Modeling Matter and Energy Flows in Marine Ecosystems Using Emergy and Eco-Exergy Methods to Account for Natural Capital Value

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ABSTRACT

World population is expected to approach 9.7 billion by 2050. This scenario will lead to an increase in food demand, worsening environmental problems due to intensive agricultural productions. For this reason, one of the major challenges is to attain both food security and sustainable agriculture worldwide. While food security is aimed at ensuring a constant and healthy food supply over time, sustainable agriculture plays a key role for the maintenance of resilient agroecosystems. In this study, we implemented a multicriteria accounting framework to explore the environmental performance and sustainability of agricultural production in Lebanon at both farm and national level. An extensive field study was conducted to collect data on natural and human-driven flows supporting nine main agricultural production systems in different Lebanese regions. The investigated cropping systems were assessed in terms of environmental costs and impacts by jointly applying the following environmental accounting methods: gross energy requirement (GER), material flow accounting (MFA), emergy accounting, and emissions accounting and contribution to impact categories. At national level, the total emergy demand resulted $5.46 \times 10^{21}$ sej yr$^{-1}$, while the total GER was $1.81 \times 10^{10}$ MJ yr$^{-1}$. The total water and abiotic demand resulted $6.27 \times 10^8$ t yr$^{-1}$ and $2.64 \times 10^6$ t yr$^{-1}$, respectively. Finally, the total contribution to global warming potential (GWP) resulted $1.45 \times 10^9$ g CO$_2$ eq yr$^{-1}$, while the acidification potential (AP) and the human toxicity (HT) resulted $5.79 \times 10^9$ g SO$_2$ eq yr$^{-1}$ and $6.88 \times 10^9$ g 1,4-DCB eq yr$^{-1}$. At farm level, orange production showed the lowest environmental performance due to a high use of water, diesel, and fertilizers. Instead, olive production showed the best environmental performance thanks to a low requirement of mass and energy inputs, and human labour, confirming the advantages of environmental friendly practices. The results of this study can help both farmers and policy makers in charge for ensuring a sustainable management of agricultural production while providing access to safe, healthy, and nutritious food for a growing population. Finally, a set of biophysical and socio-economic indicators is proposed for integrating the environmental accounting with a socio-economic perspective on food security and sustainable agriculture.

Citation
