EMERGY SYNTHESIS 3:
Theory and Applications of the Emergy Methodology

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The Introduction of Emergy Indices in the Certification of Organic Products: Adaptation and Potential

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ABSTRACT

Organic Agriculture, based on commitments to sustainability and social justice, has been growing worldwide and has made important gains in environment preservation. However, these two parameters are neither evaluated nor quantified in the certification process. The present work proposes and discusses the use of the Emergy indices for the evaluation of both sustainability and social justice in certification of organic products. The certification process, carried out by a certification body (CB), is composed of seven steps: preparation of a control plan, contract between the farmer and the CB, external control, laboratory analyses, report preparation, comparison between the standard and the data and, finally, the emission of a Certification Decision, when the Organic Stamp may be granted. The calculation of the Emergy indices can be easily incorporated without additional costs. The majority of the data necessary for the emergy calculations are already collected in the inspection procedure and those that are not can be easily obtained. These indices complement the analyses and the inspection report in the evaluation of the farm's performance and fulfillment of requirements. For the evaluation of sustainability and social justice, the proposed indices are: Renewability (% R), Environmental Loading Ratio (ELR), Labor Services Ratio (LSR), Labor Empower Ratio (LER) and Local Work Ratio (LWR). The inclusion of such indices makes possible the quantitative differentiation of farms in respect to their sustainability and the existing degree of social justice.

INTRODUCTION AND JUSTIFICATION

The market of organic products has been growing globally, not only in Europe and North America, but also in developing countries. The total organically cultivated area is already more than 22 million hectares (Yussefi and Willer, 2003). IFOAM, the International Federation of Organic Agriculture Movements, with approximately 750 members in 100 different countries (IFOAM, 2004), defines organic agriculture as, "a whole system approach based upon a set of processes resulting in a sustainable ecosystem, safe food, good nutrition, animal welfare and social justice", and lists fifteen basic principles for organic production (IFOAM, 2002). In each one of these principles there is a direct and clear reference to the commitment of organic agriculture to sustainable production and social justice. The following recommendations, among others, are presented:

- ✓ Operators should maintain a significant portion of their farms to facilitate biodiversity and nature conservation.
- ✓ Operators should respect sustainable resource management and the common good.

- ✓ The operator should provide for the maintenance and sustainability of the ecosystem when harvesting or gathering the products.
- ✓ The operator should positively contribute to the maintenance of natural areas.
- ✓ Operators shall have a policy on social justice.

However, according to current regulations of organic production, there is no requirement for quantification or evaluation of these parameters.

The National Organic Program (7 CFR Part 205) of United States establishes a national standard for the production and handling of organically produced products. Only in Subpart C - Organic Crop, Wild Crop, Livestock, and Handling Requirements, §205.200, there is a reference to the conservation of natural resources, determining that any organic production unit must maintain or improve the natural resources relied upon in the operation, including soil and water quality. However, this same standard does not require the evaluation of these parameters in the certification process. All the other determinations and demands, which should be checked by the certification body, are, basically, of two types: i) positive list of permitted inputs and handling procedures, ii) requirement of record keeping of all production and control procedures. In the same way, there is reference to renewable resources and sustainable agriculture only in item 1.3 of Annex 1, Principles of the Organic Production, of the regulation CEE N.º 2092/91 of the European Communities (EC, 1991). In Rule CEE N.º 1804/99 (EC, 1999), for animal production, there is no reference to sustainability. Therefore, sustainability, or the lack of it, is not considered as an eliminatory parameter to grant the Organic Stamp, as is, for instance, the use of forbidden inputs (FAO/WHO, 1999; IFOAM, 2002; EC, 1991, 1999; USA, 2002).

However, in spite of not quantifying sustainability, the standards concerning organic production represent progress in relation to conventional agriculture and can result in benefits to the environment and society. The FAO document "Organic agriculture: the challenge of sustaining food production while enhancing biodiversity", from April 2003, attests that organic agriculture should be considered as an appropriate starting point for combining commodities production with conservation of the environment and lists a series of current environmental benefits observed in different areas of the planet where organic agriculture has been adopted. The crucial issue is how to evaluate sustainability and social justice and how to incorporate it into the organic production standards.

Panzieri et al. (2003) propose the use of emergy indices, together with other indices, for environmental certification by the Environmental Performance Evaluation (EPE) program. This is justified because the emergy methodology identifies all energy and materials flows that circulate in the system and classifies them in terms of origin and their renewability level. Moreover, these indices include in the calculations natural resources that are not usually considered. The authors still point out that the emergy indices are relatively easy to measure and understand, in spite of being based on solid scientific concepts. The emergy methodology has also been used by different authors to evaluate and compare the viability of different methods of agricultural production (Comar, 2000; Lagerberg, 2000; Lanzotti et al., 2000; Ortega et al., 2000; Ortega et al., 2002 and Bastianoni et al., 2001). In all of these works, this methodology was shown efficient in the evaluation of the environmental impacts and survival of the project over time.

The present work discusses how some emergy indices can be included in the certification of organic products, specifically seeking the evaluation of their sustainability and associated social justice.

ORGANIC CERTIFICATION PROCESS

One of the basic characteristics of organic production requirements is the need for external certification. The FAO/WHO (1999) define the certification process as a " procedure by which official certification bodies (CB), or officially recognized certification bodies, provide written or equivalent assurance that foods or food control systems conform to requirements." The requirements of the

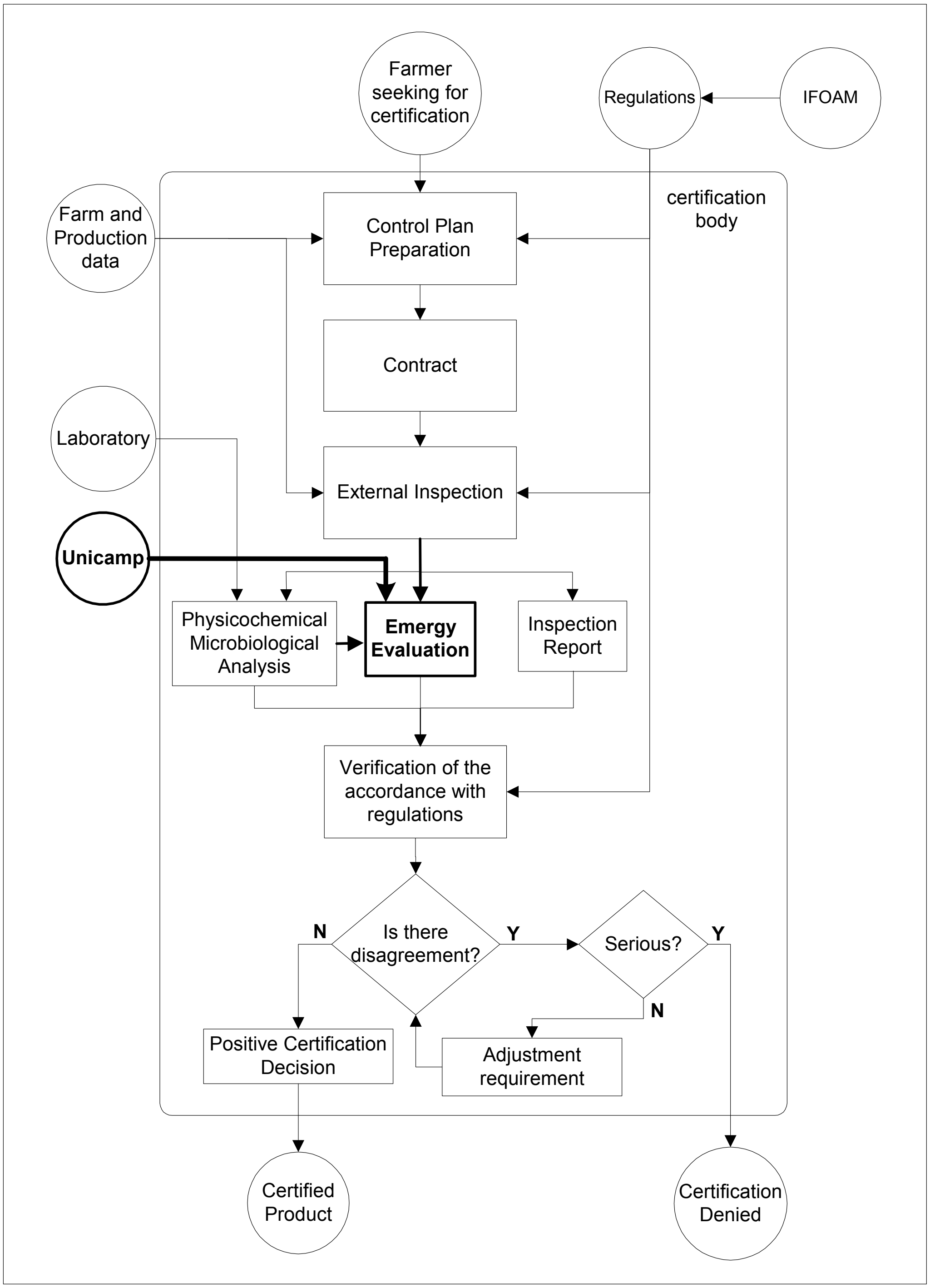

Figure 1. *Organic product certification process. Bold line shows the LEIA's (Laboratory of Ecological Engineering and Applied Computer Science of UNICAMP-State University of Campinas) proposal.*

inspection process and control are described in several regulations (FAO/WHO, 1999; IFOAM, 2002; EC, 1991, 1999; USA, 2002). Owing to its nature, the certification process establishes the practice of external inspection (in the field and of the product) and the consequent regular evaluation of the productive unit, making it possible to evaluate the efficiency of practices adopted, as well as identifiy and correct any observed deviations. Figure 1 presents the flowchart for the certification process.

As the organic certification is not mandatory, but voluntary, the first step is the contact between the interested producer and a certification body (CB) that should be accredited by some organization of national or international accreditation (e.g., IFOAM). At this stage the producer informs the CB of a series of production data (size and location of the producing unit, cultivated area and volume produced by product, characteristics of the production, etc.). Based on these data and on the rules of organic production, a control and an inspection plan are prepared, where the control type - internal control, external inspection and laboratory analyses - and their frequency are defined. At this stage, if preliminary data already indicate that it won't be possible to grant certification, the CB can, justifiably, refuse to complete the certification. To proceed ahead, a contract is signed between the producer and the CB.

During the external inspection, conducted by an enabled inspector, the information previously supplied by the producing unit and the monitored data (or internal control) are checked *in situ*. External inspection can also include some measurements and analyses, as well as the collection of samples for the physicochemical and microbiological analyses of soil, water and farming products. The results are sent directly to the CB and a copy is sent to the producer. The inspector prepares a report where the observed conditions and the collected data are compared with the standards for organic production.

With these data (inspection report and analyses results) the CB issues a Certification Decision with three possible decisions: a) granting of the Organic Stamp when the production method is in agreement with the effective regulations; b) an adaptation request when small deviations are observed with concession of the stamp after adaptation; c) the stamp is denied when serious divergences are observed.

THE INCLUSION OF EMERGY EVALUATION

The Laboratory of Ecological Engineering and Applied Computer Science (LEIA) of Unicamp (State University of Campinas) proposes the inclusion of the emergy indices to complement the conditions considered in the certification decision. Figure 1 presents the certification flowchart with the inclusion of the calculation of these indices.

In order to conduct the emergy evaluation it is necessary to prepare a flowchart of the agricultural unit showing all the inputs and outputs of the system, as presented in Figure 2, and to collect the data for the emergy flows calculations. According to the LEIA proposal, the diagram of the farm unit will be prepared as part of the control and inspection plan, while the necessary data for the emergy evaluation of the agricultural unit will be collected during the inspection and sent to an accredited body (Unicamp), together with the results of physiochemical analyses. These data will be used in the calculations, with software now in development at LEIA, that will supply a report on the sustainability and social justice of the producing unit. Therefore, the inclusion of emergy evaluation does not represent additional cost to the certification process.

Table 1 presents the necessary data for these calculations and compares these data with data already requested for CBs. This table was elaborated based on literature papers that used the emergy methodology to evaluate agricultural production (Bardi & Brown, 2000; Brandt-Williams, 2002; Comar, 1999; Lagerberg, 2000; Lanzotti et al. 2000; Odum, 1996; Ortega et al., 2000; Ortega et al., 2002).

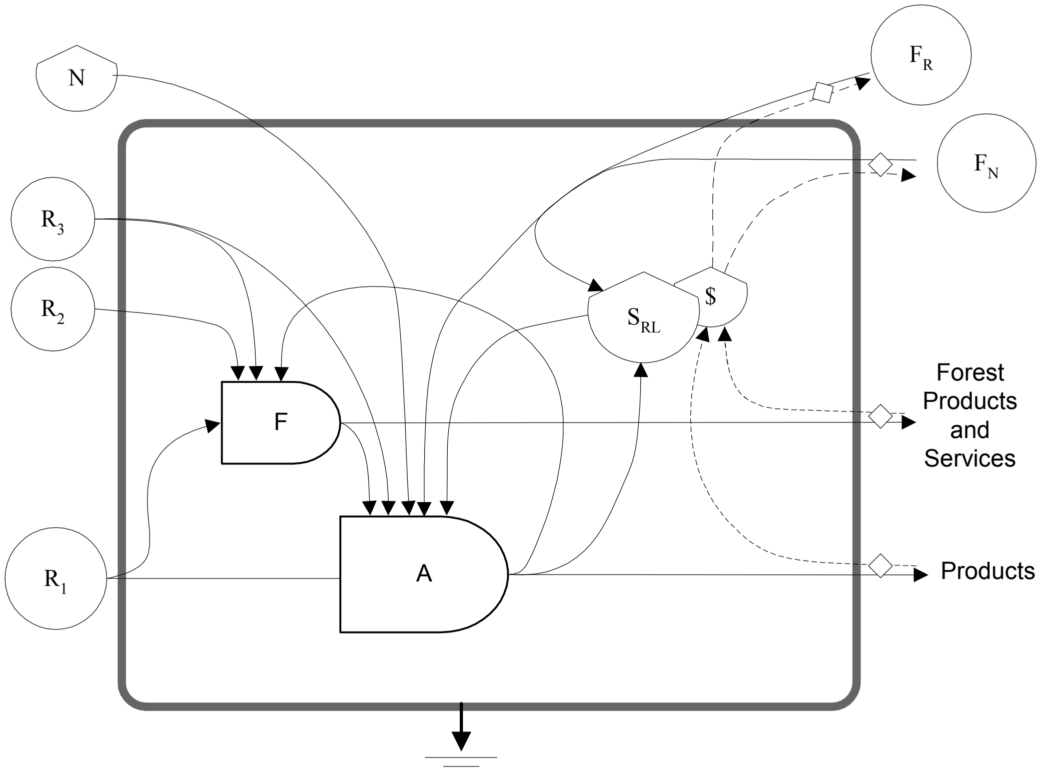

Figure 2. *Aggregated energy flows diagram of rural system with local administration. (adapted from Ortega et al., 2002). Where: F - Forest; A - Agriculture; R - Renewable resources from nature; N - Non-renewable resources from nature; F_R - Renewable Feedback from Economy (S_R+M_R); F_N - Non-Renewable Feedback from Economy (S_N+M_N); S_{RL}- Local Labor or Local Renewable Service.*

Most of these data are already requested by the certification bodies are easy to include. The data considered difficult to include in the certification process are:

- Evapotranspiration - parameter necessary for calculation of renewable resources. It depends on the climatic conditions of the area and on the type of evaluated culture. It has been calculated by simulations that consider historical data (Brandt-Williams, 2002). Such data are not available for all areas. Hence, they cannot be used in the certification process. Some authors (Ortega et al. 2002; Comar, 1999; Lanzotti et al. 2000) calculated the emergy of rain as a substitution for evapotranspiration.
- Fuel volume - hours of work classified by function and the investments in improvements. When the property is not registered (as is frequently the case with small properties), it can be easily, and in a quite reliable way, estimated (Ortega et al. 2002).

Table 2 presents the indices suggested by Ortega et al. (2002) for the evaluation of the sustainability of the agricultural activities. Ortega et al. (2002) propose the differentiation between renewable and non-renewable portions of the services and materials from the economy and the identification and segregation of local labor. They also include the externalities in the renewability calculation. In the present work the externalities are not considered since they are still difficult to estimates. However, they should be included in the future, as well as in the studies of life cycle assessment of agricultural products.

Table 1. Data required for emergy analysis and their availability status.

Needed Data	Available				Not available	
	C	T	DB	A	E	D
Farm area	X					
Evapotranspiration						X
Average insolation			X			
Eddy diffusion coefficient		X				
Wind gradient		X				
Annual precipitation			X			
Mean elevation					X	
Runoff					X	
Type of landscape	X					
Type of present vegetation	X					
Type of agricultural handling	X					
Soil organic matter				X		
Seeds:						
Types	X					
Volumes	X					
Seedling:						
Types	X					
Volumes	X					
Fertilizer:						
Types	X					
Volumes	X					
Pesticide / Herbicide:						
Types	X					
Volumes	X					
Fuel:						
Types					X	
Volumes						X
Machinery:						
Type	X					
Depreciation					X	
Manpower:						
Type of work	X					
Working hours						X
Buildings and improvements:						
Investments					X	
Depreciation					X	

Legend: C- already asked by CB; T- table data; DB – database; A- data from Analysis;
E – easy to obtain; D – difficult to obtain

POTENTIAL AND BENEFITS

The inclusion of emergy indices in the certification process supports the IFOAM recommendations, since it allows the evaluation of sustainability and social justice, to which organic agriculture is committed, while maintaining the universality of the IFOAM rule. Emergy evaluation greatly improves the ability to evaluate adherence to these rules because, even though the economic and environmental characteristics and particularities of the process and its geographic area are being considered, it supplies indices that can compare these elements on a common basis for different projects. The inclusion of emergy makes it possible to quantitatively differentiate between a family producer and a large organic monoculture enterprise (Ortega et al. 2002), both of which, under the current certification process, receive the same Organic Stamp. Such differentiation can be important for defining agricultural politics, government investments and, also, influencing consumer decisions.

The calculation of the renewable portion of each agricultural product (% R) could also be used in emergy evaluation of following stages of the productive chain, for instance to evaluate the production of orange juice. Finally, as the certification process demands regular inspections of the unit, environmental conservation and the social performance can also be regularly evaluated and monitored, allowing for effectiveness in the correction of observed deviations.

Table 2. Proposals for emergy indices (adapted from Ortega et al. 2002).

Modified Emergy Indices	**Formula**	**Concept**
Renewability *	$\mathbf{R^* = (R + M_R + S_R) / Y}$	Renewable/Total
Environmental Loading ratio*	$\mathbf{ELR^* = (N+M_N+S_N) / (R+M_R+S_R)}$	Non renewable/renewable
New Emergy Indices	**Formula**	**Concept**
Labor Services Ratio	$\mathbf{LSR = S_R / S}$	Labor/Services
Labor Empower Ratio	$\mathbf{LER = S_R / Y}$	Labor/Empower
Local Work Ratio	$\mathbf{LWR = S_{RL} / (S_R+S_N)}$	Local labor/Labor

Where: R= Renewable resources from nature; N: Non-renewable resources from nature;
M_R: Renewable Materials and Energy; M_N: Non-renewable Materials and energy; S: Services ($S=S_R+S_N$); S_R: Labor Services ($S_R = S_{RL}+S_{RE}$); S_N: Non-renewable Services ; S_{RL}: Local Renewable services; S_{RE} : External Labor Service and Y: Total Emergy
* Indicates different calculation of indices (according to Ortega et al., 2002)

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