Exploring the effects of innovations on the sustainability of sheep farming systems in Spain

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Small ruminant farming systems are among the primary sources of rural populations' livelihood and employment in arid and semiarid environments. They are relevant for regional food security, human wellbeing, and the provision of ecosystem services. In Aragón (Spain), sheep farming systems are of great importance for rural areas' economic, environmental, and social sustainability. However, they are facing many challenges such as climate change and low generational turnover, among others, which threaten their persistence in the long term. Innovative and adaptive capacities are needed to face these challenges. Here, we used a multi-method and a multi-actor approach to identify the most valued innovations by stakeholders and analyse their multi-dimensional effects on the sustainability of the extensive sheep farming systems in this region. We adapted, parameterized, and validated the model PASTOR to simulate a representative sheep farm using 1-year own monitoring data. We assessed the effects on key sustainability indicators under four management scenarios that include: (1) a business-as-usual scenario (without innovations); (2) implementing a PES scheme; (3) increasing the added value of farm products through a quality label (i.e. hormone-free); and (4) the combination of both innovations. Implementing the PES scheme improves the farm's sustainability performance, achieving optimal values for 6 out of 7 sustainability indicators. We identified a trade-off between the effects of both innovations on the economic balance of the farm. The PES innovation counteracts the negative effects of the hormone-free label in the economic balance. There is a slight synergy between the effects of both innovations reducing the indicator referring to the excess of protein. Among the trade-offs across the sustainability dimensions, we found that PES can enhance the farm's economic balance but slightly worsens the CO_2 emissions per unit of production and protein excess. These preliminary findings can guide the stakeholders' decision-making processes and facilitate and reinforce their innovation capacity.