

**Relationship between resource use, efficiency and sustainability of sheep-crop farming systems**

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Farming systems determine the resource embeddedness in agricultural products. Quantification of efficiency and sustainability is challenging in Mediterranean sheep-crop farming systems due to their different specialization, crop-animal integration and intensification. Emergy analysis computes the different qualities of energies involved in a production process and expresses them in equivalent solar energy. It provides emergy-based indicators such as intensity (emergy used per hectare and year), efficiency (emergy invested per energy obtained), and sustainability (ratio of self-sufficiency to environmental loading). Our objective was to evaluate these indicators on three representative farms of Mediterranean sheep-crop farming systems of Aragón (Spain) at two different levels: the product and the farm level (including lamb meat, permanent crops, and rainfed and irrigated arable crops). Our results show that the pasture-based sheep farm had the lowest intensity and efficiency and the highest sustainability, as opposite to the partially-integrated farm, while the fully-integrated farm obtained intermediate scores. Sheep products were less intensive and more sustainable than crops due to their capacity to use renewable natural resources (i.e. pastures). Since emergy increases with the hierarchical level of the food chain (e.g. from crops to meat), efficiency should be compared between products of similar trophic level. Lamb meat production was 1.9 and 1.3 times more intensive and efficient, respectively, in the partially-integrated farm than in the pasture-based sheep farm, but it was 5.1 times less sustainable. Increasing the boundaries of emergy analysis from the farm to the regional level could show strategies of resource sharing among farms for increased regional sustainability.

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