EMERGY SYNTHESIS 4:
Theory and Applications of the Emergy Methodology

Proceedings from the Fourth Biennial Emergy Conference,
Gainesville, Florida

Edited by
Mark T. Brown
University of Florida
Gainesville, Florida

Managing Editor
Eliana Bardi
Alachua County EPD,
Gainesville, Florida

Associate Editors
Daniel E. Campbell
US EPA
Narragansett, Rhode Island

Shu-Li Haung
National Taipei University
Taipei, Taiwan

Enrique Ortega
Centre for Sustainable Agriculture
Uppsala, Sweden

Torbjorn Rydberg
Centre for Sustainable Agriculture
Uppsala, Sweden

David Tilley
University of Maryland
College Park, Maryland

Sergio Ulgiati
University of Siena
Siena, Italy

December 2007

The Center for Environmental Policy
Department of Environmental Engineering Sciences
University of Florida
Gainesville, FL

20

What is Info?
The Role of Information in Agricultural Systems

Enrique Ortega

ABSTRACT

When agricultural projects are analyzed using emergy methodology, the systems diagram recognizes an external energy source called INFO, a short expression for information and knowledge, which until now has not been calculated. However, it seems that for soybean production systems in Brazil, information is the main emergy source (the external force that defines the system). It is a paradox! The study of soybean agriculture models in Brazil revealed the existence of two different types of agricultural production: (a) ***biological farms*** *that include the models: family-managed ecological small farms and medium sized organic enterprises and (b)* ***chemical farms*** *that include the models: chemical inputs and intensive use of machinery farm, and no-till biotechnological farm. The ecological small farm option has shown the best values in emergy indices, as well as the greatest economic profit per unit of agricultural area. Then, why isn't it the model adopted in Brazil for soybean agriculture? The hypothesis of this paper is that it is due to the impact of external INFO energy. In order to uncover the INFO flow it was necessary to study the Brazilian political, financial, and legal systems and also to understand the meaning and the dynamics of technological trends imposed by multinational enterprises and the International Monetary Fund. Moreover, it was necessary to review the scientific literature about negative externalities and environmental services produced by agricultural systems. As a result of this research effort, a new generic diagram of agriculture that includes new inputs and outputs is offered for discussion, as well as basic calculations that take into consideration information and loss of environmental services and negative externalities. This new model may be of interest for those interested in a Prosperous Way Down.*

INTRODUCTION

In Figure 1 (Ferreyra, 2001) information is an external force that feeds into local human knowledge that controls the transformations that occur within a national economy. In the emergy literature, there are several valuable works written about information (Odum, 1977, 1988, 1996, 1999; Odum & Odum, 2001; Brown, 2004), but even if it is recognized as a force and represented in the systems diagram, until now its influence in agricultural systems has not been explained and measured. An important reference for emergy calculation of agricultural systems (Folio 4, Brandt-Williams, 2002), doesn't include the symbol of external information (Figure 2) and does not discuss it.

In the case of soybean production in Brazil, previous research (Ortega et al., 2005) points out that external information could be the force that defines public policy and the behavior of a great number of soybean farmers. Therefore, it is necessary to understand the concepts of information and information processing and also to discuss the possibilities of how to measure this flow.

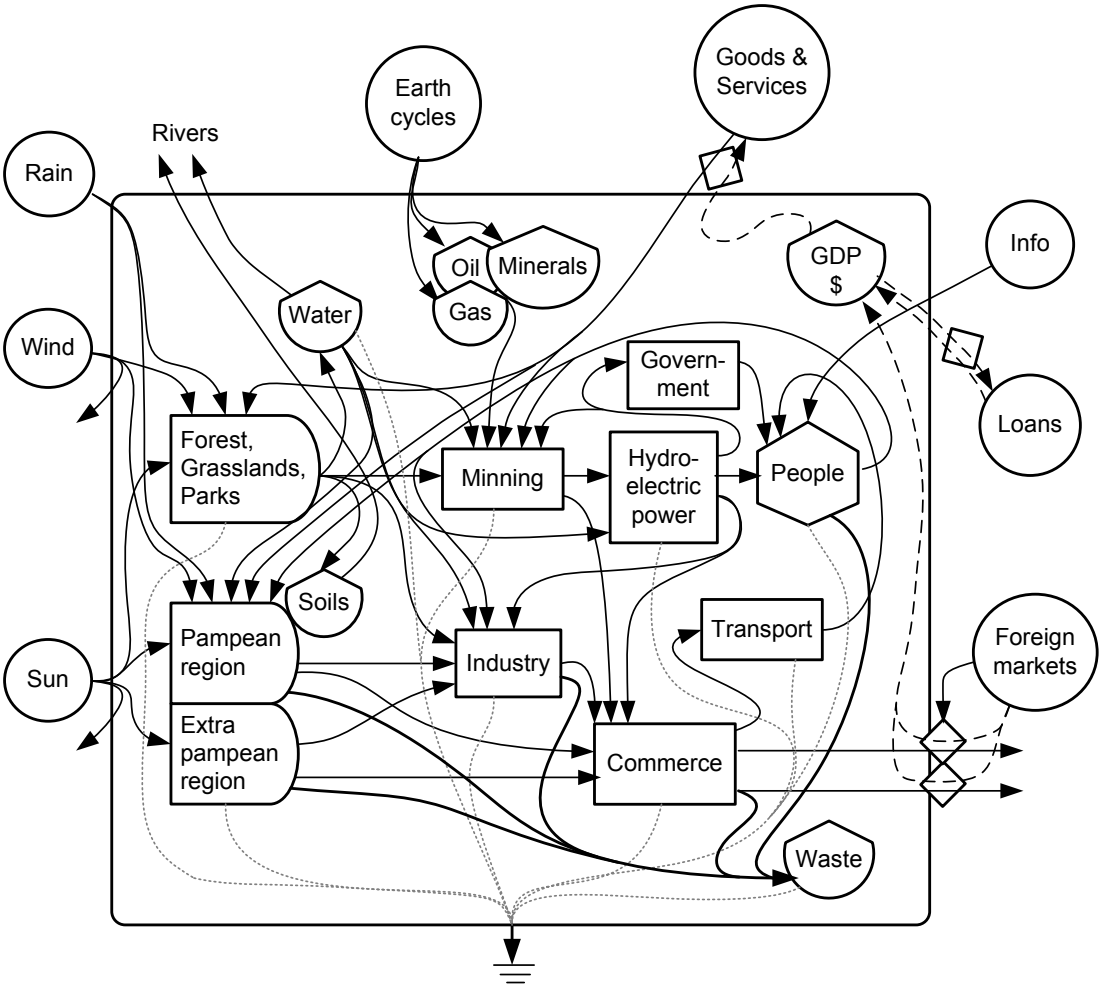

Figure 1. *Emergy diagram of Argentina (Ferreyra, 2001).*

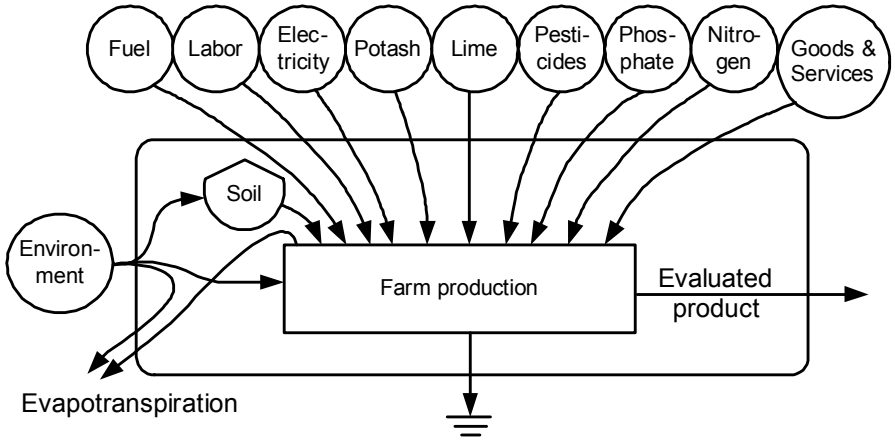

Figure 2. *Emergy diagram of Florida agriculture (Brandt-Williams, 2002).*

The Concept of Information

Human information can be defined as stocks and flows of signals, data, codes, symbols, ideas, concepts, images, emotions, feelings, smells, memories, knowledge structures, and life-style or culture produced by a system that can be interpreted and used by others. The sequence of processes through which raw data become information, knowledge, science, technology, know-how, local public policy, foreign policy, and finally norms and laws is illustrated in Figure 3. The force of information (INFO) is not neutral; it is linked to the ethical and moral values of the scientific-economic frame in which it is created. The force of knowledge does not always have positive effects on the system that receives it. For example, under present circumstances in Brazil, it often has a negative impact because it transfers most of the profits to the system that generates and controls the information.

Within the capitalism paradigm, INFO is usually understood just as new technology, but behind that neutral image there is an ideology of maximizing the return on investment, exclusion of social and environmental costs, as well as the use of powerful military forces to enforce the use of this

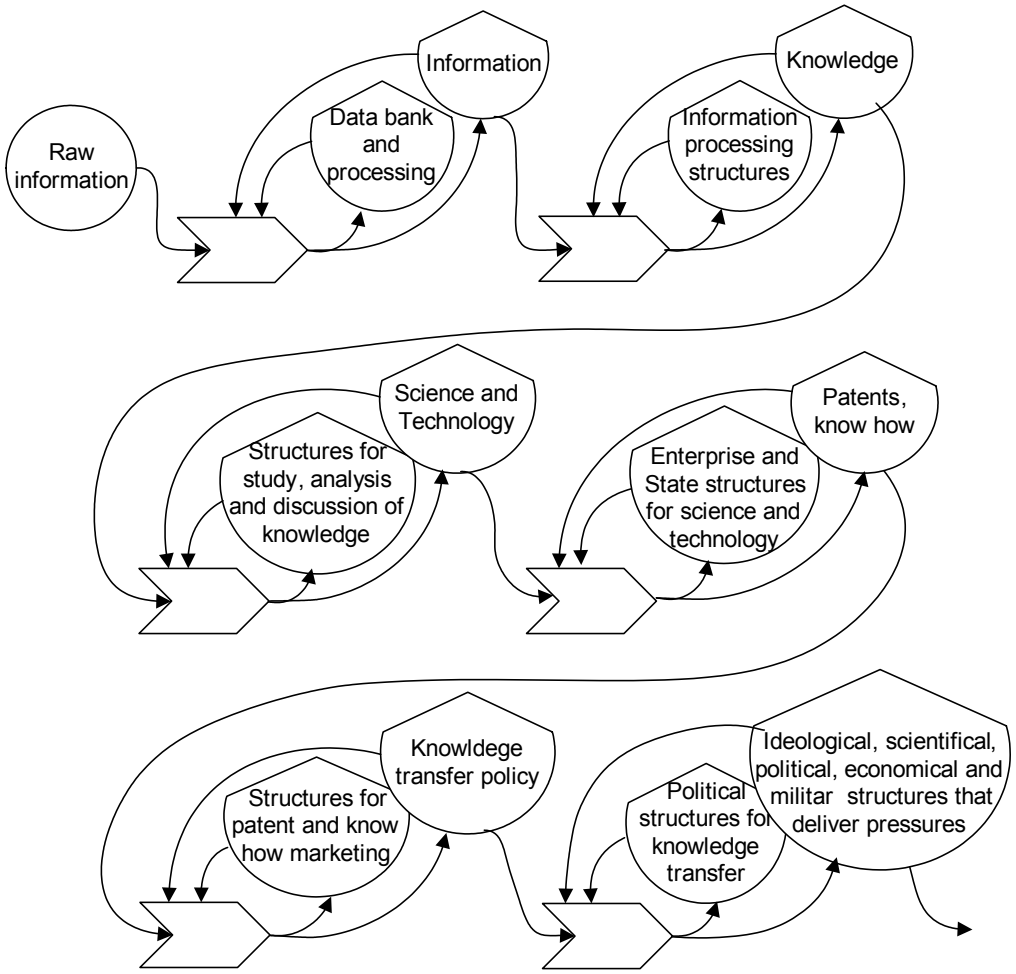

Figure 3. *Systems diagram of the transformation of information into knowledge.*

kind of INFO all over the world. The diagram in Figure 3 does not show explicitly the force of human values acting along the information pathway, but that force is implicit. INFO can be a positive force, if it belongs to a relevant ethical framework that has a clear perception of how the Biosphere and its ecosystems work. Information can be used for exploitation or for collaboration. Figure 4 compares knowledge used for dominance or for convivial interactions.

The Information Concept Applied to Soybean Farming

As is shown in Figure 5, in capitalist agriculture, INFO is basically an external force used to control an agricultural system for the benefit of the chemical and biotechnological industries of highly industrialized countries. However, in Brazil there are "local ecological agricultural traditions" and also organic farms that demand other kinds of information. Table 1 shows the link between each type of farming and the INFO that supports it.

Recently the Brazilian Congress held public hearings to discuss soybean production in order to evaluate the introduction of transgenic seeds, but only the chemical and biotechnological farming options were considered; the biological farming options were completely ignored. The main concern of the government at that time was to obtain economic resources from soybean exports to pay external debt, and in that sense, the more "practical" attitude was to support the big chemical farmers even though the small and medium sized biological farms are responsible for almost 20 percent of soybean production and provide food sustenance for the population.

Better Emergy and Economic Analyses

Emergy analysis of agricultural systems can be improved substantially if the systems diagrams include information flow and its effects on the system (see Figure 6). In the USA, soybean farmers receive direct subsidies as money deposited in their bank account. Farmers also receive indirect subsidies (as the positive effects of research and infra-structure, both supported by government) and no charges are assessed by local authorities for ecosystem destruction (ecological debt), rural exodus (social debt), climate change (atmosphere debt), or destruction of human heritage (ethical debt). What is the cost to society of these impacts? A complete emergy evaluation table will have to consider the effects of regional biodiversity, biologically fixed nitrogen, soil minerals dissolved by soil biota, increased ultra-violet radiation, excess carbon dioxide, climatic change, acid deposition, and water percolation. In addition, the specific renewability of each input should be considered as suggested by Ortega (2002). Finally, INFO should be identified and measured. This is not an easy task, because it can produce a positive or a negative effect on the receiving system, as shown in Figure 7.

A Brief Description of the Information Process

The transformation processes where raw data become information, knowledge, and finally technology transferred to other systems must be studied to discover how to measure the INFO flow and understand how it acts on the receiver. Figure 8 shows the information process at the creator and receiver sides.

The world is living a moment of strong competition. In order to overcome competitors, the social systems organize themselves to use the natural resources that deliver maximum net energy, as fast as possible. There is no concern about trade fairness, social impacts, biosphere health or nature recovery efforts; in this system the strong devours the weak. The more industrialized countries already depleted their energy resources and are now expanding their influence on other countries, to exploit the remaining natural resources, such as low priced raw materials and fuel oil. The less developed states

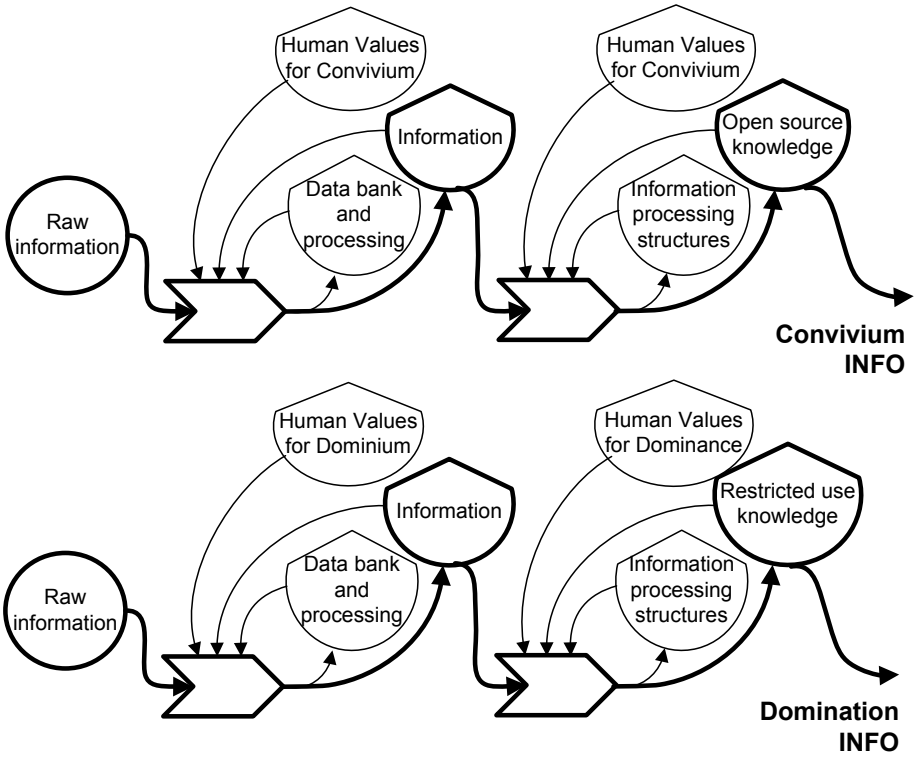

Figure 4*. Two kinds of information and knowledge configured by human values.*

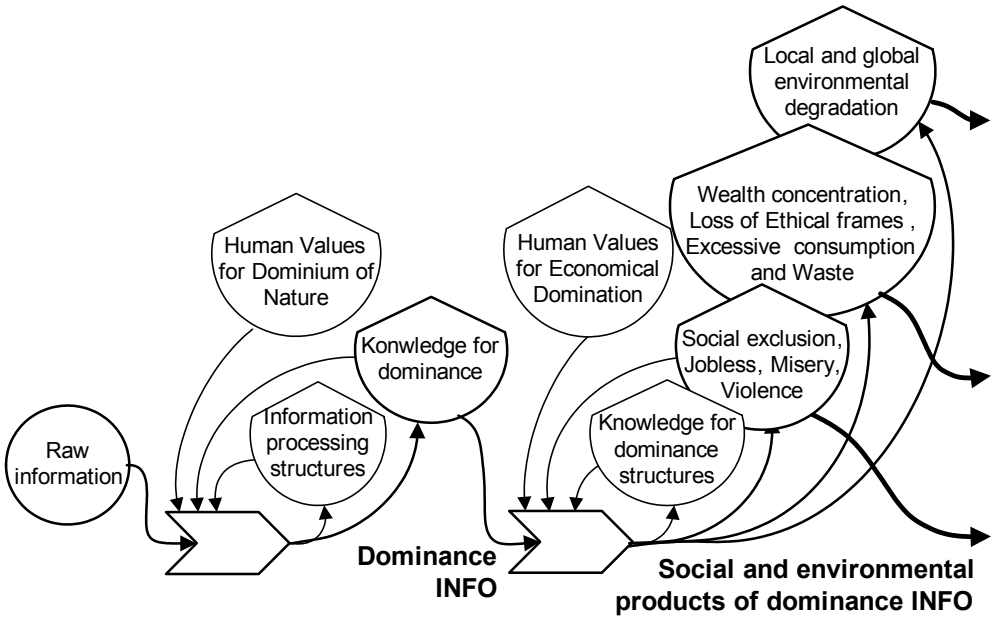

Figure 5. *Social and environmental impact of knowledge prepared for dominance. This diagram was adapted from a flow diagram prepared by Freire (2002).*

become dependent on raw materials trade and try to replicate the industrial ideology of the more developed countries.

To survive, the peripheral countries mimic the countries with central roles in the global economy. They borrow money to install infrastructure, to entice investors to produce raw materials for export and to set-up industries to process raw materials into products. These investments are made through monetary loans and later the debt payment becomes the basis of an extortion mechanism to subjugate the peripheral countries to transnational enterprises and define public policy in their favor. This process is oblivious to the real needs of the peripheral countries and their people.

It is necessary to explain that interest rates on the debt were established and afterwards raised without clear motives by the lender countries; as a result, the debt increased and became practically impossible to pay ("eternal debt"), even if it were regularly paid by the borrower. On the other side, the capital lenders created an ecological debt, a social debt, an ethical and cultural debt that could be even bigger than the economic debt, but these liabilities are not accounted for and thus never have to be paid.

As can be seen in Figure 9, INFO becomes at the receiver side corruption, omission in the application of laws, rapid change of internal regulations, modification of laws, the creation of infrastructure to benefit only part of the population, destruction of ecosystems, reduction of welfare, reduction of autonomy, and risks to the sovereignty of the nation. As a result, detrimental INFO establishes the possibility of an environmental and social collapse, both at the local and global scales.

METHODS

First of all, it is necessary to identify and characterize the actors in order to discuss how they will be affected by public policy (INFO). In Figures 3 to 9 the information mechanisms were identified and depicted. After that, it is possible to evaluate the value of destructive INFO. A first estimate can be obtained by considering the yearly expenses of the US military corps divided by the total number of countries affected by the US trade system. This coercion pressure is used to force the payment of the external debt and a great part of the revenue from raw material exports is used for that purpose.

In 2004, soybean farming in Brazil occupied 20 x 10^6 ha with a yield of 2500-2900 kg/ha and exports achieved almost 10 x 10^9 USD, at a price of 186-200 USD/ton, 38 percent of production was exported (Alice Web, 2006). After that year, the farming area increased, but at present time (2006-2007) there is an economic crisis due to low international prices.

Table 1. Type of farm, number of farmers, average farm size and supporting INFO.

Biological systems		
Ecological family-managed small farm (25,000)	10 to 30 ha	Agroecology and forestry integrated with cattle husbandry; Local markets; Environmental services.
Organic producer (500)	300 ha	Organic Agriculture, Organic foreign markets.
Chemical systems		
Petrochemical inputs small farm (500,000)	5-30 ha	Agro-chemistry; Local and external markets.
Petrochemical and pharmaceutical inputs medium farm (20,000)	300 ha	Agro-chemistry and Biotechnology; Commodities for foreign markets.
Petrochemical and pharmaceutical inputs big farm (5,000)	3000 ha or more	Agro-chemistry and Biotechnology; Commodities for foreign markets.

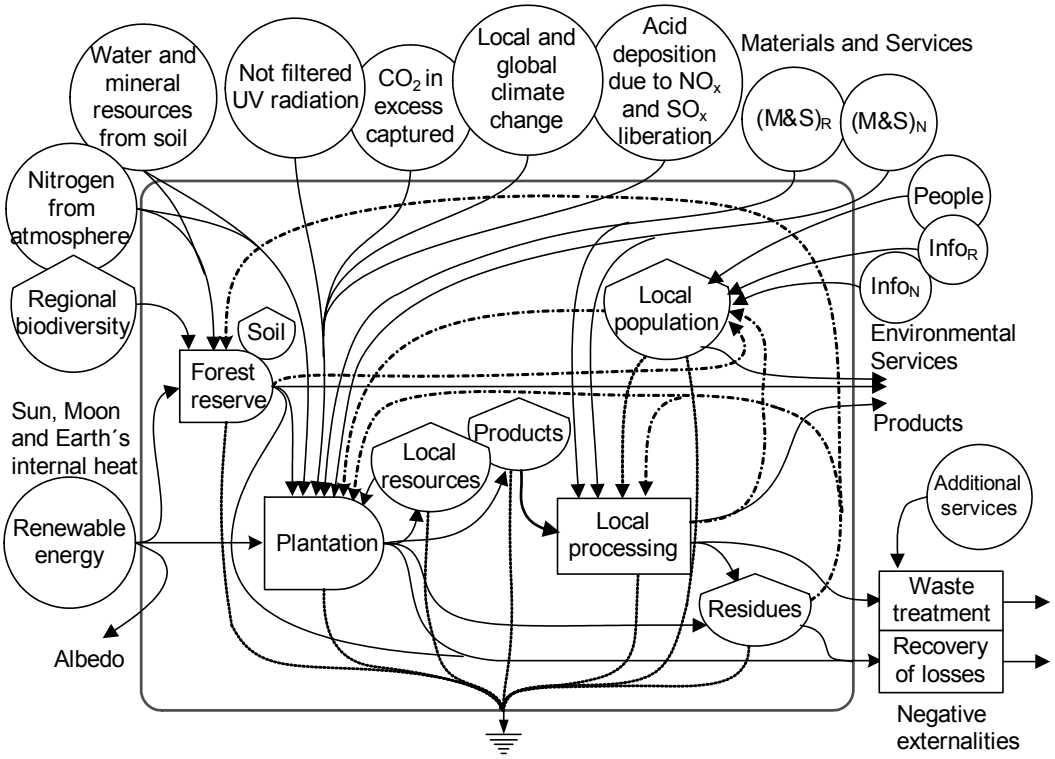

Figure 6. *Proposal of a more complete systems diagram for an agricultural system.*

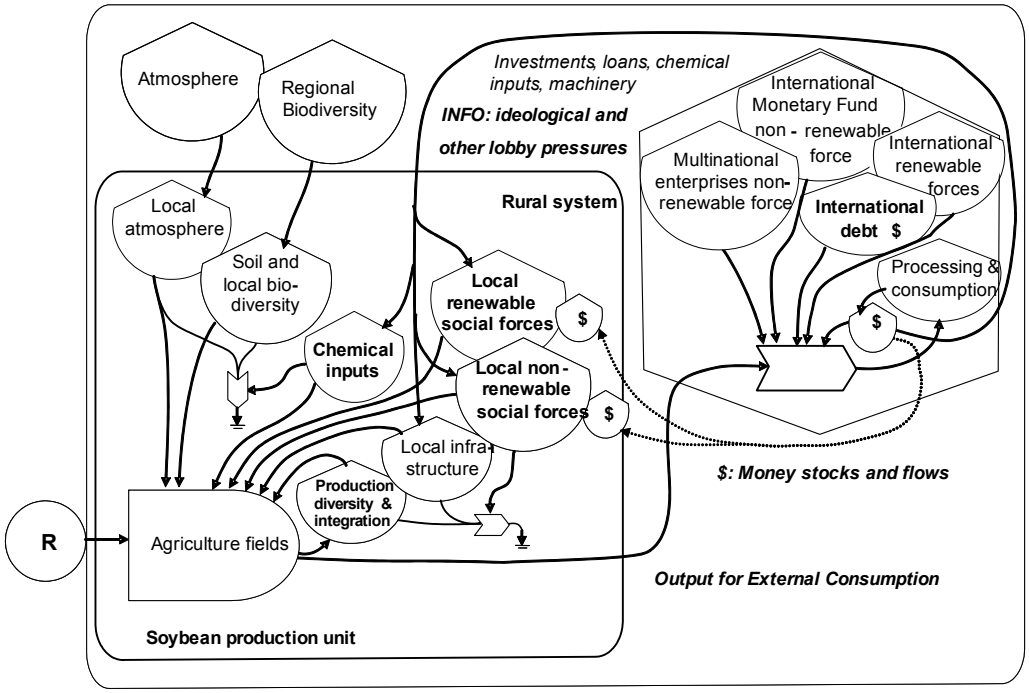

Figure 7. *Agricultural system diagram showing non-renewable INFO flow impact.*

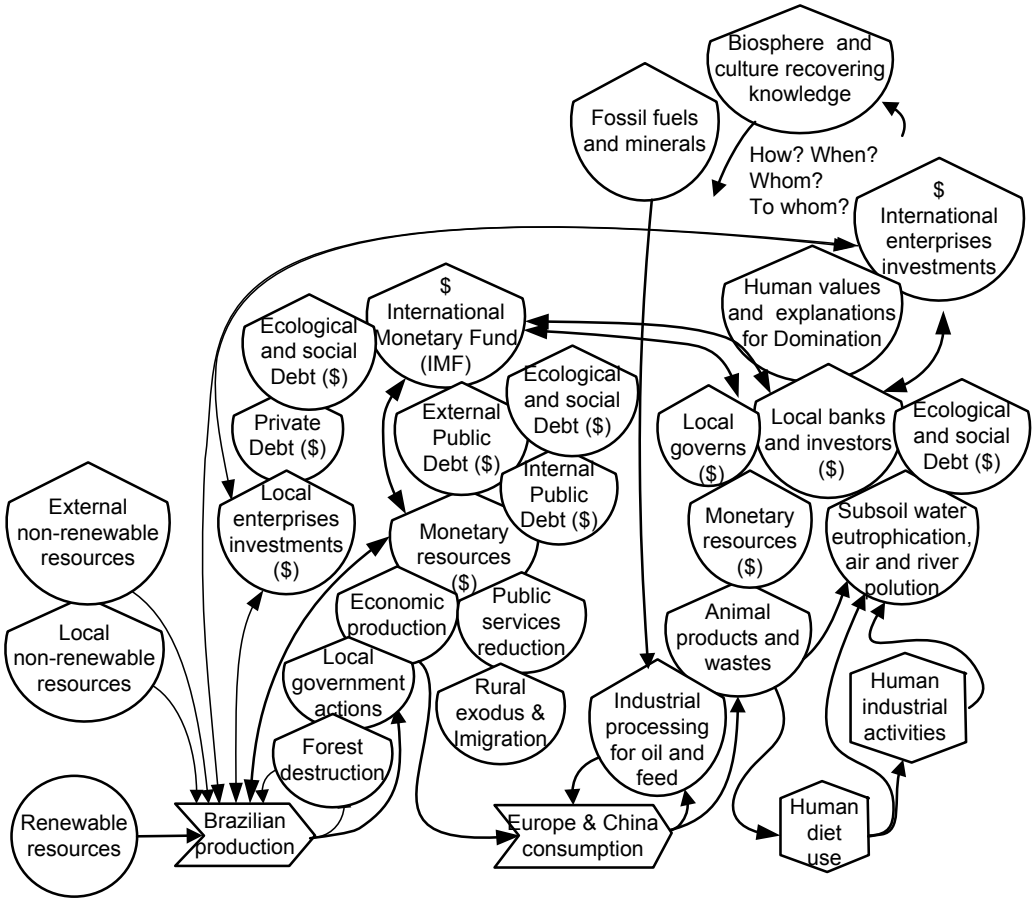

Figure 8. *Information creation at donor side and information actions at the receiver.*

RESULTS

Value of Info Pressure

The external non-renewable social force at the end of the INFO pipeline manifests itself as military pressure to other national systems. In the case of transgenic soybean seeds, Brazil suffered the menace of being considered a hostile country and was treated as those nations included in the "Axis of Evil." Therefore, the INFO value is the US military cost per farming hectare.

Military costs per country = 720 E9 USD/150 countries = 4.8 E9 USD / country.
Military costs per country / Brazilian soybean area = 4.8 E9 USD/ 20 E6 ha = 240 USD /ha/year.

For Brazilian agriculture, the "non-renewable INFO" constitutes a hidden subsidy that benefits biotechnological enterprises and chemical farmers because it creates a favorable condition for their systems growth and an adverse situation for ecological farmers. Besides that, there is the question of loss of environmental services and negative externalities. If a complete analysis of agricultural systems is desired, it is necessary to include these two issues (Ortega et al., 2005).

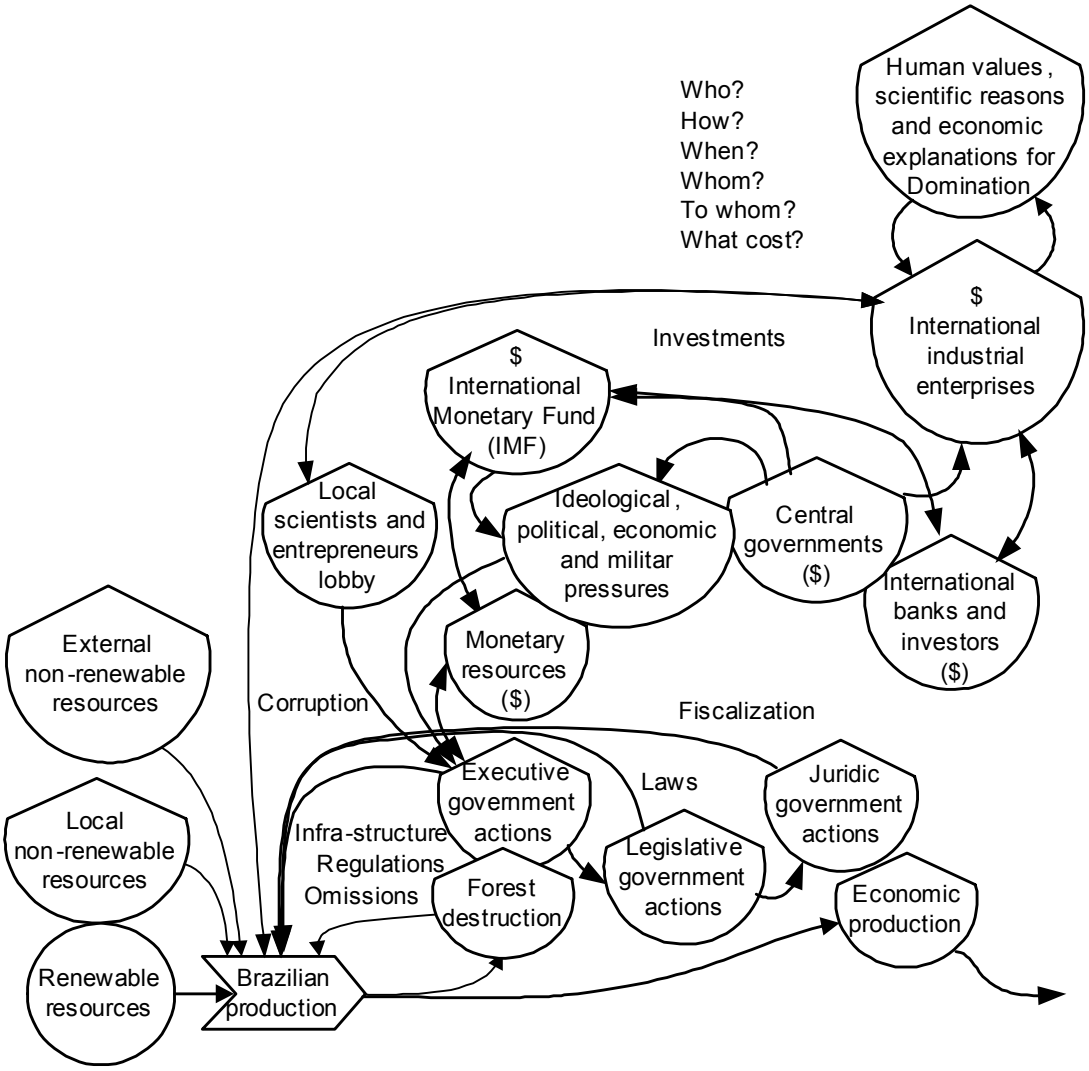

Figure 9. *How debt payment controls agricultural planning in Brazil.*

Table 2. The hidden values of chemical agriculture.

Negative externalities	360 USD/ha/year	Greater cost due to additional services.
Environmental services:	0 USD/ha/year	No ecosystem services
Military force indirect support	240 USD/ha/year	Ideological and military pressures

Table 3. The hidden values of ecological agriculture.

Negative externalities	0 USD/ha/year	No external costs
Environmental services:	400 USD/ha/year	Currently unpaid ecological services
Military force indirect support	0 USD/ha/year	Cultural damage

If the economic accounting were able to include the above mentioned additional benefits and costs to describe the farming systems in a more true form, then the economic indicators could be different, as Table 4 shows. In this table, "benefits" consider the sale of all the products and the possibility of receiving money due to the provision of environmental services (as water for aquifers, biodiversity preservation, climate regulation, conservation of landscape and cultural heritage, etc.). "Costs" include infrastructure, goods and services and, besides that, negative externalities (as pollution, human health damages, rural exodus, soil erosion, native vegetation destruction, etc.), as well as "Info," the value of information.

DISCUSSION

From a systemic perspective the ecological farm shows a better performance than the chemical farm (a total economic yield of 1100 vs. 50 USD/ha/year). However, in a traditional economic perspective both farming options are equivalent (700 vs. 650 USD/ha/year); in that case the decisive factor is farm size. Usually an ecological farmer has 15 ha of land, that means a gain of 10,500 USD per farm per year (almost 800 USD per month) and a chemical farmer with 500 ha has a yearly income of 325,000 USD per farm (almost 25,000 USD per month). Increasing size means more return per farmer even if the farms have the same benefit/cost ratio. The truth appears if externalities, environmental services, and information are accounted for. In other words, an ecological farmer should receive 400 USD/ha/year due to environmental services transferred to society and nature (e.g., percolated water, temperature reduction, carbon fixation, biodiversity maintenance and culture preservation). On the other hand, a chemical farmer should pay 360 USD for destruction of local native vegetation, pollution of soil and water, carbon dioxide emission due to fertilizer production, human exodus in rural areas (that will cause severe urban problems), and health hazards to workers and consumers. Aside from this, the ideological and military forces give an indirect support to chemical farmers (240 USD/ha/year). It can be observed that the traditional economic analysis doesn't show the real facts; it hides the subsidies and doesn't recognize the social and environmental services.

At the end of this research, it was possible to identify another important issue: global warming. Furthermore, this paper did not describe the regenerative INFO mechanisms and the calculation of their values. These factors will be discussed in future papers.

Table 4. Benefits and costs in two models of soybean farming.

	Ecological farm USD/ha/year	Chemical farm USD/ha/year
Benefits		
Soybean sales	**500**	**650**
Corn and wheat sales	**600**	**800**
Environmental services	(400)	0
Benefits	**1100**	**1450**
Total benefits	**1500**	**1450**
Costs		
Production costs	**400**	**800**
Negative Externalities	(0)	(360)
Ideological and military pressures (**INFO**)	(0)	(240)
Costs	**400**	**800**
Total costs	**400**	**1400**
Yield		
Economic yield	**700**	**650**
Total economic yield	**1100**	**50**

CONCLUSIONS

The inclusion of values for non-renewable INFO (ideological-military pressures) and also the ecosystem services and negative externalities in emergy and economic analyses improve the perception of the real benefit/cost ratio and the thermodynamic performance of farming systems. It can be argued against these arguments and results that chemical farming systems produce positive externalities in urban areas (working places in chemical industries), but because these benefits depend on fossil fuels they are not sustainable. This kind of INFO is really ignorance.

From the other point of view (renewable INFO), it would be more beneficial for a country to develop ecological farming methods and to focus on providing food, water, fiber, and energy for their own people than to export at low prices and huge hidden cost of nature destruction, cultural degradation, and global climate damage.

REFERENCES

Alice Web (2006). Internet Analysis System of Foreign Commerce Information, MDIC, Brazilian Government. Consulted in June 30, 2006. http://aliceweb.desenvolvimento.gov.br/default.asp

Brandt-Williams, Sherry L. (2002) Folio #4 (2nd printing): Emergy of Florida Agriculture. August 2001, revised: September 2002. Center for Environmental Policy. Environmental Engineering Sciences, Box 116450 University of Florida, Gainesville, 32611-6450.

Brown, Mark T. (2004). Emergy, Emformation (?), and Ecosystem Health. Emergy Synthesis. Proceedings from the Third Biennial Emergy Analysis Research Conference, 2002. Center for Environmental Policy. Box 116450 University of Florida, Gainesville, 32611- 6450.

Ferreyra, Maria Cecilia; 2001. Emergy perspectives on the Argentine economy and Food production systems of the rolling pampas during the twentieth century. Master of Science Thesis. University of Florida, Gainesville, USA.

Freire Dias, Genebaldo (2002) Introdução à Temática Ambiental. Editora Gaia, São Paulo. Brasil.

Odum, H. T. (1977). The ecosystem, energy and human values. Zygon (Journal of Religion and Science) volume 12, number 2, pages 109-133, June. Blackwell Publishing, Inc.http://www.blackwell-synergy.com/toc/zygo/12/2

Odum, H. T. (1988). Self-organization, transformity, and information. Science (Washington) Vol. 242, no. 4882, pp. 1132-1136.

Odum, H, T. (1996). Environmental Accounting: Emergy and environmental decision making. John Wiley & Sons, Inc., New York, USA.

Odum, H. T. 1999. Limits of information and biodiversity. Sozialpolitik und Okologieprobleme der Zukunft. Austrian Academy of Sciences (Centennial), Vienna, Austria. Pages: 229-269.

Odum, H. T. & Odum, E. C. (2001). The Prosperous Way Down: Principles and Policies. University of Colorado Press, USA.

Ortega E., Anami, M.H., Diniz, G., 2003. Certification of food products using Emergy Analysis . Proceedings of Third International Workshop Advances in Energy Studies, S. Ulgiati (Editor) SG Editori, Padova, Italy, pages 227-237.

Ortega E., Cavalett, O., Bonifacio, R. and Watanabe, M., 2005. Brazilian Soybean Production: Emergy Analysis with an Expanded Scope. Bulletin of Science, Technology & Society, Vol. 25 No. 4: 1-11.