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ENVIRONMENTAL ACCOUNTING OF AGRICULTURAL COMMODITIES PRODUCTION: A USA/BRAZIL CONTRAST

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INTRODUCTION

It has been a common practice to evaluate the performance of agricultural development and technology adoption according to economic, technical, and political criteria. However, the recognition of wide-ranging environmental impacts of agriculture makes mandatory the incorporation of sustainability criteria in performance evaluation. The environmental accounting techniques proposed by H.T. Odum offer a systemic approach to decide on agricultural practices intensification / diversification and technology selection / adoption, allowing consideration of questions concerning the sustainable use of natural resources, the tradeoffs between improvement and growth of economic activities, environmental conservation, and the fair sharing of wealth among the social groups involved.

The 'Sustainability Assessment Methodology Framework' (SAMeFrame – Rodrigues et al., 2002) presented in this study is a tool for carrying out the environmental accounting of energy and material flows in agricultural and livestock production, integrating the individual farm scale, the regional insertion of the farm at the county scale, the systemic evaluation at the country level and the insertion and impact of agricultural production in the national economy. Based on such a 'systems agriculture' approach, a series of performance indices is obtained for all scales and expressed in numeric and graphic formats, facilitating circumstantiated assessment of, e.g., renewable/non-renewable resources use ratio, environmental loading ratio, and general systems sustainability.

DESCRIPTION OF THE APPROACH

SAMeFrame comprises a set of integrated spreadsheets for accounting the emergy balances from the agricultural and livestock production activities at the farm level, the regional insertion of the farm at the county or State level, and the systemic evaluation of the country and national agriculture. Data needed to fulfill the requirements of SAMeFrame at the macro scales (country through county) are obtained from the national, regional, and agricultural censuses, while micro-scale data are obtained directly from individual farm records. Results of the assessment for each scale considered are expressed in emergy flow diagrams (as solar emergy Joules – seJ), summarizing resource use ratios and sustainability indices.

The emergy evaluation of the country establishes the large-scale resource base and economic setting for all productive activities developed in the smaller scales, and must be the first step in the sustainability assessment. The overall energy use and emergy evaluation of the country are combined with the market values of imports, exports, and money flows to define the emergy/money ratio for the national economy. This emergy/money ratio influences all production activities within the country, as well as the exchanges of goods and services between countries.

The general emergy analysis of the country offers the basis for assessing the National Agriculture and Livestock Production System, which sets the economic and the resources environment for the insertion of the local agriculture and individual farms. This stepwise scaling of rural productive activities determines how the local production of individual farms can match the emergy investments characteristic of the whole country, and better rely on special local conditions to improve sustainability.

In the present study the national economies and the agricultural emergy flows in Brazil and the USA have been analyzed (year 2000 basis), as examples of the sustainability assessment approach offered by emergy analysis and the broad-scale environmental accounting provided by SAMeFrame.

RESULTS AND DISCUSSION

Environmental performances, as expressed by resources dependency, are shown to be strongly influenced by agricultural product diversification and by the environmental and economic resources bases of the two economies, with the USA being more dependent on man-made and non-renewable resources.

With total national emergy used equal to 1.18E+25 seJ year^{-1}, being 1.72E+24 seJ from renewable resources, 6.80E+24 seJ from non-renewable resources and 3.26E+24 seJ from imported sources, for a throughput of 2,39E+24 seJ, the USA economy showed 72% of emergy use from home sources, 15% of which are locally renewable, a ratio of concentrated (human-economy) resources to rural equal to 2.13, 'empower density' (emergy use ha^{-1}) of 1.25E+16 seJ and an emergy use per capita of 4.18E+16 seJ.

For Brazil the total national emergy used equaled 5.17E+24 seJ year^{-1}, being 2.77E+24 seJ from renewable resources, 1.72E+24 seJ from non-renewable resources and 6.83E+23 seJ from imported sources, for a throughput of 7.19E+23 seJ, being 87% of emergy use from home sources, 54% of which locally renewable, with a ratio of concentrated (human-economy) resources to rural equal to 0.37, 'empower density' (emergy use ha^{-1}) of 6.07E+15 seJ and an emergy use per capita of 3.05E+16 seJ.

The USA national crop production amounted to 3.05E+19 J, the livestock production amounted to 7.86E+17 J, with transformities equal to 1,42E+05 seJ J^{-1} and 1.88E+06 seJ J^{-1}, respectively, corresponding to empower densities of 3.50E+16 seJ ha^{-1} for crop and 7.52E+15 ha^{-1} for livestock production, with 44% and 38% based on renewable resources, respectively.

The national crop production for Brazil amounted to 6.55E+18 J, the livestock production amounted to 1.91E+17 J, with transformities equal to 6.52E+05 seJ J^{-1} and 1.24E+06 seJ J^{-1}, respectively, corresponding to empower densities of 6.55E+16 seJ ha^{-1} for crop and 1.21E+15 ha^{-1} for livestock production, with 70% and 29% based on renewable resources, respectively.

These data indicate that urban and quite intense agricultural activities (high empower densities) are diluted in the very large natural and range areas occurring in both countries (explaining the smaller empower densities for the whole economies as compared with agricultural empower densities), while livestock production is much less intense, especially in Brazil (just 16% as intense). Also, the analysis shows that the Brazilian agricultural sector relies more heavily on natural and renewable resources, reaching net emergy ratios (return on emergy investment) of 13.4 and 1.41 (for crop and livestock), as compared to 6.27 and 1.26 for the USA. These attest to a comparatively more efficient agricultural sector in terms of resources uses in the Brazilian economy.

Contrasting with economic benefit-cost analyses normally carried out to assess the performance of agricultural activities and technology contributions toward sustainability of farm systems, which are highly influenced by transitory aspects of the market and do not account for environmental issues in general, the integrated emergy assessment made possible by SAMeFrame explicitly considers the cross-scale matching of environmental and purchased input uses. Accordingly, the results obtained with SAMeFrame point out that soil and water conservation practices (to warrant needed natural resources) are crucial for sustainability, and that these practices should be greatly stimulated.

However, resources for such are difficult to come by because, even with contrasting contexts regarding resources uses, in the two countries studied the energy flows (emergy) characteristic of rural areas impose that both the farms and the national agriculture function as net providers of large amounts of wealth to the urban markets.

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