

### **Emergy analysis of the sustainability of mountain grazing livestock systems**

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In the context of increasing social concern about livestock systems environmental impact, the development of methodologies for assessing biophysical sustainability is crucial. Livestock sustainability assessments commonly focus on greenhouse gases fluxes which, although are good for assessing livestock interaction with the climate system, generate controversy related to the need to differentiate between carbon released in human activities and carbon belonging to natural cycles. Emergy Analysis (EA) deals with sustainability in terms of energy fluxes, allowing to evaluate separately renewable and non-renewable energy sources. EA computes all the energy sources involved in the production process, expressed in Jules of equivalent solar energy (seJ). We implemented an EA on 50 cattle farms in the Spanish Pyrenees aiming to: (1) evaluate and compare the energy composition (renewable vs non-renewable) across farms using different accounting methods; and (2) determine the main variables enhancing the environmental sustainability of farms. Our results showed high heterogeneity between farms energy requirements despite all of them having similar management and productive orientation. This should raise concerns about using individual farms as representatives of farming systems in comparative sustainability assessments. Between 31 and 50% of the total Emergy used across farms came from local natural renewable sources, and 12 to 23% from purchased feeds. Human labour and services (i.e. emergy required to support the whole socioeconomic network, directly related to its economic cost) represented between 24 and 34% of the total Emergy. The high contribution of services suggests that mountain livestock systems have a reduced capacity to affect their own sustainability, due to their large dependence on the broad socioeconomic system (i.e. reduced autonomy). The contribution of natural pastures to farm Emergy showed huge differences (between 1 and 32% of the total farm Emergy) depending on how it is accounted, which requires deeper discussion.