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**Title**

**Biothermodynamics indicators for assessing sustainability agricultural  
systems; a case study in Boland village in Sistan-Iran**

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## Abstract

Agricultural production systems have become increasingly more specialized in response to the population's ever-increasing demand for food production. In recent years, integration of agricultural practices and animal husbandry has become of interest to deal with the issues caused by intensive production systems. Integrated crop-livestock systems form a direct link between agricultural and livestock products in order to create positive economic and environmental results. Thus, the present study aims to evaluate how an integrated system, producing agricultural crops and livestock, affects the efficiency and ecological sustainability and then compares this with the individual systems of crop and livestock production, using energy synthesis approach. This study was conducted in 2019, the data of which was collected from across smallholdings systems of farmlands and livestock of Boland Village, located in Sistan, Iran. Purchased inputs accounted for 51.08%, 99.96%, and 30.94% of the total input of cropping, livestock and integrated production systems, respectively. The values of Energy Yield Ratio(EYR) Energy Sustainability Indices(ESI), and Gross Benefit(GB), and Net Benefit(NB) showed that, due to the positive interactions between the crop and livestock components along with high environmental sustainability, the integrated system results in a higher net profit in comparison to the individual cropping and livestock systems. The EEA values for wheat, barley, alfalfa, and grapes were  $5.22E+06$ ,  $1.26E+06$ ,  $4.49E+05$ , and  $2.08E+05$  مگازول/ha, respectively, and for livestock production systems including cattle, sheep, and poultry rearing were  $2.88E+06$ ,  $1.78E+06$ , and  $9.75E+05$  مگازول/ha, respectively, indicating that grape production in cropping systems and poultry rearing in animal systems are more ecologically sustainable. The costs of obtaining inputs for grape production in agricultural systems and poultry raising in livestock systems, according to the Kcap, are greater than the costs of obtaining inputs for the other production systems in this study. In addition, a higher KcapEE index in livestock systems and alfalfa production in agricultural systems indicates that the system is more economically efficient. Due to the suitable weather and richness of natural resources in Sistan region, various crops are produced all year round, and many opportunities exist for integrating agricultural and livestock products in this region. The results also indicated that while the integration of crops and livestock has the potential to reduce economic risks and to increase profitability, it can also provide great benefits regarding the preservation of soil and water resources and the productivity of nutrient cycling. Accordingly,

an integrated crop-livestock production system is suggested as a suitable option for producers towards the diversification of agricultural practices which could prevent risks, improve the ecological production of crops, and prevent the environmental damages caused by soil erosion and loss of nutrients.

Keywords: Cumulative Exergy Consumption, Environmental Refining Cost, Ecological Sustainability, Economic Efficiency, Optimal Consumption.