



**University of Zabol  
Department of Agriculture**

**Thesis Submitted in Partial Fulfillment of the Requirement for the degree of  
Ph.D in Agroecology**

**Title**

**Non-monetary valuation of ecosystem service and  
dis-service of wheat systems in dry areas by using  
emergy approach (Case Study: Hirmand County)**

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**Abstract:**

The application of the emergy analysis approach to assessing the sustainability of agricultural systems results in the implementation of proper management in order to increase the sustainability of production in these systems. The goal of this study is to compare the emergy structure, emergy indices, economic efficiency, and non-monetary valuation of services and dis-services in Hirmand county based on emergy technique of wheat, onion, garlic, fennel, cumin, and black seed production systems. For this purpose, 117 farms were selected for wheat, 47 farms for onions, 32 farms for garlic, 17 farms for cumin, 12 farms for fennel and 8 farms for black caraway. A questionnaire and field measurements were used to collect the data for this study, which included environmental and economic inputs and outputs. The structure of input emergy, emergy indices, services, and dis-services were calculated as direct, indirect, and existential valuation for various systems in this study. Total emergy supporting the production systems of wheat, onion, garlic, fennel, cumin and black caraway in Hirmand County are  $3.25\text{E}+16$ ,  $3.37\text{E}+16$ ,  $4.36\text{E}+16$ ,  $2.29\text{E}+16$ ,  $1.84\text{E}+16$ , and  $1.82\text{E}+16$  sej  $\text{ha}^{-1}$ , respectively. Free environmental flows represented respectively 74.27, 67.85, 52.21, 56.16, 56.56 and 52.49% of the total input energy of the production systems of wheat, onion, garlic, fennel, cumin and black caraway. The large share of free internal inputs indicates that most of the farms studied are non-industrial systems that are traditionally managed and low-input. The values calculated for the sustainability indices (ESI and ESI\*) showed that the ecological sustainability of the fennel production system is higher than the other study systems. The main reason for the greater sustainability of this system was the high share of energy input related to free environmental inputs and economic renewable resources. In addition, high emergy exchange ratio (EER), environmental sustainability resulting from the impact on the market, less emergy expended in the production of each unit of production and higher productivity of all production factors indicate a greater comparative advantage of the fennel production system. For wheat, onion, garlic, fennel, cumin, and black seed production systems, the total direct services of biomass production, carbon sequestration, and soil formation were  $2.43\text{E}+21$ ,  $1.14\text{E}+21$ ,  $3.48\text{E}+20$ ,  $1.21\text{E}+20$ ,  $2.82\text{E}+19$ , and  $1.52\text{E}+19$  sej, respectively. The evaluation of ecosystem dis-services caused by greenhouse gas emissions revealed that the wheat production system causes the most damage to human health and the quality of the ecosystem, while the cumin and black seed production systems cause the least. Wheat, onion, garlic, fennel, cumin, and black seed production systems were  $2.18\text{E}+18$ ,  $6.78\text{E}+16$ ,  $9.76\text{E}+15$ ,  $4.48\text{E}+15$ ,  $2.64\text{E}+15$ , and  $2.11\text{E}+15$  sej, respectively, at soil erosion ecosystem dis-services. Wheat, onion, garlic, fennel, cumin, and black seed production systems were  $2.18\text{E}+18$ ,  $6.78\text{E}+16$ ,  $9.76\text{E}+15$ ,  $4.48\text{E}+15$ ,  $2.64\text{E}+15$ , and  $2.11\text{E}+15$  sej, respectively, at soil erosion ecosystem dis-services. Emergy analysis and evaluation of services and dis-services of the dominant cropping systems in Hirmand city revealed that paying attention to practical solutions in comprehensive management of production ecosystems, particularly the protection of soil organic

matter and the prevention of soil erosion, as well as a shift in cultivation pattern toward medicinal plant cultivation, particularly fennel, can have a significant impact on the ecological sustainability of these systems.

**Keywords:** Agroecosystems, Environmental burden, Emergy analysis, Services and dis-services of ecosystem, Soil erosion, Sustainability assessment.