano et al., 2008; Burton and Fischer, 2015; Cavicchioli et al., 2015; Joosse and Grubbström, 2017). The sharp reduction of farm successions is evident in regions of northern Spain (Aldanondo-Ochoa et al., 2007, Regos et al., 2016), and contributes to the abandonment of agro-pastoral activities and semi-natural grassland and to the aging of farmers (Keenleyside and Tucker, 2010; Perpiña-Castillo, 2018; Van der Zanden et al., 2017).

However, regarding social challenges, farmers in Huesca are also concerned about social acceptance and public distrust, which are somehow connected to the changing consumer habits and preferences, resulting in the reduction of sheep meat consumption. Consequently, media communication seems to be a great challenge for the future. In the EU, changing consumer habits and preferences often lead to a reduction of meat consumption (Henchion et al., 2014). According to previous research (Boogaard et al., 2011; Clark et al., 2016), livestock systems, particularly, suffer from a negative or undervalued public perception. For example, in the EU, consumers are increasingly moving from red meat consumption (such as lamb) to white meat consumption (like chicken) (Rabadán et al., 2020). These phenomena occur on top of the low profitability of sheep farming systems, also connected to low efficiency and weak market positioning (Gursoy, 2006; Gazzarin and El Benni, 2020).

The socio-economic phenomenon of decreasing lamb consumption is of great relevance. In Spain, the average lamb consumption is higher than in the EU (especially in North Spain) (Alcalde et al., 2013), though the national lamb consumption has drastically decreased over the last decades, posing one of the greatest challenge to the Spanish sheep sector. The annual lamb consumption decreased from 2.1 kg/capita in 2011 to 1.33 kg/capita in 2019 (MAPA, 2019). Lamb consumption is generally lower than other meats consumption (Escriba-Perez et al., 2017). While more than half of the consumers recognize extensive sheep farming as an environmental-friendly production, attributes like high prices and taste might influence the negative trend (Alcalde et al., 2013). However, lamb producers tend to overestimate the effect of prices on consumers' preference (Sepúlveda et al., 2011). Instead, Font i Furnols et al. (2011) found that products' origin can be more valued by consumers than price, even though this trade-off might be changing after the economic crisis (Rabadán et al., 2020). Bernués et al. (2012) highlight that a growing trend in Spain (Aragón) is the demand for easy cooking products, whereas all types of consumers are more willing to buy pasture-fed lamb rather than concentrate-fed ones. In this respect, Font i Furnols et al. (2009) calculate that about 60% of Spanish consumers prefer lamb totally or partially fed on grassland, rather than fed only by feed concentrates. As most of the Spanish lamb consumers are occasional consumers (Bernabéu et al., 2018), and that occasional consumers are less sensitive to price and more attracted by quality and origin certifications (Bernabéu and Tendero, 2005), quality labels are considered a further, potential way out to reverse the negative consumption trends (Chamorro et al., 2012). This is evident also in Aragón, where both occasional and habitual consumers value quality labelling (Ripoll et al., 2018). Changing consumers' habits pose a challenge but, also, open up new opportunities that have not been exploited by the sheep sector yet.

While economic challenges appear less relevant overall in Huesca (Spiegel et al., 2019; Soriano et al., 2020), the main specific challenges perceived by farmers are low sale prices and the implementation of new production technologies. These are in line with the weaknesses detected in sheep farming across the EU. Besides, high costs of production threaten the profitability of farms. In Spain, this is especially due to the costs for feed, which are the highest costs in sheep meat production (Aguilar et al., 2006; Toro-Mujica et al., 2012; Morris, 2017).

The main environmental challenges regard conflicts with wild fauna, especially wolves. On the other hand, climate change seems to influence the availability and productivity of grassland due to the occurrence of more intense droughts, which imply less natural-based feed for grazing flocks. This has a direct effect on the profitability of farms, as it entails higher feeding costs (Countryman et al., 2016; Salmoral et al., 2020). In addition, the increasing occurrence of wildfires may threaten existing pastures and limit the capacity of farmers to exploit natural resources. These environmental challenges are interlinked, and point to the overall hurdle to access grassland, the main resource of extensive sheep farms. Soil quality was not perceived as important. Likely, this challenge affects sectors with a more intensive use of land.

1.3 RESILIENCE THEORY: A THEORETICAL FRAMEWORK APPLIED TO THE STUDY OF THE SHEEP FARMING SECTOR OF HUESCA

During the last two decades, a growing strand of literature has focused on the application of resilience concepts in agriculture. Originally designed as a framing to explain complex dynamics under stress in socio-ecological systems (Carpenter et al., 2005), the resilience concepts have been adapted to agroecosystems and agrifood systems (Cabell and Oelofse, 2012; Meuwissen et al., 2019). A canonical definition of resilience points to the capacity of systems to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure and feedbacks, and therefore identity (Folke et al., 2010; Darnhofer, 2014). The reasons underlying the increasing attention paid to resilience concepts are the new focal points that it provides to enable systems self-organizing, coping with and adapting to challenges.

Resilience addresses the concept of change and permits exploring the factors enabling it. The concept of change is crucial in the resilience thinking (Holling et al., 2002; Carpenter and Brock, 2008). More specifically, the key concepts of adaptive and transformative changes became the vehicles for resilience understanding (Walker et al., 2004; Folke et al., 2010; Anderies et al., 2013). These concepts, in fact, are rather appropriate to explore and foster sustainable transitions and innovation paths in EU agriculture. The resilience concept is aligned with, for example, the EU farming goals for climate-adaptations, sustainable transitions, and supply chain restructuration (EC, 2020).

The resilience concepts allows for extending the focus over long-term perspectives, by considering development trajectories and system dynamics over time. As Urruty et al. (2016) and Meuwissen et al. (2019) pointed out, farming systems do not only face sudden shocks, but also deal with challenges on a mid- and long-term perspective. Thus, resilience against challenges is conceptualized as a process, rather than a property emerging at a precise point in time (Darnhofer, 2014). Resilience helps observe phenomena over time, and enhance the capacity to anticipate them.

Resilience in agriculture considers a wide range of actors behind a farming system's self-capability to cope with challenges. In line with recent advances in food system economics (FAO, 2018), resilience literature (Tendall et al., 2015; Vroegindewey and Hodbod, 2018; Meuwissen et al., 2019) highlights the importance of approaching the capacity to deal with challenges at system's level, considering all stakeholders involved in agrifood production in a specific region. Within a resilience frame, hence, it is possible to assess the roles played by multiple actors, and their interplay.

Following the growing trend in scientific research, in recent years several public and international institutions moved their focus on the resilience of agriculture. For instance the Farm to Fork action-plan delivered by the European Commission (EC, 2020) sets resilience as a goal for the future of EU agriculture. Likewise, the Food and Agriculture Organization (FAO, 2017) and the International Fund for Agricultural Development (IFAD, 2015) emphasize the need for resilient agrifood systems. Although the attention to resilience has grown, resilience research in agriculture is not abundant, and most investigations are recent. In spite of these advances, there are still gaps to cover in this domain, both from theoretical and empirical perspectives.

While a strand of literature aims to quantify resilience (Angeler and Allen, 2016), other investigations frame the resilience thinking as an unquantifiable, comprehensive concept to explain complex systems' dynamics (Quinlan et al., 2015). The hurdle to translate resilience into measurable entities has been a continuous challenge, and there is not consensus about appropriate metrics (Peterson et al., 2018). Instead, qualitative, descriptive and explorative methods have shown potential in analysing resilience at farm level (Darnhofer et al., 2010; Vroegindewey and Hodbod, 2018). Approaching farm management through resilience is useful to consider the real complexity characterizing farming (Darnhofer, 2014). However, their application on farm and farming system studies is still limited, and does not frame resilience mechanisms through precise definitions of resilience types and factors, and their interaction.

The methodological frameworks applied so far generally do not include all the aspects of resilience in a comprehensive and holistic manner, but focus on specific factors of resilience. For example, the Resilience Alliance (2010) proposes an assessment framework, but this is not specific for agriculture, and relies on very general definitions of resilience attributes. Cabell and Oelofse (2012) propose a framework for agro-ecosystems resilience based on 12 attributes, but do not consider dynamics of change overtime. Vroegindenwey and Hodbod (2018) assess the agricultural value chain resilience by integrating a resilience framework to value chain analysis techniques, but do not consider the different concpets of resilience to be analysed. Resilience assessments in agriculture are often not tailored to a well-defined and manageable scale (e.g. farm, system, region), which is important to ask relevant questions (Peterson et al., 2018).

The lack of comprehensive frameworks including the interplay among (well-defined) resilience dynamics, types and determinant factors, as well as the intended openness and vagueness of resilience concepts, might hinder the capacity of resilience approaches to identify key strategies. This also prevents evaluating operative policies that could promote the resilience of farms and farming systems. At the state of the art, therefore, there is room for advances in developing improved resilience approaches. With this regard, a new resilience assessment framework proposed by Meuwissen et al. (2019) in the context of EU farming systems represents a remarkable advance in resilience research in agriculture, and worth being exploited and tested. The strength of this new framework is that it accounts for all the functions and challenges of a farming system in a holistic way, and propose a structured analytical frame encompassing and interrelating the concepts of resilience capacities and attributes. The framework, hence, may be a useful tool to assess the extensive sheep farms of Huesca, characterized by several, complex functions and challenges. As described in previous sections, in fact, extensive sheep farms deliver numerous socio-economic functions and ecosystem services that, in turn, are affected by different types of challenges. The Meuwissen's approach allows for considering all these interplays and the complexity behind this farming system.

Beyond the methodological criticisms of resilience, there has been scarce research on the resilience of extensive sheep farming. Recent research have focused on the resilience of, for instance, hazelnut production (Nera et al., 2020), crop farmers (Slijper et al., 2020), pistachio agroecosystems (Darijani et al., 2019), and dairy cattle farms (Perrin et al., 2020). However, less attention has been paid to sheep systems, especially in the EU. Haider et al. (2012) operationalize the resilience in a pasture management system in Asia, whereas Daugstad (2019) explores the resilience of mountainous dairy sheep farms in Norway, and Ashkenazy et al. (2018) investigate the resilience of 11 case studies, among which small ruminant farms in Turkey. To our knowledge, there are few studies on the resilience of extensive sheep farms in EU, none of them in Spain. Consequently, there is a need to build knowledge regarding the resilience of extensive sheep farms in the EU and Spain, and to explore the potential factors, strategies and policies enhancing resilience. In this sense, most recent advances in resilience frameworks (Meuwissen et al., 2019) represent an opportunity to shed light on novel solutions.

2. THESIS GOALS AND RESEARCH CONTEXT

2.1 RESEARCH QUESTIONS AND OBJECTIVES

2.1.1 MAIN GOAL

The motivation of the PhD thesis is rooted in the urgent need to identify development trajectories and resilience paths that allow to conserve and boost the role played by extensive sheep farms in marginal areas of Spain, given the particular vulnerability of this sector.

The main goal of the PhD thesis, therefore, is to assess the strategies, management patterns, and policies promoting the capacity of extensive sheep farming systems to keep delivering their unreplaceable functions and services, in spite of the current and future challenges threatening the sector. To this end, the thesis research focuses on the case study of extensive sheep farms of Huesca, Aragón, Northeast Spain, with a minor incursion in the extensive beef farming of Sierra Guadarrama. The focus on beef production, however, is limited to one objective. This is discussed in the case study presented in section 3.2.

Moreover, the PhD thesis aims to develop a mixed and multidisciplinary approach to explore and analyse farms resilience, while taking into consideration the adaptive cycles, attributes and capacities determining the resilience dynamics overtime. This is based on the most recent advances in resilience assessment frameworks, and accounts for different kinds of data and information sources.

2.1.2 RESEARCH QUESTIONS AND SPECIFIC OBJECTIVES

In order to achieve the main goal, different aspects of extensive sheep farming system need to be investigated. These are addressed by five research questions, with as many corresponding specific objectives, as follows:

I. **What factors affect the farm continuity and resilience in extensive livestock systems?**

The objective is to identify the factors threatening intra-family farm succession and its characterizing phases.

II. **How resilient are the extensive sheep farm management patterns?**

The objective is to identify the resilience attributes and capacities in alternative farm management patterns.

III. **What is the economic performance and resilience of the main demand- and supply oriented strategies in extensive sheep farms?**

The objective is to quantify the economic performance of alternative production strategies to cope with main economic risks.

IV. **How can risk management strategies be improved to enhance resilience?**

The objective is to identify new ways through which risk management strategies may improve resilience.

V. **Which policies provide an enabling environment for farms' resilience?**

The objective is to assess the impact of different policies on farms' resilience, and to highlight potential developments in the policy framework.

In the first place, resilience is a process occurring overtime and, as such, it relates to the continuity of farms. This is why objective I addresses the farm continuity and the influencing factors. Along with the farm continuity, farms implement different management patterns, including agricultural practices and risk management strategies, which in turn shape the resilience capacity. Objective II, thus, addresses this issue through the lens of resilience. Alternative strategies might entail diverse economic implications at farm level, which needs to be evaluated. Objective III targets this issue by assessing the performance of two alternative demand- and supply-oriented approaches. However, many more actors other than the farmers are involved in risk management. Therefore, objective IV assesses the potential role of different actors in improving risk management and its contribution to resilience. Lastly, objective V assesses the policies having an influence on the different aspects of the system's resilience.

2.2 STRUCTURE OF THE PHD THESIS

The PhD thesis is structured in five chapters, developing from the introduction, to the thesis goals and research context, the methodological framework, results and discussion, and conclusions. The Figure 2 depicts the thesis structure.

Chapter 1 (Introduction) describes the state of European and Spanish extensive sheep farming at present, highlighting the intrinsic characteristics and weaknesses of this sector, and the recognized functions it delivers to the environment and society. Next, it provides a description of the current and future challenges affecting the sector and threatening its perspectives. At last, it reviews the most recent advances in resilience assessments in agriculture, its contributions to research, and the gaps that still need to be covered in resilience investigations.

Chapter 2 (Thesis goals and research context) sets the main and specific objectives of the thesis, depicts the structure of the thesis, and the research context of the thesis research.

Chapter 3 (Methodology) provides the theoretical underpinning on which the thesis research is based, and a description of the case study and data sources. It presents the four methodologies applied to achieve the first four specific objectives of the thesis.

Chapter 4 (Results and Discussion) includes the four sets of results aimed at achieving the corresponding specific objectives, respectively. These are:

- Research study 1 on "Farm continuity and generational renewal in extensive livestock systems", aligned with methodological section 3.4, and targeted to objective I and V.

- Research study 2 on "Resilience attributes and capacities of alternative management patterns in extensive sheep farms", aligned with methodological section 3.5, and targeted to objective II and V.

- Research study 3 on "Performance and resilience of demand- and supply-oriented strategies against economic risk", aligned with methodological section 3.6, and targeted to objective III and V.

- Research study 4 on "Risk management strategies to improve resilience", aligned with methodological section 3.7, and targeted to objective IV and V.

Chapter 5 (Conclusions) provides the major findings of the thesis research, and the main methodological limitations of this work. Lastly, it draws potential trajectories for future research in Spanish and European extensive sheep farming systems.

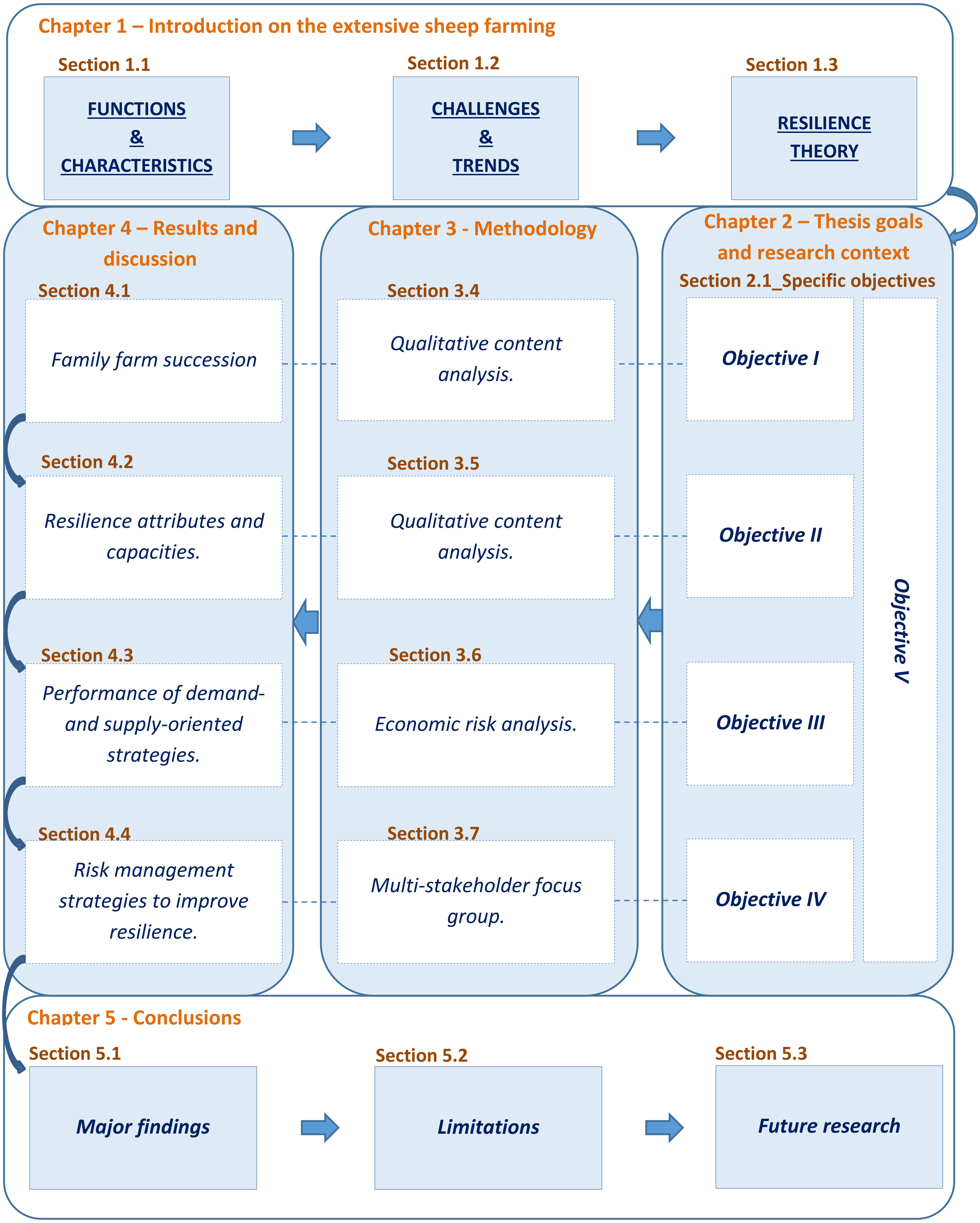


Figure 2. Scheme of the thesis' structure.

2.3 RESEARCH CONTEXT AND PUBLICATIONS

2.3.1 THE SURE-FARM PROJECT AND RESEARCH CONTEXT

The PhD thesis has begun on September 2018 at the Research Centre for the Management of Agricultural and Environmental Risks (CEIGRAM), of the Universidad Politécnica de Madrid (UPM), within the Doctoral Degree program of Agro-Environmental Technology for Sustainable Agriculture (TAPAS). CEIGRAM is a joint research centre created in 2007 under a public-private collaboration agreement, whose activity focuses on development and innovation, dissemination and training, in the field of analysis and management of agricultural and environmental risks.

The PhD thesis research has been carried out within the framework of the SURE-Farm project – Towards Sustainable and Resilient EU Farming systems (https://www.surefarmproject.eu/), an H2020 project financed by the European Commission (No 727520). This four-year project (2017-2021), involving 16 partners institutions distributed over 13 European countries, aims to analyse, assess and improve the resilience and sustainability of farms and farming systems in the EU. The project investigates the resilience of 11 case studies, among which the extensive sheep farming system of Huesca (Aragón), and the extensive cattle system of Sierra de Guadarrama (Madrid), in Spain. CEIGRAM was the Spanish research partner, coordinating the research activities in Spain, and leading various project tasks in work-package (WP)2 on the outlook of risk management in EU agriculture, and the WP7 on dissemination and communication, including the design and management of a co-creation platform. Figure 3 shows the scheme of the SURE-Farm project, including the different WP.

This PhD thesis, therefore, draws from and builds on the resilience assessment framework depicted by the project in WP1 (Meuwissen et al., 2019), and focuses on the case of extensive sheep farming system in Huesca. Indeed, the thesis research was originally started by considering a second case study, that is, the extensive cattle farms in Sierra de Guadarrama, Comunidad de Madrid. This was justified by the assumption that these two systems share common characteristics, challenges and future perspectives, and by the need to generalize research findings over more sectors. The first research study of the thesis, in fact, takes into consideration both case studies. Common factors and evidence emerged regarding the farm continuity in these areas. Hence, they could be generalized to both livestock systems, and not limited to sheep farms. After the first investigation, however, a clear difference emerged between the cases. The extensive cattle farms in Madrid do not face the same challenges, and show a more consistent development trajectory. This made the case of extensive sheep farms more appropriate for the scope of this thesis. Hence, from the second research study onwards, the thesis research has focused exclusively on extensive sheep farms in Huesca, which is the target of this thesis.

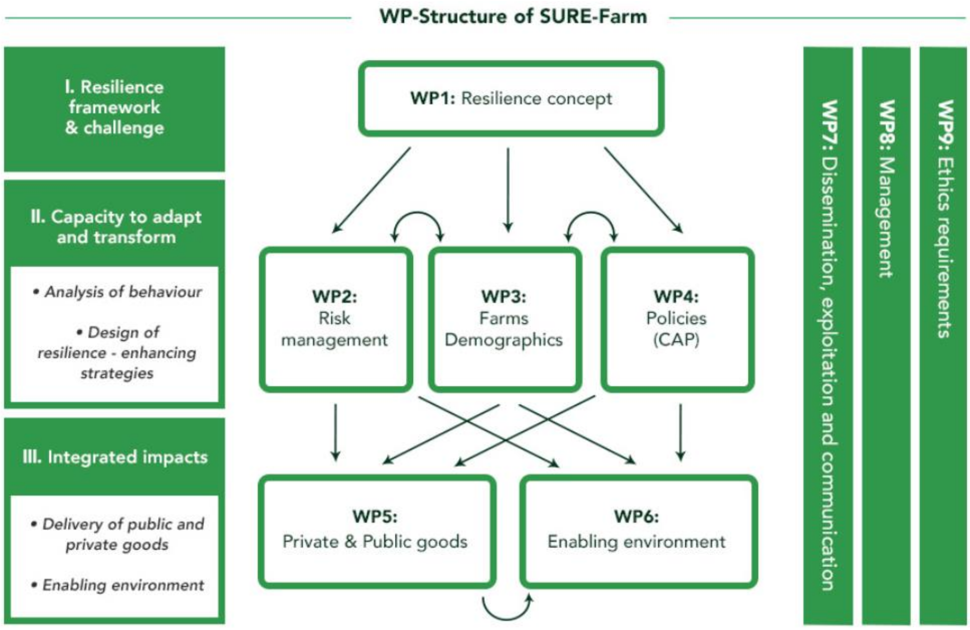


Figure 3. Scheme of the SURE-Farm project workpackages. Available at: https://www.surefarmproject.eu/

Part of the research activities were carried out along with the project tasks, including the data collection and the goal setting. In particular, the analysis of farm continuity and generational renewal (thesis chapter 4.1, objective I and V), as well as the analysis of risk management strategies to improve resilience (thesis chapter 4.4, objective IV and V), were developed upon the goals, data collection and elaboration methods addressed by the project tasks in WP3 and 2 (Coopmans, 2019; Soriano et al., 2020), respectively. The analysis of resilience capacities and attributes (thesis chapter 4.2, objective II and V) exploits the project theoretical framework and data collected through the project tasks in WP2 and 3, but develops independent objective and methodology. Lastly, the objective and methods applied for the analysis of economic performance of demand- and supply-oriented strategies (thesis chapter 4.3, objective III and V) were designed out of the project tasks and goals, though part of data were derived from the WP2 (Spiegel et al., 2019).

During the first year of the thesis, the my activities were dedicated to the collection of semi-structured interviews with farmers in Huesca, and the elaboration and analysis of the collected data. Next, I drafted and submitted the first research article corresponding to the first research study of this thesis. In the second year of the thesis, most of my work was dedicated to the elaboration of data from a multi-stakeholder focus group held in Huesca in April 2019. Afterward, I wrote the second article corresponding to the fourth research study of this thesis. In the third year of the thesis, I carried out two investigations corresponding to the second and third research studies. Deriving from this work, I drafted and submitted two research papers.

2.3.2 PUBLICATIONS

From the work done for the completion of the thesis, four research articles were written, of which three already published and one currently under review in indexed international journals, and two conference papers have been accepted for presentation in the 178th EAAE seminar (online, 18-20 May 2021), and in the XVI EAAE congress (Prague, 07.2021). Table 2 reports the list of publications and contributions by research study and thesis chapter.

Research study 1 (objective I + V)
THESIS CHAPTERS Introduction (1) Methodology (3.4) Results and Discussion (4.1) Conclusions (5)
Published articles Bertolozzi-Caredio, D.; Bardaji, I.; Coopmans, I.; Soriano, B.; Garrido, A., 2020. Key steps and dynamics of family farm succession in marginal extensive livestock farming. Journal of Rural Studies (76)131:141.
Research study 2 (objective II + V)
THESIS CHAPTERS Introduction (1) Theoretical underpinning (3.1) Methodology (3.5) Results and Discussion (4.2) Conclusions (5)
Articles under review Bertolozzi-Caredio, D., Garrido, A., Soriano, B., Bardaji, I., (2021). Implications of alternative farm management patterns to promote resilience in extensive sheep farming: a Spanish case study. Journal of Rural Studies
Research study 3 (objective III + V)
THESIS CHAPTERS Introduction (1) Methodology (3.6) Results and Discussion (4.3) Conclusions (5)
Published articles Bertolozzi-Caredio, D., Soriano, B., Bardaji, I., Garrido, A., (2021). Economic impact of quality label and productive efficiency strategies under price and cost risks: the case of Spanish sheep farms. Agricultural Systems (191)103169. **Conference Proceeding (to be presented)** Bertolozzi-Caredio, D., Soriano, B., Bardaji, I., Garrido, A., (2021). Economic impact of quality label and productive efficiency strategies under price and cost risks: the case of Spanish sheep farms. The 178thEAAE seminar, 18-20 May 2021.
Research study 4 (objective IV + V)
THESIS CHAPTERS Introduction (1) Methodology (3.7) Results and Discussion (4.4) Conclusions (5)
Published articles Bertolozzi-Caredio, D., Bardaji, I., Garrido, A., Berry, R., Gravilescu, C., Bijttebier, J., Harizanova, H., Jendrzejewsky, B., Meuwissen, M.M.P., Ollendorf, F., Pinsard, C., Rommel, J., Severini, S., Soriano, B., (2021). Stakeholder perspectives to improve risk management in European farming systems. Journal of Rural Studies, 84: 147-161. **Conference Proceeding (to be presented)** Bertolozzi-Caredio, D., Bardaji, I., Garrido, A., Berry, R., Gravilescu, C., Bijttebier, J., Harizanova, H., Jendrzejewsky, B., Meuwissen, M.M.P., Ollendorf, F., Pinsard, C., Rommel, J. (2021). Exploring Potential Pathways to Improve Risk Management Across EU Farming Systems Through a Multi-stakeholders' Approach.

Table 2. Publications related to the thesis research studies and chapters.

2.3.3 STATEMENT OF AUTHORSHIP

Along the four research studies, different authors participated across the activities of data collection, methodology design and application, and data and results analysis, beyond the undersigned PhD candidate. These are Prof. Alberto Garrido, Prof. Isabel Bardají, Prof. Barbara Soriano, and Ms. Isabeau Coopmans. Table 3 below shows the authors' contributions by research study and activity. Following, the authors' affiliations are listed.

	Data collection	**Methodology design and application**	**Data and results analysis**
Research Study 1	*Prof. Barbara Soriano* *PhD Candidate Bertolozzi-Caredio*	*Ms. Isabeau Coopmans* *Prof. Barbara Soriano* *PhD Candidate Bertolozzi-Caredio*	*Prof. Barbara Soriano* *Prof. Alberto Garrido* *Prof. Isabel Bardaji* *PhD Candidate Bertolozzi-Caredio*
Research Study 2	*Prof. Barbara Soriano* *PhD Candidate Bertolozzi-Caredio*	*Prof. Barbara Soriano* *Prof. Alberto Garrido* *Prof. Isabel Bardaji* *PhD Candidate Bertolozzi-Caredio*	*Prof. Alberto Garrido* *Prof. Barbara Soriano* *Prof. Isabel Bardaji* *PhD Candidate Bertolozzi-Caredio*
Research Study 3	*Prof. Isabel Bardaji* *PhD Candidate Bertolozzi-Caredio*	*Prof. Alberto Garrido* *PhD Candidate Bertolozzi-Caredio*	*Prof. Alberto Garrido* *Prof. Isabel Bardaji* *Prof. Barbara Soriano* *PhD Candidate Bertolozzi-Caredio*
Research Study 4	*Prof. Barbara Soriano* *Prof. Alberto Garrido* *Prof. Isabel Bardaji*	*Prof. Barbara Soriano* *Prof. Alberto Garrido* *Prof. Isabel Bardaji* *PhD Candidate Bertolozzi-Caredio*	*Prof. Barbara Soriano* *Prof. Alberto Garrido* *Prof. Isabel Bardaji* *PhD Candidate Bertolozzi-Caredio*

Table 3. Authors' contributions to the research activities.

3. METHODOLOGY

3.1 THEORETICAL FRAMEWORK

The theoretical framework of the thesis is drawn upon the resilience assessment framework proposed by Meuwissen et al. (2019) within the SURE-Farm project. Following these authors, in this thesis the resilience of farming systems is defined as their capability to ensure the provision of functions in the face of increasingly complex and accumulating economic, social, environmental and institutional challenges, through capacities of robustness, adaptability and transformability (Walker et al.; 2004; Folke et al., 2010; Anderies et al.; 2013). Deriving from this definition, the authors depicted an assessment framework considering the main aspects to account for when assessing resilience: the farming system, the challenges, the system's functions, the resilience capacities and attributes. The framework is shown by the scheme in Figure 4.

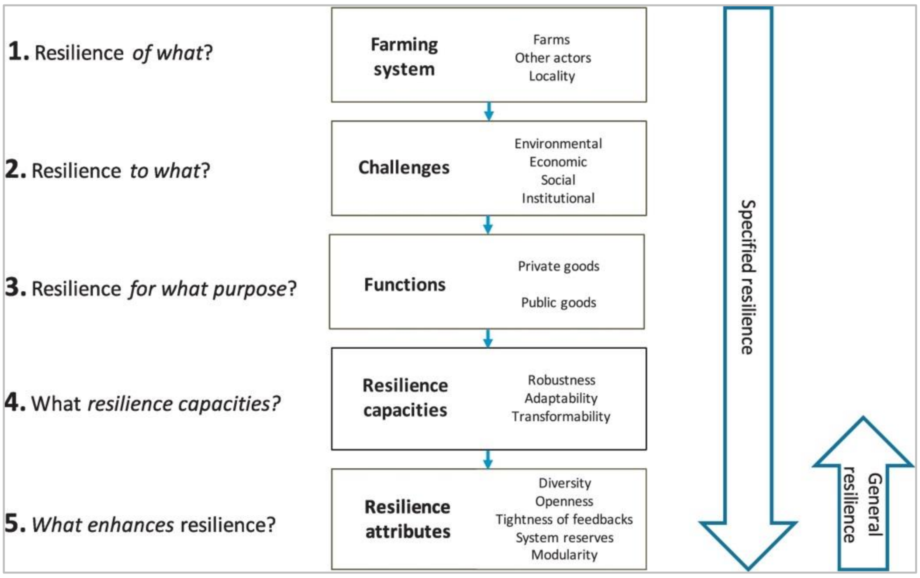


Figure 4. Resilience assessment framework. Source: Meuwissen et al. (2019).

FARMING SYSTEM AND STAKEHOLDERS

At farm level, resilience is likely to be determined by the farmers' ability to manage the farm in a contest of pressing challenges. At farming system level, however, a broader range of actors should take part in resilience dynamics. The impact of the behaviour of other stakeholders emerges clearly when moving from a single farm viewpoint to a farming system perspective (Tendall et al., 2015; Vroegindewey and Hodbod, 2018). Meuwissen et al. (2019) highlight the importance of approaching the capacity to deal with challenges at farming system level, considering all stakeholders involved in agrifood production in a specific region, as shown in Figure 5. In this conceptualization, the farming system's dynamics can be depicted as follows: sudden shocks and long-term pressures stress the farming system, which responds by adopting manifold, integrated strategies involving multiple actors. The stakeholder's behaviour might enlarge, reduce or improve the set of strategies available to farmers through the provision of products, services and collaborations. These dynamics determine the resilience responses and capacities of the farming system.

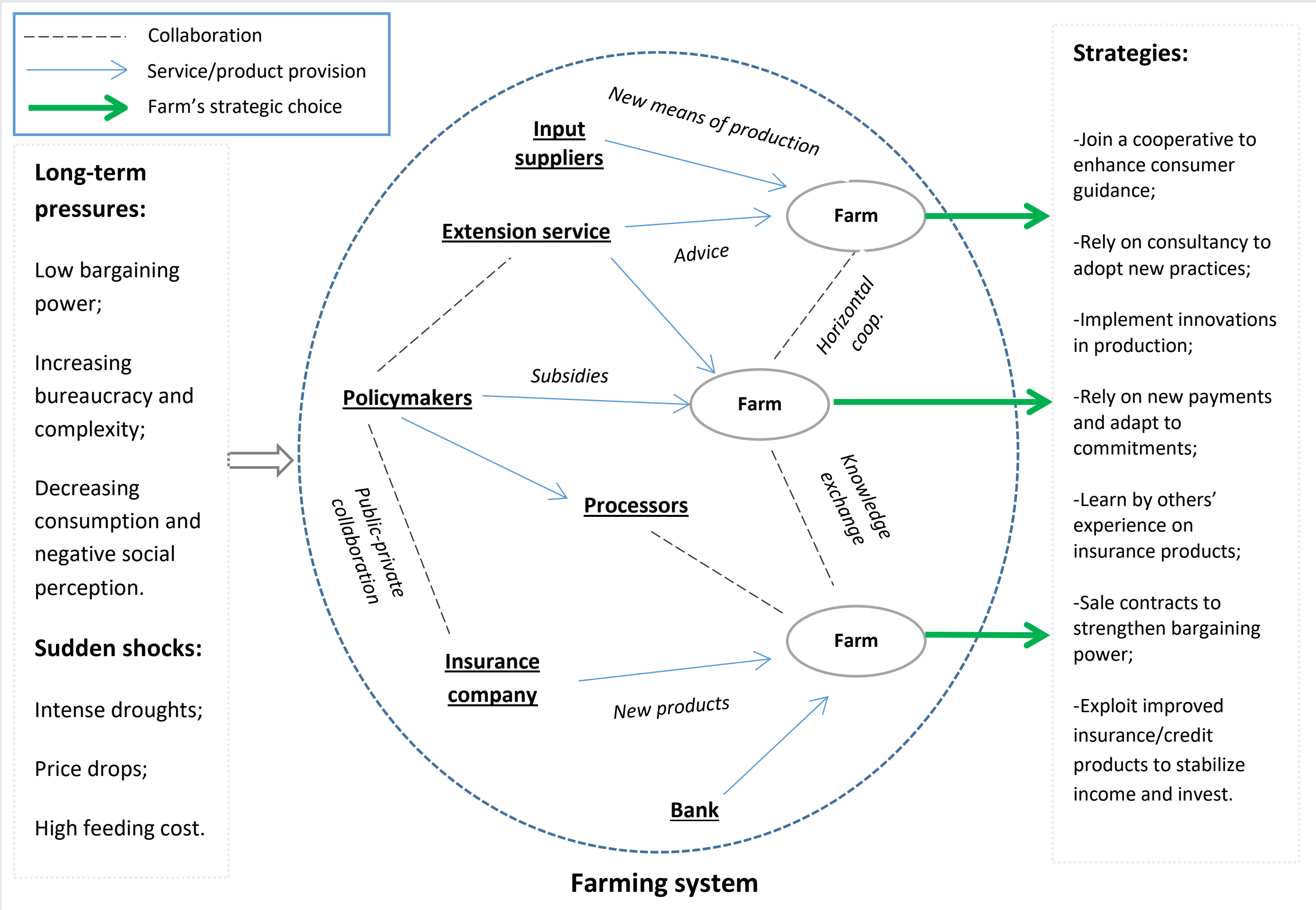


Figure 5. A conceptual scheme of the farming system actors and dynamics. The described system is an example: challenges, strategies and links might be different between sectors. Source: Bertolozzi-Caredio et al. (2021a).

CHALLENGES AND FUNCTIONS

Meuwissen et al. (2019) emphasize the need to consider all types of challenges that might affect a farming system. These challenges can be known or unknown, expected or unexpected, and cover different economic, social, institutional and environmental dimensions. Importantly, the challenges can be divided in sudden shocks impacting a system in the short-term, or pressures stressing the system in the long-run. This distinction is important as it entails different effects on a system, and diverse capacities through which farming systems respond to challenges. For example, different implications and responses emerge when considering price drops or changes in consumer habits and preferences. Likewise, there is difference between droughts and climate change, though such phenomena are interrelated.

Besides, this theoretical framework places prominence in all the potential functions that a farming system may deliver to its stakeholders and the wide society, not just the provision of economic revenues. These functions include all the public and private goods or services that stakeholders, institutions and the civil society might expect to be provided. Thus, a farming system can be said resilient whether it is able to cope with challenges while maintaining, for instance, the provision of income, job opportunities, healthy food, the protection of biodiversity, natural resources, and animal welfare.

RESILIENCE CAPACITIES

The capacity to deal with challenges while still deliver functions can emerge through the conservation of the existing state or, alternatively, through changes in farms' structure and functions. The concept of change is crucial for the resilience thinking (Carpenter and Brock, 2008), and leads to the definition of robustness, adaptability, and transformability. Following the literature, the difference between robustness and the other capacities is basically due to the absence of structural changes in farms' organization and functions when a farm responds to its pressing challenges (Daugstad, 2019; Meuwissen et al., 2019). Following Darnhofer (2014), adaptability implies marginal changes limited to the farm structure to reinforce the existing functions (Olsson et al., 2004), and guided by the original, unquestioned goals and values. In contrast, transformability regards significant, qualitative changes to the farms' structure and functions that imply a transition to a new configuration (Cumming et al., 2005; Daugstad, 2019). Robustness could emerge, for example, by building reserves in anticipation to price drops, or by opting for an off-farm job, whereas adaptability could be pursued by introducing new technologies or new crops in a rotation scheme. Transformability could be determined by a change in market orientation or, for example, a shift from cattle farming to ecotourism (Cumming et al., 2005; Ashkenazy et al., 2018; Daugstad, 2019).

Robustness, adaptability and transformability should not be interpreted as isolated or mutually-exclusive capacities, i.e. alternative options to which a system can resort. Instead, they should be considered coexisting and inter-influencing capacities. For example, farms' structural changes and re-organization (like adaptability) may strengthen the capacity to recover from shocks (robustness) (Davoudi, 2012; Darnhofer, 2014; Daugstad, 2019), whereas marginal changes (adaptability) may be functional to following deeper changes (transformability), also known as incremental adaptations (de Kraker, 2017). Likewise, reserves are functional either to the buffer capacity (robustness), or to the capacity to invest in farms' re-orientation (transformability) (Fath et al., 2015; Darijani et al., 2019). Thus, the three resilience capacities concur simultaneously (though not necessarily equally) to build the overall resilience of a farming system. The importance to focus on capacities is not limited to a theoretical definition of resilience, but it allows for capturing the changing dynamics overtime.

RESILIENCE ATTRIBUTES

Resilience attributes consist of factors enhancing the capacity of farms to adopt different strategies and build resilience. In fact, farming systems' processes are determined by exogenous and endogenous factors (Cabell and Oelofse, 2012; Kristensen et al., 2016), defined as individual/collective competences and enabling environments enhancing resilience (Meuwissen et al., 2019). They include also policies (Celio et al., 2014), available resources and the capabilities to use them in a (farm) community (Longstaff et al., 2010).

The resilience attributes, therefore, are those factors, properties or conditions intrinsic to farms (and the farmers), or in the surrounding environment which the farms belong to (the farming system), that can enable the farm's resilience. In the resilience literature, such attributes can be also referred to as properties (Carpenter et al., 2012), anchors (Ashkenazy et al., 2018), or qualities (Worstell and Green, 2017). As pointed out by Darnhofer (2014), analyses of resilience require exploring not only the processes, but also the conditions enabling them. Thus, the analysis of attributes is relevant to translate evidence into practical indications (Kerner and Thomas, 2014). Meuwissen et al. (2019) refer mainly to the five broad attribute proposed by the Resilience Alliance (2010): diversity, openness, modularity, system reserves, and tightness of feedback. Indeed, there are many investigations proposing different, context-specific resilience attributes (e.g. Cabell and Oelofse, 2012).

ADAPTIVE CYCLES

The capacity of farming systems to cope with challenges develops overtime along with the main dynamics determining a system trajectory. Originally adopted for the analysis of ecological resilience (Holling et al., 2002), such dynamics are referred to as adaptive cycles, which might cross different stages (growth, conservation, collapse, reorganization). This concept is a heuristic model to qualitatively capture different kinds of change originating from the farms' or farming system's capacity to successfully navigate the adaptive cycles while persisting, adapting or transforming (Darnhofer et al., 2016). The concept of adaptive cycles helps emphasize two key aspects of resilience. First, resilience should be considered as a process occurring overtime, rather than a property at a precise point in time (Darnhofer, 2014). Second, along this process, the concept of change assumes crucial importance (Carpenter and Brock, 2008). When putting into perspective the capacity of different farms to build resilience, it is possible to draw farm trajectories as constant processes of changes (Brédart and Stassart, 2017). Meuwissen et al. (2019) define the four adaptive cycles characterizing farming systems: namely farm demography, agricultural practices, risk management, and governance. These cycles are reported in

Figure **6**. In order to capture the resilience of a system, it is necessary to consider the state of the four cycles underlying the whole system dynamics.

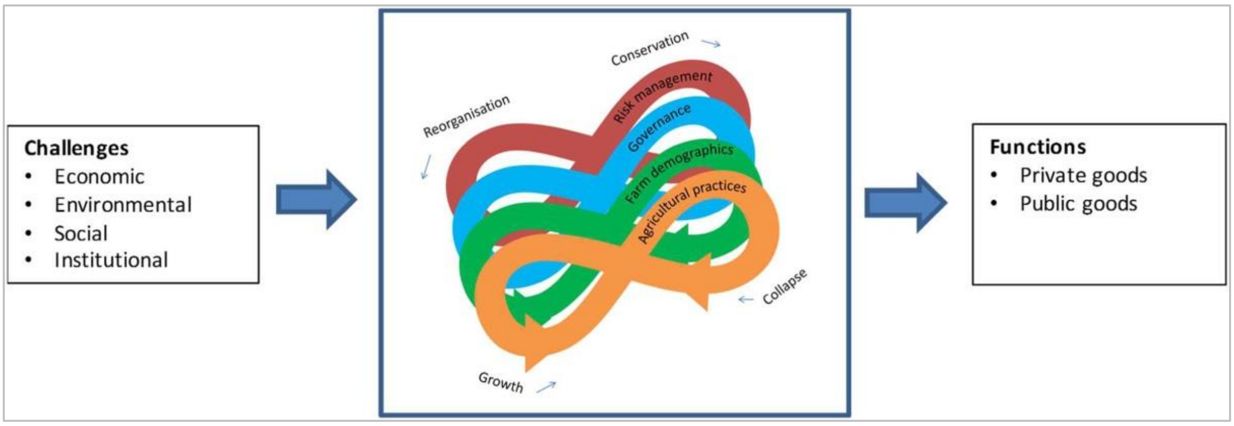


Figure 6. The four adaptive cycles characterizing farming systems. Source: Meuwissen et al. 2019.

This theoretical framework addresses manifold key concepts of resilience, which are necessary to explore all the aspects of farms and the farming system. Through this multifaceted framing, it is possible to identify and assess all the potential factors influencing the system resilience, including a wide range of resilience-enhancing strategies and policies. While focusing on the five analytical steps (farming system-stakeholders, challenges, functions, resilience capacities and attributes), the assessment of the four adaptive cycles (farm demography, agricultural practices, risk management, governance) allows for defining the strategic patterns and policies having an influence on the farms development and trajectories. The scheme in Table 4 shows how the four research studies of this thesis cover the different aspects of the resilience assessment framework.

	ASSESSMENT STEPS					
ADAPTIVE CYCLES	**Resilience Attributes**	**Resilience Capacities**	**Functions**	**Challenges**	**Farming System (actors)**	
Farm demography	*RS1*			*RS1*	*RS1*	
Agricultural Practices	*RS2*	*RS2*	*RS2*			
Risk Management	*RS2*	*RS2*	*RS2* *RS3*	*RS3* *RS4*	*RS4*	
Governance				*RS4*	*RS4*	Conclusions (5.1)
			Introduction (1)			

RS = Research Study

Table 4. The resilience assessment framework sections as addressed by the four research studies.

The first research study explores the farm succession dynamic to identify the challenges affecting generational renewal and the factors (attributes) promoting succession, while considering the influence of familial, social and institutional components of the farming system. The second research study identifies and evaluates the resilience attributes and capacities emerging across different farm strategies and management patterns, by considering their effect on provided functions. The third research study focuses on risk management strategies to face specific economic challenges (price drops, cost increases) affecting a specific function (income provision), at farm level. The fourth research study considers the main challenges and actors of the system, in order to asses main risk management strategies and patterns of governance to improve resilience. In addition, a wide overview on functions and challenges of the extensive sheep system of Huesca is provided in introduction, based on previous investigations in the case study (Becking et al., 2019; Spiegel et al., 2019; San Martín et al., 2020; Soriano et al., 2020). Lastly, the first conclusion section (5.1) provides an evaluation of the governance models and policy framework, based on the evidence from the four research studies.

3.2 THE CASE STUDIES

The cases under study in this thesis are the extensive sheep farms from the Hoya de Huesca (Aragón), and the extensive cattle farms from the Sierra de Guadarrama (Autonomous Community of Madrid), north-eastern and central Spain, respectively. These are Spain's empirical contexts in the SURE-Farm project. However, the extensive sheep farming system of Huesca is the main subject of this research, since it has been the empirical subject across all the thesis analytical phases. In contrast, the extensive cattle system of Guadarrama has been subject of the analysis in the first step of the thesis research, specifically on farm succession dynamics. The localization of the case studies is shown in Figure 7.

The choice of the case studies is due to the significant pressures they have undergone in the last decades, and the important ecosystem services and functions delivered in this marginal regions. However, the extensive cattle system is located in proximity of the large urban area of Madrid. This fact reduces significantly the marginality of cattle farms, and mitigate the phenomena of rural depopulation and lack of services and infrastructure in the area. Besides, cattle farms show higher profitability and less work commitments, with consequent higher opportunities for off-farm employment. These factors underlie the choice to address the thesis research to the extensive sheep farms of Huesca that, in turn, show several weaknesses and suffer stronger pressures.

Like sheep farm typologies identified in different Mediterranean regions (Caballero, 2001; Usai et al., 2006; Gaspar et al., 2008; Mena et al., 2016), the extensive sheep system of Huesca is characterized by small- to medium-sized family farms, mostly tended by family labour and strongly dependent on leased land (Pardos et al., 2008). In 2016, about 50% of farms had a herd size of between 200 and 1000 heads. However, there has been a drop in the total number of heads and the number of farms by 50% over the last 20 years and 60% over the last 25 years, respectively (Fau, 2016). Commonly, rented land and pastures provide a significant proportion of a farm's total land. Sheep farming is dedicated to lamb meat production. Traditionally, in this region the sheep farming can be coupled with olive and almond orchards, and cereal crops.

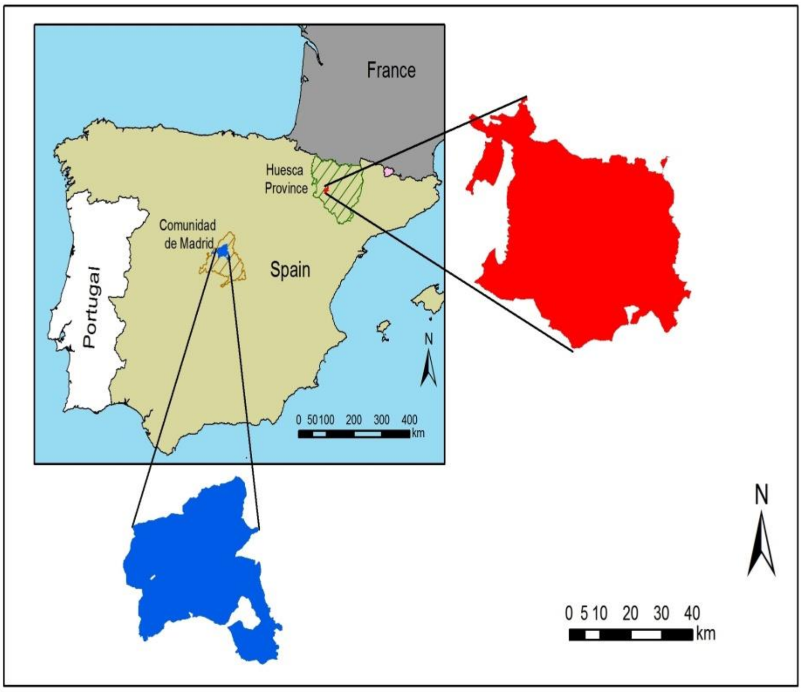


Figure 7. The localization of the two case studies. Source: Bertolozzi-Caredio et al. 2020.

In these farms the employment rate of non-family members is low, basically due to depopulation trends and because extensive livestock farming is not an attractive activity. The system is located in a marginal area with poor services and infrastructures, and a significant depopulation trend. Marginality-induced poor services, together with the heavy work commitments required by the extensive livestock farming, lead to a poor quality of life that has a profound effect on the system. Consequently, the extensive sheep system of Huesca has undergone remarkable transitions to other production activities and arrangements. Farms tend to intensify sheep breeding, and to rely more on crop production when land is available. In mountainous areas where crop production is less feasible, there have been phenomena of abandonment and transitions to more profitable activities, such as pig and calf fattening.

In Huesca, there exist cooperative networks that involve sheep farmers in cooperatives, associations and trade unions. One of the strongest cooperatives, for instance, is Oviaragón. Nonetheless, many farmers are not willing to join cooperatives. Main factors explaining the not-wide participation in cooperation schemes are the lack of trust and the affiliation costs. Cooperatives can serve sheep farms for manifold purposes, such as reinforcement of the bargaining power towards retailers, marketing innovations to strengthen consumer guidance and market positioning, experimentation of new technologies and breed selection, and knowledge exchange.

Lamb producers in Huesca can rely on a Protected Geographical Identification (PGI), namely *Ternasco de Aragón*[5]. This PGI is a quality label set up in 1996 and awarded by the *Ternasco de Aragón* supervisory body to farms following a specified protocol to ensure traditional, quality production (Sans et al., 1999). In 2017, 668 farms were registered under the PGI (33% less than in 2008), whereas the number of lambs sold under the PGI dropped by 12% over the same period (MAPA, 2020a). Moreover, a segment of sheep farms are involved in research projects. For example, the CITA[6] (*Centro de Investigación y Tecnología Agroalimentaria de Aragón*) is involved in several projects with farmers, aimed at bringing innovations in pastures and flocks management, and breed selection.

3.3 DATA AND MATERIALS

Approaching the resilience of a farming system requires a variety of data and information of different nature and from alternative sources to account for the multifaceted aspects of the resilience concept, from multiple viewpoints. Consequently, quantitative and qualitative data were collected through various methods, including farmers semi-structured interviews, stakeholders focus group, and statistical data from institutional and public sources. With the exception of statistical data provided by public databases, the collection of data was carried out along with the tasks and activities of the SURE-Farm project, between 2018 and 2019. Three different sources of data, related to as many data collection phases, were defined as follows:

- 23 in-depth, semi-structured interviews, of which 14 to sheep farms of Huesca, and 9 to cattle farms of Guadarrama. They were conducted between June and October 2018 with 28 persons between farmers and their relatives. In fact, interviews were not all confined to the farm head, as some farmers' sons/daughters/wives were also interviewed, and respondents were interviewed together in other cases. The interviewees were selected purposively to represent diverse farm types and experiences, by the help of the local administration. Semi-structured interviews were chosen to gather hidden information and build a fully explained context of study in which to better embed further quantitative and qualitative data. Open interviews are characterized by interviewees expressing themselves in their own way during a conversation with the interviewer. The interviews lasted between one and one and half hours, and the main objective was to understand the farm demographic dynamics and the farmers' network of influence (the set of actors having an influence on the farmer behaviour and decision making). The interviews, however, included rich information regarding farms characteristics and the farmers' strategic decision-making over the last decade. All the interviews were recorded and transcribed ad verbatim. Information on collected interviews is shown in Appendix I.

[5] http://www.ternascodearagon.es/consejo-regulador-ternasco-de-aragon/
[6] https://www.cita-aragon.es/

- A multi-stakeholder focus group was held in Huesca in April 2019, involving nine participants representing different actors belonging to the farming system. These includes farmers, farmers' organizations and cooperatives, banks and insurance companies, and local administrators and policymakers. By means of a participatory brainstorming approach, the focus group aimed to identify ways through which stakeholders can concur to improve the risk management strategies. Qualitative information was collected regarding the main challenges affecting the farming system, the main strategies (either implemented or to be implemented), the role played by different stakeholders in each strategy and their performance, and indications to improve stakeholder role in those strategies. Information on focus groups participants are reported in Appendix II.

- Farm economic and production data were provided by institutional and public sources. A dataset of farms accountancy data was provided by the Spanish National Agrarian Accounting Network (RECAN) team at the Spanish Ministry of Agriculture in June 2019. This includes data on costs, revenues and subsidies for 230 sheep farms in Aragón, between 2014 and 2017. This information were integrated by national price data for the period 2004-2017, available on public datasets provided by the Price Observatory of the Spanish Ministry of Agriculture[7]. In addition, data on sheep prolificacy rates in Aragón (regional level) were derived from the freely available Studies on Costs and Revenues of Agricultural Farms (ECREA) provided by the Spanish Ministry of Agriculture[8].

[7] https://www.mapa.gob.es/es/alimentacion/servicios/observatorio-de-precios-de-los-alimentos/default2.aspx
[8] https://www.mapa.gob.es/es/ministerio/servicios/analisis-y-prospectiva/ECREA-Informes_Ganaderia.aspx

3.4 ANALYSIS OF THE FACTORS AFFECTING FARM RESILIENCE AND GENERATIONAL RENEWAL IN EXTENSIVE LIVESTOCK

The objective of the research study 1 is to identify the factors threatening generational renewal and its characterizing phases. Most of the analyses are based on econometric and non-linear models (Mann, 2005 and 2007), and they generally consider quantitative factors (Morais et al., 2017). This branch of the literature has mainly focused on quantifiable and less idiosyncratic parameters. Besides, econometric and non-linear methods are not completely able to explain succession in all its complexity (Corsi, 2017). It is worth further exploring the social and human aspects of farm succession (Pindado et al., 2018; Bertoni and Cavicchioli, 2016), especially in the small-scale farming systems of southern Europe, such as the extensive livestock farming, where patterns of succession require further investigation (Zagata & Sutherland, 2015). To this end, a qualitative content analysis of 23 semi-structured interviews was performed.

By taking a qualitative approach, we can understand the relationships between the social and human factors characterizing the family farm succession process (Tsang, 2014). We followed the methodology of qualitative inductive content analysis (Mayring, 2000; Hsieh & Shannon, 2005; Schreier, 2012). The strength of this approach is that it uncovers new evidence from data and can describe what role social and human factors play in the family farm dynamics. The method involves the collection of data and information by means of open interviews, the elaboration and coding of collected data, and the construction of an explanation of the farm succession process. In this method, data analysis is based on an interview transcript coding process. This process extrapolates qualitative evidence concerning the research topic and questions. This approach initially leaves out predetermined theories, and paves the way for an in-depth understanding of less-known factors (Konecki, 2018). In fact, other theories and knowledge about the topic come into play after the data are analysed and results emerge (Potter & Levine-Donnerstein, 1999). Thanks to this methodology, therefore, we have been able to gather particular evidence about the social functioning of the farm succession process by integrating our results with evidence from previous studies. The method is explained below. This analysis was supported by the use of Nvivo software.

3.4.1 DATA COLLECTION AND ANALYSIS

The raw data were collected from 23 thorough one- to two-hour interviews conducted between June and October 2018 with 28 farmers and their relatives. The interviews were held in three phases, as highlighted in Appendix I. The optimal number of interviews depends on the theoretical saturation point: the theoretical saturation is reached when further interviews fail to show up new data with respect to the concepts revealed by the iterative process (Gehrels, 2013). Participants were selected according to a purposive sampling approach, as the research goal is to uncover all useful evidence to gain an in-depth understanding rather than to output statistically generalizable results. In addition, this enhances the internal validity of the method.

Sampling criteria were gender, alternative specialization, farm size in terms of hectares and herds, young/old farmers, new entrants and experienced farmers. Interviews were not all confined to the farm head, as some farmers' sons/daughters/wives were also interviewed, and respondents were interviewed together in other cases. Such interviews have a proven potential for collecting deeper information (Riley, 2014), although there is a risk of responses obeying social expectation.

Semi-structured interviews were chosen to gather hidden information and build a fully explained context of study in which to better embed further quantitative and qualitative data. Open interviews are characterized by interviewees expressing themselves in their own way during a conversation with the interviewer. Nevertheless, later interviews could become more structured as a result of the interviewer's growing understanding of the topic to guarantee greater consistency. For this reason, they can also be referred to as in-depth interviews (Denzin and Lincoln, 2008).

Farm succession was the central topic of the interview framework. Therefore, plenty of specific data were gathered about this issue. The conversations were conducted in order to try to understand farm succession processes and contextual farm demography and focus attention on the specific characteristics of each story with respect to the evolution of farm succession. All the interviews were recorded and transcribed ad verbatim. Appendix I provides a brief description of the family members who were interviewed.

Interview recording, transcription, and data analysis were carried out iteratively. This facilitates a sharper focus on the issues of most concern and improves the quality of the interviews. It is known as constant comparative analysis and is also needed to get more accurate evidence and establish the generality of facts (Cho and Lee, 2014). Nvivo software facilitates the coding process, enabling us to easily select and classify key sentences that help to answer the research questions. Following Corbin and Strauss (1990), the coding phase consists of three steps: open coding, axial coding and selective coding (see Figure 8).

Open coding consists of reading transcriptions line by line and gathering fragments of text constituting possible responses to the research questions. These fragments are then listed with short and meaningful labels (open codes). Open codes identify incidents that can indicate concepts. A single fragment can be linked to more than one code, and it is possible to build a 'coding tree'.

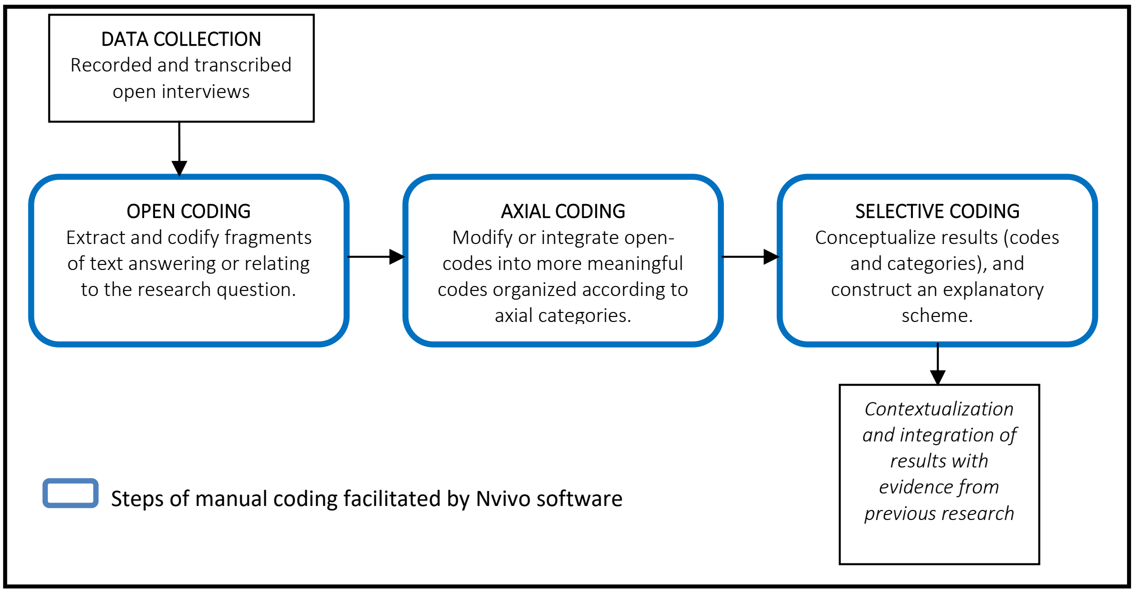


Figure 8. Scheme of the analytical steps. Source: Bertolozzi-Caredio et al. 2020.

Axial coding should be regarded as the data analysis of the output of open coding. During this phase, the relationships between codes were explored and tested against data (Corbin and Strauss, 1990). Axial coding involves deleting, refining and integrating open codes into more comprehensive and meaningful axial codes, which are organized in axial categories by finding interrelations. This process identified three axial categories. The first category was potentiality, where axial codes identify the recognition of a potential successor by the family as a central concept in family farm succession. The second category was willingness, where axial codes point to the central concept of the successor's willingness to take over the farm. The third category was effectiveness, which describes the concept of taking over the farm business. Appendix III reports the axial categories, and the related codes uncovered during this second stage.

Selective coding is a process of organizing the results of axial coding in a conceptually coherent manner in order to comprehensively answer the research question and explain the main aspects of the phenomenon (Konecki, 2018; Cho and Lee, 2014).

The analysis was concluded by comparing results with the findings reported in the farm succession literature. The topic has been studied in other research, albeit using different approaches. Therefore, other works report relevant evidence that may explain, clarify, modify or enrich understanding of succession. This sort of triangulation is part of the theoretical framework, as it provides for further development and a deeper understanding of the processes under study (Petty et al., 2012). The literature was collected regardless the applied methodology (e.g. qualitative or quantitative) and the location (worldwide). The criteria was the study of factors affecting the succession process in its different phases.

3.5 ANALYSIS OF THE RESILIENCE ATTRIBUTES AND CAPACITIES OF ALTERNATIVE MANAGEMENT PATTERNS IN EXTENSIVE SHEEP FARMS

3.5.1 ANALYTICAL STEPS

The objective of the research study 2 is to identify the resilience attributes and capacities in alternative farm management patterns. Farm management patterns are combination of different farming practices and farm strategies. Alternative combinations may have different implications on the functions delivered by the system, and show diverse capacity to cope with challenges. Therefore, it is relevant to study these patterns through the lens of resilience. To achieve the goal, a mixed approach based on cluster analysis and qualitative content analysis of data from 14 of the 23 semi-structured interviews collected along the thesis research. These were conducted exclusively with extensive sheep farmers in Huesca, Aragón. Yet, the characteristics of the sample are reported in Appendix I. The interviews lasted between one and one and half hours. The interviewees were selected purposively to represent diverse farm characteristics and management, by the help of the local administration. Unfortunately, no female farmers could be interviewed, impeding any gender-based conclusion. In a certain sense, this is a representative feature of this sector, in which male gender is predominant. The interviewees were asked to describe farms' characteristics, to share their concerns on challenges they have been facing so far, and their farm management strategies over the last two decades.

Interviews were recorded and transcribed, and an analysis was carried out following three steps, as shown in Figure 9. Each methodological step targets a research objective. In the first step, the strategies implemented by farms were identified and four management patterns were defined through a cluster analysis. Secondly, the content of the interviews was analysed by means of a coding process aimed at identifying resilience attributes. In the third and last step, a further content analysis was carried out by coding the resilience capacities. The methodological steps are described below.

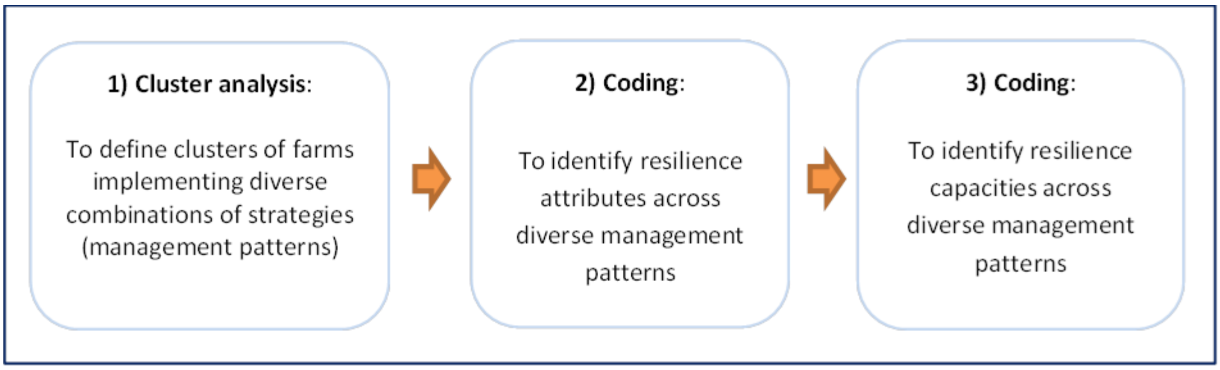


Figure 9. Methodological steps. Source: own elaboration.

3.5.2 IDENTIFICATION OF STRATEGIES AND MANAGEMENT PATTERNS

Firstly, farm management strategies implemented by the 14 farmers were identified across the farmers' narratives. As a result, we obtained a list of 20 farm management strategies. Based on this information, alternative combinations of strategies could be identified, which we refer to as farm management patterns hereinafter. Though the limited number of observations would allow to qualitatively group farms based on the interviews' content, a hierarchical agglomerative cluster analysis of the 20 strategies was performed to support the identification of patterns. The cluster analysis was applied to the binary information about implemented/non-implemented strategies extracted from the interviews.

Following Weltin et al. (2017), the cluster analysis was based on a Gower dissimilarity matrix, due to its flexibility in handling binary data. We applied a complete linkage fusion algorithm, as it was found to be successful in a wide variety of applications (Großwendt and Röglin, 2017). In order to choose a convincing number of patterns, we first computed various indexes, as proposed in Charrad et al. (2015). Based on a majority criterion, eight indexes suggested four clusters as the most proper number. Next, the cluster dendrogram and the corresponding grouped farms were evaluated to confirm whether meaningful differences were captured by the clustering solution (Barbosa-Carvalho et al., 2015). Finally, four major clusters of farms, each representing a management pattern, were selected. A cluster, therefore, contains those farms implementing a similar combination of strategies. The Gower matrix and cluster dendrogram are reported in Appendix V.

3.5.3 RESILIENCE ATTRIBUTES

In the second step, the resilience attributes were coded. Coding consists of the qualitative analysis of narratives to select fragments of text (quotes) and group them into meaningful labels named codes (Hsieh and Shannon, 2005; Glaser and Laudel, 2013). Each code contains information on a specific topic (e.g. a resilience attribute) from multiple sources of data (the transcribed interviews). Deriving from the literature, and based on the information gathered through the farmers' narratives, nine attributes to be assessed in the analysis were identified. The quotes were coded into these nine attributes. In practice, the quotes were identified by searching in the narratives for factors (i.e. attributes) having an influence on farmers' capacity to implement strategies. Next, the quotes were classified based on the pre-established nine attributes' definitions. For example, when encountering a fragment of text explaining how important was a learning visiting trip to understand how to implement technologies on pastures, then this quote could be classified into the attribute 'Learning capacity'. The content analysis, therefore, can be referred to as deductive since codes were identified prior to the coding analysis. The Appendix IV shows the nine resilience attributes, their definition and the conceptual linkages with attributes defined in previous investigations.

The attributes were then divided as whether they enable or constrain a given management pattern, based on the farmers' narratives on what factors impede their strategic choice, or induce them to make one. In fact, an attribute can constrain a management pattern, while enabling another. For example, available labour force may enhance a pattern (e.g. intensification), while weakening another (e.g. extensification) due to scarce availability of workers in the latter pattern.

The relative importance of attributes for a pattern is measured by a quotes' intensity +/- scale, which is based on the share of quotes related to an attribute for a specific management pattern on the total quotes referred to that pattern. If the share is minor than 25% it assumes a plus (+), between 25 and 50% double plus (++), and major than 50% triple plus (+++). To mark the difference between enabling and constraining impacts, constraining attributes are signed by minus (-) instead of plus. However, exclusive quantitative interpretations should be derived with caution as they could be subject to biases in coding and overrepresentation of some interviews in the quotes selection (the number of selected quotes vary among interviews), and accompanied by the qualitative content in the analysis of findings.

3.5.4 RESILIENCE CAPACITIES

In the third step, the three resilience capacities were analysed through further coding. In their narratives, farmers described the impact of implemented strategies on their own farms' structure, organization and delivered functions. Such narratives were analysed to learn about the impact of strategies in each management pattern, by coding explicative and meaningful quotes into three codes of robustness, adaptability and transformability. Thus, a quote contains a description of a strategy's impact (or an aspect of it) on the farm, which needs to be referred to a resilience capacity. Importantly, farmers do not explicitly refer to robustness, adaptability and transformability in their narratives, being these mainly academic concepts. Therefore, to infer information on which resilience capacities emerged behind the quotes, a deductive scheme based on three questions to be answered while coding was used, as reported in Figure 10. These questions were answered for each quote explaining an aspect of the strategy's impact on the farm. Each quote, therefore, relates to one capacity. This implies that a strategy, which can be described by many quotes, could relate to all capacities (although likely to different extents).

Following the prior deductive scheme, for example, when analysing a quote explaining the impact of feed sharing, we should wonder whether this strategy had altered the original farm structure and functions. If it did not, the quote had to be coded as robustness, otherwise the following two questions had to be answered to infer adaptability or transformability. As a result, the farmers' quotes were grouped across three codes of robustness, adaptability and transformability. Being management patterns characterized by different strategies (which relates to resilience capacities to varying extents), the three capacities were observed by single pattern. Similarly to the analysis of attributes, the results are shown through an quotes' intensity (+/++/+++) scale, per management pattern.

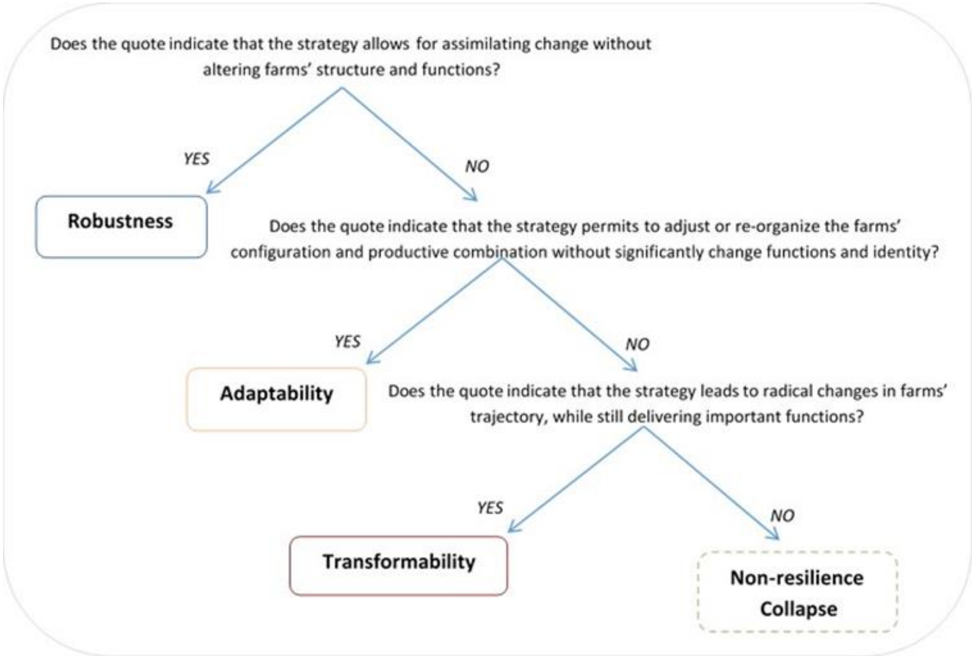


Figure 10. Deductive scheme to infer resilience capacities. Source: own elaboration.

3.6 ANALYSIS OF THE PERFORMANCE AND RESILIENCE OF DEMAND- AND SUPPLY-ORIENTED STRATEGIES TO COPE WITH ECONOMIC RISK

The objective of the research study 3 is to quantify the economic performance of alternative demand- and supply-oriented strategies to cope with main economic risks. The approach is based on the definition of a gross margin model, and four strategic scenarios. The analysis consists of Monte Carlo simulations and stress analysis under two risk factors, namely lamb price and feeding cost. Stochastic simulations are commonly used to evaluate economic performance and vulnerability, as well as a variety of climate and financial risk-specific assessments (e.g., Gibbons and Ramsden, 2005; Castañeda-Vera and Garrido, 2007; Lien et al., 2007; Bielza Díaz-Caneja and Garrido, 2009; Graveline et al., 2012; Kadigi et al., 2020). These analyses are often based on the evaluation of risk factors over a density function representing a model's outcome by means of risk indexes and sensitivity analyses (Monjardino et al., 2013; Luo et al., 2017). This was, in fact, the first step of our analysis. In addition, we evaluated performance and vulnerability subject to two pre-established price and cost risks by means of a stress analysis. The methodology is explained below.

3.6.1 DEFINITION OF THE FARM MODEL AND SCENARIOS

Lamb production is characterized by the breeding of ewes. The key cycle of this system is the pregnancy and gestation of ewes, with offspring fattened and sold as lambs. Thus, the ewe represents the production unit characterized by a prolificacy rate (lambs born per ewe in a year, net of miscarriages), which can vary depending on management techniques and technologies. The lamb price determines the revenue provided by a ewe, and varies depending on whether the lamb is sold with the *Ternasco de Aragón* PGI label or as a standard product. A sheep farm economic model can be depicted as shown in Figure 11. Based on the characteristics of this lamb production system, alternative scenarios and stressors can be addressed in the analysis. On the one hand, the performance and vulnerability of alternative scenarios can be tested against the baseline scenario to represent potential improvements. On the other, specific risks can be incorporated into the model to highlight the performance of different scenarios under stress.

Sheep farm gross margin can be defined at different levels and measured by alternative indexes. Previous research on lamb production economic performance account for flock production (Farrel et al., 2020), margin per hectare (Bohan et al., 2018), gross or net profit per ewe (Thompson and Young, 2002; Milàn et al., 2003; Krupovà et al., 2014; Rosasco et al., 2019), and lamb prices (Kopke et al., 2008). In this research, I opted for an index of unitary gross margin per ewe (€/ewe), as this helps to assess the economic efficiency of units of production (i.e., the ewe) on which lamb production is based.

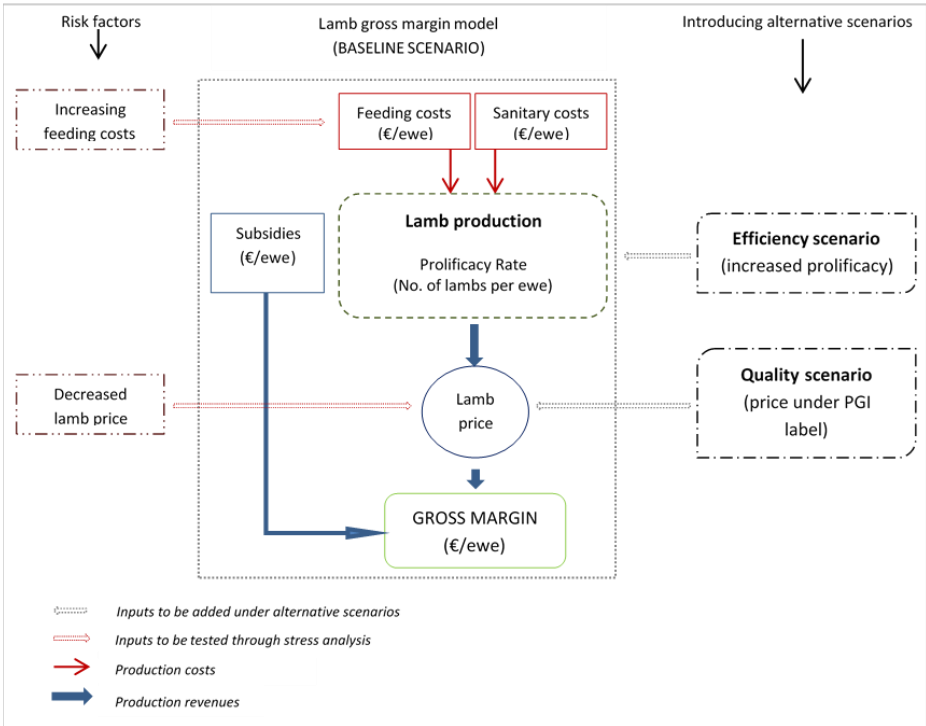


Figure 11. The diagram of the baseline farm gross margin model, the main risk factors affecting feeding costs and price, and two alternative strategic scenarios implying increased prolificacy and PGI prices. Source: Bertolozzi-Caredio et al. (2021b).

The farm model is defined as follows:

$$\tilde{\pi}_{ntz} = (\tilde{r}_{tz}\tilde{P}_{tz}) - (\widetilde{Cf}_{ntz} + \widetilde{Cs}_{ntz}) + \tilde{S}_{ntz}, \qquad (1)$$

Where z represents scenarios, π_{ntz} is the stochastic gross margin per ewe (€/ewe) achieved by the n-th farm in the year t, r_{tz} is the prolificacy rate in the year t, P_{tz} is the price per lamb in the year t, and S_{ntz} is the coupled payment (€/ewe). The index takes into account the specific variable costs of production, which in this case are feeding costs (Cf) and sanitary costs (Cs).

This model, as well as the diagram in Figure 11, are a simplified model of lamb production, as they do not consider fixed costs such as infrastructures and labour costs. Figure 13 shows the cost decomposition per ewe (based on average values from our 230 farm sample records), where feeding costs account for 57% of the expenses. Labour costs were not included as farms under study typically do not hire external workers, partly because there is a widespread shortage of farm workers in the region and farms are mostly unable to pay external labour (Pardos et al., 2008). Though sheep farms rely on significant extensions of non-owned land (Fau, 2016), their leasing costs are relatively small, as shown in Figure 13. Also, the relative importance of general costs can differ between farms, which make it difficult aggregating and comparing them (Zinnanti et al., 2019). In addition, general costs are fixed, i.e., they are rather stable overtime and do not represent an uncertainty (unlike price and specific costs). As shown in Figure 13, sanitary costs cover a limited portion of costs. However, due to the increasing risk of new diseases in the sector (San Martín et al., 2020), we opted for including these costs into the model to evaluate potential risks.

BASELINE SCENARIO

In the baseline scenario, the model assumes conventional lamb prices, an average prolificacy rate in Aragón, and includes variable costs, and coupled subsidies per ewe. Table 5 shows the data on prices, weight of sold lambs, and prolificacy rate used in the model.

The ewe prolificacy rate measures the average number of lambs born to each lambing ewe in a specific year, net of abortions, and survived at the weaning. In our case, we used the annual prolificacy rate showed by sheep farms at regional level in the period 2010-2017 (ECREA, 2020). There are other strategies such as rearing, replacement management, and feeding system that in turn influence the ewe prolificacy and improve the efficiency. Prolificacy can be a proper indicator of productive efficiency, because it ultimately reflects management choices.

The conventional lamb price series (expressed in €/kg of slaughtered lamb) is provided by the Price Observatory of the Spanish Ministry of Agriculture (MAPA, 2020c), covering the period 2004-2017. These are producer prices. These prices have been deflated to the reference year (i.e., 2017) by using yearly general index provided by the Spanish National Statistics Institute (INE, 2020). In order to calculate the price per lamb, the average weight of lambs sold and slaughtered in Aragón in the period 2004-2017 (MAPA, 2020b) was used: the price per kg was multiplied by the average weight for each year to get an average price per lamb in each year. Although the lamb price was deflated, a trend component was still present, which was eliminated from the series (Zinnanti et al., 2019).

Year	Conventional prices (€/kg)	Average lamb weight (kg)	Conventional price (€/lamb)	PGI prices (€/kg)	Average PGI lamb weight (kg)	PGI Price (€/lamb)	Average prolificacy rate (lambs/ewe)
2004	5.6	12.0	70.8	-	-	-	-
2005	5.9	12.0	74.7	-	-	-	-
2006	5.5	12.0	69.6	-	-	-	-
2007	5.4	12.0	66.3	-	-	-	-
2008	5.6	11.9	67.7	6.1	11.1	73.0	-
2009	5.7	11.9	68.4	6.0	11.1	71.0	-
2010	5.5	12.1	67.1	6.1	10.9	70.1	1.03
2011	6.0	12.0	70.9	6.9	11.1	78.1	1.02
2012	6.0	12.0	71.0	7.2	11.1	81.1	1.12
2013	5.9	11.9	68.9	6.1	11.0	66.0	1.06
2014	6.4	11.7	72.8	7.0	11.0	75.5	1.06
2015	6.0	12.1	70.1	6.9	11.0	73.0	1.10
2016	6.1	12.1	71.0	7.4	11.0	77.2	1.13
2017	5.9	12.4	68.8	6.8	10.9	69.1	1.05
Source:	MAPA (2020c)	MAPA (2020b)	Own elaboration	MAPA (2020a)	MAPA (2020a)	Own elaboration	ECREA (2020)

Table 5. Data series of conventional and PGI prices €/kg (real values deflated to 2017 and detrended), average weights of sold lambs (kg), and prolificacy (lambs/ewe) used in the analysis. Lamb price (€/lamb) was obtained by multiplying price €/kg by lamb weight for the respective year. Source: Bertolozzi-Caredio et al. (2021b)

The feeding and sanitary costs were derived from the accountancy data of a sample of 230 extensive sheep farms provided by the Spanish National Agrarian Accounting Network (RECAN). The sample includes observations of Aragón farm financial results over four years (2014-2017). The costs are reported in €/ewe and include the expenses for the lambs born per ewe, which are added to the ewe unit. Table 6 shows the observed farms per year and cost values per year (mean and standard deviation).

	Year	**2014**	**2015**	**2016**	**2017**	**Total**
	Observed farms	*60*	*59*	*57*	*54*	*230*
Feeding costs (€/ewe)	mean	33.2	37.1	35.9	36.2	35.6
	std.dev.	16.1	21.0	16.4	17.9	17.9
Sanitary costs (€/ewe)	mean	3.7	4.0	4.1	3.5	3.8
	std.dev.	1.8	1.9	1.8	2.0	1.9

Table 6. Sampled farms and deflated cost values (€/ewe) by year. Source: Bertolozzi-Caredio et al. (2021b)

In the case under study, sheep receive a coupled payment per ewe (Cimpoies, 2015). The subsidy consists of a payment per head, allocated for a minimum herd size of 30 ewes with a prolificacy rate of at least 0.6. As all the sampled farms met such requirements, these were omitted from the model. The coupled support assigned in the reference year (i.e., 2017) was added to the model, which was 12.11 €/ewe (FEGA, 2018).

QUALITY SCENARIO

In the study area, one of the main concerns of farmers is the low lamb price (Becking et al., 2019). A strategic option farmers can pursue is to adhere to the *Ternasco de Aragón* PGI (Sans et al., 1999). This quality label fetches higher lamb prices with respect to conventional lamb. The research question that we aim to answer is: "to what extent can PGI prices improve the sheep farm performance?" Therefore, a first alternative to the baseline scenario is a quality scenario based on *Ternasco de Aragón* prices over conventional prices. Data on PGI price in €/kg and average weight of sold and slaughtered PGI-labelled lambs in the period 2008-2017 are provided by the Spanish Ministry of Agriculture (MAPA, 2020a). As for the case of conventional prices, the price in €/kg was multiplied by the average weight of lambs sold and slaughtered every year in the series under the PGI label in Aragón to obtain an annual price per lamb from 2008 to 2017. A further difference between conventional and PGI lamb price is the weights of sold lambs, which is slightly higher in conventional production. This is due to a specific restriction of the PGI production protocol under which producers are bound to sell lambs bearing the *Ternasco de Aragón* label with a maximum weight of 12.5 kg. Data are reported in Table 5. The PGI prices, used to model this scenario, were also detrended.

PRODUCTIVE EFFICIENCY SCENARIO

Previous research underscores the role of increased prolificacy in reducing production costs (Bohan et al., 2018) and, generally, improving efficiency (Earle et al., 2017). Efficiency, in fact, contributes significantly to sheep farms' profitability (Morgan-Davis et al. (2017)). As prolificacy was found to be generally low in the Mediterranean area (Gursoy, 2006), most attention focused on increasing prolificacy. In the case study area, one of the main objectives to enhance production efficiency is to increase the prolificacy rate (San Martín et al., 2020). This goal can be achieved by means of diverse breed selection and choice techniques (Viñoles et al., 2009; Gootwine, 2020). The prolificacy rate can vary significantly across farms (Amer et al., 1999). In the baseline scenario, the average rate reported at regional level between 2010 and 2017 (on average 1.1) was used. In addition, the researchers surveyed 54 farmers from Huesca (a province within the case study region of Aragón) in 2018. The survey analysis revealed significant variability of prolificacy rates between farms (from 0.9 to 2.2), with average prolificacy rates being higher than the regional average, indicating that surveyed farms relied on more efficient breeds. Although the survey was limited to one province, an alternative scenario was devised, namely the productive efficiency scenario, with the aim of observing how the economic performance of sheep farms would change if all farms were as efficient as the surveyed farmers in Huesca. To run the efficiency scenario, the baseline farm model is modified by replacing the prolificacy rate at regional level by the improved prolificacy rate of Huesca.

Nevertheless, an increased prolificacy rate entails higher feeding costs as the number of lambs per ewe increases as well. Previous studies in the case study area (Oliván and Pardos, 2000; Pardos et al., 2007) find that farms with a prolificacy rate higher than the cut-off value of 1.3 show a 23-26% increase in feeding costs per ewe with respect to farms with lower prolificacy. Based on this evidence, it is possible to assume that farms with prolificacy above the reference threshold of 1.3 need to account for a 25% increase in feeding costs per ewe on average. Therefore, we integrated the gross margin model (1) into the efficiency scenario by means of a conditional function:

$$\text{if } \tilde{r}_t > 1.3; \;\; \text{then } \widetilde{Cf}_{n,t,z} \text{ is increased by 25\%}; \;\; \text{else } \widetilde{Cf}_{n,t,z} \text{ is not increased}$$

Assuming a capped feeding cost at 25% for $\tilde{r}_t$>1.3 is certainly a modelling simplification. While data are derived from other studies on the same case study area, they are outdated (2007, the most recent). To the best of our knowledge, there is no available data on lamb nutrition and corresponding costs for our case study. Data from other regions are possibly not appropriate to be used because the nutritional requirements depend on genetic, environmental and managerial factors, which can differ significantly between regions (Cannas et al., 2019). Though limited, our simplified model allows for considering a feeding cost-prolificacy linkage.

Lastly, a fourth scenario was derived by integrating the quality and efficiency scenarios, which models both improved prolificacy rates and PGI prices.

3.6.2 MAIN RISK FACTORS

Previous investigations in the case study area identified several institutional, economic, social, and environmental challenges threatening the performance and prospects of extensive sheep farms (Becking et al., 2019; San Martín et al., 2020; Soriano et al., 2020). With particular regard to farm economic performance, however, two main risk factors can be defined, namely falling lamb prices and rising feeding costs. Figure 12 plots these data series.

Falling lamb prices is an important determinant of low sheep farm gross margin (Becking et al. 2019; Spiegel et al., 2019), most likely explained by the sharp decline in lamb consumption in Spain (Alcalde et al., 2013). The annual lamb consumption decreased from 2.1 kg/capita in 2011 to 1.33 kg/capita in 2019 (MAPA, 2019). As this consumption trend is likely to persist in the coming years, concerns about possible drops in lamb price are widespread.

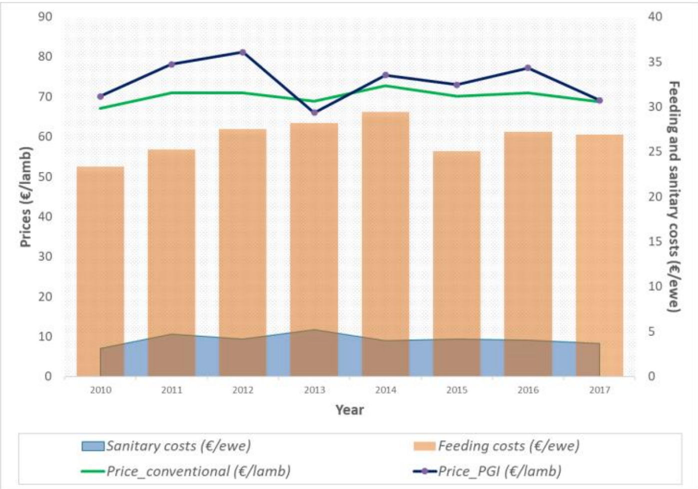


Figure 12. The development in conventional and PGI lamb price (€/lamb), and feeding and sanitary costs (€/ewe) in Aragón – Years 2010-2017. Source: Bertolozzi-Caredio et al. (2021b).

Generally, feeding is the largest expense in lamb production (Toro-Mujica et al., 2012; Morris, 2017). Previous research in the case study area shows that feeding costs are much higher than other specific costs (Pardos et al., 2008). Accordingly, Figure 13 shows the cost decomposition per ewe (based on average values from the 230 farm sample records), where feeding costs account for 57% of the expenses. Feeding costs have been increasing for the last twenty years, also leading to important changes in farm management and a sizeable reduction in gross margin (Olaizola et al., 2008). The feeding cost trend can be also affected by periodic droughts (Countryman et al., 2016; Salmoral et al., 2020), which reduce grazing potential. The increase in feeding costs is probably the main factor affecting lamb production gross margin, and is therefore an important source of risk.

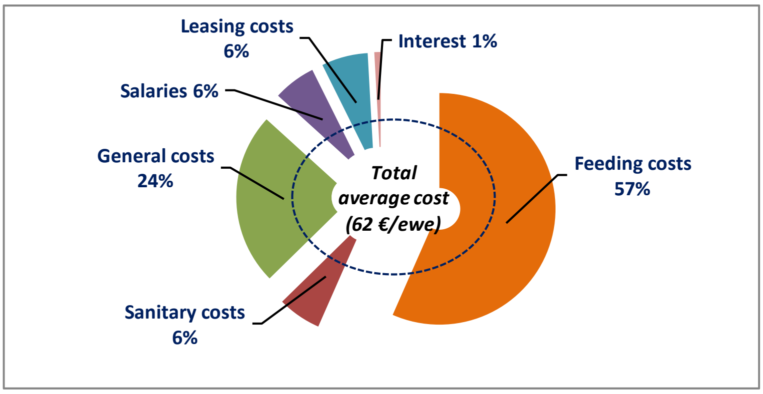


Figure 13. Percentage decomposition of costs per ewe. Source: Bertolozzi-Caredio et al. (2021b).

3.6.3 MONTE CARLO SIMULATIONS AND STRESS ANALYSIS

All inputs in the model (Equation 1) are stochastic variables. For all inputs, a probability density function (PDF) was either assumed or fitted. For the coupled support, I allowed a ±10% variation range from the given value of 12.11 €/ewe (i.e., the support provided in 2017). This is explained by the fact that coupled support is determined on a year-by-year basis and depends on the estimated total number of eligible ewes at regional level, therefore the subsidy could vary slightly (FEGA, 2020).

Table 7 shows the model input distributions and statistics. The fitting distributions were identified by observing the four moments (μ, σ, skewness, kurtosis) for each input variable. The best fitting distributions were selected for feeding and sanitary costs (Triangular and BetaGeneral, respectively) by the BestFit @Risk function (Zinnanti et al., 2019). The Akaike information criterion (AIC) was used to rank the tested distributions, namely normal, PERT, Gamma, Lognormal, Triangular, Beta, Loglogistic, Pearson5 and uniform. In the case of prices, prolificacy rates and subsidies, however, the data series were too short to perform a best-fit distribution function. Based on the observed moments, three commonly used distributions were assumed (Triang, PERT, uniform). Prices revealed positive skewness. Therefore, a PERT function was used to best fit the positive asymmetry of the available data. Due to the use of only three values, subsidies were modelled by a uniform distribution. The Monte Carlo simulations were based on the above PDFs, and the correlations between input variables were incorporated into the model (see the correlation matrix in Table 8). Following Zinnanti et al. (2019), 10.000 iterations were performed to ensure output's consistency.

In the first step, the four scenarios were run under no stressors. The economic performance was measured by the mean (μ), standard deviation (σ), and coefficient of variation (CV). Also, other indicators of risk were computed, such as the semi-standard deviation (SSD) and the semi coefficient of variation (SCV) that measure the downside risk exposure (in practice, the σ and CV of all values below the mean, the left-hand side of the distribution), to target the risk of gaining a value below the expected model's average outcome (Hardaker et al., 1997). With outcome, we refer to the range of gross margin values obtained when running the model. The downside risk evaluation also helps identify the amount of losses that a farm can sustain. In addition, the value at risk (VaR) index gives a measure of potential losses. The VaR is measured as the percentage share of the difference between the mean and the expected outcome value at a 95% confidence level on the average gross margin (Dowd, 2007; Zinnanti et al., 2019). Besides, the break-even probability (BEP) was used to indicate the probability of returning a profit, which is measured as the percentage of non-negative gross margin outcomes (π ≥0) over total outcomes. Lastly, the kurtosis statistic indicates the probability of extreme events occurring: the higher the kurtosis, the higher the probability.

	Prolificacy rate	**Improved prolificacy rate**	**Price (€/lamb)**	**PGI price (€/lamb)**	**Sanitary costs (€/ewe)**	**Feeding costs (€/ewe)**	**Coupled Subsidies (€/ewe)**
Minimum	1.02	0.90	66.3	66.0	0.0	4.6	10.90
Maximum	1.13	2.20	74.7	81.1	9.2	96.6	13.32
Mean	1.07	1.40	69.9	73.4	3.8	35.6	12.11
Mode	1.06	1.20	70.6	73.2	2.9	55.0	-
Median	1.06	1.40	69.8	73.0	3.5	34.4	-
Std. Deviation	0.04	0.26	2.3	4.6	1.9	17.9	-
Skewness	0.35	0.93	0.5	0.1	0.5	0.7	-
Kurtosis	1.58	4.32	3.3	2.4	2.7	3.3	-
5% (percentile)	1.0	1.0	66.3	66.0	1.1	12.8	-
95% (percentile)	1.1	2.0	74.7	81.1	7.2	71.3	-
Fitting distribution	*Triang*	*Triang*	*Pert*	*Pert*	*Triang*	*Beta General*	*Uniform*

Table 7. Input variable distribution parameters in the stochastic model. Source: Bertolozzi-Caredio et al. (2021b).

Sensitivity analyses were carried out to gain insight into the main risk factors. A sensitivity analysis measures the extent to which input variables impact the gross margin outcomes. Tornado charts were used to display a ranking of the input distributions that influence the output. There are different types of tornado charts. First, the input regression coefficients were compared by scenario in a multiple tornado chart. By so doing, it is possible to observe the magnitude and direction of the effect of input variables on the output in each scenario. Subsequently, an analysis of the regression mapped values by input variable was applied (Zinnanti et al., 2019; Kamali et al., 2017; Ghasemi et al., 2012). This analysis measures the amount of change in the output (mapped values) due to a one standard deviation change in one input variable, while other input variables remained unchanged at their mean value. The mapped values are beta coefficients from a regression in which the mean gross margin is the dependent variable, and the independent variables are random functions of the input variables, where all variables are standardized. This approach compares variables with different units of measurement (Zinnanti et al., 2019). Results are shown by means of multiple tornado charts in which each bar represents the change in the output (gross margin) corresponding to a one standard deviation change in a specific input variable.

In the second step, the analysis simulated the four scenarios under stressors. Two stressors were selected: decreased lamb price and increased feeding costs. The stressors were introduced by running the simulations while limiting the PDFs of selected input variables to a specified percentile. The analysis was carried out at two stress levels: 10 and 50 percentile. First, the lamb price was limited to its 0-10% PDF (to simulate lowest possible prices only) for the price stressor; the feeding costs to their 90-100% PDF (to simulate highest possible costs only). Then, the analysis was repeated by limiting simulations to 0-50% and 50-100% for prices and costs, respectively. First, the stressors were introduced in the model one by one, and the impact on performance was observed separately for each stressor. Then, the stressors were introduced simultaneously to capture the whole effect on performance. To analyse the effect of stressors on scenario outcomes, the percentage variation between the average gross margin outcome under stress was measured, and the expected average under no stress, as well as the percentage BEP. Besides, scenario PDFs were compared by stress type.

In addition, a sensitivity analysis was performed to assess the impact of a reduction in subsidies on gross margin. This was carried out by running the models under different values of the coupled subsidies through the iterative reduction of the variable output value by percentage levels. The profitability outcome was observed at five levels of the coupled subsidies output value —base outcome (0% change), -25%, -50%, 75%, and -100% (complete removal)— across the four strategic scenarios.

	Price	PGI price	Prolificacy	Improved prolificacy	Feeding costs	Sanitary costs
Price	1					
PGI price	-0.285	1				
Prolificacy	-0.671	-0.036	1			
Improved prolificacy	0.217	0.343	-0.379	1		
Feeding costs	0.275	-0.539	-0.551	0.045	1	
Sanitary costs	0.112	0.030	-0.108	-0.076	0.149	1

Table 8. Input variables correlation matrix in the stochastic model. Source: Bertolozzi-Caredio et al. (2021b).

3.7 ANALYSIS OF RISK MANAGEMENT STRATEGIES TO IMPROVE RESILIENCE

The objective of the research study 4 is to identify new ways through which risk management strategies may improve resilience. The assessment consists in a multi-stakeholder focus group involving nine participants, through which main challenges, strategies, actors' involved, and potential improvements are identified. The approach is described below.

3.7.1 MULTI-STAKEHOLDER FOCUS GROUP

Considering the conceptualization and research goal, a qualitative and participatory approach based on focus groups was chosen. As risk management is assumed to be the result of complex interactions between actors of the farming systems (see conceptualization in Figure 14), focus groups were judged to be the best method for this research inquiry. Focus group is a widely used technique to engage stakeholders in informal or semi-structured group discussions focusing on one or more topics. It is a way of collecting qualitative data from multiple individuals simultaneously (Wilkinson, 2004). According to Kamberelis and Dimitriadis (2011), focus groups enable researchers to observe the dynamics of social interactions among specific groups of people, such as defining training needs or community reaction to face threats (Winlow et al., 2013), and stimulating multiple stakeholders to find a common approach to an issue that affects them all (Roloff, 2008).

The focus group involved nine participants. It took place at the Agricultural Administration Office in Huesca on April the 4th 2019. They were chosen purposively to represent the stakeholders involved in the farming system, that are farmers, farmers' associations and cooperatives, banks and insurance companies, and the public sector. Appendix II reports information on participants. Different activities were developed during the focus group, as shown in Figure 14. The first two steps of the focus groups helped identify the main challenges and strategies of the extensive sheep farming system of Huesca. Stakeholders participated in identifying and ranking the top 10 challenges to be tackled, and up to five strategies to deal with the identified challenges (currently and with a view to the future).

To ensure that the identification of challenges and strategies was consistent with the existing empirical evidence, the researchers provided information on the most often perceived challenges and significant strategies derived from previous surveys in the case study area (Spiegel et al., 2019). The participants, therefore, could discuss, integrate and agreed with such rankings.

Once the strategies had been selected, participants were invited to identify the actors involved in each strategy, and then to discuss their performance in the third and fourth steps. The last step was a brainstorming activity to suggest improvements on actor roles and behaviour. Improvements were proposed by participants within an open discussion, and each was written down on a post-it. Participants were allowed to suggest as many improvements as they wished. An improvement is a suggestion (sentence) made by a focus group participant on how to improve the input of a specific actor to better implement a specific strategy. Therefore, each improvement is related to a strategy, and an actor involved in that strategy. A total of 60 differentiated improvements were collected. These are reported in Appendix VI.

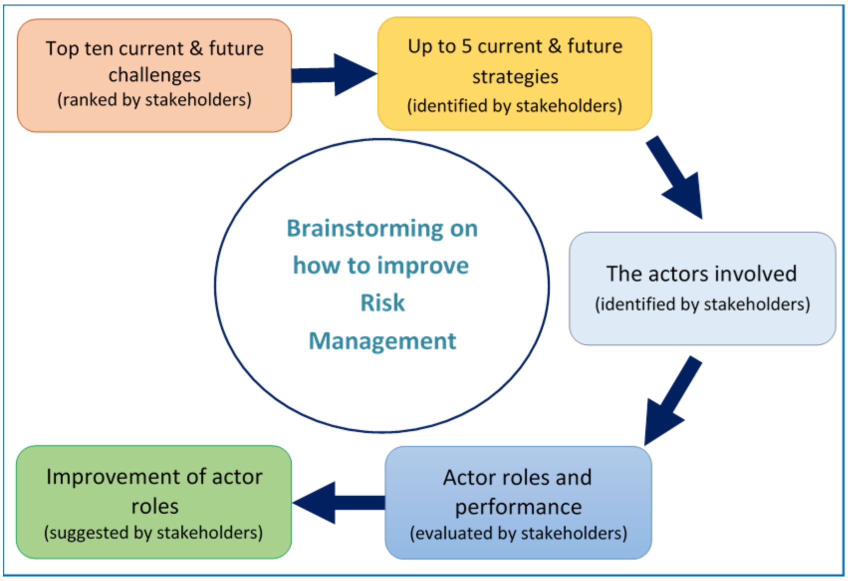


Figure 14. Methodological design of focus group activities. Source: Bertolozzi-Caredio et al. (2021a).

3.7.2 DATA REPORTING AND ANALYSIS

The qualitative results collected throughout the focus group, were reported by tables and figures and discussed against the literature. The main challenges, strategies and actors identified by participants are shown in two separated tables. Next, the main suggested improvements are shown, by actor and strategy, by means of a table. Lastly, improvements were grouped into three main topics, namely *Cooperation & Marketing*, *Knowledge System*, *Policy & Financial Tools*. These main topics were analysed, by actor and strategy separately, based on the number of improvements contained in each topic for each actor/strategy, in order to define which topics were more important in the focus group participants' opinion. The results are displayed through two bar chart graphs.

4. RESULTS AND DISCUSSION

4.1 FARM RESILIENCE AND GENERATIONAL RENEWAL IN EXTENSIVE LIVESTOCK SYSTEMS

In this chapter, the first step of the thesis' analysis is reported, whose aim is to identify the factors threatening generational renewal and its characterizing phases (objective I). To this end, a qualitative content analysis of 23 semi-structured interviews was performed, as explained in section 3.4.

4.1.1 RESULTS

Farm succession develops over many years, generally aligned with the family life cycle, beginning at the birth of a child to a farmer, going through a series of transitions, and ending with full transfer of managerial control from the farmer to this child (Lobley et al., 2010). Thus, it is correct to refer to succession as a process. The first result of the analysis is the identification of three typical steps that are likely to take place consecutively throughout succession. Therefore, the broadest definition is that family farm succession is a long-term, three-step process involving individual evolution. The characteristics of the successor as an individual are central to, and evolve throughout, the three-step process. The first step is recognition by the farmer and the farming family as the future potential successor; the second step refers to future potential successor's willingness to take over the farm, and the third step is effective succession.

Figure 15 shows the three steps of the family farm succession process and the corresponding axial codes that emerged during the analysis. The axial codes represent the main topics that became clear from the interviews. These codes contain references (fragments of text) from a varying number of interviews. The number of references shows how many times the topic was referenced in all the interviews, whereas the number of interviews indicates in how many interviews the topic was mentioned. With respect to the succession process, a high number of references are a possible indicator of the relevance of a topic under some circumstances, whereas a high number of interviews possibly suggest that the topic is of widespread relevance.

The bar chart in Figure 15 indicates which issues are put forward during the interviews. There are more references for the willingness, potentiality, and effectiveness steps, respectively. Regarding the potentiality step, several references describing the growing experience of children and the shaping of their individual attributes were found ('shaping personal identity' and 'building up experience'). It is also found that potentiality is recognized by the farmers and families ('farmer's and family's recognition'). Interviewees underlined the importance of children's involvement in farming (rather than other activities) for shaping attributes and favouring the family recognition.

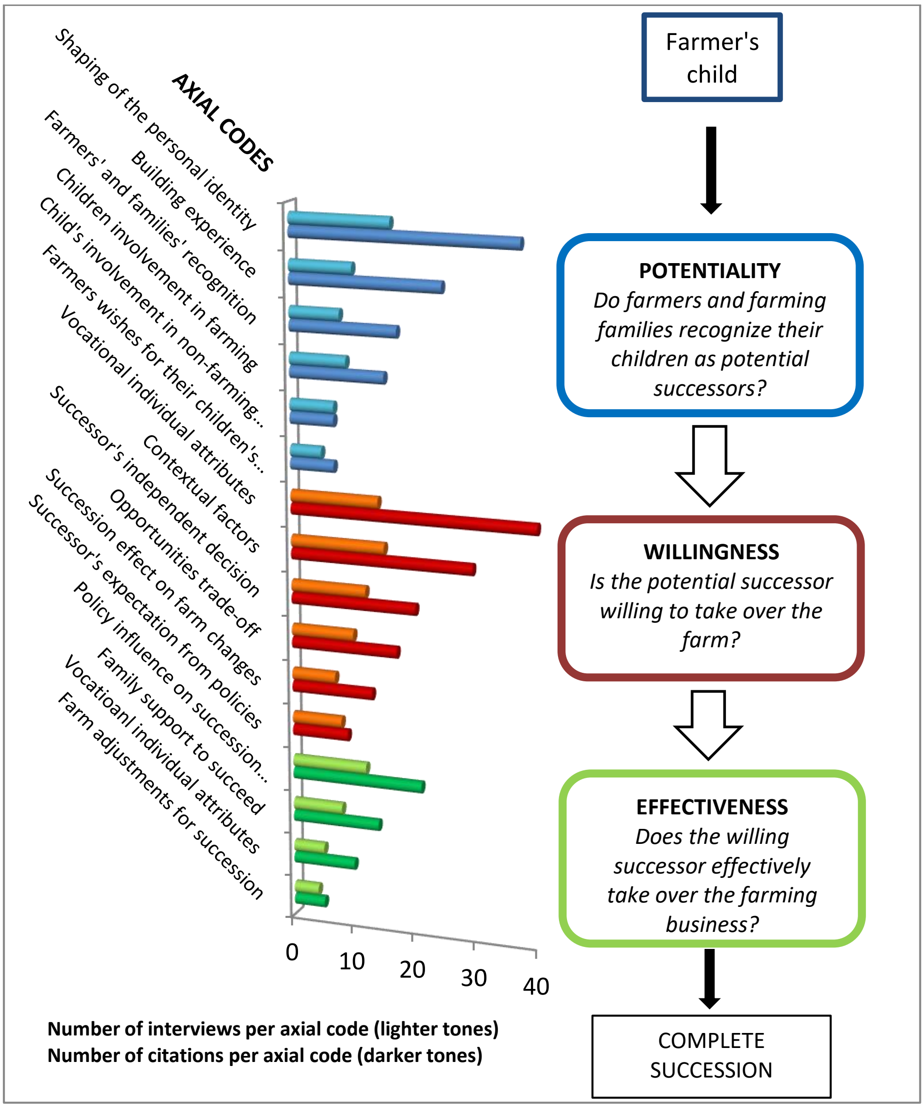


Figure 15. Representation of the three steps of succession and related axial codes. On the left, the vertical bar chart shows axial codes according to the number of supporting interviews (lighter tones) and references (darker tones). On the right, the flowchart represents the three steps of succession. The steps and related axial codes are highlighted using the same colours (blue, red and green). Source: Bertolozzi-Caredio et al. 2020.

Regarding the willingness step, there was general concern about the successor's individual vocational attributes, which are crucial for this step. Interviewees described the development of willingness as an evaluation of the trade-off between socioeconomic contextual factors stifling willingness, and individual attributes that are likely to be the real reason behind a successor's willingness to take over the farm.

With regard to the effective succession step, interviewees were particularly concerned about policies which are perceived to have only a marginal potential for influencing effectiveness, whereas the only real prospect for entering the sector was through family. There is also evidence about the process of farm adjustments undertaken by the actual successor in order to pave the way for effectively taking over management. Importantly, as emerged from the interviews, adjustments brought in by successors may be preceded by or complementary to investments made by current farmers before retirement when they know that there will be a successor.

Surprisingly, successor gender did not appear to have an influence on the three-step process. This could mean that the gender difference is irrelevant. Nevertheless, it is prudent to suggest that the gender effect requires further investigation. Unlike other cases (Wang, 2010), however, there is no evidence of a phenomenon whereby daughters are systematically excluded.

The factors that emerged from the analysis have been further analysed. The emerging factors involved in farm succession belong to four different dimensions, covering individual, familial, institutional, and contextual factors. By reorganizing the references contained in codes according to this multidimensional framework, it is possible to explain the role of different actors or influencers in encouraging or discouraging succession in the different steps (Figure 16).

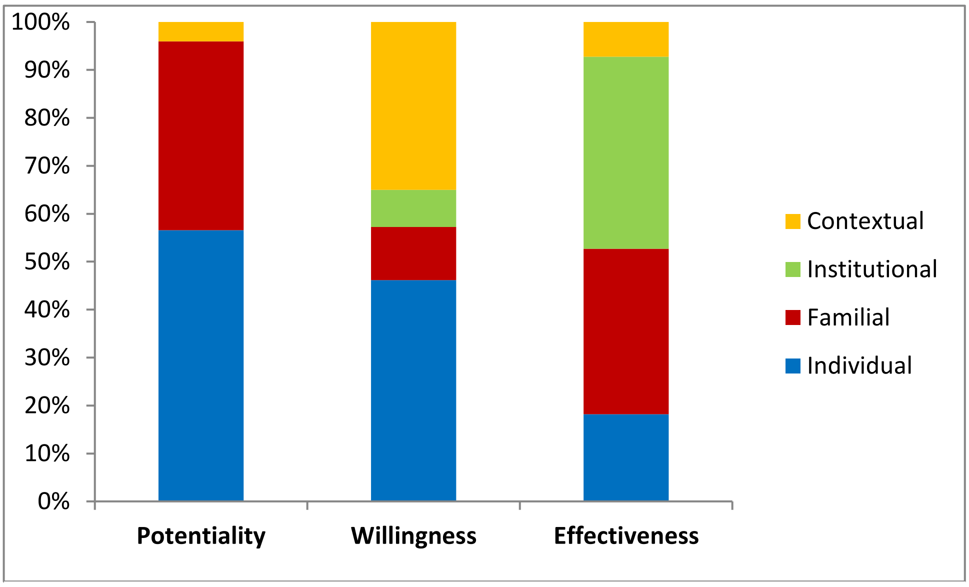


Figure 16. Bar chart representing the distribution of references in the four dimensions of influence throughout the three steps of succession. Source: Bertolozzi-Caredio et al. 2020.

Figure 16 shows references from the analysis re-organized into four dimensions. The individual sphere is the most relevant to the potentiality and willingness steps, mainly because the successor's individuality is shaped within potentiality, and individual development determines willingness. Some fundamental attributes that can shape the successor's individuality throughout the succession process are recognized, such as a feeling for farming, awareness about farming difficulties and importance, and emotional attachment to the farm on the one hand, and farming knowledge, experience, skills and ability on the other.

The relevance of the familial dimension is alternate: it is significant in the potentiality and effectiveness steps, but has less influence on willingness as the willingness decision is made by the successor.

The institutional dimension could be included in the contextual dimension. However, there is an institutional issue in farm succession as attested to by the specific attention attached to this question by interviewees. The role of the institutional dimension and related policies is totally irrelevant in potentiality, while its impact on farm succession increases throughout the process: it is present in the willingness step and even more so in the effectiveness step. The main policy measures that were mentioned are direct payments from the first pillar, and measures for new young farmers and investments from the second pillar, of the CAP.

Finally, the farming context has a particular influence on the willingness step, when the successor takes all contextual factors into consideration to make his final decision. In this step, farm succession is affected by economic, social and environmental contextual factors. Many constraining factors were cited in the case under study, which can, however, be primarily synthesized as low profitability and poor quality of life.

4.1.2 THREE STEPS OF SUCCESSION

Succession comes out of the analysis as a three-step process involving an individual recognized to be a potential future successor, an individual willing to take over the farm, and an individual effectively taking over the farm.

Other authors have focused on the successor's evolving individuality. In particular, Chiswell (2014) underlines the importance of focusing in farm succession research on the different individuals resulting from the developmental dynamics of succession, as they result in diverse aspects evolving throughout the process. Chiswell introduces the figures of successor and potential successor. In Chiswell's scheme, the successor is defined as the individual who is in full managerial control of the farm. In the scheme developed along this research, this figure is equivalent to the effective successor, which shares the same definition.

The figure of the potential successor is more structured. It is described as "someone who could, potentially, in the future, gain managerial control of the farm" (Chiswell, 2014). Nevertheless, Chiswell divides this figure into two different potential successors: the possible successor and the prospective successor. The possible successor is assumed by him- or herself or by the farmer to be the future successor. The prospective successor is actively moving towards managerial control of the farm as a consequence of a collective recognition by the current farmer, the family and the potential successor. The threshold that separates these two actors is known as the possible-prospective transition (Chiswell, 2014).

The analysis uncovered individuals both assumed to be the future successor and actively moving towards succession, which is consistent with Chiswell's discourse. Based on evidence from the case study, a slightly different conceptual framework to define the successor can be suggested. First, the potential successor is identified as a young individual that is recognized by the farmer and his family as the potential future successor. From the interviews, it emerges that such recognition is commonplace and due, in part at least, to the successor's involvement in farming or, by contrast, in other non-farming activities. This could encourage or discourage the farmer to recognize potentiality. Recognition can be influenced by the attributes and experience gained by the successor that tip the scales towards or against farming. In the following case, for instance, the farmer recognizes his child's potentiality, encouraged by the child's emotional attachment to and feelings about farming:

The child likes the farm a great deal; I don't know whether or not it is down to how we educated him. He decided to study close by, in Zaragoza, and come home to the farm every weekend; he likes hunting and he likes to help me on the farm, he says that he really likes working with livestock. [I26]

Therefore, it was the current farmer and farming family, and not necessarily the successor, that decided on the child being a potential successor. At this point, the successor does not yet have a clear idea about his/her future, and therefore about his/her willingness to take over the farm. Consequently, potentiality does not imply an active movement or willingness of the potential successor to take over the farm, as in the following case:

My daughter is a talented girl, and I believe that she would be quite happy to stay at home. She is a hard worker and has good manners. Anyway, she decided to study a course in Huesca about…to take care of drug addicts or something like that, and so now she is practising in a centre.[I27]

Second, the possible-prospective transition is found to be mainly determined by the individual development of the successor's willingness to take over the farm rather than a collective recognition by the current farmer and farming family. Usually, farmers and farming families recognize the successor when he or she is just potential successor: this recognition determines the potentiality of a successor. Thus, the real threshold between 'be assumed to become the future successor' and 'actively moving towards managerial control of the farm' is basically due to the successor's willingness to go ahead with the succession process, whereas it is a wish worth pursuing for the farming family.

In fact, moving on in the analysis, there was evident concern among interviewees about the willingness of the successor. In the interviews, the successor appears to develop this willingness individually through a trade-off process in which vocational attributes play a significant role. Despite there being a risk of bias when interviewees refer to vocational attributes, they are consistent with respect to the description of how vocation is socially constructed within the farming family (especially knowledge and skills) and the rural environment (focusing mainly on emotional attachment).

In the following example, the farmer explains the development of willingness as an individual process:

When my son wanted to enter farming, I said, "Let's see, why don't you move away instead of staying at home?" But he didn't want to move away, and I couldn't chase him away. I neither forced him to stay nor to go away. [I3-I4]

In another example, the farmer's daughter is very much involved in farming. Therefore, she is recognized as a potential successor by her family, but the farmer is hanging on for her willingness to take over the farm business:

(…) of course, they (daughters) could always surprise me, by God! They might (the farm transfer)… my younger daughter comes to help me, even at night…Currently they (daughters) are studying. They are good students, and if they were to say to me in six years' time, "Daddy, I want to own the sheep and take over the farm", it would make me the happiest man in the world. [I9]

4.1.3 MULTIDIMENSIONALITY OF SUCCESSION

THE INDIVIDUAL DIMENSION

In the analysis, the interviewees' concerns within the individual dimension appear to be central to the process. The individual dimension influences the potentiality and willingness steps more than the effectiveness step. Potentiality refers to the development of children's attributes and experience and to their involvement in farming. In the willingness step, the role of the successor could be explained by the relevance of individual vocational attributes, such as skills, experience, attachment and feelings, in determining the development of willingness. This is the main concern of interviewees in this step (see Figure 15). For instance, a young farmer speaks about his attachment to farming below:

I did it (took over the farm) because I wanted to… People, even the bank employee, kept telling me to 'find a girl and settle down'; but I said 'no, this is my life; this is what I want to do'. [I28]

Previous research underlines how important a successor's emotional attachment and perception of his or her capabilities are to the decision to take over the farm (Morais et al., 2018). This also has a bearing on to the process of successor identification (Jenkins, 2008). The individual dimension is decisive: if individual attributes have not matured, the key steps of succession are less likely to be achieved.

When deciding whether or not to go ahead with succession and take over the farm, the successor weighs up other socioeconomic and institutional factors, such as low profitability and poor quality of life. In the example below, the interviewee describes this trade-off between vocation and contextual factors:

Sheep farming is not profitable, and that is all there is to it. Farming is vocational, if you like it, you like it, of course, but there comes a time when it is not just about whether or not you like it, because you have to be able to make a living... and, if you have other opportunities, you get out of farming and you look for another career. [I7-I8]

THE FAMILIAL DIMENSION

The family is a core institution in agriculture (Stiglbauer and Weiss, 2000; Leonard et al., 2017). The findings of this study are no exception. Not only is the family a collective actor, but it is also a dimension in which successors develop. Within this space, family relationships contribute to the development of successors (Brandth and Overrein, 2013), shaping teenagers' emotions and knowledge (Cassidy and McGrath, 2015). The family is at the heart of recognition and provides potential successors with attributes, such as knowledge, experience and attachment. This evidence is referred to in the literature as the transfer of intangible assets (Grubbström and Sooväli-Sepping, 2012). The familial dimension is important, as explained by the two references below:

Farming is very special because nobody teaches you how to farm. There is no vocational training... you inherit it, you live it and either your predecessors show you or else you start farming very young and you learn. [I19]

But it (farming) is not a classroom. It is like teaching and educating children, which is the most important thing. Children get a formal education and so on at school, but I believe they learn the basics at home. [I21-I22]

The influence of family drops in the willingness step, as it is the actual successor that has to cross this threshold. This contrasts with previous research (Morais et al., 2017), which suggests that the family has an influence on the succession decision. On the one hand, it could be due to interviewees underestimating the role of the family; on the other, factors like low profitability and poor quality of life could discourage families from trying to influence successors about such a tricky decision. Note, however, that the family plays a crucial role, even though it is mainly limited to the potentiality step when a successor is recognized and his or her attributes are developed. These attributes play a role in decision making by the individual successor.

At a later stage, when the successor is willing and effective takeover is approaching, familial support for acquiring physical and economic assets comes back into play. In this case, the farmer refers to succession as being smooth because the family farm was already running:

(...) we didn't have much trouble (with the takeover), because the business was already ticking over nicely, you know? I was about to take over the farm and continue to operate the business that originally was my father's... so, actually, I didn't have any problems at all. [I20]

THE FARMING CONTEXT

The socioeconomic context influences the succession process. The biggest barriers to farm succession are often access to land and credit (Eistrup et al., 2019). These are minor issues in this context of study, as family farm succession were mainly explored. Increasing cost trends, steady low sale prices, and a drop in consumption, have led to a generally low profitability in both cases under study, but especially in Huesca. Poor quality of life, which is linked to the work commitments of extensive livestock farming, is often mentioned in both cases. Isolation due to remoteness affects liveability, above all in Huesca. A farmer's daughter explains her concerns about such factors below:

It is hard work and lately there have been significant drops in livestock farming profitability. Thus, business (extensive livestock farming) prospects do not look good… …Besides, you have to work all day round and have no time for yourself. You have to spend all your time tending the animals, calling the vet, feeding, and so on. [I11-I12]

Contextual factors affect mainly the second step of succession, when a potential successor evolves into a successor willing to take over the farm. As the successor approaches the threshold of willingness to succeed, his or her decision is affected by a pragmatic evaluation of the potential business prospects of farming with respect to other opportunities (Cavicchioli et al., 2018). Here contextual factors appear to have a significant negative impact, although they apparently do not have a prominent bearing on the importance of the individual vocational attributes of the successor.

New generations could weigh up new opportunities and potential for innovation (Milone and Ventura, 2019). In the case under study, the prospects cited by successors were based mainly on new pasture management and feeding system techniques, and improved technology in the stables. In some cases, the possibility of converting extensive into intensive management was vaguely mentioned.

THE INSTITUTIONAL INFLUENCE

In both specializations, the interviewees focused almost exclusively on CAP subsidies, especially the direct payments of the first pillar, and the support for investments and new entrants of the second pillar of the CAP (measures 4 and 6, respectively). Nonetheless, some regulatory issues emerged, such as conflicts with nature reserve regulations, access to public pastures (mainly in Sierra de Guadarrama), and animal health legislation. An early retirement policy does not appear to be a critical issue, unlike other cases (Hamilton et al., 2015). Interestingly, no mention was made of non-monetary policy to support young farmers and successors.

Institutions and their policies have a more pronounced impact on the last step of effectiveness to support the acquisition of production factors and initial investments. Policies also have an impact on the willingness step when successors take into account favourable policies in the opportunity trade-off. As Figure 16 shows, there is no mention of the institutional dimension in the potentiality step, and policies do not seem to have a decisive influence on either willingness or effectiveness. In the willingness phase, the individual attributes of successors appear to have a greater bearing than policy, whereas the farming family is the key factor in family farm succession in the effectiveness phase, as it provides the main production factors to start up the business: policy measures may be an additional factor, but not a trigger, in this respect. For example, this farmer explains that farm ownership is inherited from a relative, and policies come into play at a later stage of effective succession:

So it's clear…subsidies for young farmers...what subsidies? I own (the farm) because my uncle left it to me, and there was no help from institution to prosper. And, then, once you are in (into the farm), institution say that you can ask for subsidies. [I15]

As in previous studies (Eistrup et al., 2019), policies are not perceived as able to resolve the complexity of generational renewal. The absence of non-monetary support might suggest that other types of policies are required and could play a role with respect to 'untouched' aspects of succession. However, it could also mean that the farmers are not fully aware of available policies or that farmers' concern about profitability is uppermost.

4.1.4 IMPLICATIONS FOR THE ENDOGENOUS SUCCESSION CYCLE

The information captured in the interviews uncovered evidence about the processes of the successors' individuality construction, the successor's involvement in farming, and the reciprocal influence between succession progress and farm changes. The integration of findings with knowledge concerning these dynamics may improve the understanding of family farm succession. These processes have been studied and conceptualized under the notion of the socially constructed endogenous succession cycle (Fischer and Burton, 2014). The endogenous succession cycle is described as playing a key role in the understanding of farm succession (Chiswell and Lobley, 2015). The cycle is determined by the intertwined dynamics of three processes: the construction of successor identities (Glover, 2013; Fischer and Burton, 2014; Bertoni and Cavicchioli, 2016), the progression of the successor on the farm ladder (Commins and Kelleher, 1973; Errington, 1988), and the development of farm business trajectories (Potter and Lobley, 1992; Uchiyama et al., 2008; Lobley et al., 2010).

The endogenous succession cycle involves the individual and familial dimensions and considers their relationship, even though the extent to which they influence succession is not easily definable. Instead, the influence of contextual and institutional dimensions is incorporated into individual and familial dimensions, due to the subjective elaboration of exogenous factors within the family farm (Fischer and Burton, 2014). However, the three dynamics of the endogenous succession cycle evolve differently across the three steps.

The construction of a successor identity is a process of building the potential and willing successors, and it is likely to be more important in the earlier stages. Specifically, the potential successor has to be constructed with the individual attributes that will make the successor willing to take over the farm. This emerges in axial codes such as '*building up experience*' and '*shaping individual identity*', and also explains the individual dimension to which the successor's individual identity is evidently central. Beyond the willingness threshold, the successor's identity is already more or less formed and influences succession in terms of individual vocational attributes.

The progression on the farm ladder is a process of growing involvement in farming, which increases as the successor moves from potentiality to willingness, and finally peaks with effective succession. It is a fundamental process for shaping successor attributes, such as knowledge, awareness, feelings, emotional attachment, skills and ability. Therefore, it significantly contributes to the construction of potential and willing successors. This evidence is contained in axial codes like 'children's involvement in farming' in the potentiality step, while involvement should increase in subsequent steps. The farmer below explains the process with respect to potentiality:

Now that she (daughter) has grown up she is better able to help me….We no longer have to call the vet like we used to… (for example) when there is a difficult birth, I call her because she has more agile hands… if we need to sew up a sheep, she does it. [I9]

The farm business trajectory changes as a result of farm succession development (Inwood and Sharp, 2012); it is connected to the key stages of the process. The farm trajectory comprises the well-studied dynamics of the succession effect and the successor effect (Calus and Van Huylenbroeck, 2008; Chiswell, 2018). The succession effect explains the attitude of the current farmer towards making improvements and innovations to the farm structure and production if there is a potential successor, whereas the successor effect refers to the capacity of new farmers to introduce new technologies and innovation into the farm business (Potter and Lobley, 1996). The succession effect is bigger when the successor moves from potentiality to willingness, and it is particularly relevant from willingness onwards: in practice, the willingness of a successor works as a trigger for farm development. Also other works have identified the influence of identifying a successor on farm management (Wheeler et al., 2012). It is patent from the following farmer's story:

I don't know, anything I do to expand the business is because I know that someone will follow in my footsteps and carry on the operation (in the future). You do not do this if you think you are going to have to sell tomorrow what you buy today... the same applies to land. Why should I buy land or plant almond trees if I am going to sell within two years because my sons decide not take over the farm? [I10]

While the relevance of the succession effect gradually increases, the successor effect does not occur until succession is effective. In fact, the successor effect is down to the new skills, abilities and knowledge that a new successor is likely to bring into the farm activity. The experience gained by the successor through involvement in farming and familial support plays an important role here. The process of farm adjustment is usually carried out by the current farmer and the successor jointly until the farmer retires and the successor takes over. The interviews did not show up any evidence about particular conflicts during this process.

In the example below, a farmer and a son who is a willing successor explain how they worked together to change the farm in the light of an effective succession, even though it is not clear which one most influenced the process:

Father*: "When my son got involved in the farm (with the prospect of taking over), we said 'OK, let's make a go of this business' …"*

Son*: "…and we bought land and animals, we built a stable, and we bought the seeding machine and the electric fence. We made a quite big investment." [I3-I4]*

The succession and successor effects, which are dynamics embedded in the succession process, improve the likelihood of an effective succession by 'adjusting' the farm to the successor's expectations.

Overall, both effects (succession and successor) can lead to innovation and changes on farms. However, the above effects are not limited to effective succession. Instead, they start as early as in the willingness step. Therefore, concerns about the effects of young farming entrepreneurs on farm viability and innovations (Hamilton et al., 2015) could be extended to the whole process of succession, including the potential entrepreneurial attitude of a willing successor. This constitutes a proven benefit of a planned succession process for family farms (Harris et al., 2012).

4.2 RESILIENCE ATTRIBUTES AND CAPACITIES OF ALTERNATIVE MANAGEMENT PATTERNS IN EXTENSIVE SHEEP FARMS

This chapter reports the results of the second step thesis' analysis, with the objective to identify the resilience attributes and capacities in alternative farm management patterns. To achieve the goal, a mixed approach based on cluster analysis and qualitative content analysis of data from 14 of the 23 semi-structured interviews is performed, as described in section 3.5.

4.2.1 STRATEGIES AND FARM MANAGEMENT PATTERNS

Along farmers' narratives, 20 farm management strategies were identified, together with the binary information about which strategies are implemented by each farm (see Table 9). By means of a cluster analysis, four major combinations of strategies were identified as shown by the Table 10.

Type of strategy	**Coded strategies**	INTERVIEWED FARMERS													
		I1	***I2***	***I3***	***I5***	***I6***	***I7***	***I9***	***I13***	***I14***	***I23***	***I24***	***I26***	***I27***	***I28***
COOPERATE for	*Learning & experimentation*								X	X			X		
	Input sharing								X					X	
	Trade & marketing						X		X	X		X	X		
	Technical support & advice	X		X								X	X	X	
DIVERSIFICATION to	*Intensive pig farming*	X	X												
	Perennials (Almonds/Olive trees/Vine)	X		X		X	X	X			X			X	
	Agricultural crops	X	X	X	X	X		X		X	X				
	Calf fattening									X			X	X	
	Agritourism													X	X
	Off-farm job	X	X							X					
INNOVATION by	*Insemination & breed selection*					X	X	X	X		X	X			X
	Virtual or drone shepherd	X			X	X				X		X			
	GPS & video control					X			X						X
	Forage selection										X	X			
	Unifeed[2] and new structures			X		X							X		
LIVESTOCK PRODUCTION MANAGEMENT	*Reduce livestock number*	X		X		X						X		X	
	Quality products	X			X	X	X		X			X			
	Intensification		X			X		X			X				
	Extensification								X	X					X
	Reserves and self-feeding		X									X	X	X	X

X= the coded strategy is implemented in the relative farm, otherwise it is not.

[2] *Unifeed is a feeding technique based on a mechanical system to ensure balance feed.*

Table 9. The 20 identified strategies across the 14 farms. Own elaboration.

Clusters	Strategies																				Characteristics	
	Learning & experimentation	Input sharing	Trade & marketing	Technical support & advice	Intensive pig farming	Perennials	Agriculture	Calf fattening	Off-farm job	Agritourism	Insemination & breed selection	Virtual or drone shepherd	GPS & video control	Forage selection & CRISPR	Unifeed and new structures	Reduce livestock number	Quality products	Intensification	Extensification	Reserves and self-feeding	Average livestock (no. of heads)	Average land (hectares)
A_Intensification (I2,I9,I23,I27)	0	1	0	1	1	3	3	1	1	1	2	0	0	1	0	1	0	3	0	2	1,368	693
B_Extensification (I13,I14,I26,I28)	3	1	3	1	0	0	1	2	1	1	2	1	2	0	1	0	1	0	3	2	1,025	955
C_Re-orientation (I1,I3,I6)	0	0	0	2	1	3	3	0	1	0	1	2	1	0	2	3	2	1	0	0	523	543
D_Conservation (I5,I7,I24)	0	0	2	1	0	1	1	0	0	0	2	2	0	1	0	1	3	0	0	0	833	230

Table 10. Resulted clusters and strategic combinations. The numbers in the table indicate how many of the farms included in a cluster has implemented the corresponding strategy. Own elaboration.

Cluster A (including farms I2,I9,I23 and I27) fits with the ‘intensification’ pattern. Farmers included in this cluster indicate strategies leading to an intensification, with a low degree of innovation (limited to insemination and forage selection), and no cooperation (except I27). They describe a shift from extensive management based on grazing, to a ‘more intensive’ management of livestock based on stables, and less dependence on pastures. Most of the land is usually dedicated to intensive crops for feeding the livestock on the stable, and/or diversified to agricultural and perennial crops. In this cluster, there is the highest average livestock per farm.

Cluster B (I13,I14,I26,I28) is referred to as ‘extensification’ pattern. In this cluster, farmers indicate strategies leading to more extensive and self-feeding systems, which does not regard a shift from ‘non-extensive’ to extensive, but from ‘already extensive’ to ‘more pastures-based’. This strategy relies on the advantages of exploiting available natural resources instead of external feed input, which is crucial for costs management and self-reliance. Such pattern is characterized by many innovations (e.g. insemination, GPS/video control and virtual shepherds), and by cooperation for learning & experimentation and for trade & marketing. Diversification is limited to calf fattening and agro-tourism. Coherently, in this cluster there is the highest average land per farm.

The cluster C (I1,I3,I6) fits with the ‘re-orientation’ pattern. This cluster shows a reduction of the livestock size on the one hand, and a high diversification on the other. Formerly, the process of livestock reduction has occurred gradually over the last 15 years as a reaction to the reduction in the CAP payments scheme and lamb meat consumption. Later on, these farms re-oriented to diverse activities (e.g. cereal crops, almonds, intensive pig) to compensate the low profitability. Importantly, the sheep extensive farming has continued in any case. The cluster shows innovation (virtual shepherd and insemination), and cooperation for trade & marketing. This pattern presents the lowest average livestock per farm.

The cluster D (I5,I7,I24) is referred to as 'conservation' pattern. There is not any evident intention to intensify/extensify, or to diversify (there is the lowest degree of diversification), but farmers are more oriented to quality production. These farms opted for the exploitation of the intrinsic added value of extensive farming, which is materialized by the Protected Geographical Identification (PGI) label '*Ternasco de Aragón*', in order to combat low sale prices. To do so, affiliation to cooperatives is fundamental. They also implemented some innovations for pasture management and breed selection. These farms show the lowest extension of land on average.

These four farm management patterns are consistent with the trajectories captured by previous research on extensive farming. A focus group with farmers and other stakeholders of the extensive sheep farming system of Huesca (San Martín et al., 2020) identified two potential projections of farms in future scenarios, namely 'semi-intensive' and 'hi-tech extensive' systems, which are consistent with the patterns intensification and extensification, respectively. In addition, cooperation for quality production and marketing value (as in the identified conservation pattern) was also described as a potential target for extensive livestock farms (Escribano et al., 2016), whereas similarly with the identified re-orientation pattern, crop-livestock integration strategies were found in other extensive systems (Sanderson et al., 2013).

4.2.2 ENABLING AND CONSTRAINING ATTRIBUTES

Figure 17 shows the nine coded attributes by the intensity of quotes mentioned by farmers within each management pattern. In terms of attributes enabling and constraining management patterns, there is a marked difference among those favouring intensification and re-orientation, and the ones enhancing extensification and conservation.

The farms addressing conservation and extensification rely on the availability of grazing land (Match with natural resources), on the buffer provided by subsidies (Subsidies buffer), the farmers' capacity and willingness to cooperate (Farmers' network), and the traditions and perspectives influencing the farmers' strategic choice. The effect of matching with natural resources can be well explained by the following quote, which underlines the role played by this attribute in farm management:

"Regarding the capacity to increase the activity, sometimes you need to stop, mainly in extensive farming. Because the natural resources are limited and located in certain areas, and you cannot overcome this boundary, but you can find other ways". [I26]

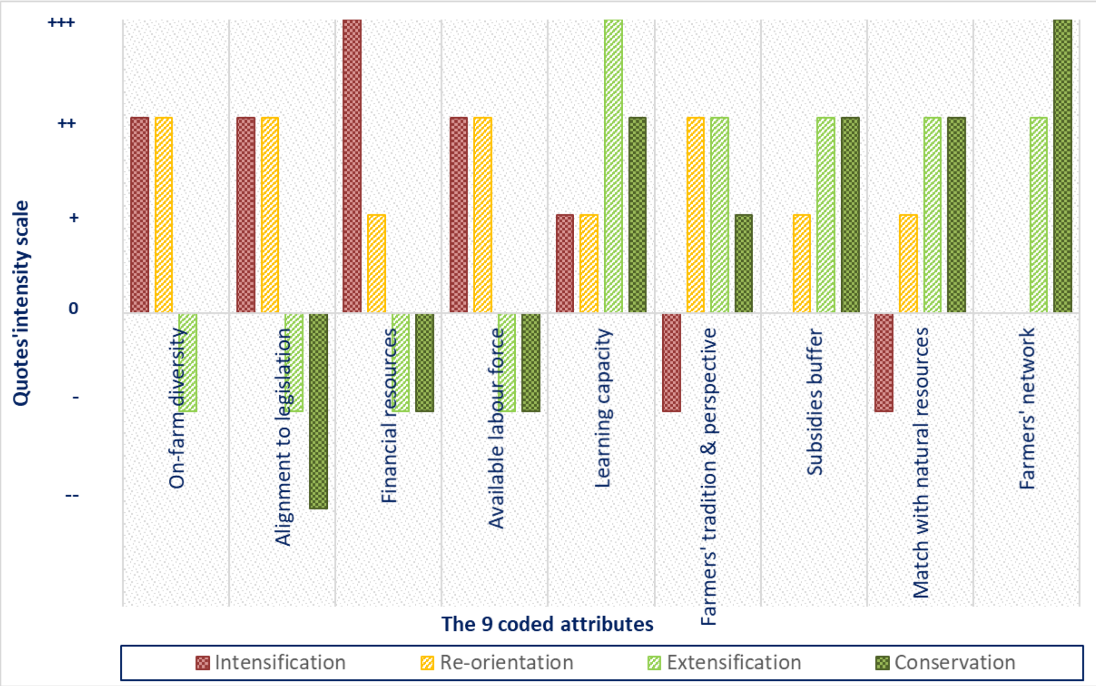


Figure 17. The attributes that enable (+) or constrain (-) the four farm management patterns. Own elaboration.

In line with previous investigations on mountainous farming (Daugstad, 2019), traditions appear as a factor against abandonment of the activity. It is also evident in the re-orientation pattern in which the extensive sheep livestock is reduced consistently, but not eliminated. According to previous research in the case study area (Bertolozzi-Caredio et al., 2020), the narratives also indicate how the perception of farm continuity could influence farmers keep investing in extensive sheep. In the extensification and conservation patterns, the farmers' capability to cooperate is significant. According to Stringer et al. (2020), collaborative actions were found to be essential for pooling resources and input sharing (e.g. land, knowledge), joint farm management actions, marketing added value against price drops.

The intensification and re-orientation patterns rely on the availability of workers and financial resources. While the buffer capacity given by available financial resources is often put under focus (e.g. savings, assets) (Darijani et al., 2019), such resources may also be an indispensable precondition to carry out deep changes and new orientations (Fath et al., 2015). Furthermore, when a farm is already diversified to some extent (On-farm diversity), the intensification or re-orientation options seem facilitated by a more solid profitability, and the easier availability of skilled workers in the farm. An example is provided by the following quote:

"At the moment that you need to hire workers for handling almonds or olive trees, it is not hard to find them. But, if I had a thousand sheep to bring to the pastures, it would be hard to find a shepherd. Besides, it would not be profitable". [I3]

The attribute alignment to legislation remarkably favours the transition from extensive management to intensification and re-orientation patterns, having also a serious impact on land use. A critical, common example is that cultivated lands receiving greening payments are subject to commitments forbidding grazing activities, which restricts the access of land and accentuates conflicts among extensive farming and intensive or crop productions. A further, widespread example is given by natural parks regulations, as well as municipal rules on public pastures. These regulations constrain the access to potential grazing lands necessary for extensive farming, and limits the farming practices to be used by farmers.

Farmers' learning capacity seems crucial for innovations and improvements across all patterns (e.g. virtual shepherd on pasture, or unifeed system in the stable), which is consistent with the literature (Allen and Holling, 2010). This capacity is enhanced by the farmers' willingness to participate in learning networks for exchanging knowledge and experiences, relying on consultants and collaborating with research centres for experimentations, leading to multiple, incremental adaptations and changes at group level (de Kraker, 2017). This farmer provides an example:

"We (the farmers) have training trips, to visit and learn from different management systems. This is important, above all for younger farmers, to learn different ways to improve the extensive management without necessarily following the 'conventional' strategy, that is, to grow, grow and grow". [I26]

4.2.3 THE ANALYSIS OF RESSILIENCE CAPACITIES

Figure 18 reports the intensity to which farmers mentioned quotes related to a resilience capacity, within a management pattern. Adaptability is built by all patterns, especially extensification and re-orientation. However, the patterns intensification and re-orientation seem to be leading mainly to transformability, whereas the patterns conservation and, to a lower degree, extensification contribute to robustness.

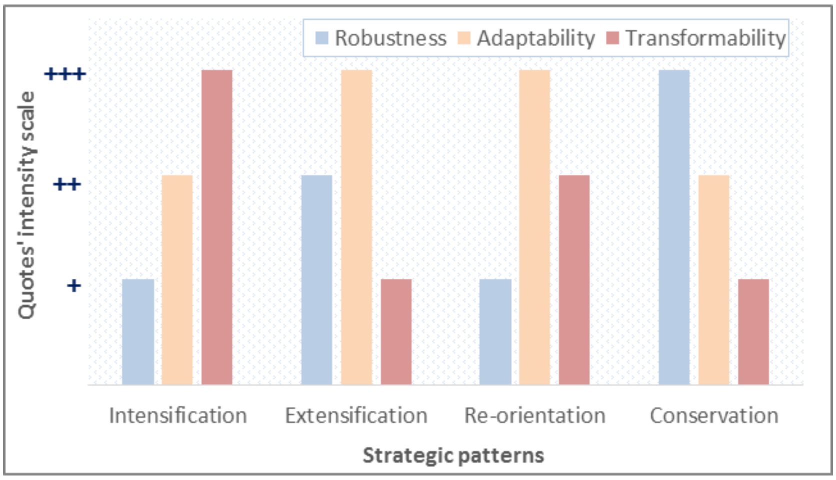


Figure 18. The resilience capacities across the four farm management patterns. Own elaboration.

The extensification and conservation patterns contribute to robustness and adaptability because they seem to preserve and improve original functions such as the quality of life (by innovating pasture management), the ecosystem services provided (by extending pastures) and, to some extent, the farm income (by exploiting added values and reducing feeding costs), while adjusting farms' structure and assets. An evidence of adaptability in extensification patterns is shown in this quote:

"I have friends who adapted the farm by pursuing extensification and enlarging the livestock (…) I can see that this kind of family farming (extensive farming) is resisting, because it has adapted." [I1]

In fact, to improve and innovate the pastures management the cluster extensification shows much more adaptability. The original structure is somewhat reinforced. For example, these farmers explain how innovations improve the quality of life by reducing work commitments, and the need of workforce:

"To improve the quality of life is one of the priorities of this sector. Much is changed by the use of, for example, virtual shepherds and mobile, electric fences. My father went out home every day, but now it's not like that anymore." [I24]

The pattern conservation builds mainly robustness due to its capacity to maintain the original farms' organization through quality production despite price drops and decreasing consumption. In previous investigations (Ashkenazy et al., 2018), the strategy of quality production could be related to transformability. Instead, evidence from this research suggest that this strategy does not imply drastic changes to the farm configuration and, therefore, it does not appear as a transformation. Such interpretative difference could be due to different scale of analysis (farm level versus regional scale), or farms' original structure. For instance, this farmer describes the 'non-structural' implications in choosing quality production:

"My production must be certificated as 'Ternasco de Aragón' by a cooperative, but it does not imply particular changes on-farm. When a buyer comes to my farm, if I'm into the cooperative he buys as Ternasco de Aragón, otherwise he buys as normal lamb meat. There is no difference in breeds." [I9]

On the other side, the management patterns of intensification and re-orientation put into question the identity and functions of the farm itself and, thus, show much transformability. Those farms re-orienting production adjust the livestock size to cope with the reduction of lamb meat consumption and the low sale price, which appears to fit with adaptability. At the same time, these farms address new productions and reverse the relative importance of sheep farming into the farm business, which appears to be transformability as the original functions somewhat change. The following quote describes the re-orientation:

"I believed that we could deal with lower lamb meat consumption and low prices by reducing livestock size: the lesser the lamb on the market, the higher the price. But it did not work, so we had to improve the farm." [I3]

The impact of the re-orientation pattern could be ambiguous. On the one side, it reduces but maintains socio-ecological functions linked to pasture-based management and food provision; on the other it provides more jobs and profitability. Nevertheless, it is challenging to determine if functions related to biodiversity, natural resources, and ecosystem services have been affected positively or not by the re-orientation. It could be due to, for example, the kinds of diversification, which in some cases are found to be ecologically positive (Bell et al., 2014). As Sanderson et al. (2013) pointed out, crop-livestock diversification can enhance resilience and sustainability by delivering additional ecosystem services. To this regard, however, specific investigations are needed.

The pattern intensification reduces characterizing functions of pasture-based livestock, such as animal welfare, ecological benefits and landscape conservation, which underline the transformability of the pattern (Ilea, 2009). Although the potential loss in traditional functions could remark an approach to what is called 'non-resilience' (Cumming and Peterson, 2017), such interpretation could be biased by subjective assumptions on what is desirable or not, which are intrinsic in resilience assessments (Ashkenazy et al., 2018). In fact, as proven also by previous research (Riedel et al., 2007), it should be considered that while reducing some functions, this pattern strengthens others such as food production, farm income, and job provision.

4.2.4 DISCUSSION

Farms are able to build diverse resilience capacities to keep delivering important functions through alternative trajectories, whose difference strongly depends on the resilience attributes on which the farms rely. There is clear distinction among resilience attributes determining transformative patterns like intensification and re-orientation (e.g. labour availability and financial resources), and those favouring the conservation or re-adjustment of traditional extensive management (e.g. match with natural resources and farmers' networks).

The literature usually addresses single trajectories shaping a farming system dynamic, such as intensification of extensive systems (e.g. Caraveli, 2000), the development of labelled quality products in conventional production systems (e.g. Iraizoz et al., 2011), or the diversification from livestock to crop productions (e.g. Sanderson et al., 2013). Rather, the analysis highlights that more trajectories can characterize the same farming system simultaneously, due to all the alternative farm management patterns to be potentially pursued by farms. For example, Perrin et al. (2020) identified a single farming model (i.e. grazing-based) as more resilient than others in a dairy system, while in the case under study it is found that, at farm level, all patterns can contribute to build resilience, but through diverse capacities.

Stringer et al. (2020) explain that different types of farms (e.g. conventional/traditional, large/small scale) emphasize economic, environmental or socio-cultural imperatives to a different extent (e.g. conventional, large scale emphasizes productivity and profitability), but sustainability (and the balance among its dimensions) should be sought at overall scale.

Accordingly, while building its own resilience, a single farm could be unable to deliver equally all the desirable public/private services, though the whole farming system might be. This evidence is relevant for either practitioners or policymakers, since farms' resilience does not appear as a matter of a unique, successful farm model to be identified and enhanced, but as an array of alternative and equally valuable solutions that can be flexibly tailored to diverse farming needs and characteristics.

Following this reasoning, a further consideration is that, while farms seem able to build their own resilience by following diverse alternatives, there could be significant implications at farming system scale in terms of functions to be delivered. Farm trajectories determine dynamics at higher scale (Debolini et al., 2018), including changes in land use (Celio and Gret-Regamey, 2016), agro-ecosystems (Schirpke et al., 2017), and cultural landscape (Schulp et al., 2019). Consistent with previous research in the case study area (Becking et al., 2019), findings indicate that the socio-economic and policy environment seems to favour the transitions from extensive to intensive and crop farming, which could have serious implications for the functions delivered by the system overall.

This approach does neither attempt to obtain precise measurements of the prevalent patterns across the farming system, nor the quantification of potential losses in functions delivered (e.g. ecosystem services) caused by the progress of any predominant trajectory (such as the intensification and re-orientation in the case under study). Yet, results suggest that the interplay and balance among alternative trajectories should be considered when assessing the resilience of farming systems. As Andersen (2017) indicates, in order to design the agricultural landscape, all the patterns involved should be targeted to some extent. However, the implications at farming system scale due to the evolution of alternative farms trajectories would require considering many more actors and factors involved (Meuwissen et al., 2019), which are beyond the scope of this article.

It is recognized that policy schemes influence or determine farmers' perspectives and decision-making (Celio et al., 2014), and that the diversity in policies can favour all the resilience capacities (Reidsma et al., 2019). Through this lens, it seems that the current policy does not appear to support equally the diverse farm management patterns and, thus, the different capacities to deliver functions. Policy is not diverse enough to enable significantly robustness and adaptability (as in extensification and conservation patterns), but it evidently favours intensification and re-orientation at the expense of the original farms' configuration. As Sneessens et al. (2019) pointed out in the context of economic vulnerability of farming systems, policy could promote not only the diversity into the farms, but also the diversity among farms. This highlights the need for a more diversified or flexible policy, whose instruments, measures and regulations could create a favourable environment for diverse farm management patterns to build resilience by different ways. For example, the large array of ecosystem services provided by extensive sheep farming could be formally defined and compensated along with other aids (Rodriguez-Ortega et al., 2018), and the environmental policy goals could be better aligned to the agricultural needs (e.g. conflicts with wild fauna) (Hinojosa et al., 2018).

The support to different models, however, could raise questions on the system's governance. When scaling up at farming system level and, therefore, considering the impact of farms' trajectories on the whole system, policymaking may become more complex because it must take into account not only single farm models, but the interplay between them. At this level, policymakers may be called to define the system orientation which any intervention should be addressed to (Ashkenazy et al., 2018), which might reflect the policymakers' understanding of what is desirable and what is not in terms of functions to be delivered (Nelson et al., 2007). A further indication for policymakers could be the need to define the extent to which patterns are desirable, based on the functions that policymakers expect to be delivered by the whole system in the future. This appears as a key step to operationalize an evidence-based resilient policy considering the cross-scale interplay among farm management and system dynamics. However, the complexity to adapt overall frameworks to alternative development trajectories emphasizes the potential of bottom-up solutions (Koopmans et al., 2018) and the opportunity of prioritizing participatory, locally-based policy design (Schleyer et al., 2015).

4.3 PERFORMANCE AND RESILIENCE OF DEMAND- AND SUPPLY-ORIENTED STRATEGIES TO COPE WITH ECONOMIC RISK

In this chapter, the results of the third research study are reported, which aim to quantify the economic performance of alternative production strategies to cope with main economic risks. The approach is based on the definition of a gross margin model, and four strategic scenarios. The analysis consists of Monte Carlo simulations and stress analysis under two risk factors, namely lamb price and feeding cost. The methodology is explained in section 3.6.

4.3.1 ECONOMIC PERFORMANCE AND VULNERABILITY

Table 11 reports the performance and risk indexes comparing the four scenarios (baseline, quality label, productive efficiency, and joint strategies). Figure 19 shows the fitted PDFs for each scenario. As reported in Table 11, all scenarios show an almost full BEP (around 98 and 99%), meaning that the probability of obtaining a negative gross margin outcome is almost zero in all scenarios. There is a clear difference in economic performance, especially for the efficiency and joint scenarios, where the increase in average gross margin is much more evident (70.8 and 75.7 €/ewe, respectively, as opposed to 47.35 and 50.75 in the baseline and quality scenarios). Baseline and quality scenarios show a similar vulnerability to risk, although quality labelling yields slightly larger potential losses and greater probability of extreme events (with VaR and SCV being 2% higher than in the baseline scenario). Also, baseline and quality scenarios result in SCV being greater than the CV, indicating potentially higher overall losses with respect to the average expected gross margin. While the efficiency scenario significantly increases the average gross margin, it does not avoid a significant probability of extreme events (with VaR and CV being equal to 62% and 37%, respectively). It also shows a SSD of 16, greater than the baseline scenario (where SSD is equal to 13). Likewise, the joint scenario yields the best performance, but still shows a significant risk of potential losses. It has a 2-3% higher CV, SCV and VaR than the efficiency scenario. In fact, vulnerability indexes are similar across scenarios, with a high probability of losses in all cases. This applies especially to VaR, which ranges from 62% to 74%.

	ECONOMIC PERFORMANCE AND VULNERABILITY INDEXES								
SCENARIOS	*Gross Margin €/ewe (mean)*	σ	*SSD*	*Skewness*	*Kurtosis*	*CV (%)*	*SCV (%)*	*VaR (%)*	*BEP (%)*
Baseline	47.35	18.4	13.0	-0.61	2.97	39	42	72	98.7
Quality	50.75	20.5	14.3	-0.54	2.91	40	44	74	98.5
Efficiency	70.84	26.3	16.0	-0.06	2.87	37	32	62	99.6
Joint	75.74	29.8	17.8	-0.002	2.85	39	34	65	99.5

Table 11. Descriptive statistics of gross margin (€/ewe) and vulnerability indexes across the strategic scenarios. Source: Bertolozzi-Caredio et al. (2021b).

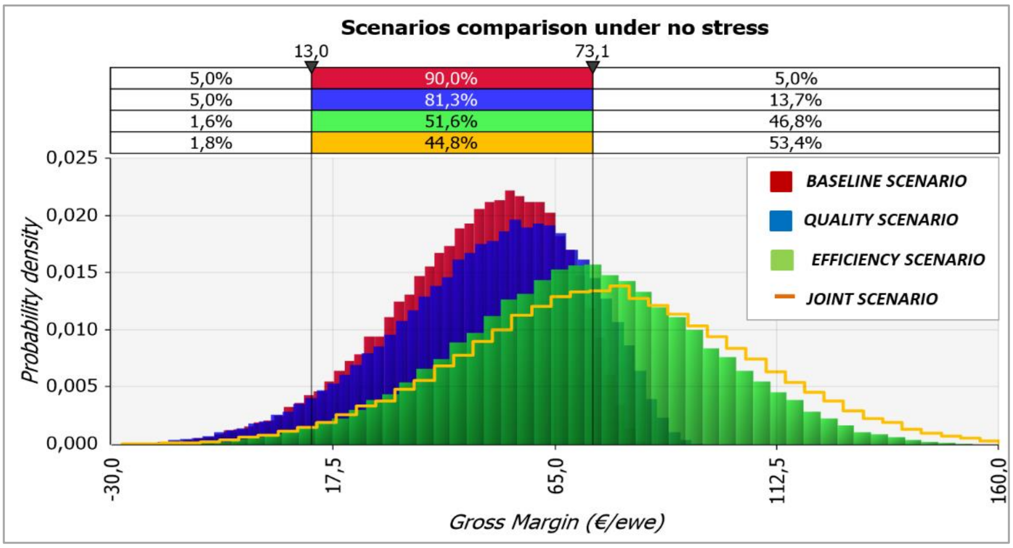


Figure 19. Probability density functions of gross margin (€/ewe) across the strategic scenarios under no stress. Source: Bertolozzi-Caredio et al. (2021b).

Figure 20 and Figure 21 show the impact analyses of input variables on gross margin outcomes, using regression coefficients and regression-mapped values, respectively. With regard to the input regression coefficients shown in Figure 20, feeding costs represent the main influencing factor (ranging from -0.7 to -0.96). However, their influence drops within the quality, efficiency and joint scenarios. Sanitary costs behave similarly, although they have a noticeably lower impact than feeding costs (from -0.1 to -0.06). Lamb prices appear to play a major role in the quality and joint scenarios (where coefficients reach 0.15 and 0.14), but conventional lamb prices have a smaller impact in the efficiency and joint scenarios (equal to 0.09). Coupled subsidies have little (near-zero) influence in all cases, but their importance seems slightly higher in the baseline and quality scenarios, where coefficient values are 0.04 and 0.03.

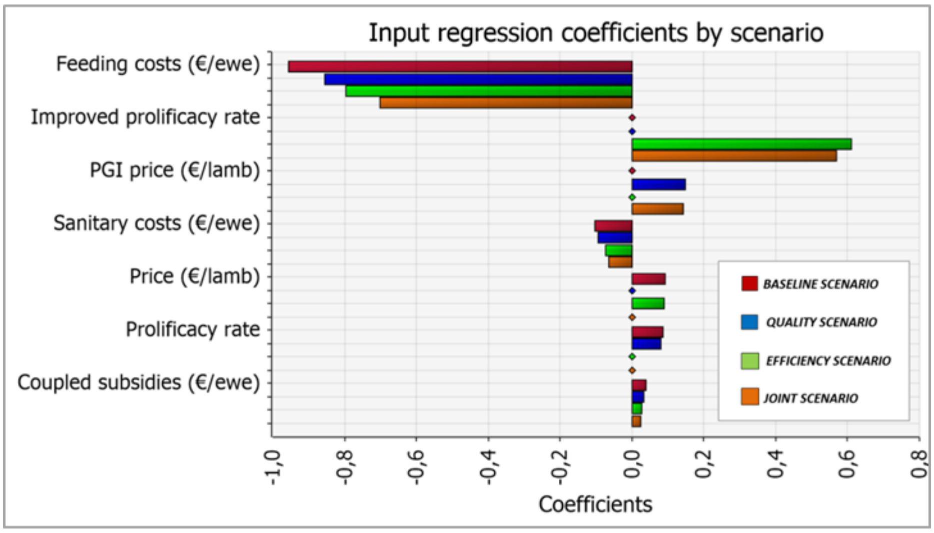


Figure 20. Input variable regression coefficients across the strategic scenarios. Source: Bertolozzi-Caredio et al. (2021b).

However, Figure 21 shows that feeding costs constitute a major factor in all cases. Their variation entails slightly higher decreases for gross margin in the efficiency and joint scenarios (by about 21 €/ewe), compared with the baseline and quality scenarios (17 €/ewe). Variations in sanitary costs could bring about gross margin losses of 2 €/ewe in all cases. PGI lamb prices are more important in the quality and joint scenarios (with a gross margin variation of 3-4 €/ewe). The impact of the prolificacy rate increases remarkably in the efficiency and joint scenarios, showing potential gross margin increases of up to 16-17 €/ewe. As already mentioned, the coupled subsidies do not have much influence, as they are quite stable over time.

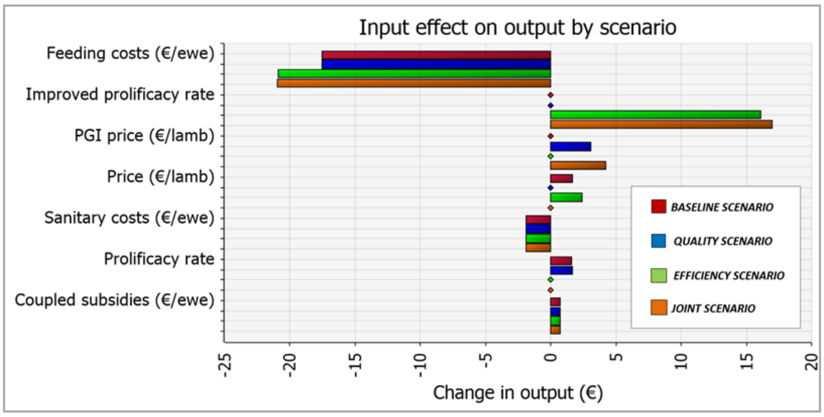


Figure 21. Multiple tornado graph showing the regression mapped values by input variable across strategic scenarios. Source: Bertolozzi-Caredio et al. (2021b).

4.3.2 PERFORMANCE UNDER STRESSORS

Table 12 reports performance under stressors and losses in gross margin. In all scenarios, farms are much more vulnerable to an increase in feeding costs, irrespective of the stress intensity. All scenarios are subject to significant losses under feeding cost stress. In particular, sharp reductions of BEP are evident in the baseline and quality scenarios (88% and 89% BEP, respectively) under intense feeding cost stress. This result is relevant because the gross margin, which does not consider fixed costs of farm, possibly would be expected to be positive. As expected, simultaneous stresses would have the greatest impact. However, they appear to be mitigated under the efficiency and joint scenarios. The efficiency scenario shows high BEP under different stresses, meaning that positive gross margin outcomes are achieved in 94-99% of the cases. Although there is a lower impact of feeding cost stress in this scenario, it also shows losses similar to the baseline scenario if subjected to price stress (around 3% and 5% in the 10% and 50% stress percentiles, respectively). This suggests that higher prolificacy provides farms with a cushion against vulnerability to feeding cost risks, although they would be equally vulnerable to price drops as farms with lower prolificacy. Interestingly, subjected to price stress, the quality scenario performs worse than the baseline and efficiency scenarios in terms of gross margin losses (percentage losses are doubled), highlighting some vulnerability to price drops.

	SCENARIOS															
	Baseline				***Quality***				***Efficiency***				***Joint***			
	Gross margin €/ewe (mean)	σ	*Gross margin loss (% var.)*	BEP (%)	*Gross margin €/ewe (mean)*	σ	*Gross margin loss (% var.)*	BEP (%)	*Gross margin €/ewe (mean)*	σ	*Gross margin loss (% var.)*	BEP (%)	*Gross margin €/ewe (mean)*	σ	*Gross margin loss (% var.)*	BEP (%)
Lamb price stress																
10percentile	44.6	18.7	-5.8%	98.1	45.68	19.2	-10.0%	98	66.91	26	-5.5%	99.4	68.44	26.8	-9.6%	99.4
50percentile	45.96	18.6	-2.9%	98.4	48.23	19.7	-5.0%	98.3	68.83	26.1	-2.8%	99.5	72.09	28	-4.8%	99.4
Feeding costs stress																
10percentile	12.24	9.3	-74.1%	88	15.64	11.4	-69.2%	89	29.15	17.8	-58.9%	96.2	34.05	20.9	-55.0%	96.0
50percentile	33.26	13.9	-29.8%	97.5	36.66	16	-27.8%	97.2	54.11	21.9	-23.6%	99.3	59.01	25.3	-22.1%	99.1
Simultaneous stress																
10percentile	9.05	9.62	-80.9%	82.8	10.57	10.1	-79.2%	83.8	25.21	17.1	-64.4%	94.0	26.75	17.9	-64.7%	94.2
50percentile	31.87	14.1	-32.7%	96.8	34.14	15.2	-32.7%	96.8	52.11	21.6	-26.4%	99.0	55.37	23.5	-26.9%	98.9

Table 12. The average gross margin (€/ewe), percentage loss and break-even probability (%) by strategic scenario under stressors. Source: Bertolozzi-Caredio et al. (2021b).

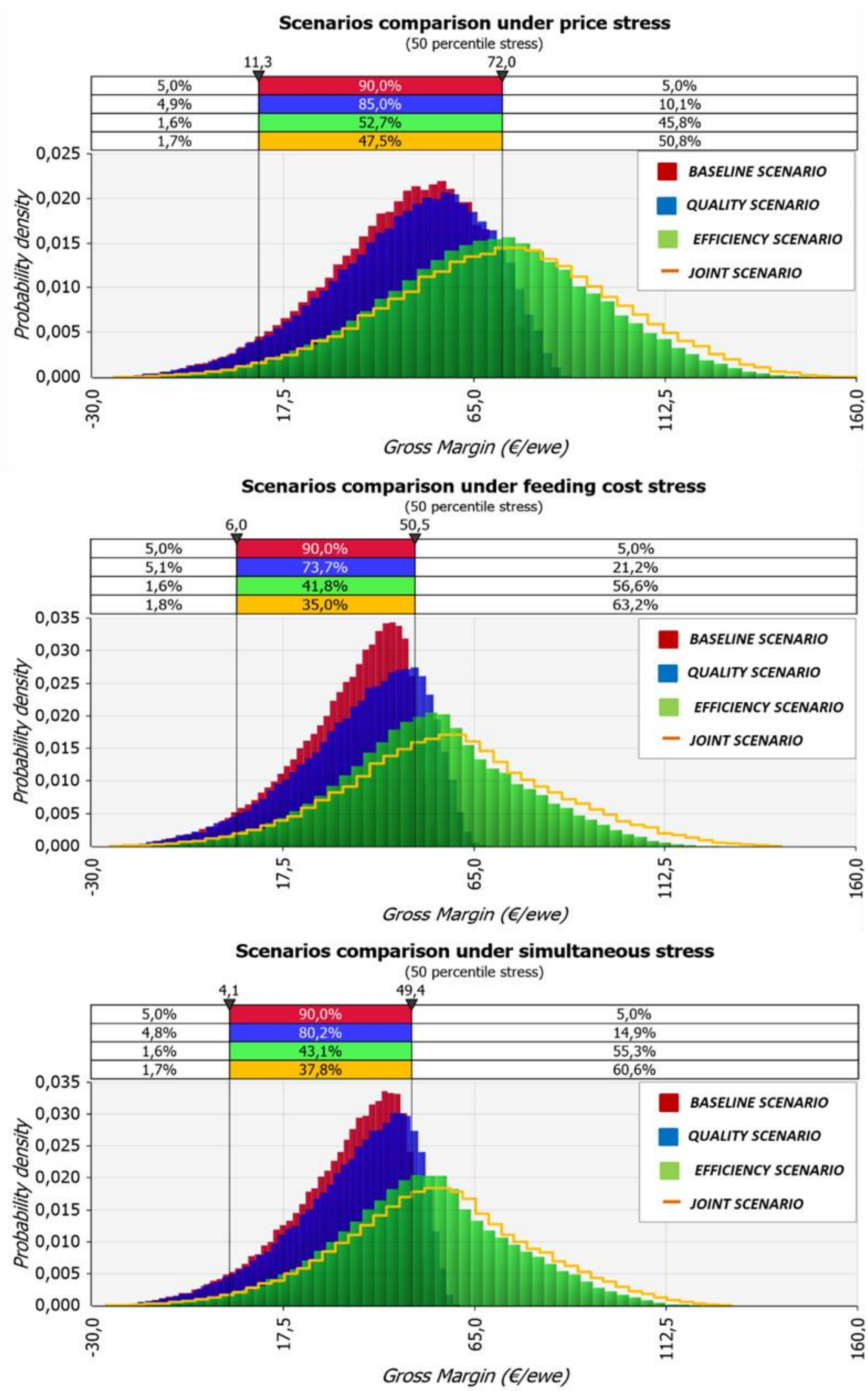


Figure 22. Comparison of profitability density distributions (€/ewe) under price, feeding cost and simultaneous stressors (percentile 50% stress level). Source: Bertolozzi-Caredio et al. (2021b).

Figure 22 compares distributions of scenarios under different stressors. The baseline and quality scenarios reveal similar responses to price and simultaneous stressors, as also suggested by the average gross margin in Table 12 (which is similar). The efficiency scenario performs best under all stressors, but its gross margin outcome is much more variable. This is consistent with the high standard deviation reported in Table 12. This suggests that a farm relying on increased prolificacy is likely to be more profitable, but the expected outcome will be less certain.

	base outcome (€/ewe)	[% decrease in subsidies value] -25%	-50%	-75%	-100%
Baseline	*47.3*	*-6.4%*	*-12.8%*	*-19.2%*	*-25.6%*
Quality	*50.7*	*-6.0%*	*-11.9%*	*-17.9%*	*-23.9%*
Efficiency	*70.8*	*-4.3%*	*-8.5%*	*-12.8%*	*-17.1%*
Joint	*75.7*	*-4.0%*	*-8.0%*	*-12.0%*	*-16.0%*

Table 13. Gross margin loss (%) under subsidy decreases. Source: Bertolozzi-Caredio et al. (2021b).

Table 13 shows the sensitivity of the gross margin outcome to reductions in coupled subsidies by scenario. As previously shown (see Figure 21), coupled support is relatively more important in the baseline and quality scenarios without stressors. Accordingly, larger gross margin drops are found in the baseline and quality scenarios when the value of the coupled subsidies is reduced in the simulation. In the case of withdrawal of all coupled subsidies (-100%), for example, support accounts for about one-quarter of the gross margin in the baseline and quality scenarios and about one-sixth in the efficiency and joint scenarios.

4.3.3 DISCUSSION

In the baseline scenario, the most important threat to farms is feeding costs. This is consistent with previous research (Aguilar et al., 2006; Toro-Mujica et al., 2012; Morris, 2017). Lamb price variation is a minor risk component. This sheds light on the general concern about lamb price trends mentioned by the stakeholders in the region (Becking et al., 2019). The findings suggest that the price concerns result from long-term low prices rather than price variability.

This analysis offers contradictory evidence regarding the impact of the PGI label. Firstly, the quality scenario improves gross margin under no stressors and under increasing feeding costs, but there appears to be little room for improvement, and vulnerability to extreme events increases slightly. Secondly, and most importantly, this strategy performs worse (in terms of percentage losses) than conventional production under the price stressor, highlighting a significant vulnerability to price drops. PGI lamb prices are on average higher than conventional prices, but probably more unstable. This is consistent with the study carried out by Ferrer-Perez et al. (2020), which describes the long-term positive correlation between conventional and PGI lamb prices in Spain, and PGI price trend volatility over the last decade. Consistent with this research (which focused on Aragón's north-western neighbouring region, Navarre), the variability in PGI prices also appears to be higher than for conventional lamb in the case of Huesca.

A recent literature review on PGI studies by Santeramo and Lamonaca (2020) demonstrates that the relevance of PGI varies depending on product types (e.g., high-low value) and regional or country-specific factors. In our case study, the impact of the strategy of adhering to PGI is relatively low with respect to other cases (e.g., Bardají et al., 2009). Our findings could explain why the share of sheep farms opting for the *Ternasco de Aragón* PGI is relatively low. In 2017, 668 farms were registered under the PGI (33% less than in 2008), whereas the number of lambs sold under the PGI dropped by 12% over the same period (MAPA, 2020a). However, there could be other factors explaining farmers' decision to join PGIs, including the drive to join cooperatives, reduced certification costs, and public support (Belletti et al., 2007; Requillart, 2007; Bardají et al., 2009). In addition, it is troublesome to distinguish the quality of PGI products from conventional production, which is, quite often, based on the same breeds, farm practices and region (Sans et al., 1999).

Despite their vulnerability to price variability, PGI labels might be a tool against the reducing lamb consumption (Chamorro et al., 2012). Spanish and Aragón lamb consumers are less sensitive to price and more attracted by quality and origin certifications (Bernabéu et al., 2018). Besides, Font i Furnols et al. (2009) calculate that about 60% of Spanish consumers prefer lamb totally or partially fed on grassland, whereas Bernués et al. (2012) highlight that a growing trend in Aragón is the demand for easy cooking products. These trends in consumers' habit may represent an opportunity for improving quality labelling strategies in future.

On the other hand, the margin for improvement brought about by the efficiency scenario stands out in all cases. This is consistent with previous research carried out in different EU regions (Bohan et al., 2018; Gazzarin and El Benni, 2020), which finds that there is a positive correlation between increased prolificacy and improved economic performance. While the average expected gross margin is more likely to be higher than within other scenarios, uncertainty surrounding expected gross margin is high as well. An explanation for this result could be the high variability of within-farm (from one year to another) and between-farm prolificacy. This high variability can be explained by several factors, such as breed genetics, slaughtering methods (by age VS by weight), abortions (also linked to environmental factors) (Amer et al., 1999), and feeding techniques (Viñoles et al., 2009).

Therefore, a possible interpretation is that increased prolificacy is a strategy worth pursuing, although it will not reduce profit variability. Consistent with previous research carried out in Aragón by Ripoll-Bosch et al. (2014), we also found that higher prolificacy detracts from the relative importance of coupled subsidies in farm gross margin. In recent years more and more farmers are implementing breed selection, novel rearing and feeding systems, and introducing new breeds (Becking et al., 2019; Bertolozzi-Caredio et al., 2020). The farmers' involvement in research projects for breed selection and management systems, as well as the technical support of cooperatives, appear as a promising way to increase farms' efficiency and ewe prolificacy.

The joint scenario performs better than all scenarios in terms of average gross margin, but it is highly sensitive to price stress with a generally high uncertainty surrounding expected outcomes. The joint strategies could definitely be useful for addressing multiple risks at once and help to offset their respective weaknesses. Increased prolificacy and adherence to PGI help to assure both higher average gross margin and reduced variability. Regarding the specific case study, a recent multi-stakeholder focus group (San Martín et al., 2020) identified increased prolificacy and PGI labelling as belonging to alternative future paths (semi-intensive and hi-tech extensive, respectively). Instead, the findings suggest that productive efficiency and demand-oriented strategies could be integrated into a single strategic path.

The relative importance of coupled payments has been decreasing in the sector over the last twenty years (Soriano et al., 2018). Galanopoulos et al. (2011) argue that the less efficient sheep farms are more dependent on support, although evidence in the literature is contentious (Martinez-Cillero et al., 2018). The research findings show that the relative share of coupled subsidies in gross margin diminishes sharply within the efficiency scenario, suggesting that increased prolificacy has the potential to reduce the relative weight of coupled support in the farm gross margin. While previous research explored the relations between support and technical efficiency (Minviel and Latruffe, 2017), none, to the best of the present knowledge, focused on the interplay between increased sheep prolificacy and public support, which may be an interesting aim for future investigations.

4.4 RISK MANAGEMENT STRATEGIES TO IMPROVE RESILIENCE

This chapter shows the results of the fourth research study aimed to identify new ways through which risk management strategies may improve resilience. The assessment consists of a multi-stakeholder focus group involving nine participants, through which main challenges, strategies, actors' involved, and potential improvements are identified. The approach is described in section 3.7.

4.4.1 THE MAIN CHALLENGES, STRATEGIES AND ACTORS INVOLVED

Table 14 shows the main strategies affecting extensive sheep farming, in the focus group participants' view. These challenges, however, are consistent with those identified by previous research in the case study area (Becking et al., 2019; Spiegel et al., 2019; Soriano et al., 2020). Yet, the endemic low profitability of sheep farms, the steady-low prices of lamb meat, and the increasing costs (especially feeding costs) are top-ranked, according to the overview provided in the introduction of the thesis. Again, social challenges like low quality of life, lack of skilled labour, and reducing lamb meat consumption are emphasized by the system' stakeholders. In addition, great relevance is attached to environmental challenges such as conflicts with the wild fauna, animal diseases and climate change (mainly referred to intense droughts). Also, stakeholders are concerned about changes in the policy and regulatory framework, which are likely to entail significant impacts (and opportunities) for the sector.

Main challenges
Low profitability
Remaining lamb prices
Increasing costs
Quality of life (intense labour demanding)
Lack of skilled labour
Changing policies and bureaucracy
Wild fauna (wolves and bears attacks)
Social negative perception-Reducing meat consumption
Diseases
Climate change

Table 14. The main challenges in the focus group participants' perception. Challenges are listed from the most important (top) to the least important (bottom), in the participants' perception. Own elaboration.

Table 15 below shows the four main strategies according to the focus group participants' scoring. These strategies are seen as the most valuable solutions to cope with the main challenges, and to enhance the resilience of the sector. The four selected strategies were: *improving investment, financing capacity and insurance*; *promoting lamb meat consumption* (including bargaining power in value chain); *value extensive livestock contribution to environmental conservation and population retention*; and *training and knowledge transfer*.

However, the strategy of protection from wildlife was joint with the strategy of *valuing the environment contribution*, being wolf issue a major one. The strategy *promoting lamb consumption* includes reinforcing the negotiation capacity with value chain actors. These two strategies were brought together. The strategy *valuing the environment contribution* also needs to include the contribution of extensive farming to fixing population in the rural areas Besides, participants considered that insurance products should be placed within the financing and investing strategies.

Table 15 also reports the actors' involvement in the selected strategies. Almost all stakeholders are involved in every selected strategy. According to participants, financial institutions are not present in actions towards valuing lamb meat and its contribution to the environment conservation.

A consensus was reached about the key role of the cooperatives and farmer's associations in promoting the consumption and boosting the bargaining power of farmers in the value chain. Farmers also have a role by providing quality products. The role of public sector in promoting consumption involves launching promotional campaigns. Banks and financial companies do not have a direct role in this strategy.

While farmers contribute to environment conservation and population retention in rural areas by holding their activities, farmers' associations and cooperatives are key to value, raise awareness and communicate this contribution. Cooperatives also contribute to population retention by providing local services to their partners, i.e. collecting livestock in remote areas to drive them to the slaughterhouse. By providing local services, cooperatives discourage farmers to shut down their farm operations and leave the rural areas.

Cooperatives and associations are the main players in training and knowledge transfer strategies. Likewise, farmers participate in this strategy, as they expressed interest in raising their technical and management profiles. Public sector is present in every strategy mainly because it supports the actions performed by the rest of the actors in the farming system.

		Risk Management Strategies	Total points	*Farmer*	*Farmer's association*	*Cooperatives*	*Banks-insurance companies*	*Public sector*
Selected strategies	1	Value extensive livestock contribution to environmental conservation and population retention	7	X		X		X
	2	Investment and financing capacity	6	X	X	X	X	X
	3	Promoting of lamb meat consumption	6	X	X	X		X
	4	Training and knowledge transfer	5	X	X	X		X
	5	Promoting the participation in cooperatives and farmers' organization	5					
	6	Improving bargaining power in the value chain	4					
	7	Improving farm management and animal handling	3					
	8	Wild animal protection	3					
	9	Agricultural insurance contract	2					
	10	Off-farm income	1					

Table 15. The main strategies and actors involved as selected by focus group participants. Own elaboration.

4.4.2 RISK MANAGEMENT IMPROVEMENTS TO RESILIENCE

Table 16 below shows the main focuses to improve risk management strategies and resilience. Farmers, associations and cooperatives may play the greatest role in promoting consumption and exploiting the sector's socio-ecological functions. On the other hand, financial and public sectors may contribute more to the investment and financing capacity. Improvements in training and knowledge call into question the role of cooperatives and the public sector.

Farmers are asked to be pro-active in shortening the distance with consumers, and in increasing consumers' awareness about the positive contribution of the sector to the environment and the wider society. Farmers' business could rely more on the ecosystem services provided by extensive sheep farming, and address them as the biggest opportunity.

Yet, farmers' associations are called to play a part in fostering the consumers' awareness, and could improve the transparency of their actions, and hire expert consultants. On the other hand, cooperatives are seen as the most important actor in guiding consumers' preference. Several marketing strategies could be adopted by cooperatives, such as the design of new high-quality brands adapted to the changing consumers' habits (kebab, hamburger, easy-to-cook), and a reinforced use of labelling and traceability. Moreover, cooperatives are asked to extend their extension services (by providing new contents in training courses and hiring new experts), their network of collaborations with the educational system (school, universities, research institutes), and with sheep sectors in other regions. This may enhance knowledge exchange, innovation spill-over, and lobby power. The collaboration with educational system may help shaping the consumers' awareness in the long-run.

Financial institutions can provide new, improved credit and insurance products tailored on specific farmers' needs, also by relying on a more solid public-private collaboration. Special attention is paid to the provision of middle-long term soft credits, partially guaranteed by the public sector. Besides, new insurance products are required to cope with emerging animal diseases, such as the *Rift Valley* fever and *Maedi-Visna*. Overall, financial products could be adapted to the farms' cash-flow, considering revenues, subsidies, and the use of other financial tools.

The public sector should address the challenges of land access and generational renewal. They are asked to design a land bank, and to ensure sheep farmers with the free access to public lands. More effort could be made to attract young farmers by implementing, for example, an entrepreneur Hub. In addition, existing aids should be re-thought to consider the variable vulnerabilities across the region, like in less-favoured areas, and more linked to the ecosystem services provided by the sector.

ACTORS	STRATEGIES			
	Value extensive livestock contribution	**Investment and financing capacity**	**Promoting lamb meat consumption**	**Training and knowledge**
Farmer	*Focus on the need to be pro-actively involved in fostering the consumers awareness of the sector's positive contribution to the environment and animal welfar, and turn it into an opportunity*		*Focus on direct relationship with consumers. Joint activities to boost local trade, reduce intermediaries and open the farm to consumers.*	
Farmer's association	*Focus on the need to increase the public awareness on the sector's positive functions*		*Focus on the need for transparency and expert knowledge. Involve more professionals on communication and marketingtasks.*	
Cooperatives	*Extend cooperation over sheep sectors in other regions, and strenghten collaboration with research institues to promote research on the sector's positive functions.*		*Strong focus on new marketing strategies. Communicate research on lamb meat nutrition value, the positive contribution of lamb meat to the region and rural population. Create a new high-quality brand adapted to consumers needs (easy to cook: lamb kebab, lamb hamburgers). Enhance labellin and traceability.*	*Extend collaboration with schools and universities to improve education on the sector. More expert trainers and training courses on new contents adapted to sector's opportunities.*
Banks-insurance companies		*Focus on public-private collaborationto develop new credit and insurance products tailored on farmers' needs. Adapt products to farmers' profile and farms' cashflow. New middle-long term soft credits. New insurance products to cope with emerging diseases.*		
Public sector	*Focus on land access (land bank, free access to public land), generational renewal (entrepreneur Hub), and new aids adapted to varying vulnerabilities in the region, and linked to ecosystem services.*	*Focus on an efficient regulatory framework, specific aids for less-favoured areas, and public-private collaboration to improve diseases insurance and negotiate loans' guarantees.*		*Support and provide training courses, and promote sector's collaboration with educational system.*

Table 16. The main improvements as addressed by focus group participants, by actor and strategy. Own elaboration.

Figure 23 below shows the importance of the three main topics by strategy. *Cooperation & Marketing* is the most addressed topic, and appears crucial to promote consumption and exploit the sector's socio-ecological contributions. These results highlight horizontal cooperation and consumer guidance as the greatest opportunity to enhance the extensive sheep system's resilience. However, *Policy & Financial Tools* are the key aspects to be improved in order to increase investment and financing capacity, and to support the provision of ecosystem services. Not less importantly, the *Knowledge System* seems relevant not just to foster trainings and knowledge exchange, but also to pursue strategies to promote consumption and the sector's socio-ecological functions.

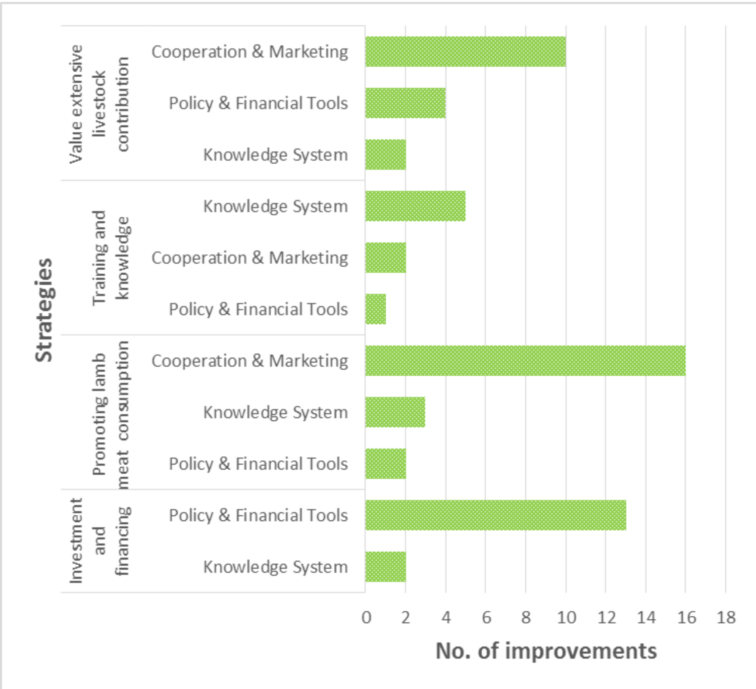


Figure 23. The relative importance of the three main topics by strategy.
Own elaboration.

Figure 24 below shows the importance of the three main topics by actor. Extended collaborations, extension services and marketing strategies should be the main targets of cooperatives and farmers' association. Rather, the public sector, banks and insurance companies should focus on the provision of new tools and aids. Policymakers might also support the *Knowledge System*. Farmers should focus mainly on *Cooperation & Marketing*, which appears to be the greatest avenue to improve the farms capacity to cope with socio-economic challenges like low profitability and reducing lamb meat consumption.

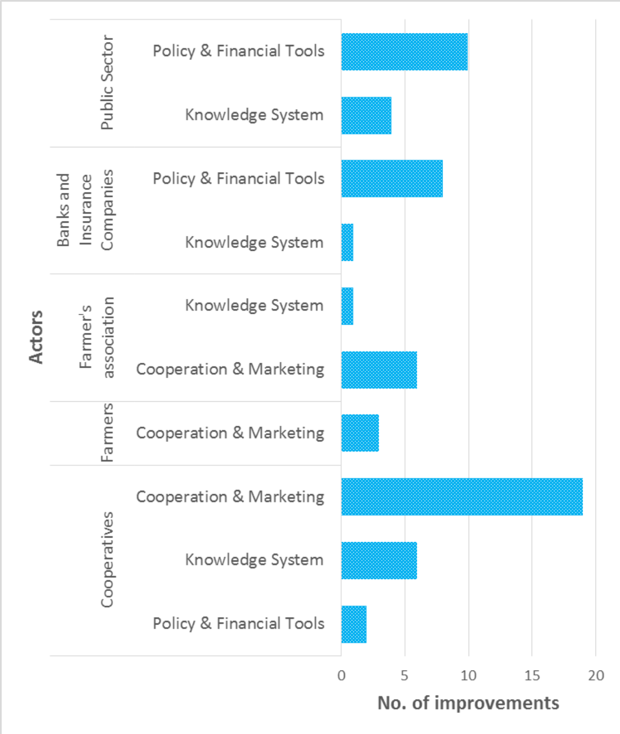


Figure 24. The relative importance of the three main topics by actor.
Own elaboration.

4.4.3 DISCUSSION

The focus group participants put great emphasis on the role of cooperatives to improve consumer guidance, and implement new marketing strategies. According to previous research in the EU (Boogaard et al., 2011; Clark et al., 2016), livestock systems, particularly, suffer from a negative or undervalued public perception, highlighting the need for cooperation to improve consumer guidance and shape a more positive, long-term public acceptance. The focus group underlined how cooperatives may help to create new, locally-based organizations to strengthen connections among multiple actors (e.g. farmers, local administrations, consumers), which is consistent with recent developments in research (Berti and Mulligan, 2016; Fonte and Cucco, 2017). Most farms are likely to pursue some sort of cooperation (Dias and Franco, 2018). Even though the actual, social impact of cooperatives is not always clear (Benos et al., 2018), cooperation can lead to important changes in farm structure and performance (Balmann et al., 2006). However, different forms of cooperation could affect farm performance in diverse ways (Kontogeorgos et al., 2018). In this focus group, importance is attached to cooperation for learning, which is likely to be one of the key strategies in the future (Prager and Creaney, 2017; Thomas et al., 2020). Interestingly, the focus groups highlight the opportunity to extend cooperation beyond regional borders and productive orientation, grouping different sectors within a region (see Regan et al., 2017, for an example), and the same specializations across different regions. These findings could suggest alternative forms of collaboration between actors that typically do not cooperate (Dyg and Mikkelsen, 2016). According to Severini and

Sorrentino (2017), the CAP could be rethought to support the emergence of novel, more tailored organizational forms.

The focus group pointed to the need to reinforce the knowledge system. The focus group's indications could be aligned with the concept of agricultural knowledge and innovation systems (AKIS) (EU SCAR, 2015). However, the traditional AKIS concept refers mainly to the actors of extension services (private advisors, research, public information services), while, like previous research (Hermans et al., 2015), the participants suggested that more stakeholders could be involved (e.g. consumers, financial institutions). Besides, AKIS are based particularly on knowledge as a stock to be transferred (Poppe, 2016), whereas, in the focus group, learning emerges as a significant aspect of the knowledge network. Beyond the farmers' learning process (Urquhart et al., 2019), other actors in the farming system should learn too, including regional/local public officers, insurance companies and consumers. Since farmer learning depends on knowledge support by others (e.g. training, data provision, experience exchange), and that other actors are asked for learning as well, the understanding emerging from this research corroborates the concept of networks as learning entities (Gibb et al., 2017). In line with Labarthe and Laurent (2013), public authorities should integrate more deeply the private extension service to increase dissemination and research, and reach those farms that are less connected to the network. Santeramo (2016), for instance, proposes a policy strategy to increase information campaigns and to trigger farmers' learning by doing and spill-overs through highly-supported first-participation schemes in financial tools. Also, Cordier and Santeramo (2019) propose the creation of public platforms to favour experience exchange.

The main financial tools indicated by the focus group participants were credit and insurance products. In fact, hedging with futures is an option mainly used in dairy farming (Schulte and Musshoff, 2018), hit by the abolition of the milk quota, and by large cereal producers (Garrido et al., 2016). Farmers are unfamiliar with how it works. Mutual funds and income stabilization tools are not mentioned, instead the focus is placed on insurance feasibility. Commonly, insurance tools are seldom tailored to farmers' specific needs (Meuwissen et al., 2001). Despite their potential, index insurances are still not seen as a workable option (Chartier and Cronin, 2017). Consistently with the literature (Meuwissen et al., 2018), the use of livestock insurance is not widespread. In line with previous research (Varga, 2016), there is limited access to credit, especially for small farms, and credit products are not adapted to farm cash flow seasonality.

As reported by previous research, the use of financial products increases when farms are more diversified (Lefebvre et al., 2014), specialized in arable farming (Liesivaara and Myyrä, 2014), or generally larger (van Asseldonk et al., 2016). Also, the farmers whose revenue depends to a larger extent on direct payments are less likely to use insurance (Finger and Lehmann, 2012), whereas a sharp reduction of subsidies would increase farmers' demand for insurance (O'Donoghue, 2014). To some extent, this might be the case of extensive sheep farms, which depends on large subsidies and significant fixed assets.

Like previous research, important barriers to the use of these instruments are the high costs and requirements (Chartier and Cronin, 2017), and the low awareness and knowledge of what instruments are available and how to use them (Meuwissen et al., 2018). However, the focus group participants pointed mainly to the need for new products tailored on farmers' needs (e.g. animal diseases) and cash flow. This implies a need for more public-private, and private-private (e.g. insurance-bank) collaboration. For instance, insurance products and loans could be designed jointly to reduce the risks assumed by financial institutions, and, therefore, costs and requirements (Carter et al., 2016; Farrin and Miranda, 2015). The integration of different tools has been suggested before (see, for example, Tadesse et al., 2015), as part of a cost-minimization framework that facilitates the treatment of multiple RM tools jointly (Chambers and Quiggin, 2004). Many examples of potential synergies have been reported in the literature, for example, contingent credit contracts to reduce default rate (Farrin and Miranda, 2015), the integration of different insurance types (weather index, yields, crops) (Tadesse et al., 2015), the interplay between insurances and direct payments (Bardají and Garrido, 2016), between agricultural credit and off-farm income (Akhtar et al., 2019), and between flexible insurance schemes and diversification (Santeramo, 2017).

Second, there is need of more structured planning of integrated strategies from a long-term farm business perspective (Meuwissen et al., 2018). Indeed, the business planning gap has been identified as one of the factors reducing, for example, access to credit (fi-compass, 2020). For example, loan re-payments and insurance premiums could be adapted to the vagaries of farm cash flow and public funding in the medium to long term. This suggests the need to create specific comprehensive tools to design, plan, and manage the usage of integrated instruments within farm accounting over longer business plan periods.

5. CONCLUSIONS

5.1 MAJOR FINDINGS

This thesis aimed to assess the strategies, management patterns, and policies promoting the capacity of Spanish extensive sheep farming systems to keep delivering their irreplaceable functions and services. The research questions are posed in a context of urgent need to cope with the current and future challenges threatening the sector. In order to achieve the main goal, five research questions, with as many corresponding specific objectives, were investigated through four research studies. Along this research, major findings were brought to light; these findings are described below as answers to the thesis' research questions.

I. **What factors affect the farm continuity and resilience in extensive livestock systems?**

Farms' resilience is a process occurring over time along with the farm development trajectory. Farm continuity, therefore, is a key dynamic determining resilience. Farm continuity can be ensured with succession or new entrants, but in our case study mainly intra-family farm succession takes place. The intra-family farm succession process develops over three steps: potentiality, willingness and effectiveness. Successor's willingness is a key step in succession and, according to our case study, is likely to be the weakest. Most potential successors do not complete it, a problem compounded by the little attention paid to this step by policy makers. Furthermore, this investigation highlights that the factors involved in succession belong to four dimensions, namely, individual, familial, institutional, and contextual.

While the individual dimension is central to the process, the other factors contribute in differing degrees to the three steps. The individual dimension is decisive: if individual attributes have not matured, the key steps of succession are less likely to be achieved. The research underlines the importance of the successor's emotional attachment and perception of his or her capabilities for the decision to take over the farm. The familial dimension is crucial to the recognition of the potentiality of succession and to developing the successor's individual attributes that contribute to the succession process. Interestingly, our results suggest that while it is crucial to the potentiality step, the familial dimension has less influence on the willingness step, where the individual dimension is central. As the successor approaches the threshold of willingness to succeed, his or her decision is affected by a pragmatic evaluation of the potential business prospects of farming with respect to other opportunities. Here contextual factors appear to have a significant negative impact, although they apparently do not have a prominent bearing on the importance of the individual vocational attributes of the successor. Although a pragmatic opportunity trade-off evaluation (involving contextual factors) might influence the evolution of willingness, our research casts light on the importance of individual and vocational attributes developed during the previous potentiality step. Vocation is socially constructed within the farming family (especially knowledge and skills) and the rural environment (focusing mainly on emotional attachment).

The three-step, multidimensional, long-term process of family farm succession is aligned with the understanding of socially constructed endogenous succession cycles, including the three cycles of construction of successor identity, the successor's progression over the farm ladder, and the development of the farm business trajectory. The construction of a successor identity is a process of building the potential and willing successors, and is likely to be more important in the earlier stages. Specifically, the potential successor has to be constructed with the individual attributes that will make the successor willing to take over the farm. The progression on the farm ladder is a process of growing involvement in farming, which increases as the successor moves from potentiality to willingness, and finally peaks with effective succession. It is a fundamental process for shaping successor attributes, such as knowledge, awareness, feelings, emotional attachment, skills and ability. Therefore, it significantly contributes to the construction of potential and willing successors. The succession effect on the farm business trajectory is bigger when the successor moves from potentiality to willingness, and it is particularly relevant from willingness onwards: in practice, the willingness of a successor works as a trigger for farm development.

II. How resilient are the extensive sheep farm management patterns?

Farms having a continuity follow alternative development trajectories along which they build resilience. Our findings suggest that, within the same farming system, farms are likely to build resilience by implementing very diverse farm management patterns. Specifically, we defined four patterns, namely extensification (more reliance on pasture-based), intensification (more stable-based), re-orientation (reduction of sheep and diversification), and conservation (farms' structure maintenance based on quality production). All patterns contribute to adaptability, especially extensification and re-orientation. However, patterns extensification and conservation mainly contribute to robustness to reinforce the original farms' structure, whereas the patterns re-orientation and intensification lead to much more transformability. We found a clear distinction among resilience attributes determining transformative patterns like intensification and re-orientation, and those favouring the conservation or re-adjustment of traditional extensive management. Specifically, match with natural resources, the farmers' network, and the traditions and perspective behind sheep farming are crucial for preserving or extensifying existing farms. In contrast, financial and labour resources, and on-farm diversity characterize re-oriented and intensified farms.

While investigating the alternative farm management patterns to build resilience, this research casts light on the significant diversity of ways through which farms succeed in delivering functions within the same farming system. This diversity of observed management patterns could be considered as a strength of resilient systems. Likewise, our findings suggests that trajectories of intensification or re-reorientation are likely to affect the overall capacity of a system to keep delivering functions (especially those linked with pasture-based management and grazing flocks), highlighting the importance to balance the diverse patterns.

III. What is the economic performance and resilience of the main demand- and supply oriented strategies in extensive sheep farms?

Across the alternative management patterns, the two most common on-farm strategies implemented so far belong to supply- and demand-oriented approaches, in particular the implementation of innovations to increase sheep prolificacy, and the use of protected geographical identification labels. These strategies aimed to cope with main economic risks: price drops and high feeding costs. These are the main challenges in both farmers' and stakeholder perception.

Results indicate that feeding costs are the leading risk factor, whereas lamb prices have a smaller impact on vulnerability. The quality labelling strategy (i.e., protected geographical indication) could be an ineffective solution for reversing declining gross margin per raised ewe. This strategy is more vulnerable to price drops than conventional lamb meat prices due to a higher variability of PGI prices, while it yields scant improvements under feeding cost stressors. The increased prolificacy scenario performs much better than the baseline and quality scenarios in terms of average gross margin. Furthermore, this scenario seems a promising option, especially for mitigating increasing feeding costs, which are the main source of risk. However, there is high uncertainty surrounding increased prolificacy with regard to expected outcomes, most likely due to the high variability in prolificacy between farms and within the same farms overtime. The integration of demand-oriented and efficiency strategies may help compensate for their respective weaknesses and address multiple risks. Lastly, the relative contribution to gross margin of coupled support (subsidy) is lower under the efficiency than the baseline and quality scenarios, pointing to potentially lower dependence on support for more efficient farms.

IV. How can risk management strategies be improved to enhance resilience?

Scaling up at farming system level, there appears to be wide room for advances in the area of risk management strategies. The research draws three main avenues through which the farms' resilience may develop further: the knowledge system, the cooperation and marketing, and the policy and financial tools. Great importance is attached to the knowledge system, which seems to be an indispensable precondition to enlarge the set of available strategies to be potentially implemented. According to the second research study, farmers' learning capacity and network is a crucial resilience attribute determining the robustness and adaptability of extensive and cooperative-involved farms. If the aim were to foster extensification and cooperative patterns, then knowledge systems would need to be reinforced through a deeper involvement of financial institutions and local administrations.

The greatest margin of improvement in the farms' strategic approach considers the cooperation for marketing purposes. In fact, a stronger alignment between the extensive sheep farms supply and the changing consumer demand is required. There are numerous marketing strategies that could be implemented to exploit the intrinsic socio-ecological values of extensive sheep farming, and meet emerging consumer habits (e.g. environmental-friendly, traditional and local, and easy-to-eat food). More farmers' cooperation might increase the know-how (e.g. design new high-quality products, traceability, labelling), the bargaining power in the value chain (processors and retail sector), and/or shorten the farmer-consumer link.

Risk management financial tools are inadequate for the sector. The existing instruments do not cover specific farmers risks, such as emerging animal diseases for which specific insurance products are required (e.g. Rift Valley fever and Maedi-Visna), and more intensive droughts affecting grassland production (for which a workable weather index insurance is needed). Also, farms cannot easily access middle-long term credit products, which constrain the capacity of farms to implement new technologies and re-organize, hence their adaptability or transformability. New credit products should be tailored to the farms' cash flow, considering revenues, subsidies, and seasonality.

V. Which policies provide an enabling environment for farms' resilience?

The farm development and continuity is ensured by succession, and can follow alternative patterns and orientations. The policy framework provides an environment influencing (enabling/constraining) the farm development trajectory and, importantly, its continuity. Intra-farm succession develops across three key steps: potentiality, willingness and effectiveness. Institutions and their policies have a more pronounced impact on the last step of effectiveness to support the acquisition of production factors and initial investments, and the young farmer's income through direct payments. Policies also have an impact on the willingness step when successors take into account favourable policies in the opportunity trade-off to take over the farm business. However, there is no influence of the policy in the potentiality step, neither does it seem to have a decisive influence on either willingness or effectiveness. In fact, the family plays the greater role in providing the starting capital, while public aids work as a supplement. The role of policies, at this stage, is to make the business more economically attractive. In the case study region, however, policymakers should focus more on the early stages of succession, when young generations acquire the necessary attributes to become willing to enter the sector, and effectively take over a farm business. In this regard, educational policies become crucial. The problem of generational renewal seems to be inevitably connected to overall socio-economic phenomena affecting EU rural regions. Thus, not only agricultural policies, but also other policies intervening on rural infrastructures, services and society, should be taken into account when facing the farm succession problem. This aspect is significant in the (depopulating) region of Aragón, and sheds light on another source of generational renewal to be further empowered and investigated, i.e., the extra-family farm succession.

The current policy does not appear to support equally the diverse farm management patterns and, thus, the different capacities to deliver functions. Policy is not diverse enough to enable significantly robustness and adaptability (as in extensification and conservation patterns), but it evidently favours intensification and re-orientation at the expense of the original farms' configuration. Instead, policy could promote not only the diversity into the farms, but also the diversity among farms. In the case study area, a single management pattern would not be able to deliver the expected socio-economic functions and ecosystem services, and to ensure the resilience of the whole system. For example, extensification would provide the region with many ecosystem services, but could not deliver job and sufficient income for the whole system. By reverse, more intensive farms can provide more job opportunities and ensure income, but might lead to land abandonment and/or loss of ecosystem services. This highlights the need for a more diversified or flexible policy framework, whose instruments, measures and regulations could create a favourable environment for diverse farm management patterns to build resilience by different ways. For example, more emphasis could be given by policymakers on the set of ecosystem services provided by pasture-based models. The support to different models, however, could raise questions on the system's governance. Policymakers may be called to define the system orientation to which any intervention should be addressed, which might reflect the policymakers' understanding of what is desirable and what is not in terms of functions to be delivered. A further indication for policymakers could be the need to define the extent to which patterns are desirable, based on the functions that policymakers expect to be delivered by the whole system in the future. This appears as a key step to operationalize an evidence-based resilient policy considering the cross-scale interplay among farm management and system dynamics.

Along with the design of the new CAP post-2020, there seems to be space for relevant improvements to risk management strategies. Greater attention should be paid to the knowledge system and to implement inclusive digital platforms for knowledge exchange, capillary informative campaigns and structured extension services. Public authorities should integrate more deeply the private extension service to increase dissemination and research, and reach those farms that are less connected to the network. In addition, there is a need to further develop regulations to allow new or improved forms of cooperation. The new CAP could be rethought to support the emergence of novel, more purposeful and goals-oriented organizational forms. This includes cooperation for less conventional purposes like collective farm management, learning and marketing strategies. Cordier and Santeramo (2019) provide useful recommendations regarding, for example, improvements in risk pooling tools. Yet, more efforts should be made to provide detailed regulations to formalize and exploit synergies between existing financial tools. In particular, there is a need to develop and improve weather index-based and animal-disease insurances. Index insurance is a promising tool to face droughts that, in turn, threaten the feed self-sufficiency of farms. As demonstrated by this research, feeding costs are the main source of risk for sheep farms in the region. As a necessary precondition to improve financial tools, at local and national level more effort should be made to foster public-private collaborations, which are key to design new insurance and credit products tailored on specific farmers' needs, and to increase their accessibility. This research has highlighted the weaknesses of the Protected Geographical Identification label in Huesca and Aragón. Policymakers should pay particular attention to new cooperative-based marketing strategies to enhance the position of lamb in the regional and national marketing. There are opportunities in the development of quality labels for grazing-based and non-conventional (e.g.

easy-to-cook, kebab) products. Besides, efficiency and increased sheep prolificacy have demonstrated potential in the region. However, efforts to implement technologies and techniques to increase prolificacy (e.g. breed selection, innovative feeding systems) have been made mainly by farmers' cooperatives, also in collaboration with regional research centres. Policies should support these local initiatives, and incentivize the adoption of new technologies.

5.2 LIMITATIONS

This thesis omits quantitative assessments and systematic analysis of resilience at large scale, forbidding the statistical generalization of the findings. However, being the research purpose to explore the interplay among resilience and farm management patterns, the aim was the understanding of the conceptual linkages and resilience dynamics along farms' development trajectories, rather than drawing a general formulation about what is resilient and what is not. For example, Perrin et al. (2020) succeed in identifying the practices connected to resilience in dairy farming but, as the authors underline, they fail to find the reasons and mechanisms behind that result. The approach used in this thesis could help covering this gap. In addition, former investigations about resilience capacities at farm level rely on the farmers' perception and understanding of robustness, adaptability, and transformability. While such approach facilitates systematic analysis at large scale, it incorporates significant cognitive bias by farmers (Herrera, 2017; Perrin et al., 2020). In contrast, the perception of resilience was replaced by a deductive scheme that, anyway, does not exclude biases, but it frames results within a formally constructed resilience theory and conceptual definitions established in the literature.

The first and second research studies are based on a limited sample of interviews. While the qualitative content analysis provided insightful results from an in-depth assessment of mechanisms and dynamics, the sample size advises against the generalization of results over the whole farming system. It should be taken into account that further aspects related to the investigated topic, were not considered in this research.

The farm model used in the economic risk assessment in the third research study does not consider all the costs of production, though it investigates the principal ones: feeding costs and sanitary costs. As explained in chapter 3.6, labour costs were not included as the farms under study typically do not hire external workers, partly because there is a widespread shortage of farm workers in the region and farms are mostly unable to pay external labour. While sheep farms rely on significant extensions of non-owned land, their leasing costs are relatively small. Also, the relative importance of general and labour costs can differ consistently between farms, which make it difficult to aggregate and compare them. Sanitary costs cover a limited portion of costs. However, due to the increasing risk of new diseases in the sector, we opted for including these costs into the model to evaluate potential risks. In addition, increase in feeding costs is capped at 25%, and is based on data from outdated studies. Despite these simplifications, the model provides a link between increasing prolificacy and increasing feeding costs.

The multi-stakeholder approach used in the fourth research study is also subject to some methodological limitations. Some findings rely on the codification of qualitative data, converting a number of verbal statements gathered in moderated discussions into quantitative evaluations. The focus group involved a limited number of participants, representing the main stakeholders of the system, but not all (e.g. retailers, other farmers' cooperatives, NGOs and consumers' associations). This fact could somewhat hinder generalization over the whole farming system and, in the future, might be improved by involving more actors, or by carrying out multiple focus groups. Findings, though, offer insights that warrant more attention in future research, and have specific policy relevance with respect to agricultural policy design.

5.3 FUTURE RESEARCH

This thesis research focuses on the case of the extensive sheep farms of Huesca, and provides a comprehensive analysis of the farm succession process, the resilience capacities and attributes, the management patterns and risk management strategies that can enable farms' resilience. Nonetheless, there are still knowledge and methodological gaps to cover in future research, regarding both the case under study and the generalization over other farming systems.

The thesis research attempts to explain the intra-farm succession process and determinant influencing factors. The 'step-by-step' approach to succession used in this work helps improve the understanding of such a complex dynamic, and could be applied in different case studies either to test its usefulness, or to improve it. However, future investigations should attempt to provide a quantification of key steps, and to explore the succession process across alternative farm management patterns and trajectories. In particular, future research should focus more on the figure of the willing successor and the attributes that make a potential successor become willing to take over. From this viewpoint, the most commonly asked research question '*What makes a young successor able to take over a farm?*' should be preceded by the question '*Where does a young successor come from?*'. Furthermore, future research on generational renewal should investigate the opportunity to incorporate to the sector young successors out of the family farms, and to favour entrance from other sectors.

The thesis suggests that trajectories such as intensification or re-reorientation in the case under study are likely to affect the overall capacity of a system to keep delivering functions, highlighting the importance to balance the diverse patterns. Indeed, this aspect draws the attention of an emerging feature of resilience to be addressed in future investigations, that is, the cross-scale resilience effects (i.e. from farms to farming systems). In addition, though this work offers an understanding of resilience capacities and attributes, and the mechanisms behind them, a quantification of these conceptual constructs would help deliver indications that are more precise to decision-makers, and further developing scientific research.

Regarding the risk management tools, while stakeholders are called for designing new products tailored on farmers' specific needs, scientific research should explore opportunities to integrate existing policy tools and financial products (e.g. insurances, credit, direct payments), and to provide evidence about the benefits of risk management tools adapted to the farms' cash flows. Besides, advances are required to improve weather index-based insurance schemes, which appear to be a promising solution to cover risks in grasslands, although they do not seem workable yet.

Though the thesis adopted a broad policy perspective, there is room for numerous advances in investigating resilience-enhancing policies. Further research questions arose from all the aspects investigated in this thesis. Above all, future research on extensive sheep farming should investigate the effects of public support on quality labels, and the relationship between public support and increased prolificacy. The thesis' findings account for the role that policies could (or should) play in the earlier steps of succession, when a potential successor needs to be shaped. A hypothesis to be tested in future research is whether more wide-ranging types of support for young farmers might condition the succession process, strengthening the weakest links.

Overall, the comprehensive approach to resilience applied in this thesis may be a useful starting point to carry out resilience assessments in other farming systems, and could be easily adapted to different case studies' specificities. In this sense, it would be of interest to extend this type of resilience assessment on other livestock systems to allow comparisons and generalizations.

REFERENCES

1. Aguilar, C., Vera, R., Allende, R., Toro, P., 2006. Supplementation, stocking rates, and economic performance of lamb production systems in the Mediterranean-type region of Chile. *Small Ruminant Research* 66 (2006) 108–115. doi:10.1016/j.smallrumres.2005.07.057

2. Akhtar, S., Gu-Cheng, L., Nazir, A., Razzaq, A., Yllah, R., Faisal, M., Naseer, M., Raza, M.H., 2019. Maize production under risk: The simultaneous adoption of off-farm income diversification and agricultural credit to manage risk. *Journal of Integrative Agriculture* 18(2): 460–470. doi: 10.1016/S2095-3119(18)61968-9

3. Alcalde, M.J., Ripoll, G., Panea, B., 2013. *Consumer attitudes towards meat consumption in Spain with special reference to quality marks and kid meat*. In EAAP scientific series (No.133) 97-107. Wageningen Academic Publisher – The Netherlands 2013. Link: http://www.eaap.org/publications/eaap-scientific-series/

4. Aldanondo Ochoa, A., Casanovas Oliva, V., & Almansa Sáez, C., 2007. Explaining farm succession: the impact of farm location and off-farm employment opportunities. *Spanish Journal of Agricultural Research 5(2)*: 214-225. http://dx.doi.org/10.5424/sjar/2007052-241

5. Allen, C.R., and Holling, C.S., 2010. Novelty, Adaptive Capacity, and Resilience. *Ecology & Society* 15(3):24. http://www.ecologyandsociety.org/vol15/iss3/art24/

6. Amer, P.R., McEwan, J.C., Dodds, K.G., Davis, G.H., 1999. Economic values for ewe prolificacy and lamb survival in New Zealand sheep. *Livestock Production Science* 58 (1999) 75–90. https://doi.org/10.1016/S0301-6226(98)00192-4

7. Anderies, J.M., Folke, C., Walker, B., Ostrom, E., 2013. Aligning key concepts for global change policy: robustness, resilience, and sustainability. *Ecology & Society* 18(2):8. https://doi.org/10.5751/ES-05178-180208

8. Andersen, E., 2017. The farming system component of European agricultural landscapes. *European Journal of Agronomy* 82(B):282-291. https://doi.org/10.1016/j.eja.2016.09.011

9. Angeler, D.G., Allen, C.R., 2016. Quantifying resilience. *Journal of Applied Ecology* 53(3):617-624. https://doi.org/10.1111/1365-2664.12649

10. Anguaiano, E., Bamps, C., Terres, J., Pointereau, P., Coulon, F., Girard, P., Lambotte, M., Stuczynski, T., Sánchez Ortega, V. & Del Rio, A., 2008. *Analysis of farmland abandonment and the extent and location of agricultural areas that are actually abandoned or are in risk to be abandoned.* JRC Scientific and Technical Reports (EUR 23411 EN). https://publications.jrc.ec.europa.eu/repository/handle/JRC46185

11. Ashkenazy, A., Calvao Chebach, T., Knickel, K., Peter, S., Horowitz, B., Offenbach, R., 2018. Operationalising resilience in farms and rural regions e Findings from fourteen case studies. *Journal of Rural Studies* 59 (2018) 211-221. http://dx.doi.org/10.1016/j.jrurstud.2017.07.008

12. Balmann, A., Dautzemberg, K., Happe, K., Kellermann, K., 2006. On the dynamics of structural change in agriculture: Internal frictions, policy threats and vertical integration. *Outlook on Agriculture*, 35(2), pp. 115–121. doi: 10.5367/000000006777641543.

13. Barbosa-Carvalho, N., Rodrigues Minim, V.P., Nascimento, M., Vidigal, M.C., Marques Ferreira, M.A., Arruda Gonçalves, A.C., Minim, L.A., 2015. A discriminant function for validation of the cluster analysis and behavioral prediction of the coffee market. *Food Research International*, 77:400-407. https://doi.org/10.1016/j.foodres.2015.10.013

14. Bardají, I., and Garrido, A., 2016. *State of play of risk management tools implemented by Member States during the period 2014-2020 : national and European frameworks*. Research for Agri Committee – Directorate General for Internal Policies. doi: 10.2861/305797. Available at: http://www.europarl.europa.eu/studies

15. Bardají, I., Irazoiz, B., Rapun, M., 2009. Protected Geographical Indications and Integration into the Agribusiness System. *Agribusiness*, Vol. 25 (2) 198–214 (2009). DOI: 10.1002/agr.20198

16. Becking, J., Bardají, I., Soriano, B., 2019. *FoPIA-Surefarm Case-study Report Spain*. SURE-Farm deliverable 5.2. SURE-Farm H2020 project (No. 727520). https://www.surefarmproject.eu/deliverables/publications/

17. Bell, L.W., Moore, A.D., Kirkegaard, J.A., 2014. Evolution in crop–livestock integration systems that improve farm productivity and environmental performance in Australia. *Europ. J. Agronomy* 57 (2014) 10–20. http://dx.doi.org/10.1016/j.eja.2013.04.007

18. Belletti, G., Burgassi, T., Marescotti, A., Scaramuzzi, S., 2007. The effects of certification costs on the success of a PDO/PGI. *Quality Management in Food Chain* (2007) 107-121. DOI: 10.3920/978-90-8686-605-2

19. Benos, T., Kalogeras, N., Wetzels, M., de Ruyter, K., Pennings, J.M.E., 2018. Harnessing a "currency matrix" for performance measurement in cooperatives: A multi-phased study. *Sustainability*, 10(12), pp. 1–38. doi: 10.3390/su10124536.

20. Bernabéu, R., Tendero, A., 2005. Preference structure for lamb meat consumers. A Spanish case study. *Meat Science* 71 (2005) 464–470. doi:10.1016/j.meatsci.2005.04.027

21. Bernabéu, R., Rabadàn, A., El Orche, N.E., Dìaz, M., 2018. Influence of quality labels on the formation of preferences of lamb meat consumers. A Spanish case study. *Meat Science* 135 (2018) 129–133. http://dx.doi.org/10.1016/j.meatsci.2017.09.008

22. Bernués, A., Riedel, J.L., Asensio, M.A., Blanco, M., Sanz, A., Revilla, R., Casasus, I., 2005. An integrated approach to studying the role of grazing livestock systems in the conservation of rangelands in a protected natural park (Sierra de Guara, Spain). *Livestock Production Science* 96 (2005) 75–85. doi:10.1016/j.livprodsci.2005.05.023

23. Bernués, A., Ripoll, G., Panea, B., 2012. Consumer segmentation based on convenience orientation and attitudes towards quality attributes of lamb meat. *Food Quality and Preference* 26 (2012) 211–220. http://dx.doi.org/10.1016/j.foodqual.2012.04.008

24. Berti, G., and Mulligan, C., 2016. Competitiveness of small farms and innovative food supply chains: The role of food hubs in creating sustainable regional and local food systems. *Sustainability*, 8(7). doi: 10.3390/su8070616.

25. Bertolozzi-Caredio, D., Bardaji, I., Coopmnas, I., Soriano, B., Garrido, A., 2020. Key steps and dynamics of family farm succession in marginal extensive livestock farming. *Journal of Rural Studies* 76 (2020) 131–141. https://doi.org/10.1016/j.jrurstud.2020.04.030

26. Bertolozzi-Caredio, D., Bardaji, I., Garrido, A., Berry, R., Gravilescu, C., Bijttebier, J., Harizanova, H., Jendrzejewsky, B., Meuwissen, M.M.P., Ollendorf, F., Pinsard, C., Rommel, J., Severini, S., Soriano, B., 2021(a). Stakeholder perspectives to improve risk management in European farming systems. *Journal of Rural Studies*, 84: 147-161. https://doi.org/10.1016/j.jrurstud.2021.04.004

27. Bertolozzi-Caredio, D., Soriano, B., Bardaji, I., Garrido, A., 2021(b). Economic risk assessment of the quality labels and productive efficiency strategies in Spanish extensive sheep farms. *Agricultural Systems*, (191)103169. https://doi.org/10.1016/j.agsy.2021.103169

28. Bertoni, D. & Cavicchioli, D., 2016. Process description, qualitative analysis and causal relationships in farm succession. *CAB Re views 43 (11)*: 1-11. http://hdl.handle.net/2434/459420

29. Bielza Díaz-Caneja, M.B., and Garrido, A., 2009. Evaluating the potential of whole-farm insurance over crop-specific insurance policies. *Spanish Journal of Agricultural Research* 2009 7(1), 3-11. DOI: 10.5424/sjar/2009071-393

30. Biggs, R., Schluter, M., Biggs, D., Bohensky, E.L., BurnSilver, S., Cundill, G., Dakos, V., Daw, T.M., Evans, L.S., Kotschy, K., Leitch, A.M., Meek, C., Quinlan, A., Raudsepp-Hearne, C., Robards, M.D., Schoon, M.L., Schultz, L.,

West, P.C., 2012. Toward Principles for Enhancing the Resilience of Ecosystem Services. *Annu. Rev. Environ. Resour.* 2012. 37:421–48. doi:10.1146/annurev-environ-051211-123836.

31. Bohan, A., Shaloo, L., Creighton, O., Earle, E., Boland, T.M., McHugh, N., 2018. Investigating the role of stocking rate and prolificacy potential on profitability of grass based sheep production systems. *Livestock Science* 210 (2018) 118–124. https://doi.org/10.1016/j.livsci.2018.02.009

32. Boogaard, B.K., Bock, B.B., Oosting, S.J., Wiskerke, J.S.C., van der Zijpp, A.J., 2011. Social Acceptance of Dairy Farming : The Ambivalence Between the Two Faces of Modernity. *Journal of Agricultural and Environmental Ethics*, 24: 259–282 (2011). https://doi.org/10.1007/s10806-010-9256-4

33. Brandth, B., & Overrein, G., 2013. Resourcing Children in a Changing Rural Context: Fathering and Farm Succession in Two Generations of Farmers. *Sociologia Ruralis* 53(1):95-111. https://doi.org/10.1111/soru.12003

34. Brédart, D., Stassart, P.M., 2017. When farmers learn through dialog with their practices: A proposal for a theory of action for agricultural trajectories. *Journal of Rural Studies* 53 (2017) 1-13. http://dx.doi.org/10.1016/j.jrurstud.2017.04.009

35. Burton, R.J.F. & Fischer, H., 2015. The succession crisis in European agriculture. *Sociologia Ruralis 55* (2):155-166. http://dx.doi.org/10.1111/soru.12080

36. Caballero, R., 2001. Typology of sheep-cereal farming systems in Castile-La Mancha (south-central Spain). *Agricultural Systems*, 68(2001):215-232. https://doi.org/10.1016/S0308-521X(01)00009-9

37. Cabell, J.F., Oelofse, M., 2012. An Indicator Framework for Assessing Agroecosystem Resilience. *Ecology & Society* 17(1):18. http://dx.doi.org/10.5751/ES-04666-170118

38. Calus, M., & Van Huylenbroeck, G., 2008. *The succession effect within management decisions of family farms*. The 12th Congress of the European Association of Agricultural Economists – EAAE 2008.

39. Cannas, A., Tedeschi, L.O., Atzori, A.S., Lunesu, M.F., 2019. How can nutrition models increase the production efficiency of sheep and goat operations? *Animal Frontiers* 9(2):33–44. https://doi.org/10.1093/af/vfz005

40. Caraveli, H., 2000. A comparative analysis on intensication and extensication in mediterranean agriculture: dilemmas for LFAs policy. *Journal of Rural Studies* 16 (2000) 231-242. https://doi.org/10.1016/S0743-0167(99)00050-9

41. Carpenter, S.R., Westley, F., Turner, M.G., 2005. Surrogates for Resilience of Social-Ecological Systems. *Ecosystems*, (8):941–944. https://doi.org/10.1007/s10021-005-0170-y

42. Carpenter, S.R., Arrow, K.J., Barrett, S., Biggs, R., Brock, W.A., Crépin, A.S., Engstrom, G., Folke, C., Hughes, T.P., Kautsky, N., Li, C.Z., McCarney, G., Meng, K., Maler, K.G., Polasky, S., Scheffer, M., Schogren, J., Sterner, T., Vincent, J.R., Walker, B., Xepapadeas, A., de Zeeuw, A., 2012. General Resilience to Cope with Extreme Events. *Sustainability* 2012, 4, 3248-3259. doi:10.3390/su4123248.

43. Carpenter, S.R., Brock, W.A., 2008. Adaptive Capacity and Traps. *Ecology and Society* 13(2): 40. http://www.ecologyandsociety.org/vol13/iss2/art40/

44. Carter, M.R., Cheng, L., Sarris, A., 2016. Where and how index insurance can boost the adoption of improved agricultural technologies. *Journal of Development Economics*, 118:59–71. doi: 10.1016/j.jdeveco.2015.08.008.

45. Cassidy, A., & McGrath, B., 2015. Farm, place and identity construction among Irish farm youth who migrate. *Journal of Rural Studies 37* (2015) 20-28. http://dx.doi.org/10.1016/j.jrurstud.2014.11.006

46. Castañeda-Vera, A., Garrido, A., 2017. Evaluation of risk management tools for stabilising farm income under CAP 2014-2020. *Economía Agraria y Recursos Naturales - Agricultural and Resource Economics*, 17(1),3-23. doi: https://doi.org/10.7201/earn.2017.01.01

47. Cavicchioli, D., Bertoni, D. & Pretolani, R., 2018. Farm succession at a crossroads: The interaction among farm characteristics, labour market conditions, and gender and birth order effects. *Journal of Rural Studies 61* (2018)73-83. https://doi.org/10.1016/j.jrurstud.2018.06.002

48. Cavicchioli, D., Bertoni, D., Tesser, F., & Frisio, D.G., 2015. What factors encourage intrafamily farm succession in mountain areas? Evidence from an alpine valley in Italy*. Mountain Research and Development 35(2)*: 152–160. http://dx.doi.org/10.1659/MRD-JOURNAL-D-14-00107.1

49. Celio, E., Flint, C.G., Schoch, P., Gret-Regamey, A., 2014. Farmers' perception of their decision-making in relation to policy schemes: A comparison of case studies from Switzerland and the United States. *Land Use Policy* 41 (2014) 163–171. http://dx.doi.org/10.1016/j.landusepol.2014.04.005

50. Celio, E., Gret-Regamey, A., 2016. Understanding farmers' influence on land-use change using a participatory Bayesian network approach in a pre-Alpine region in Switzerland. *Journal of Environmental Planning and Management* 59(11): 2079 – 2101. https://doi.org/10.1080/09640568.2015.1120713

51. Chambers, R.G., Quiggin, J., 2004. Technological and financial approaches to risk management in agriculture: An integrated approach. *Australian Journal of Agricultural and Resource Economics*, 48(2), pp. 199–223. https://doi.org/10.1111/j.1467-8489.2004.00250.x

52. Chamorro, A., Miranda, F.J., Rubio, S., Valero, V., 2012. Innovations and trends in meat consumption: An application of the Delphi method in Spain. *Meat Science*, 92(4):816-822. https://doi.org/10.1016/j.meatsci.2012.07.007

53. Charrad, M., Ghazzali, N., Boiteau, V., Niknafs, A., 2015. Determining the Best Number of Clusters in a Data Set. Package 'NbClust', CRAN repository. https://sites.google.com/site/malikacharrad/research/nbclust-package

54. Chartier, O., and Cronin, E., 2017. *Study on risk management in EU agriculture: final report*. European Commission - Publication Office of the EU. https://op.europa.eu/en/publication-detail/-/publication/5a935010-af78-11e8-99ee-01aa75ed71a1#

55. Chiswell, H.M., & Lobley, M., 2015. A recruitment crisis in agriculture? A reply to Heike Fischer and Rob J.F. Burton's *Understanding farm succession as socially constructed endogenous cycles*. *Sociologia Ruralis 55*(2): 150-154. https://doi.org/10.1111/soru.12071

56. Chiswell, H.M., 2014. The Importance of Next Generation Farmers: A Conceptual Framework to Bring the Potential Successor into Focus. *Geography Compass 8* (5):300-312. https://doi.org/10.1111/gec3.12131

57. Chiswell, H.M., 2018. From generation to generation: changing dimensions of intergenerational farm transfer. *Sociologia Ruralis 58*(1):104-125. https://doi.org/10.1111/soru.12138

58. Cho, J.Y., & Lee, E-H. , 2014. Reducing Confusion about Grounded Theory and Qualitative Content Analysis: Similarities and Differences. *The Qualitative Report 19*(32):1-20. Retrieved from https://nsuworks.nova.edu/tqr/vol19/iss 31/2

59. Cimpoies, L., 2015. *EU farm support policy: an analysis of direct payments implementation in Spain*. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development Vol. 15, Issue 4, 2015.

60. Clark, B., Stewart, G.B., Panzone, L.A., Kyriazakis, I., Frewer, L.J., 2016. A Systematic Review of Public Attitudes , Perceptions and Behaviours Towards Production Diseases Associated with Farm Animal Welfare. *Journal of Agricultural and Environmental Ethics*, 29(3), pp. 455–478. https://doi.org/10.1007/s10806-016-9615-x

61. Commins P., & Kelleher C., 1973. *Farm inheritance and succession*. Macra Na Feirme, Irish Farm Centre, Dublin, Ireland.

62. Conway, S.F., McDonagh, J., Farrell, M. & Kinsella, A., 2017. Uncovering obstacles: The exercise of symbolic power in the complex arena of intergenerational family farm transfer. *Journal of Rural Studies 54* (2017) 60-75. http://dx.doi.org/10.1016/j.jrurstud.2017.06.007

63. Coopmans, I., 2019. *Report on a qualitative analysis in 11 case studies for understanding the process of farm demographic change across EU-farming systems and its influencing factors*. SURE-Farm Deliverable 3.2, (H2020, No.727520). https://www.surefarmproject.eu/deliverables/publications/

64. Corbin, J., & Strauss, A., 1990. Grounded theory research: Procedures, canons, and evaluative criteria. *Qualitative Sociology, 13*(1):3-21. DOI: 10.12691/education-2-9-4

65. Cordier, J., and Santeramo, F.G., 2019. Mutual Funds and the Income Stabilisation Tool in the EU: Retrospect and Prospects. *EuroChoices* 0(0). DOI: 10.1111/1746-692X.12210

66. Corsi, A., 2017. *Succession decisions in family farms and public policies in developed countries*. Routledge Press-London (2017) 338-356. http://hdl.handle.net/2318/1638607

67. Countryman, A.M., Paarlberg, P.L., Lee, J.G., 2016. Dynamic Effects of Drought on the U.S. Beef Supply Chain. *Agricultural and Resource Economics Review* 45/3 (December 2016) 459–484. DOI: 10.1017/age.2016.4

68. Cramer, V.A., Hobbs, R.J. & Standish, R.J., 2008. What's new about old fields? Land abandonment and ecosystem assembly. *Trends in Ecology & Evolution 23 (2)*: 104-112. https://doi.org/10.1016/j.tree.2007.10.005

69. Cumming, G.S., Barnes, G., Perz, S., Schmink, M., Sieving, K.E., Southworth, J., Binford, M., Holt, R.D., Stickler, C., Van Holt, T., 2005. An Exploratory Framework for the Empirical Measurement of Resilience. *Ecosystems* (2005) 8: 975–987. DOI: 10.1007/s10021-005-0129-z.

70. Cumming, G.S., Peterson, G.D., 2017. Unifying Research on Social–Ecological Resilience and Collapse. *Trends in Ecology & Evolution* 32(9):695. http://dx.doi.org/10.1016/j.tree.2017.06.014

71. Darijani, F., Veisi, H., Liaghati, H., Nazari, M.R., Khoshbakht, K., 2019. Assessment of Resilience of Pistachio Agroecosystems in Rafsanjan Plain in Iran. *Sustainability* 2019, 11, 1656. doi:10.3390/su11061656.

72. Darnhofer, I., Bellon, S., Dedieu, B., Milestad, R., 2010. Adaptiveness to enhance the sustainability of farming systems: A review. *Agron. Sustain. Dev.* 30 (2010) 545–555. DOI: 10.1051/agro/2009053.

73. Darnhofer, I., 2014. Resilience and why it matters for farm management. *European Review of Agricultural Economics* 41(3): 461–484. doi:10.1093/erae/jbu012.

74. Darnhofer, I., Lamine, C., Strauss, A., Navarrete, M., 2016. *Journal of Rural Studies*, 44: 111-122. https://doi.org/10.1016/j.jrurstud.2016.01.013

75. Daugstad, K., 2019. Resilience in Mountain Farming in Norway. *Sustainability* 2019, 11, 3476. doi:10.3390/su11123476.

76. Davoudi, S., 2012. Resilience: A Bridging Concept or a Dead End? *Planning Theory & Practice*, 13(2):299–333. https://doi.org/10.1080/14649357.2012.677124

77. Debolini, M., Marraccini, E., Dubeuf, J.P., Geijzendorffer, I.R., Guerra, C., Simon, M., Targetti, S., Napoléone, C., 2018. Land and farming system dynamics and their drivers in the Mediterranean Basin. *Land Use Policy* 75 (2018) 702–710. http://dx.doi.org/10.1016/j.landusepol.2017.07.010

78. Denzin, N.K., & Lincoln, Y.S., 2008. *Collecting and interpreting qualitative materials*. Thousand Oaks, Calif.: Sage Publications.

79. Dias, C., and Franco, M., 2018. Cooperation in tradition or tradition in cooperation? Networks of agricultural entrepreneurs. *Land Use Policy*, 71: 36–48. https://doi.org/10.1016/j.landusepol.2017.11.041

80. Dowd, K., 2007. *Measuring Market Risk*, second ed. John Wiley and Sons, Chichester, West Sussex, United Kingdom.

81. Dubeuf, J.P., Aw-Hassan, A., Chentouf, M., Mena, Y., Pacheco, F., Boutonnet, J.P., 2016. *The Mediterranean sheep and goat sectors between constants and changes over the last decade: Future challenges and prospects*. Options Méditerranéennes : Série A. Séminaires Méditerranéens (115):43-52. http://om.ciheam.org/article.php?IDPDF=00007252

82. Dyg, P.M., and Mikkelsen, B.E., 2016. Cooperation Models , Motivation and Objectives behind Farm – School Collaboration : Case Insights from Denmark. *International Journal of Sociology of Agriculture and Food*, 23(1), pp. 41–62. http://www.ijsaf.org/contents/23-1/dyg/index.html

83. Earle, E., Boland, T., McHugh, N., Creighton, P., 2017. Measures of lamb production efficiency in a temperate grass-based system differing in ewe prolificacy potential and stocking rate. *Journal of Animal Science* 95(8):3504–3512. https://doi.org/10.2527/jas.2017.1427

84. EC, 2019. EU Agricultural Outlook for Markets and Incomes 2019-2030. European Commission, DG Agriculture and Rural Development, Brussels. https://ec.europa.eu/info/sites/info/files/food-farming-fisheries/farming/documents/agricultural-outlook-2019-report_en.pdf

85. EC, 2020. *The Farm to Fork Strategy, For a fair, healthy and environmentally-friendly food system*. European Commission, Bruxelles. https://ec.europa.eu/food/sites/food/files/safety/docs/f2f_action-plan_2020_strategy-info_en.pdf

86. ECREA, 2020. Studies of costs in livestock farms. Spanish Ministry of Agriculture. Accessed in 2020. Link: https://www.mapa.gob.es/es/ministerio/servicios/analisis-y-prospectiva/ECREA-Informes_Ganaderia.aspx

87. Eistrup, M., Sanches, A.R., Muñoz-Rojas, J., & Pinto-Correira, T., 2019. A "Young Farmer Problem"? Opportunities and Constraints for Generational Renewal in Farm Management: An Example from Southern Europe. *Land* 2019, 8, 70. doi:10.3390/land8040070

88. EP, 2008. *The future of the sheep and goat sector in Europe*. Brussels, European Parliament, 2008. http://www.europarl.europa.eu/activities/committees/studies.do?language=en

89. Errington A., 1998. The intergenerational transfer of managerial control in the farm-family business: A comparative study of England, France and Canada. *The Journal of Agricultural Education and Extension 5*(2):123-136. https://doi.org/10.1080/13892249885300241

90. Escribano, A.J., Gaspar, P., Mesias, S.J., Escribano, M., 2016. The role of the level of intensification, productive orientation and self-reliance in extensive beef cattle farms. *Livestock Science* 193 (2016) 8–19. http://dx.doi.org/10.1016/j.livsci.2016.09.006

91. Escriba-Perez, C., Baviera-Puig, A., Buitrago-Vera, J., Montero-Vicente, L., 2017. Consumer profile analysis for different types of meat in Spain. *Meat Science*, 129:120-126. https://doi.org/10.1016/j.meatsci.2017.02.015

92. ESPON, 2018. *Fighting rural depopulation in Southern Europe*. ESPON EGTC – Luxembourg (May 2018). https://www.espon.eu/sites/default/files/attachments/af-espon_spain_02052018-en.pdf

93. EU Farm Economics Overview, 2018. European Commission – Directorate-General for Agriculture and Rural Development. https://ec.europa.eu/info/sites/info/files/food-farming-fisheries/farming/documents/eu-farm-economics-overview-2015_en.pdf

94. EU SCAR 2015. *Agricultural Knowledge and Innovation Systems Towards the Future – a Foresight Paper*, Brussels, European commission. Available at: https://ec.europa.eu/research/scar/pdf/akis-3_end_report.pdf.

95. FAO, 2017. *The future of food and agriculture: trends and challenges*. Food and Agriculture Organization of the United Nations, Rome, 2017. http://www.fao.org/3/i6583e/i6583e.pdf

96. FAO, 2018. *Sustainable food systems: concept and framework*. Food and Agriculture Organization of the United Nations. http://www.fao.org/3/ca2079en/CA2079EN.pdf

97. Farrel, L.J., Kenyon, P.R., Tozer, P.R., Ramilan, T., Cranston, L.M., 2020. Quantifying sheep enterprise profitability with varying flock replacement rates, lambing rates, and breeding strategies in New Zealand. *Agricultural Systems* 184 (2020) 102888. https://doi.org/10.1016/j.agsy.2020.102888

98. Farrin, K., and Miranda, M.J., 2015. A heterogeneous agent model of credit-linked index insurance and farm technology adoption. *Journal of Development Economics*, 116:199–211. https://doi.org/10.1016/j.jdeveco.2015.05.001

99. Fath, B.D., Dean, C.A., Katzmair, H., 2015. Navigating the adaptive cycle: an approach to managing the resilience of social systems. *Ecology and Society* 20(2): 24. http://dx.doi.org/10.5751/ES-07467-200224

100. Fau, L.R., 2016. *El ovino y el caprine en Aragón, evoluciòn en los ultimos 20 años* (Sheep and goats in Aragón, trends in the last 20 years). Aragón Government. http://bibliotecavirtual.aragon.es/

101. FEGA, 2018. Coupled Aids For Sheep Farms, 2017 campaign. Spanish Fund for Agricultural Guarantee. Link: https://www.fega.es/sites/default/files/Ayuda_Asociada_Ovino_C2017_rev_septiembre_2018.pdf?token=3jdtnfOI

102. FEGA, 2020. Campaign data of aids to ovine sector. Spanish Fund for Agricultural Guarantee. Link: https://www.fega.es/es/el-fega/documentos-fega/datos-campanas-clasificadas-por sector/sector/Ovino%20y%20Caprino

103. Ferrari, E., Chatzopoulos, T., Pérez Domínguez, I., Boulanger, P., Boysen-Urban, K., Himics, M., M'barek, R., 2021. *Cumulative economic impact of trade agreements on EU agriculture*. European Commission, JRC Science for Policy Report, Update 2021. https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/cumulative-economic-impact-trade-agreements-eu-agriculture

104. Ferrer-Pérez, H., Abdelradi, F., Gil, J.M., 2020. Geographical Indications and Price Volatility Dynamics of Lamb Prices in Spain. *Sustainability* 2020, 12, 3048. doi:10.3390/su12073048

105. fi-compass, 2020. *Financial needs in the agriculture and agri-food sectors in The Netherlands*. Study report, 75 pages. Available at: https://www.ficompass.eu/sites/default/files/publications/financial_needs_agriculture_agrifood_sectors_Netherlands.pdf

106. Finger, R., and Lehmann, N., 2012. The influence of direct payments on farmers' hail insurance decisions. *Agricultural Economics*, 43(3). https://doi.org/10.3929/ethz-b-000048438

107. Fischer, H., & Burton, R. J. F., 2014. Understanding Farm Succession as Socially Constructed Endogenous Cycles. *Sociologia Ruralis 54* (2014) 417-438. https://doi.org/10.1111/soru.12055

108. Folke, C., Carpenter, S.R., Walker, B., Scheffer, M., Chapin, T., Rockström, J., 2010. Resilience Thinking: Integrating Resilience, Adaptability and Transformability. *Ecology & Soc*iety 15(4). http://www.ecologyandsociety.org/vol15/iss4/art20/

109. Font i Furnols, M., Realinia, C.E., Guerreroa, L., Olivera, M.A., Sañudob, C., Campob, M.M., Nutec, G.R., Cañequed, V., Álvarezd, I., San Juliáne, R., Luzardoe, S., Britoe, G., Montossie, F., 2009. Acceptability of lamb fed on pasture, concentrate or combinationsof both systems by European consumers. *Meat Science* 81 (2009) 196–202. doi:10.1016/j.meatsci.2008.07.019

110. Font i Furnols, M., Realinia, C., Montossib, F., Sañudoc, C., Campoc, M.M., Olivera, M.A., Nuted, G.R., Guerrero, L., 2011. Consumer's purchasing intention for lamb meat affected by country of origin,feeding system and meat price: A conjoint study in Spain, Franceand United Kingdom. *Food Quality and Preference*, 22(5):443-451. https://doi.org/10.1016/j.foodqual.2011.02.007

111. Fonte, M., and Cucco, I., 2017. Cooperatives and alternative food networks in Italy. The long road towards a social economy in agriculture. *Journal of Rural Studies*, 53:291–302. https://doi.org/10.1016/j.jrurstud.2017.01.019

112. Galanopoulos, K., Abas, Z., Laga, V., Hatziminaoglou, I., Boyazoglu, J., 2011. The technical efficiency of transhumance sheep and goat farms and the effect of EU subsidies: Do small farms benefit more than large farms? *Small Ruminant Research* 100 (2011) 1– 7. doi:10.1016/j.smallrumres.2011.05.008

113. Garrido, A., Brümmer, B., M'Barek, R., Meuwissen, M. P. M., & Morales-Opazo, C. (2016). *Agricultural Markets Instability: Revisiting the recent food crises*. Routledge (London). https://doi.org/10.4324/9781315676265

114. Gaspar, P., Escribano, M., Mesias, F.J., Rodriguez de Ledesma, A., Pulido, F., 2008. Sheep farms in the Spanish rangelands (dehesas): Typologies according to livestock management and economic indicators. *Small Ruminant Research* 74 (2008) 52–63. doi:10.1016/j.smallrumres.2007.03.013

115. Gazzarin, C., El Benni, N., 2020. Economic assessment of potential efficiency gains in typical lamb production systems in the alpine region by using local resources. *Small Ruminant Research* 185 (2020) 106066. https://doi.org/10.1016/j.smallrumres.2020.106066

116. Gehrels, S.A. (2013). Grounded Theory Application in Doctorate Research. *Research in Hospitality Management*, 3(1). https://doi.org/10.1080/22243534.2013.11828299

117. Ghasemi, E., Sari, M., Ataei, M., 2012. Development of an empirical model for predicting the effects of controllable blasting parameters on flyrock distance in surface mines. *Int. J. Rock Mech. Min. Sci.* 52, 163–170. https://doi.org/10.1016/j.ijrmms.2012.03.011

118. Giannakis, E., Bruggeman, A., 2015. The highly variable economic performance of European agriculture. *Land Use Policy* 45 (2015) 26–35. http://dx.doi.org/10.1016/j.landusepol.2014.12.009

119. Gibb, J., Sune, A., and Albers, S., 2017. Network learning: Episodes of interorganizational learning towards a collective performance goal. *European Management Journal*, 35(1):15–25. https://doi.org/10.1016/j.emj.2016.09.001

120. Gibbons, J.M., and Ramsden S.J., 2005. Robustness of recommended farm plans in England under climate change: a Monte-Carlo Simulation. *Climatic Change* 68: 113–133, 2005. https://doi.org/10.1007/s10584-005-1585-3

121. Glaser, J., Laudel, G., 2013. Life With and Without Coding: Two Methods for Early-Stage Data. Analysis in Qualitative Research Aiming at Causal Explanations. *Qualitative Social Research* 14(2), 5. https://www.qualitative-research.net/index.php/fqs

122. Glover, JL., 2013. Capital usage in family farm businesses. *Journal of Family Business Management 3*(2): 136-162. https://doi.org/10.1108/JFBM-01-2013-0001

123. Gootwine, E., 2020. Invited review: Opportunities for genetic improvement toward higher prolificacy in sheep. *Small Ruminant Research* 186 (2020) 106090. https://doi.org/10.1016/j.smallrumres.2020.106090

124. Graveline, N., Loubier, S., Gleyses, G., Rinaudo, J.D., 2012. Impact of farming on water resources: Assessing uncertainty with Monte Carlo simulations in a global change context. *Agricultural Systems* 108 (2012) 29–41. doi:10.1016/j.agsy.2012.01.002

125. Großwendt, A., Röglin, H., 2017. Improved Analysis of Complete-Linkage Clustering. *Algorithmica* (78):1131–1150. DOI 10.1007/s00453-017-0284-6

126. Grubbström, A., & Sooväli-Sepping, H., 2012. Estonian family farms in transition: a study of intangible assets and gender issues in generational succession. *Journal of Historical Geography* 38 (2012) 329-339. doi:10.1016/j.jhg.2012.03.001

127. Gursoy, O., 2006. Economics and profitability of sheep and goat production in Turkey under new support regimes and market conditions. *Small Ruminant Research* 62 (2006) 181–191. doi:10.1016/j.smallrumres.2005.08.013

128. Haider, L.J., Quinlan, A.L., Peterson, G.D., 2012. Interacting Traps: Resilience Assessment of a Pasture Management System in Northern Afghanistan. *Planning Theory & Practice*, 13(2):299-333. https://doi.org/10.1080/14649357.2012.677124

129. Hamilton, W., Bosworth, G.; and Ruto, E., 2015. Entrepreneurial younger farmers and the "Young Farmers Problem" in England. *Agriculture & Forestry*, Vol. 61, Issue 4: 61-69. DOI: 10.17707/AgricultForest.61.4.05

130. Hardaker, J.B., Huirne, R.B.M., Anderson, J.R., 1997. *Coping with risk in agriculture*. CABI Publishing.

131. Harris, J.M., Mishra, A.K., & Williams, R.P., 2012. *The impact of farm succession decisions on the financial performance of the farm*. Presentation at the AAEA Joint Annual Meeting, Seattle, 2012.

132. Henchion, M., McCarthy, M., resconi, V.C., Troy, D., 2014. Meat consumption: Trends and quality matters. *Meat Science* 98(3):561-568. https://doi.org/10.1016/j.meatsci.2014.06.007

133. Hermans, F., Klerkx, L., and Roep, D., 2015. Structural Conditions for Collaboration and Learning in Innovation Networks: Using an Innovation System Performance Lens to Analyse Agricultural Knowledge Systems. *Journal of Agricultural Education and Extension*, 21(1):35–54. https://doi.org/10.1080/1389224X.2014.991113

134. Herrera, H., 2017. Resilience for Whom? The Problem Structuring Process of the Resilience Analysis. *Sustainability* 2017, 9, 1196. doi:10.3390/su9071196.

135. Hinojosa, L., Napoléone, C., Moulery, M. & Lambin, E.F., 2016. The "mountain effect" in the abandonment of grasslands: Insights from the French Southern Alps. *Agriculture, Ecosystems and Environment 221* (2016) 115–124. http://dx.doi.org/10.1016/j.agee.2016.01.032

136. Holling, C.S., Gunderson, L.H., Peterson, G.D., 2002. Panarchy: Understanding Transformations in Human and Natural Systems. Island Press, pp. 63-102.

137. Hsieh, H.F., & Shannon, S.E., 2005. Three approaches to qualitative content analysis. *Qualitative Health Research 15 (9)*: 1277-1288. https://doi.org/10.1177/1049732305276687

138. IFAD, 2015. *Climate-resilient agricultural development*. Scaling up note, International Fund for Agricultural Development, Rome. https://www.ifad.org/documents/38714170/40264252/climate_sun.pdf/15655fe0-d06f-434e-b4ea-df9017c93ef2

139. Ilea, R.C., 2009. Intensive Livestock Farming: Global Trends, Increased Environmental Concerns, and Ethical Solutions. *J Agric Environ Ethics* 22, 153–167 (2009). https://doi.org/10.1007/s10806-008-9136-3

140. INE, 2020. Spanish National Statistical Institute. Accessed in 2020. Link: https://www.ine.es/dyngs/INEbase/es/operacion.htm?c=Estadistica_C&cid=1254736176802&menu=ultiDatos&idp=1254735976607

141. Inwood, S., Sharp, J., 2012. Farm persistence and adaptation at the rural–urban interface: Succession and farm adjustment. *Journal of Rural Studies* 28(1):107-117. DOI: 10.1016/j.jrurstud.2011.07.005.

142. Iraizoz, B., Bardaji, I., Rapùn, M., 2011. Do 'Protected Geographical Indications' (PGI)-certified farms perform better? The case of beef farms in Spain. *Outlook on Agriculture* 40(2): 125–130. doi: 10.5367/oa.2011.0045.

143. Jenkins, R., 2008. *Social Identity*. Routledge, London; New York.

144. JRC, 2013. *Assessing the risk of farmland abandonment in the EU*. Joint Research Centre of the European Commission. Luxembourg: Publications Office of the European Union, 2013. Final Report. https://ec.europa.eu/agriculture/sites/agriculture/files/external-studies/2013/farmland-abandonment/fulltext_en.pdf

145. Joosse, S. & Grubbström, A., 2017. Continuity in farming-not just family business. *Journal of Rural Studies 50* (2017) 198-208. http://dx.doi.org/10.1016/j.jrurstud.2016.11.018

146. Kadigi, I.L., Mutabazi, K.D., Philip, D., Richardson, J.W., Bizimana, J.C., Mbungu, W., Mahoo, H.F., Sieber, S., 2020. An Economic Comparison between Alternative Rice Farming Systems in Tanzania Using a Monte Carlo Simulation Approach. *Sustainability* 2020, 12, 6528. doi:10.3390/su12166528

147. Kamali, F.P., Meuwissen, M.P., de Boer, I.J., van Middelaar, C.E., Moreira, A., Lansink, A.G.O., 2017. Evaluation of the environmental, economic, and social performance of soybean farming systems in southern Brazil. *J. Clean. Prod.* 142, 385–394. https://doi.org/10.1016/j.jclepro.2016.03.135

148. Kamberelis, G. and Dimitriadis, G., 2011. *Focus Groups: Contingent Articulations of Pedagogy, Politics and Inquiry*. In: Denzin, N.K. and Lincolc, Y.S., Eds., The SAGE Handbook of Qualitative Research, Vol. 4, Sage, Los Angeles, 545-561.

149. Keenleyside, C., & Tucker, G.M., 2010. *Farmland Abandonment in the EU: an Assessment of Trends and Prospects*. Report prepared for WWF. Institute for European Environmental Policy, London.

150. Kerner, D.A., Thomas, J.S., 2014. Resilience Attributes of Social-Ecological Systems: Framing Metrics for Management. *Resources* 3, 672-702. doi:10.3390/resources3040672.

151. Komarek, A.M., De Pinto, A., and Smith, V.H., 2020. A review of types of risks in agriculture: What we know and what we need to know. *Agricultural Systems*, 178,102738. https://doi.org/10.1016/j.agsy.2019.102738

152. Konecki, K., 2018. Classic grounded theory – The Latest Version: Interpretation of Classic Grounded Theory as a Meta-Theory for Research. *Symbolic Interaction, 41*(4), 547-564. https://doi.org/10.1002/symb.361

153. Kontogeorgos, A., Sergaki, P., Kosma, A., Semou, V., 2018. Organizational Models for Agricultural Cooperatives: Empirical Evidence for their Performance. *Journal of the Knowledge Economy*, 9(4):1123–1137. https://doi.org/10.1007/s13132-016-0402-8

154. Koopmans, M.E., Rogge, E., Mettepenningen, E., Knickel, K., Šūmane, S., 2018. The role of multi-actor governance in aligning farm modernization and sustainable rural development. *Journal of Rural Studies*, 59:252–262. https://doi.org/10.1016/j.jrurstud.2017.03.012

155. Kopke, E., Young, J., Kingwell, R., 2008. The relative profitability and environmental impacts of different sheep systems in a Mediterranean environment. *Agricultural Systems* 96 (2008) 85–94. doi:10.1016/j.agsy.2007.06.003

156. de Kraker, J., 2017. Social learning for resilience in social–ecological systems. *Environmental Sustainability* 28:100–107. http://dx.doi.org/10.1016/j.cosust.2017.09.002

157. Kristensen, S.B.P., Busck, A.G., van der Sluis, A.T., Gaube, V., 2016. Patterns and drivers of farm-level land use change in selected European rural landscapes. *Land Use Policy* 57 (2016) 786–799. http://dx.doi.org/10.1016/j.landusepol.2015.07.014

158. Krupová, Z., Krupa, E., Wolfová, M., Michalicková, M., 2014. Impact of variation in production traits, inputs costs and product prices on profitability in multi-purpose sheep. *Spanish Journal of Agricultural Research* 2014 12(4): 902-912. http://dx.doi.org/10.5424/sjar/2014124-6166

159. Labarthe, P., and Laurent, C., 2013. Privatization of agricultural extension services in the EU : Towards a lack of adequate knowledge for small-scale farms?. *Food Policy*, 38:240–252. https://doi.org/10.1016/j.foodpol.2012.10.005

160. Lefebvre, M., Nikolov, D.N., Gomez-y-Paloma, S., Chopeva, M., 2014. Determinants of insurance adoption among Bulgarian farmers : the importance of other risk management decisions on the farm. *Agricultural Finance Review*, 74(3): 326-347. doi: 10.1108/AFR-05-2013-0022.

161. Leonard, B., Kinsella, A., O'Donoghue, C., Farrell, M. & Mahon, M., 2017. Policy drivers of farm succession and inheritance. *Land Use Policy 61* (2017) 147–159. http://dx.doi.org/10.1016/j.landusepol.2016.09.006

162. Lien, G., Hardaker, J.B., Flaten, O., 2007. Risk and economic sustainability of crop farming systems. *Agricultural Systems* 94 (2007) 541–552. doi:10.1016/j.agsy.2007.01.006

163. Liesivaara, P., and Myyrä, S., 2014. Willingness to pay for agricultural crop insurance in the northern EU Article information. Agricultural Finance Review, 74(4):539-554. https://doi.org/10.1108/AFR-06-2014-0018

164. Lobley, M., Baker, J.R. & Whitehead, I., 2010. Farm succession and retirement: Some international comparisons. *Journal of Agriculture, Food Systems, and Community Development 1*(1):49-64. DOI: https://doi.org/10.5304/jafscd.2010.011.009

165. Longstaff, P.H., Armstrong, N.J., Perrin, K., Parker, W.M., Hidek, M.A., 2010. Building Resilient Communities: A Preliminary Framework for Assessment. Homeland Security Affairs (September 2010), v.6 no.3. http://hdl.handle.net/10945/25107

166. Luo, Q., Behrendt, K., Bange, M., 2017. Economics and risk of adaptation options in the Australian cotton industry. *Agricultural Systems* 150 (2017) 46–53. http://dx.doi.org/10.1016/j.agsy.2016.09.014

167. MacDonald, D., Crabtree, J.R., Wiesinger, G., Dax, T., Stamou, N., Fleury, P., Gutierrez Lazpita, J., & Gibon, A., 2000. Agricultural abandonment in mountain areas of Europe: Environmental consequences and policy response. *Journal of Environmental Management 59* (2000) 47–69. doi:10.1006/jema.1999.0335

168. Mann, S., 2005. Ethological farm programs and the "market" for animal welfare. *Journal of Agricultural and Environmental Ethics 18*(4):369-382. https://doi.org/10.1007/s10806-005-7049-y

169. Mann, S., 2007. Understanding farm succession by the objective hermeneutics method. *Sociologia Ruralis 4* (47):369-383. http://dx.doi.org/10.1111/j.1467-9523.2007.00442.x

170. MAPA, 2019. Statistics on Food Consumption in Spain. Spanish Ministry of Agriculture. https://www.mapa.gob.es/es/alimentacion/temas/consumo-tendencias/panel-de-consumo-alimentario/series-anuales/default.aspx

171. MAPA, 2020(a). Spanish Ministry of Agriculture – Differentiated Quality – Statistical data on PGI agrifood products. Accessed in 2020. Link: https://www.mapa.gob.es/es/alimentacion/temas/calidad-diferenciada/

172. MAPA, 2020(b). Spanish Ministry of Agriculture – Statistical data on livestock slaughter. Accessed in 2020. Link: https://www.mapa.gob.es/es/estadistica/temas/estadisticas-agrarias/ganaderia/encuestas-sacrificio-ganado/

173. MAPA, 2020(c). Spanish Ministry of Agriculture – Price Observatory. Accessed in 2020. Link: https://www.mapa.gob.es/es/alimentacion/servicios/observatorio-de-precios-de-los-alimentos/default2.aspx

174. Martinez-Cillero, M., Thorne, F., Wallace, M., Breen, J., Hennessy, T., 2018. The Effects of Direct Payments on Technical Efficiency of Irish Beef Farms: A Stochastic Frontier Analysis. *Journal of Agricultural Economics*, Vol. 69, No. 3, 2018, 669–687. doi: 10.1111/1477-9552.12259

175. Matthews, A., 2018. *The EU's Common Agricultural Policy Post 2020: Directions of Change and Potential Trade and Market Effects*. Geneva: International Centre for Trade and Sustainable Development (ICTSD). Link: http://web.uvic.ca/~kooten/Agriculture/EUPolicyMatthews(2018).pdf

176. Mayring, P., 2000. Qualitative Content Analysis. *Qualitative Social Research 1* (2) Art.20. doi:http://dx.doi.org/10.17169/fqs-1.2.1089.

177. Mena, Y., Ruiz-Mirazo, J., Ruiz, F.A., Castel, J.M., 2016. Characterization and typification of small ruminant farms providing fuelbreak grazing services for wildfire prevention in Andalusia (Spain). *Science of the Total Environment* 544 (2016) 211–219. http://dx.doi.org/10.1016/j.scitotenv.2015.11.088

178. Meuwissen, M.P.M., Huirne, R.B.M., Hardaker, J.B., 2001. Risk and risk management: An empirical analysis of Dutch livestock farmers. *Livestock Production Science*, 69(1):43–53. https://doi.org/10.1016/S0301-6226(00)00247-5

179. Meuwissen, M.P.M., de May, Y., van Asseldonk, M., 2018. Prospects for agricultural insurance in Europe. *Agricultural Finance Review*, 78(2):174-182. https://doi.org/10.1108/AFR-04-2018-093

180. Meuwissen, M.P.M., Feindt, P.H., Spiegel, A., Termeer, C.J.A.M., Mathijs, E., Mey, Y. de, Finger, R., Balmann, A., Wauters, E., Urquhart, J., Vigani, M., Zawalińska, K., Herrera, H., NicholasDavies, P., Hansson, H., Paas, W., Slijper, T., Coopmans, I., Vroege, W., Ciechomska, A., Accatino, F., Kopainsky, B., Poortvliet, P.M., Candel, J.J.L., Maye, D., Severini, S., Senni, S., Soriano, B., Lagerkvist, C.-J., Peneva, M., Gavrilescu, C., Reidsma, P., (2019). A framework to assess the resilience of farming systems. *Agricultural Systems*, 176(2019), 102656. https://doi.org/10.1016/j.agsy.2019.102656

181. Milàn, M.J., Arnalte, E., Caja, G., 2003. Economic profitability and typology of Ripollesa breed sheep farms in Spain. *Small Ruminant Research* 49 (2003) 97–105. doi:10.1016/S0921-4488(03)00058-0

182. Milone, P., & Ventura, F., 2019. New generation farmers: Rediscovering the peasantry. *Journal of Rural Studies* 65 (2019) 43–52. https://doi.org/10.1016/j.jrurstud.2018.12.009

183. Minviel, J.J., Latruffe, L., 2017. Effect of public subsidies on farm technical efficiency: a meta-analysis of empirical results. *Applied Economics*, 49(2) 213:226. http://dx.doi.org/10.1080/00036846.2016.1194963

184. Monjardino, M., McBeath, T.M., Brennan, L., Llewellyn, R.S., 2013. Are farmers in low-rainfall cropping regions under-fertilising with nitrogen? A risk analysis. *Agricultural Systems* 116 (2013) 37–51. http://dx.doi.org/10.1016/j.agsy.2012.12.007

185. Morais, M., Binotto, E. & Borges, J.A.R., 2017. Identifying beliefs underlying successors' intention to take over the farm. *Land Use Policy 68* (2017) 48–58. http://dx.doi.org/10.1016/j.landusepol.2017.07.024

186. Morais, M., Borges, J.A.R., & Binotto, E., 2018. Using the reasoned action approach to understand Brazilian successors' intention to take over the farm. *Land Use Policy 71* (2018) 445-452. https://doi.org/10.1016/j.landusepol.2017.11.002

187. Morgan-Davies, C., Wilson, R., Waterhouse, T., 2017. Impacts of farmers' management styles on income and labour under alternative extensive land use scenarios. *Agricultural Systems* 155 (2017) 168–178. http://dx.doi.org/10.1016/j.agsy.2017.04.011

188. Morris, S.T., 2017. *International perspectives in sheep production: differences in systems and welfare risks*. In Advances in Sheep Welfare – Woodhead Publishing – Duxford, United Kingdom.

189. Nelson, D.R., Adger, W.N., Brown, K., 2007. Adaptation to Environmental Change: Contributions of a Resilience Framework. *Annu. Rev. Environ. Resour.* 32:395–419. doi:10.1146/annurev.energy.32.051807.090348.

190. Nera, E., Paas, W., Reidsma, P., Paolini, G., Antonioli, F., Severini, S., 2020. Assessing the Resilience and Sustainability of a Hazelnut Farming System in Central Italy with a Participatory Approach. *Sustainability* 2020, 12, 343. doi:10.3390/su12010343

191. O'Donoghue, E.J., 2014. *The Effects of Premium Subsidies on Demand for Crop Insurance*. USDA - Economic Research Report No.169. Available at: https://www.ers.usda.gov/publications/pub-details/?pubid=45230

192. Olaizola, A.M., Chertouh, T., Manrique, E., 2008. Adoption of a new feeding technology in Mediterranean sheep farming systems: Implications and economic evaluation. *Small Ruminant Research* 79 (2008) 137–145. doi:10.1016/j.smallrumres.2008.07.022

193. Oliván A., Pardos L., 2000. Importance of a sheep selection programme for prolificacy. *Options Méditerranéennes*, Série A(43),93:100. http://om.cih eam.org/article.php?IDPD F=600473

194. Olsson, P., Folke, C., Hahn, T., 2004. Social-Ecological Transformation for Ecosystem Management: the Development of Adaptive Co-management of a Wetland Landscape in Southern Sweden. *Ecology and Society* 9(4): 2. http://www.ecologyandsociety.org/vol9/iss4/art2

195. Pardos, L., Maza Rubio, M.T., Fantova Puyalto, E., 2007. Influence of the prolificacy in meat sheep farms of Rasa breed in Aragón. *Arch. Zootec*. 56 (215): 363-366. http://www.redalyc.org/articulo.oa?id=49521512

196. Pardos, L., Maza, M.T., Fantova, E., Sepulveda, U., 2008. The diversity of sheep production systems in Aragón (Spain): characterisation and typification of meat sheep farms. *Spanish Journal of Agricultural Research* 2008 6(4), 497-507. Available online at www.inia.es/sjar

197. Peco, B., Navarro, E., Carmona, C.P., Medina, N.G., Marques, M.J., 2017. Effects of grazing abandonment on soil multifunctionality: the role of plant functional traits. *Agric. Ecosyst. Environ.* 249 (2017), 215–225. https://doi.org/10.1016/j.agee.2017.08.013

198. Perpiña Castillo C., Kavalov, B., Diogo, V., Jacobs-Crisioni, C., Batista & Silva, F., Lavalle, C., JRC113718, European Commission 2018. https://ec.europa.eu/jrc/en/luisa

199. Perrin, A., San Cristobal, M., Milestad, R., Martin, G., 2020. Identification of resilience factors of organic dairy cattle farms. *Agricultural Systems* 183 (2020) 102875. https://doi.org/10.1016/j.agsy.2020.102875

200. Peterson, C.A., Eviner, V.T., Gaudin, A.C.M., 2018. Ways forward for resilience research in agroecosystems. *Agricultural Systems* (162):19-27. https://doi.org/10.1016/j.agsy.2018.01.011

201. Petty, N.J., Thomson, O.P., & Stew, G., 2012. Ready for a paradigm shift? Part 2: Introducing qualitative research methodologies and methods. *Manual Therapy 17* (2012) 378-384. doi:10.1016/j.math.2012.03.004

202. Peyraud, J.L., MacLeod, M., 2020. *Study on Future of EU livestock: how to contribute to a sustainable agricultural sector?* European Commission, Final Report, Luxembourg: Publications Office of the European Union, 2020. https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/cmef/farmers-and-farming/future-eu-livestock-how-contribute-sustainable-agricultural-sector_en

203. Pindado, E., Sanchez, M., Verstegen, J.A.A.M., & Lans, T., 2018. Searching for the entrepreneurs among new entrants in European Agriculture: the role of human and social capital. *Land Use Policy 77* (2018) 19–30. https://doi.org/10.1016/j.landusepol.2018.05.014

204. Poppe, K.J., 2016. Agricultural Knowledge and Innovation Systems: Stimulating Creativity and Learning. EIP-Agri – European Commission. https://ec.europa.eu/eip/agriculture/sites/agri-eip/files/eip-agri_brochure_knowledge_systems_2018_en_web.pdf

205. Porqueddu, C., Melis, R.A.M., Franca, A., Sanna, F., Hadjigeorgiou, I., Casasús, I., 2016. The role of grasslands in the less favoured areas of Mediterranean Europe. In *Grassland Science in Europe* Vol. 22. http://hdl.handle.net/10532/3679

206. Potter C., & Lobley M., 1996. Unbroken threads? Succession and its effects on family farms in Britain. *Sociologia ruralis 36*(3): 286-306. https://doi.org/10.1111/j.1467-9523.1996.tb00023.x

207. Potter, C., & Lobley, M., 1992. Aging and succession on family farms - the impact on decision-making and land-use. *Sociologia Ruralis 32* (1992) 317-334. https://doi.org/10.1111/j.1467-9523.1992.tb00935.x

208. Potter, W.J., & Levine-Donnerstein, D., 1999. Rethinking the validity and reliability in content analysis. *Journal of Applied Communication Research 27* (1999) 258-284. https://doi.org/10.1080/00909889909365539

209. Prager, K., and Creaney, R., 2017. Achieving on-farm practice change through facilitated group learning: Evaluating the effectiveness of monitor farms and discussion groups. *Journal of Rural Studies*, 56:1–11. https://doi.org/10.1016/j.jrurstud.2017.09.002

210. Quinlan, A.E., Berbés-Blazquez, M., Haider, L.J., Peterson, G.D., 2015. Measuring and assessing resilience: broadening understanding through multiple disciplinary perspectives. *Journal of Applied Ecology* 53(3): 677-687. https://doi.org/10.1111/1365-2664.12550

211. Rabadán, A., Martínez-Carrasco, L., Brugarolas, M., Navarro-Rodríguez de Vera, C., Sayas-Barberá, E., Bernabéu, R., 2020. Differences in Consumer Preferences for Lamb Meat before and during the Economic Crisis in Spain: Analysis and Perspectives. *Foods* 2020,9, 696. doi:10.3390/foods9060696

212. Ramírez-López, A., Figueroa-Sandoval, B., Figueroa-Rodríguez, K.A., Ramírez-Valverde, B., 2020. Structure and concentration of the global sheep meat market. *Revista Brasileira de Zootecnia* 49:e20190033. https://doi.org/10.37496/rbz4920190033

213. de Rancourt, M., Fois, N., Lavìn, M.P., Tchakerian, E., Vallerand, F., 2006. Mediterranean sheep and goats production: An uncertain future. *Small Ruminant Research* 62 (2006) 167–179. doi:10.1016/j.smallrumres.2005.08.012

214. Regan, J.T., Marton, S., Barrantes, O., Ruane, E., Hanegraaf, M., Berland, J., Korevaar, H., Pellerin, S., Nesme, T., 2017. Does there coupling of dairy and crop production via cooperation between farms generate environmental benefits? A case-study approach in Europe. *Europ.J.Agronomy*, 82(2017):342–356. http://dx.doi.org/10.1016/j.eja.2016.08.005

215. Regos, A., Dominguez, J., Gil-Tena, A., Brotons, L., Ninyerola, M., & Pons, X., 2016. Rural abandoned landscapes and bird assemblages: winners and losers in the rewilding of a marginal mountain area (NW Spain). *Regional Environmental Change* (2016) 16:199–211. DOI 10.1007/s10113-014-0740-7

216. Reidsma, P., Spiegel, A., Paas, W., Accatino, F., Antonioli, F., Appel, F., Bardají, I., Berry, R., Bertolozzi-Caredio, D., Bijttebier, J., Black, J., Buitenhuis, Y., Coopmans, I., Courtney, P., Feindt, P., Gavrilescu, C., Hansson, H., Jendrzejewski , B., Khafagy, A., Krupin, V., Lagerkvist, C.J., Larson, S., Lievens, E., Mathijs, E., Manevska-Tasevska, G., Maye, D., Ollendorf, F., Peneva, M., Pettit, A., Pinsard, C., Rommel, J., Senni, S., Severini, S., Slijper, T., Soriano, B., Urquhart, J., Valchovska, S., Vigani, M., Wauters, E., Zawalińska, K., Meuwissen, M., 2019. *Resilience assessment of current farming systems across the European Union*. SURE-Farm Deliverable 5.1 (H2020, No.727520). https://www.surefarmproject.eu/deliverables/publications/

217. Réquillart, V., 2007. *On the Economics of Geographical Indications in the EU*. Conference Paper in 'Geographical Indications, Country of Origin and Collective Brands: Firm Strategies and Public Policies' (Toulouse, June 14-15, 2007).

218. ResilienceAlliance,2010. *Assessing resilience in social-ecological systems: workbook for practitioners*. Version 2.0. Online. http://www.resalliance.org/3871.php

219. Riedel, J.L., Casasùs, I., Bernués, A., 2007. Sheep farming intensification and utilization of natural resources in a Mediterranean pastoral agro-ecosystem. *Livestock Science* 111 (2007) 153–163. doi:10.1016/j.livsci.2006.12.013.

220. Riley, M., 2014. Interviewing fathers and sons together: Exploring the potential of joint interviews for research on family farms. *Journal of Rural Studies 36* (2014) 237-246. http://dx.doi.org/10.1016/j.jrurstud.2014.09.003

221. Ripoll, G., Joy, M., Panea, B., 2018. Consumer Perception of the Quality of Lamb and Lamb Confit. *Foods* 2018, 7, 80. doi:10.3390/foods7050080

222. Ripoll-Bosch, R., Joy, M., Bernués, A., 2014. Role of self-sufficiency, productivity and diversification on the economic sustainability of farming systems with autochthonous sheep breeds in less favoured areas in Southern Europe. *Animal* (2014), 8:8, pp 1229–1237. doi:10.1017/S1751731113000529

223. Rodriguez-Ortega T., Oteros-Rozas E., Ripoll-Bosch R., Tichit M., Martin-Lopez B.,Bernués A. (2014). Applying the ecosystem services framework to pasture-based livestock farming systems in Europe. *Animal*, 8(8): 1361–1372. doi:10.1017/S1751731114000421.

224. Rodríguez-Ortega, T., Olaizola, A.M., Bernués, A., 2018. A novel management-based system of payments for ecosystem services for targeted agri-environmental policy. *Ecosystem Services* 34, 74–84. https://doi.org/10.1016/j.ecoser.2018.09.007

225. Roloff, J., 2008. A life cycle model of multi-stakeholder networks. *Business Ethics*, 17(3):311-325. https://doi.org/10.1111/j.1467-8608.2008.00537.x

226. Rosasco, S.L., Beard, J.K., Hallford, D.M., Summers, A.F., 2019. Evaluation of estrous synchronization protocols on ewe reproductive efficiency and profitability. *Animal Reproduction Science* 210 (2019) 106191. https://doi.org/10.1016/j.anireprosci.2019.106191

227. Rossi, R., 2017. *The sheep and goat sector in the EU Main features, challenges and prospects*. European Parliamentary Research Service (EPRS) Briefing PE 608.663.

228. Ruiz F.A., Vazquez M., Camunez J.A., Castel J.M., Mena Y. (2020). Characterization and challenges of livestock farming in Mediterranean protected mountain areas (Sierra Nevada, Spain). *Spanish Journal of Agricultural Research*, 18(1). https://doi.org/10.5424/sjar/2020181-14288

229. Salmoral, G., Ababio, B., Holman, I.P., 2020. Drought Impacts, Coping Responses and Adaptation in the UK Outdoor Livestock Sector: Insights to Increase Drought Resilience. *Land* 2020, 9, 202. doi:10.3390/land9060202

230. San Martín, C., Bardaji, I., Garrido, A., Soriano, B., 2020. *FoPIA-SURE-Farm 2 Case Study Report Spain.* SURE-Farm Deliverable 5.5. SURE-Farm H2020 project (No. 727520). https://www.surefarmproject.eu/deliverables/publications/

231. Sanderson, M.A., Archer, D., Hendrickson, J., Kronberg, S., Liebig, M., Nichols, K., Schmer, M., Tanaka, D., Aguilar, J., 2013. Diversification and ecosystem services for conservation agriculture: Outcomes from pastures and integrated crop–livestock systems. *Renewable Agriculture and Food Systems* 28(2): 129–144. doi:10.1017/S1742170512000312.

232. Sans, P., De Fontguyon, G., Wilson, N., 1999. *Protected product specificity and supply chain performance: the case of three PGI lambs*. Conference Paper, 67th EAAE Seminar, pp. 417 – 421. Link: https://econpapers.repec.org/paper/agseaae67/241751.htm

233. Santeramo, F., 2017. *Study on risk management in EU agriculture - Case study 2: How to enhance the participation of small-scale and non-specialised farms in crop insurance schemes?*. Study on risk management in EU agriculture – European Commission, p. 299. doi: 10.2762/387583.

234. Santeramo, F.G., 2016. I Learn, You Learn, We Gain. Experience in Crop Insurance Markets. *Applied Economic Perspectives and Policy*. https://mpra.ub.uni-muenchen.de/86379/

235. Santeramo, F.G., Lamonaca, E., 2020. Evaluation of geographical label in consumers' decision-making process: A systematic review and meta-analysis. *Food Research International* 131 (2020) 108995. https://doi.org/10.1016/j.foodres.2020.108995

236. Schirpke, U., Kohler, M., Leitinger, G., Fontana, V., Tasser, E., Tappeiner, U., 2017. Future impacts of changing land-use and climate on ecosystem services of mountain grassland and their resilience. *Ecosystem Services* 26 (2017) 79–94. http://dx.doi.org/10.1016/j.ecoser.2017.06.008

237. Schleyer, C., Görg, C., Hauck, J.,Winkler, K.J., 2015. Opportunities and challenges for mainstreaming the ecosystem services concept in the multi-level policy-making within the EU. *Ecosystem Services*, 16:174–181. https://doi.org/10.1016/j.ecoser.2015.10.014

238. Schreier, M., 2012. *Qualitative Content Analysis in practice*. Sage, London.

239. Schulp, C.J.E., Levers, C., Kuemmerle, T., Tieskens, K.F., Verburg, P.H., 2019. Mapping and modelling past and future land use change in Europe's cultural landscapes. *Land Use Policy* 80 (2019) 332–344. https://doi.org/10.1016/j.landusepol.2018.04.030

240. Schulte, H., and Musshoff, O., 2018. Insurance prospects after the European dairy quota abolition. *Agricultural Finance Review*, 78(2):223-232. https://doi.org/10.1108/AFR-06-2017-0047

241. Scocco, P., Piermarteri, K., Malfatti, A., Tardella, F.M., Catorci, A., 2016. Increase of drought stress negatively affects the sustainability of extensive sheep farming in sub-Mediterranean climate. *Journal of Arid Environments* 128 (2016): 50-58. http://dx.doi.org/10.1016/j.jaridenv.2016.01.006

242. Sepúlveda, W.S., Maza, M.T., Pardos, L., 2011. Aspects of quality related to the consumption and production of lamb meat. Consumers versus producers. *Meat Science* 87 (2011) 366–372. doi:10.1016/j.meatsci.2010.11.013

243. Severini, S., and Sorrentino, A., 2017. Efficiency and coordination in the EU agri- food systems. *Agricultural and Food Economics*, 5, 15. https://doi.org/10.1186/s40100-017-0086-9

244. Slijper, T., De May, Y., Poortvliet, P., Meuwissen, M., 2020. From risk behavior to perceived farm resilience: a Dutch case study. *Ecology and Society* 25(4):10. https://doi.org/10.5751/ES-11893-250410

245. Sneessens, I., Sauvée, L., Randrianasolo-Rakotobe, H., Ingran, S., 2019. A framework to assess the economic vulnerability of farming systems: Application to mixed crop-livestock systems. *Agricultural Systems* 176 (2019) 102658. https://doi.org/10.1016/j.agsy.2019.102658

246. Soriano, B., Bardaji, I., Bertolozzi-Caredio, D., San Martìn, C., Spiegel, A., Slijper, T., Meuwissen, M., Rommel, J., Hansson, H., Severini, S., Antonioli, F., Berry, R., Kahfagy, A., Urquhart, J., Harizanova-Bartos, H., Stoyanova, Z., Coopmans, I., Wauters, E., Bijttebier, J., Neumeistern, D., Accatino, F., Pinsard, C., Tudor, M., Gravilescu, C., Luca, L., Izvoranui, A.M., Zawalinska, K., Jendrzejewskij, B., Gradziuk, P., Bankowska, K., Krupin, V., Ollendorf, F., Appel, F., Garrido, A., 2020. *Report on state and outlook for risk management in EU agriculture.* SURE-Farm Deliverable 2.6, (H2020, No.727520). https://www.surefarmproject.eu/deliverables/publications/

247. Soriano, B., Bertolozzi-Caredio, D., Bardaji, I., 2018. *Assessing how policies enable or constrain the resilience of the extensive sheep grazing system in Northeast Spain (Spain): An application of the Resilience Assessment Tool (ResAT).* SURE-Farm Deliverable 4.2, (H2020, No.727520). https://www.surefarmproject.eu/deliverables/publications/

248. Spiegel, A., Slijper, T., De Mey, Y., Poortvliet, M., Rommen, J., Hansson, H., Vigani, M., Soriano, B., Wauters, E., Appel, F., Antonioli, F., Harizanova, H., Gavrilescu, C., Gradziuk, P., Neumeister, D., Meuwissen, M., 2019. *Report on farmers' perceptions of risk and resilience capacities — a comparison across EU farmers*. SURE-Farm Deliverable 2.1, (H2020, No.727520). https://www.surefarmproject.eu/deliverables/publications/

249. Stiglbauer, A.M. & Weiss, C.R., 2000. *Family and Non-Family Succession in the Upper-Austrian Farm Sector*. Cahiers d'Economie et de Sociologie Rurales, INRA Editions, 2000, 54, pp.5-26. https://hal.archives-ouvertes.fr/hal-01200950

250. Stringer, L.C., Fraser, E.D.G. , Harris, D., Lyon, C., Pereira, L., Ward, C.F.M., Simelton, E., 2020. Adaptation and development pathways for different types of farmers. *Environmental Science and Policy* 104 (2020) 174–189. https://doi.org/10.1016/j.envsci.2019.10.007

251. Tadesse, M.A., Shiferaw, B.A., Erenstein, O., 2015. Weather index insurance for managing drought risk in smallholder agriculture: lessons and policy implications for sub-Saharan Africa. *Agricultural and Food Economics*, 3, 26. https://doi.org/10.1186/s40100-015-0044-3

252. Tendall, D.M., Joerin, J., Kopainsky, B., Edwards, P., Shreck, A., Le, Q.B., Kruetli, P., Grant, M., Six, J., 2015. Food system resilience: Defining the concept. *Global Food Security*, 6:17–23. https://doi.org/10.1016/j.gfs.2015.08.001

253. Thomas, E., Riley, M., Spees, J., 2020. Knowledge flows: Farmers' social relations and knowledge sharing practices in "Catchment Sensitive Farming". *Land Use Policy*, 90, 104254. https://doi.org/10.1016/j.landusepol.2019.104254

254. Thompson, A.N., Young, J.M., 2002. *Potential Economic Benefits from Improving Ewe Nutrition to Optimise Lifetime Wool Production and Quality in South-west Victoria*. Proceedings Wool Industry Science & Technology Conference 2002. http://www.lifetimewool.com.au/pdf/088thompson.pdf

255. Toro-Mujica, P., García, A., Gómez-Castro, A., Perea, J., Rodríguez-Estévez, V., Angón, E., Barba, C., 2012. Organic dairy sheep farms in south-central Spain: Typologies according to livestock management and economic variables. *Small Ruminant Research* 104 (2012) 28– 36. doi:10.1016/j.smallrumres.2011.11.005

256. Tsang, E.W.K., 2014. Generalizing from research findings: the merits of case studies. *Inernational Journal of Management Review 16*(4):369.383. https://doi.org/10.1111/ijmr.12024

257. Uchiyama, T., Lobley, M., Errington, A. & Yanagimura, S., 2008. Dimensions of Intergenerational Farm Business Transfers in Canada, England, the USA and Japan. *Japanese Journal of Rural Economy 10* (2008) 33-48. https://doi.org/10.18480/jjre.10.33

258. Urquhart, J., Accatino, F., Appel, F., Antonoili, F., Berry, R., Bertolozzi-Caredio, D., Bijttebier, J., Black, J., Bohateret, V.M., Bruma, I.S., Coopmans, I., Courtney, P., Daskiewicz, P., Dinculescu, C., Dinu-Vasiliu, C., Dobay, K.M., Gavrilescu, C., Gradziuk, P., Heinrich, F., Izvoranu, A.M., Johansson, S., Klein, K., Matei, D., Maye, D., Peneva, M., Petit, A., Pitson, C., Severini, S., Slijper, T., Soriano, B., Tanasa, L., Toma, C., Tudor, M.M., Vigani, M., Zawalinkska, K., 2017. *Report on farmers ' learning capacity and networks of influence in 11 European case studies*. SURE-Farm Deliverable 2.3, (H2020, No.727520). https://www.surefarmproject.eu/wordpress/wp-content/uploads/2019/07/D2.3-Report-on-farmers-learning-capacity-and-networks-of-influence.pdf

259. Urruty, N., Tailliez-Lefebvre, D., Huyghe, C., 2016. Stability, robustness, vulnerability and resilience of agricultural systems. A review. *Agron. Sustain. Dev.* (2016) 36: 15. DOI 10.1007/s13593-015-0347-5.

260. Usai, M.G., Casu, S., Molle, G., Decandia, M., Ligios, S., Carta, A., 2006. Using cluster analysis to characterize the goat farming system in Sardinia. *Livestock Science* 104 (2006) 63– 76. doi:10.1016/j.livsci.2006.03.013

261. van Asseldonk, M., Tzouramani, I., Ge, L., Vrolijk, H., 2016. Adoption of risk management strategies in European agriculture. *Studies in Agricultural Economics*, 118(3), pp. 154–162. doi: 10.22004/ag.econ.252984.

262. Van der Zanden, E.H., Verburg. P.H., Schulp, C.J.E. & Verkerk, P.J., 2017. Trade-offs of European agricultural abandonment. *Land Use Policy 62* (2017) 290–301. http://dx.doi.org/10.1016/j.landusepol.2017.01.003

263. Varga, M., 2016. Small Farms Survival and Growth: Making Investments Despite Credit Constraints. *Sociologia Ruralis*, 57(1):641:660. https://doi.org/10.1111/soru.12149

264. Viñoles, C., Meikle, A., Martin, G.B., 2009. Short-term nutritional treatments grazing legumes or feeding concentrates increase prolificacy in Corriedale ewes. *Animal Reproduction Science* 113 (2009) 82–92. doi:10.1016/j.anireprosci.2008.05.079

265. Vroegindewey, R., Hodbod, J., 2018. Resilience of Agricultural Value Chains in Developing Country Contexts: A Framework and Assessment Approach. *Sustainability* 2018, 10, 916. doi:10.3390/su10040916.

266. Walker, B., Holling, C.S., Carpenter, S.R., Kinzig, A., 2004. Resilience, adaptability and transformability in social-ecological systems. *Ecol. Soc*. 9(2):5-9. https://doi.org/10.5751/ES-00650-090205

267. Wang, C., 2010. Daughter Exclusion in Family Business Succession: A Review of the Literature. *J Fam Econ Iss* (2010) 31:475–484. DOI 10.1007/s10834-010-9230-3

268. Weltin, M., Zasada, I., Franke, C., Piorr, A., Raggi, M., Viaggi, D., 2017. Analysing behavioural differences of farm households: An example of income diversification strategies based on European farm survey data. *Land Use Policy* (62):172-184. https://doi.org/10.1016/j.landusepol.2016.11.041

269. Wheeler, S., Bjornlund, H., Zuo, A., & Edwards, J., 2012. Handing down the farm? The increasing uncertainty of irrigated farm succession in Australia. *Journal of Rural Studies* 28 (2012) 266-275. doi:10.1016/j.jrurstud.2012.04.001

270. Wilkinson, S. 2004. *Focus Groups Research*. Doing Social Psychology Research. G.M. Breakwell (Ed.). Oxford: Blackwell.

271. Winlow, H., Simm, D., Marvell, A., Schaaf, R., 2013. Using Focus Group Research to Support Teaching and Learning. *Journal of Geography in Higher Education*, 37(2):292–303. https://doi.org/10.1080/03098265.2012.696595

272. Worstell, J., Green, J., 2017. Eight qualities of resilient food systems: Toward a sustainability/resilience index. *Journal of Agriculture, Food Systems, and Community Development*, 7(3), 23–41. http://dx.doi.org/10.5304/jafscd.2017.073.001

273. Zagata, L., Sutherland, L.A., 2015. Deconstructing the 'young farmer problem in Europe': towards a research agenda. *Journal of Rural Studies*, 38(2015):39-51. https://doi.org/10.1016/j.jrurstud.2015.01.003

274. Zinnanti, C., Schimmenti, E., Borsellino, V., Paolini, G., Severini, S., 2019. Economic performance and risk of farming systems specialized in perennial crops: An analysis of Italian hazelnut production. *Agricultural Systems* 176 (2019) 102645. https://doi.org/10.1016/j.agsy.2019.102645

APPENDICES

APPENDIX I – INFORMATION ON THE SEMI-STRUCTURED INTERVIEWS

Nº	Research study (1/2)	Reference	Date	Specialization	Interviewees	Status
1	1 & 2	I1	05.6.18	Sheep	Farm manager	Age: 41-65; Male; Family business; with offspring involved in farming
2	1 & 2	I2	05.6.18	Sheep	Farm manager	Age: 41-65; Male; Cooperative; without offspring
3	1 & 2	I3 & I4	06.6.18	Sheep	Farm manager and his son	[I3] Age: 41-65; Male; Family business; [I4] Age: 18-40; Succession occurring
4	1 & 2	I5	06.6.18	Sheep	Farm manager	Age: 18-40; Male; Family business; with offspring
5	1 & 2	I6	06.6.18	Sheep	Farm manager	Age: 41-65; Male; Family business
6	1 & 2	I7 & I8	12.6.18	Sheep	Farm manager and his son	[I3] Age: 41-65; Male; Family business; [I4] Age: <18; involved in farming
7	1 & 2	I9	12.6.18	Sheep	Farm manager	Age: 41-65; Male; Family business;
8	1	I10	12.6.18	Sheep	Farmer's wife	Age: 41-65; Family business; involved in the farm
9	1	I11 & I12	12.6.18	Sheep	Farmer's daughters	[I11] & [I12] <18; involved in farming; currently studying
10	1 & 2	I13	13.6.18	Sheep	Farm manager	Age: 41-65; Male; Family business; with offspring
11	1 & 2	I14	13.6.18	Sheep	Farm manager	Age: 41-65; Male; Family business;
12	1	I15	15.6.18	Cattle	Farm manager	Age: 18-40; Female; Individual entrepreneur; new entrant
13	1	I16	20.6.18	Cattle	Farm manager	Age: 41-65; Female; Individual entrepreneur; mother of [I15]
14	1	I17	15.6.18	Cattle	Farm manager	Age: 41-65; Male; Individual entrepreneur; few years long farmer
15	1	I18	27.6.18	Cattle	Farmer's daughter	Age: 18-40; Off-farm employment
16	1	I19	18.6.18	Cattle	Farm manager	Age: 41-65; Male; Family business; with offspring
17	1	I20	20.6.18	Cattle	Farm manager	Age: 18-40; Female; family business; previous experience in farming; succession occurring
18	1	I21 & I22	22.6.18	Cattle	Farmer and his son	[I21]: Age: 18-40; previous experience in farming; new entrant; family business; [I22]: Age: >65; Retired
19	1 & 2	I23	25.10.18	Sheep	Farm manager	Age: 41-65; Male; Family business; with offspring
20	1 & 2	I24 & I25	25.10.18	Sheep	Farmer and his son	[I24] Age: 41-65; Family business; [I25] Age: 18-40; previous experience in farming; succession occurring
21	1 & 2	I26	26.10.18	Sheep	Farm manager	Age: 41-65; Male; Family business; with offspring
22	1 & 2	I27	26.10.18	Sheep	Farm manager	Age: 41-65; Male; Family business; with offspring
23	1 & 2	I28	26.10.18	Sheep	Farm manager	Age: 18-40; Male; Family business; new entrant

Note: different colours highlight the three iterative phases of collection. Source: Bertolozzi-Caredio et al. 2020

APPENDIX II – MULTI-STAKEHOLDER FOCUS GROUP PARTICIPANTS INFORMATION

Participant	Sector	Sex	Age
1	Farmer	Male	30-40
2	Farmer's organization	Male	40-50
3	Farmer's organization	Male	40-50
4	Bank	Male	40-50
5	Insurance company	Male	50-60
6	Cooperative	Male	40-50
7	Policy maker	Male	+60
8	Local administration	Male	30-40
9(*)[9]	Local administration	Male	40-50

*He attended the second part of the Focus Group

[9] He attended the second part of the Focus Group

APPENDIX III – THE AXIAL CODES IDENTIFIED ALONG THE CONTENT ANALYSIS OF RESEARCH STUDY 1

Axial categories	Axial codes	Content description of codes
POTENTIALITY (Children are recognized by the family as potential successors)	Involvement of children in non-farming activities	*Children develop an interest in activities other than farming. This affects the recognition of potentiality on the side of the farming family before a decision has been made.*
	Involvement of children in farming activities	*Children are involved in farming, taking on different degrees of responsibility. This facilitates recognition of potentiality by the farming family, as well as attribute growth.*
	Farmer and family recognition	*Farmers and farming families recognize their children as the potential farm successors. Even though they envision a different future for their children, children are rationally assumed to be potential successors.*
	Farmer ambitions for their children's future	*Farmers and families have aspirations for their children, sometimes with respect to careers outside farming; this could either boost or slow down, but not necessarily trigger or stop, the recognition of potentiality.*
	Building up of experience	*Involvement in farming and a gradual acquisition of responsibility lead to an increase in farmers' children's farming experience, knowledge, skills.*
	Shaping of personal identity	*Involvement in farming shapes the identity of the farmers' children. This is related to feelings about farming, awareness of what farming means, emotional attachment to the farm and the rural community.*
WILLINGNESS (Successor is willing to move towards succession)	Individual vocational attributes	*Individual attributes of experience and personal identity determine the willingness to take over the farm.*
	Successor's expectations of policies	*Policies could marginally influence the successor's willingness to take over the farm.*
	Contextual factors	*Some socioeconomic or environmental factors (such as low profitability, poor quality of life, shortage of workers) could stifle willingness to take over the farm.*
	Opportunities trade-off	*The trade-off of different opportunities is a factor shaping the willingness to take over the farm. Better off-farm opportunities stifle willingness to succeed, whereas the shortage of other opportunities boosts willingness to take over the farm.*
	Effect of successor on farm changes	*Farmers' recognition of there being a successor willing to take over the farm influences the farm trajectory. This improves succession by making the farm a more attractive and functional business to take over.*
	Successor's independent decision	*The farmer's child decides to take over the farm. This is an individual decision made by the successor.*
EFFECTIVENESS Farm effectively transferred to successor	Family support for succession	*The family provides aids and support to overcome the barriers to succession.*
	Individual vocational Attributes	*Individual attributes of experience and personal identity can influence effectiveness.*
	Policy influences effective succession	*Policy aids can have a negative influence on, but do not determine, the effectiveness of succession.*
	Farm adjustments for succession	*When succession is effectively taking place, the successor implements change to facilitate the process, and to adjust the farm business to his/her needs.*

Source: Bertolozzi-Caredio et al. 2020.

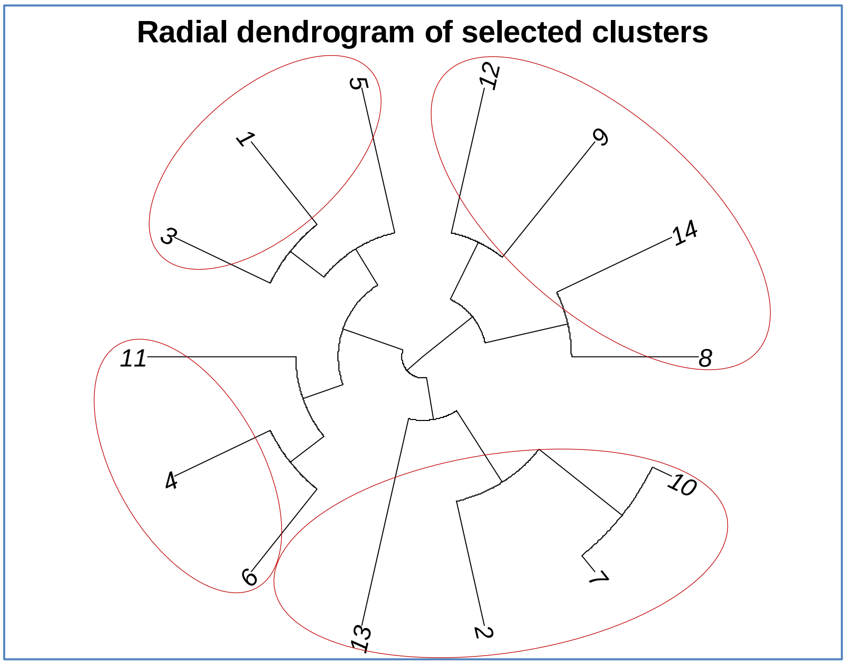
APPENDIX IV – THE NINE RESILIENCE ATTRIBUTES ANALYZED IN RESEARCH STUDY 2

The identified Attributes	Definitions	Conceptual linkages to attributes defined in previous research
On-farm diversity	The availability of different sources of revenue, means of productions, and skills on the farm determines different degrees of flexibility, and support the farm capacity to implement drastic changes.	'Response Diversity' (Kerner and Thomas, 2014) 'Response Diversity' & 'Optimally Redundant' (Cabell & Oelofse, 2012; Reidsma et al., 2019) 'Complementary Diversity' (Worstell & Green, 2017) 'Diversity' (Carpenter et al., 2012) 'Diversity & Redundancy' (Biggs et al., 2012)
Alignment with legislation	The regulatory framework can favour some farm configurations/production/management, rather than others. It has an influence on the strategic choice.	'Diverse Policy' & 'Legislation coupled with local and natural capital' (Reidsma et al., 2019)
Financial resources	Revenues and savings influence the buffer capacity, but also determines a major capacity to implement deep changes.	'Abundance/Reserves' (Kerner and Thomas, 2014) 'Reasonably Profitable' (Cabell & Oelofse, 2012) 'Responsive Redundancy' (Worstell & Green, 2017) 'Economic Resources' (Darijani et al., 2019)
Available labour force	The availability of workers and their skills influence the farms' opportunity to develop or undertake changes.	'Human Capital' (Cabell & Oelofse, 2012; Darijani et al., 2019) 'Support Rural Life' (Reidsma et al., 2019)
Learning capacity	The farmers' propensity to learn, exchange knowledge with others, engage in group learning, and be pro-active in experimentation processes determine the capacity to undertake changes and innovation.	'Learning Capacity' (Kerner and Thomas, 2014) 'Reflective & Shared Learning' (Cabell and Oelofse, 2012; Reidsma et al., 2019) 'Social Learning' (de Kraker, 2017) 'Learning & Experimentation' (Biggs et al., 2012)
Farmers' traditions & perspective	A sense of attachment to sheep farming due to traditions, familial heritage, identity or emotions, can influence farmers' choices. The farmers' perception of future (e.g. succession) could create meaningful reasons to improve, innovate, change, or "conserve in good conditions" the farm.	'Honor Legacy' (Cabell and Oelofse, 2012) 'Succession and successors effects' (Inwood and Sharp, 2012) 'Conservative Innovation' (Worstell & Green, 2017)
Subsidies buffer	CAP direct payments and other aids represent an economic safety net and, eventually, a basis for undertaking changes. Their impact depends on the relative significance on farm revenues, which might imply also a dependence from subsidies.	'Abundance/Reserves' & 'False subsidies' (Kerner and Thomas, 2014) 'Diverse Policy' (Reidsma et al., 2019)
Matching with natural resources	Availability of pastures and forage lands, and the ability to exploit them.	'Coupled with Local and Natural Capital' (Cabell and Oelofse, 2012; Reidsma et al., 2019) 'Ecologically self-regulated (works with nature)' (Worstell and Green, 2017)
Farmers' network	The farmers' propensity and capacity to build relations, to self-organize, and to address coordinated actions for specific responses (strategies).	'Collaborative Capacity' & 'Connectivity' (Kerner and Thomas, 2014) 'Socially Self-organized' & 'Appropriately Connected' (Cabell and Oelofse, 2012) 'Modular Connectivity' & 'Locally Self-organized' (Worstell and Green, 2017) 'Connectivity' (Biggs et al., 2012)

APPENDIX V – GOWER DISSIMILARITY MATRIX AND CLUSTER DENDROGRAM

Gower dissimilarity matrix

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13
F2	0.4												
F3	0.25	0.4											
F4	0.25	0.3	0.3										
F5	0.35	0.5	0.3	0.3									
F6	0.4	0.45	0.35	0.25	0.35								
F7	0.4	0.25	0.25	0.25	0.25	0.2							
F8	0.65	0.6	0.6	0.4	0.5	0.25	0.45						
F9	0.45	0.4	0.5	0.3	0.6	0.45	0.45	0.4					
F10	0.45	0.3	0.3	0.3	0.3	0.25	0.05	0.5	0.5				
F11	0.4	0.55	0.45	0.35	0.45	0.3	0.5	0.45	0.55	0.45			
F12	0.6	0.45	0.35	0.45	0.65	0.4	0.5	0.45	0.35	0.55	0.4		
F13	0.45	0.5	0.3	0.5	0.6	0.45	0.45	0.6	0.6	0.5	0.45	0.35	
F14	0-65	0.4	0.5	0.4	0.5	0.35	0.35	0.3	0.5	0.4	0.45	0.45	0.4



APPENDIX VI – LIST OF IMPROVEMENTS SUGGESTED BY FOCUS GROUP PARTICIPANTS

	STRATEGIES			
ACTORS	**Value extensive livestock contribution**	**Investment and financing capacity**	**Promoting lamb meat consumption**	**Training and knowledge**
Farmers	*Active participation on public awareness raising actions on the positive contribution of lamb meat to environment conservation*		*Join initiatives to boost local trade and reduce the number of intermediaries*	
	Active participation on public awareness raising actions on the positive contribution of lamb meat to the region and rural population and knowledge		*Pay more attention to consumers' needs and demands (breeds selection)*	
	Turn into an opportunity the provision of public goods by the sheep extensive farming		*Join activities to show the farm and the animals*	
Farmers' associations	*Remain as an independent institution. Better defend the interest of the sector*		*Involve in the sector professionals in communication tasks.*	
	Support public awareness raising actions on the positive contribution of sheep sector to environment conservation		*More transparency and information of the actions perform by the associations, why and impact of the actions*	
Cooperatives	*Collaboration with universities to improve education on sheep sector*		*Communicate research on lamb meat nutrition value*	*Adapted training considering the challenges facing the sector*
	Create alliances with sheep sectors in different regions at country and European level		*Communicate the positive contribution of lamb meat to the region and rural population.*	*Alliance with primary and secondary schools to improve the awareness and knowledge on extensive livestock*
	Define public awareness raising actions on the positive contribution of lamb meat to the region and rural population and knowledge		*Create a new brand to sell high-quality products. Well differentiated product*	*Alliance with universities to improve the education on extensive livestock*
	Involve in the sector professionals in communication tasks.		*Create catering, restaurants chains to sell high-quality products*	*Find new teachers with more knowledge and experience in the sector*
	Make the sector attractive to new entrants: Create the idea of new business built on ancient costumes		*Create public confidence by giving more information about trazability (block chain)*	*Include new contents and more applicable in training courses*
			Develop new products based on lamb meat adapted to consumers needs (easy to cook): lamb kebab, lamb hamburgers	*Reinforce the training programs on veterinary services*
			Find new promotion channels	

			Involve in the sector professionals in communication tasks.	
			Open new markets	
			Organize open-days for students to attend	
			Organize special days (fairs) to show new products and how to cock them	
			Promotion of child consumption through school canteens	
			Raise awareness campaigns directed to family doctors about the impacts of lamb meat on health	
			Support research on lamb meat nutrition value	
			Support labelling and traceability initiatives	
			Support new high-quality brand and commercial channels	
Banks and insurance companies		*Adapt products to livestock sector: Adapt the payments periods to the farmer's cash flow/ revenues/CAP aids reimbursements*		
		Very knowledgeable about the farmer and the capacity of get debts and get them back. Study alternatives according to the farmer profile		
		Adapt products to livestock sector: Offer referred payments adapted to the farmer's cash flows		
		Public-private collaboration_ negotiate loans guarantees with public sector. Define the risk level to be assumed by the financial institutions		
		Public-private collaboration_ Search opportunities to launch soft credits, medium-long term		
		Public-private collaboration_Specific products for young people		
		Develop new insurance products to manage new diseases risks (Rift Valley fever and Maedi-Visna)		

		Awareness campaign about the relevance of contracting diseases insurance		
		Public-private collaboration_ strengthen the collaboration with public sector to develop the product and /or cover insurances premiums on infectious diseases		
Public sector	*Create a land bank to better redistribute land*	*Public-private collaboration_ strengthen the collaboration with insurance companies to cover insurances premiums on infectious diseases*		*Support initiatives on training courses*
	Free access of the sheep farmers to State owned land	*Adequate and efficient regulatory framework*		*Support alliance with education systems*
	Support the entrepreneur Hub to support new entrants and farm improvements	*Public-private collaboration_ negotiate loans guarantees with banks. Define the risk level to be assumed by the financial institutions and make it attractive for the private sector to join the initiative*		
	Promote research on the vulnerability of the different regions	*Widely communicate and inform in detail about new aids programs supporting the investment plans*		
	Define different incentives according to the regions vulnerability	*Public-private collaboration_ negotiate subsidised rates with banks*		
	Reinforce aids linked to environment protection and rural living areas	*Positive discrimination measures directed at less favoured areas*		