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Comparison of Emergy Indices of Organic and Conventional Horticulture Systems in Brazil

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ABSTRACT

Emergy evaluations of horticultural systems were carried out in three family-managed farms located in Ibiuna County and in the horticulture subsystem of Yamaguishi Eco-Village in Jaguariuna County, both in the state of Sao Paulo, Brazil. The emergy indices of these systems were compared to those obtained in five organic horticultural systems located in the highland area of the state of Rio de Janeiro, studied by Nobre Junior (2009). The results obtained in Ibiuna and Jaguariuna farms study were: Total Emergy (Y) varying from 1.91E+16 to 5.31E+16 seJ.ha^{-1}.year^{-1}, Transformity (Tr) ranging from 1.27E+06 to 3.96E+06 seJ/J, Renewability (Ren) from 17% to 55%, EYR from 1.20 to 2.21, EIR ranging 0.83 to 4.95, ELR indice showed a great variation for organic a range from 0.83to 1.38 and for conventional from 4.25 to 4.96, EER showed a great variation from 0.03 to 2.86. In the Rio de Janeiro studies made by Nobre Junior(2009) the results were: Y= 1.72 to 6.24E+17, Tr= 6.72E+06 to 3.14E+07 , Ren= 60% to 85% , EYR = 2.45 to 6.82, EIR = 0.17 to 0.69, ELR = 0.17 to 0.69 and EER= 1.93 to 12.09. The indices Y, Tr, Ren, EYR for Ibiuna and Jaguariuna systems show less sustainability than in the Rio de Janeiro systems. The emergy indices of all the system studied were organized according to the intensity of energy (EIR) and this plot revealed performance trends related with the sustainability of horticultural system. The results of these analyses will be offered to the municipal government of Ibiuna in order to be used in a program for sustainable agriculture production through the reduction of the pesticides and chemical fertilizers usage.

INTRODUCTION

In Brazil the chemical industry offers a technological package to small farmers in order to “improve the development” of their properties. Although the adoption of technological innovations resulted in an increased productivity, it did not necessarily resulted in more income for the farmers (Lima Neto, 2001). With the adoption of intensive use of machinery, chemical fertilizers and pesticides, the productivity (kg.ha^{-1}.year^{-1}) increased, but on the other hand, crops prices went down and it was possible to witness soil degradation, erosion and rural exodus.

The organic production is an important strategy for sustainable agriculture as it avoids the use of costly and dangerous industrial chemicals, it improves the quality of food crops and provides control along the entire production chain through the certification process that is requested to be recognized like an organic product (Castellini et al., 2006). This model of organic production is based on the substitution of the chemical inputs for biological ones. (Gusman et al, 2000).

The Ibiuna County is located near Sao Paulo city and comprises an area of 1023 km^2. It has about 73400 inhabitants and the city is 152 years old. 67% of its population lives in the rural area and only 33% live in the urban area. Agriculture is a traditional activity in this county, and it is responsible for almost 30% of its economy (SEADE, 2009). Agriculture has been practiced for many decades in the region but some families have abandoned the farms and moved to the urban areas due to the increase of production costs, the decrease of prices of agricultural products and the criminality increase in the rural area. In recent years, some farmers have become worried about the overuse of chemical fertilizers, pesticides and soil degradation, and also become aware of the market potential for organic products, and then they decided to adopt organic farming (Prefeitura Municipalde Ibiuna, 2008). Thus nowadays the county has several farmers that are using organic methods, others that continued to practice conventional production and some who work with both production systems.

The Ibiuna County supplies both the city of Sao Paulo and many other important cities in the surrounding area with horticulture goods and environmental services. This county is also responsible for the maintenance of a state protected forest reserve that produces the water of Jurupara River basin which is an important water supply for the city of Sao Paulo metropolitan region.

The objective of this work is to carry out an emergy evaluation in 3 properties in Ibiuna: (1) Novo Mundo Farm that is organized in two subsystems (organic and conventional), (2) Joao Dias Farm that is an organic system and (3) Nakajima Farm that is a conventional production system, and finally (4) a complex ecological farm that has a horticulture production subsystem (Yamaguishi) in Jaguariuna county, 30 km far away from Campinas. As additional objective the emergy indices of Ibiuna and Jaguariuna counties were compared to horticultural systems studied by Nobre Junior, (2009), in the highland area of the state of Rio de Janeiro.

METHODOLOGY

Case Study

Figure 1 shows the location of Ibiuna and Jaguariuna in Sao Paulo state, Brazil. A brief description of each of the systems studied is given below. It was observed that the horticultural systems produce cabbage, lettuce, tomato, parsley, chives, broccoli carrots, chicory endive, spinach, mint, basil and others.

Novo Mundo farm

Novo Mundo farm was chosen because it has both productions, organic and conventional. The whole property has 79.3 ha. An area of 25.5 ha has been used for organic production since the year2000. In other part of the farm, a piece of land of 53.8 ha, the owner continued using its conventional production. The geographical location is: altitude of 922 m above sea level; latitude:

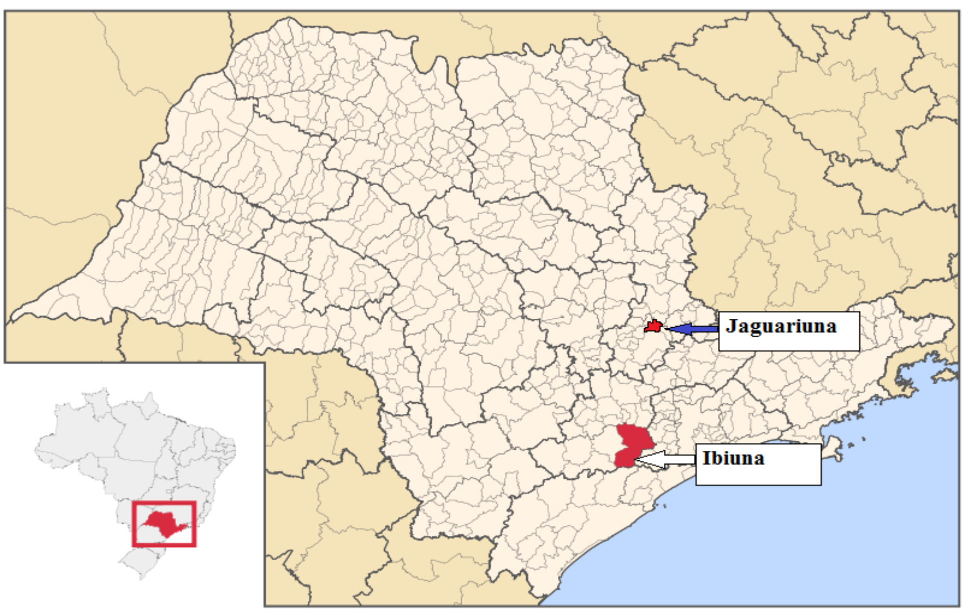

Figure 1. *Location of Ibiuna and Jaguariuna in Sao Paulo State. Source: http://commons.wikimedia.org/wiki/File:SaoPaulo_Municip_Ibiuna.svg (modified by author).*

23 º45'29"S and longitude: 47 º 14'18 ". Novo Mundo farm sells its products directly to organic product stores and through an agricultural cooperative that supplies the metropolitan area of Sao Paulo, Santos, Campinas and Sorocaba regions.

Joao Dias farm

A farm located in the Verava neighborhood of Ibiuna. The geographical location is: altitude of 922m above sea level, latitude 23 º 47'03"S and longitude 47 º05'46 W". This farm is managed by the family members that also work in other agricultural activities. During short periods of the year when farming demands more labor, the land owner contracts in partial time regime a few workers. This region is in the humid tropical forest area close to the sea and the surrounding vegetation is quite dense. This property sell its production in the regional cooperative.

Nakajima farm

Nakajima farm is located in the Paruru neighborhood in Ibiuna County. The geographical location is: altitude of 922 m above sea level, latitude 23 º 40'23"S and longitude 47 º 20'46"W. This property uses the conventional agrochemical methods in the production of vegetables, based on chemical inputs such as fertilizers and pesticides. It is the most common farm model in the region, in which the family lives in the property and has the help of 18 workers who live in the small towns in the rural area. This property sells its products in full to the regional cooperative.

Yamaguishi horticulture system

The "Yamaguishi farm" is an ecological community that is characterized by agro-ecological production. This ecovillage has 19 adults and 5 children as permanent residents. All the adults perform activities in the farm, in agricultural and administration work. The farm is organized as a business enterprise and uses the labor hand of 12 agricultural workers that do not live within the property. The site studied for evaluation of horticultural subsystem (10 ha), is located in Jaguariuna, Sao Paulo, Brazil. The geographical coordinates are altitude of 621 m above sea level, latitude 22^{o}42'24"S and longitude 47^{o}59'50"W.

One interesting characteristic of Yamaguishi Village is that they follow the philosophy of "Yamaguishi movement" that seeks harmony between nature and human actions. There are "Yamaguishi farms" in Brazil, Switzerland, Germany, U.S., Korea, Thailand, Australia and Japan. During 40 years in Japan these villages have gathered many volunteer families that live together without ostentation. Housing, food and clothing are all free for families. There are no salaries to family members and there are no bosses, the profit is divided among all the people who live in the village and everyone knows the work they should do(Takahashi et al, 2008).

Data Collection and Emergy Accounting

A list of questions shown in Appendix A was prepared to obtain raw data from the administrator. During the interview, data was collected related to production, inputs, infrastructure, products, packaging and product sales.

The evaluation of emergy performance of the organic and conventional production systems studied was performed using three methodological steps: a) development of a systems diagram; b) elaboration of the emergy table; c) discussion of emergy indices (Table 1) according to Odum (1996) and Brown & Ulgiati (2004), considering the partial renewability proposed by Ortega et al (2002).

RESULTS AND DISCUSSION

Diagrams in Figures 2 to 6 describe the processes of 5 systems in 4 properties. Figure 2 and Figure 3 show organic and conventional production in Novo Mundo Farm. Figure 4 shows organic production in Joao Dias farm and Figure 5 portrays conventional production in Nakajima farm. Finally, Figure 6 shows the agro ecological vegetable production subsystem in Yamaguishi Village.

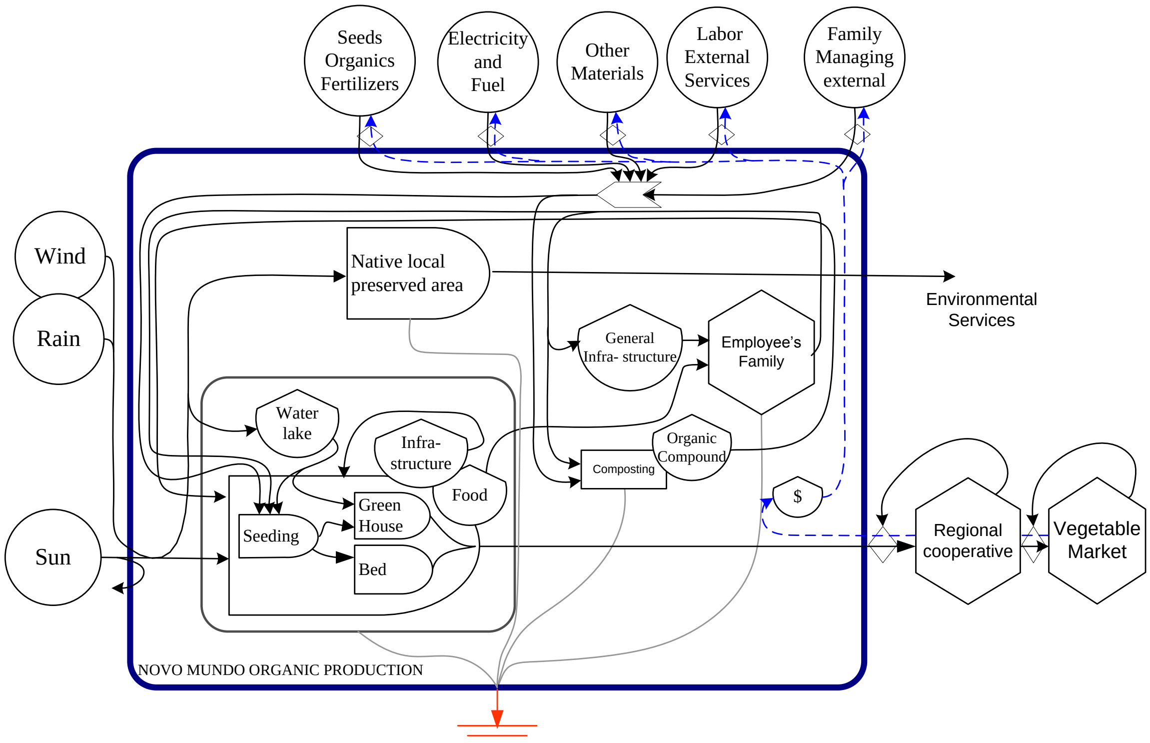

Figure 2. *Diagram of Organic Production in Novo Mundo Farm.*

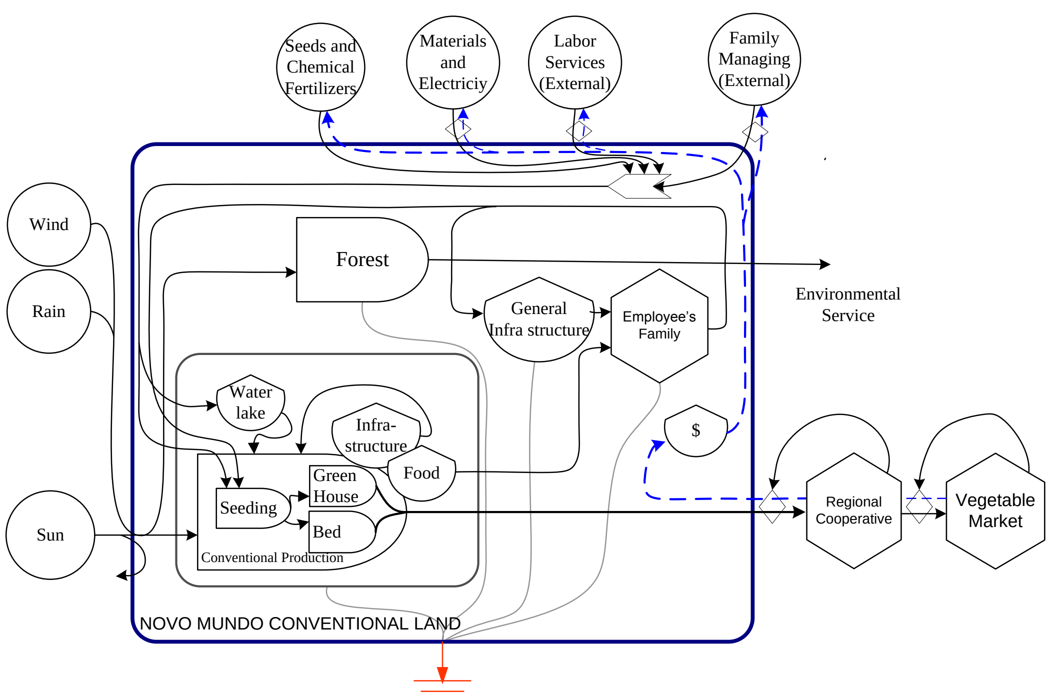

Figure 3. *Diagram of Conventional production in Novo Mundo Farm.*

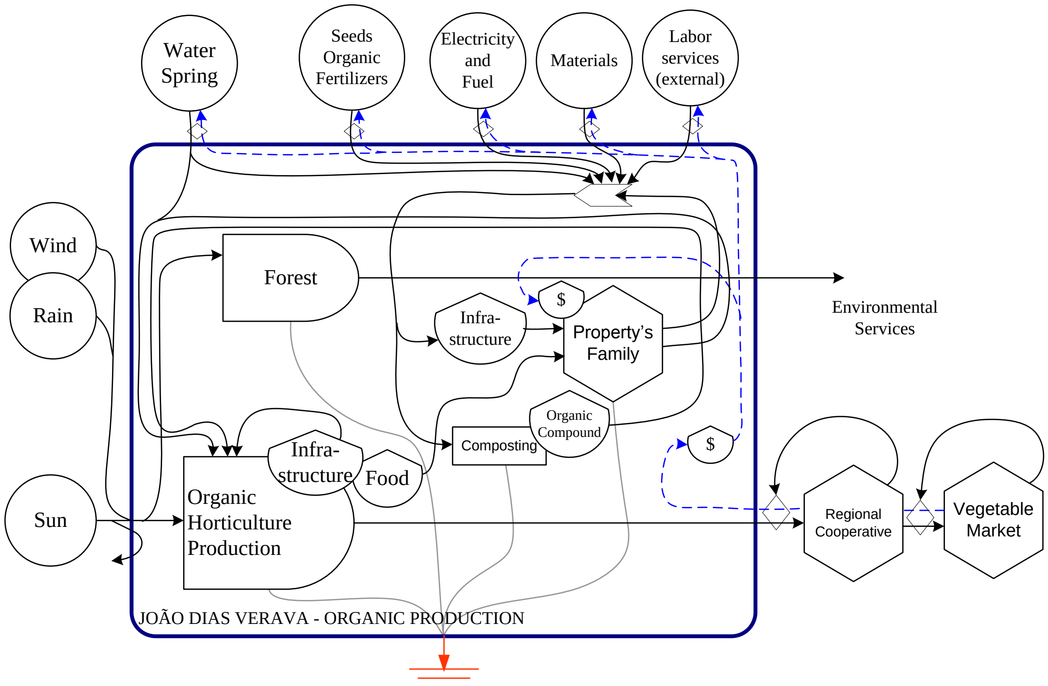

***Figure 4**. Diagram of organic production in Joao Dias Farm.*

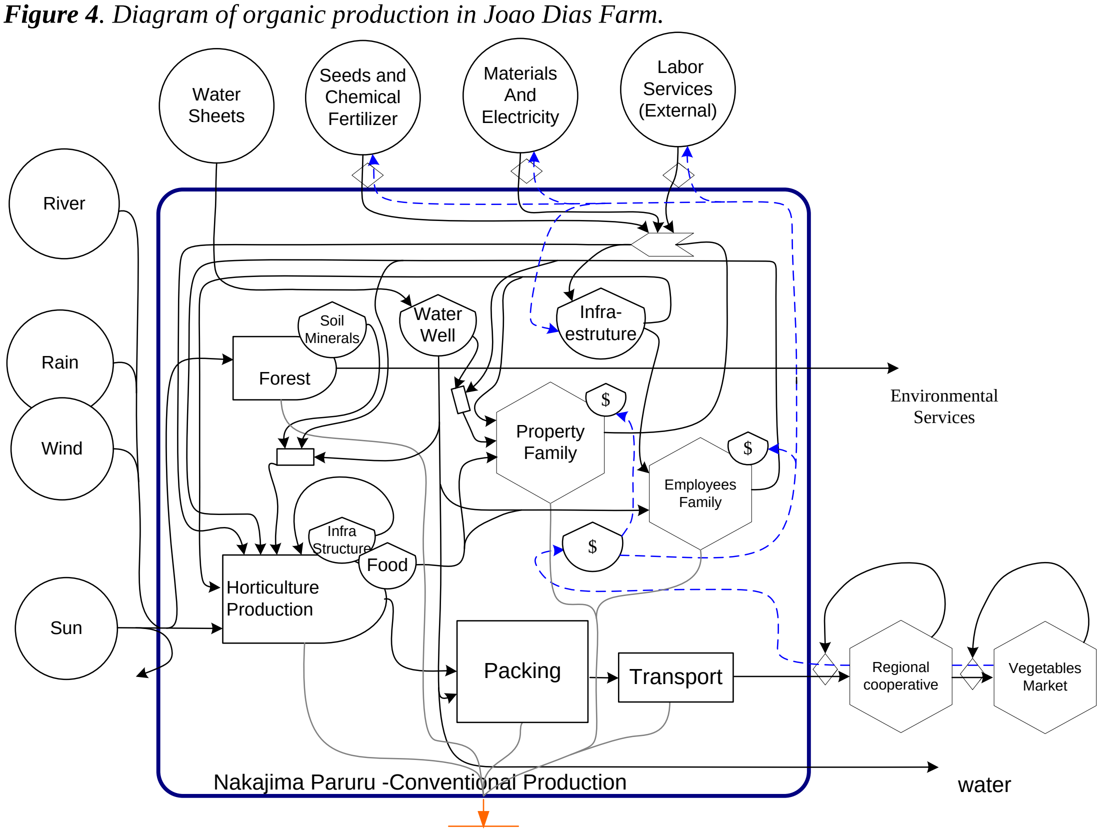

***Figure 5**. Diagram of Conventional Production in Nakajima farm.*

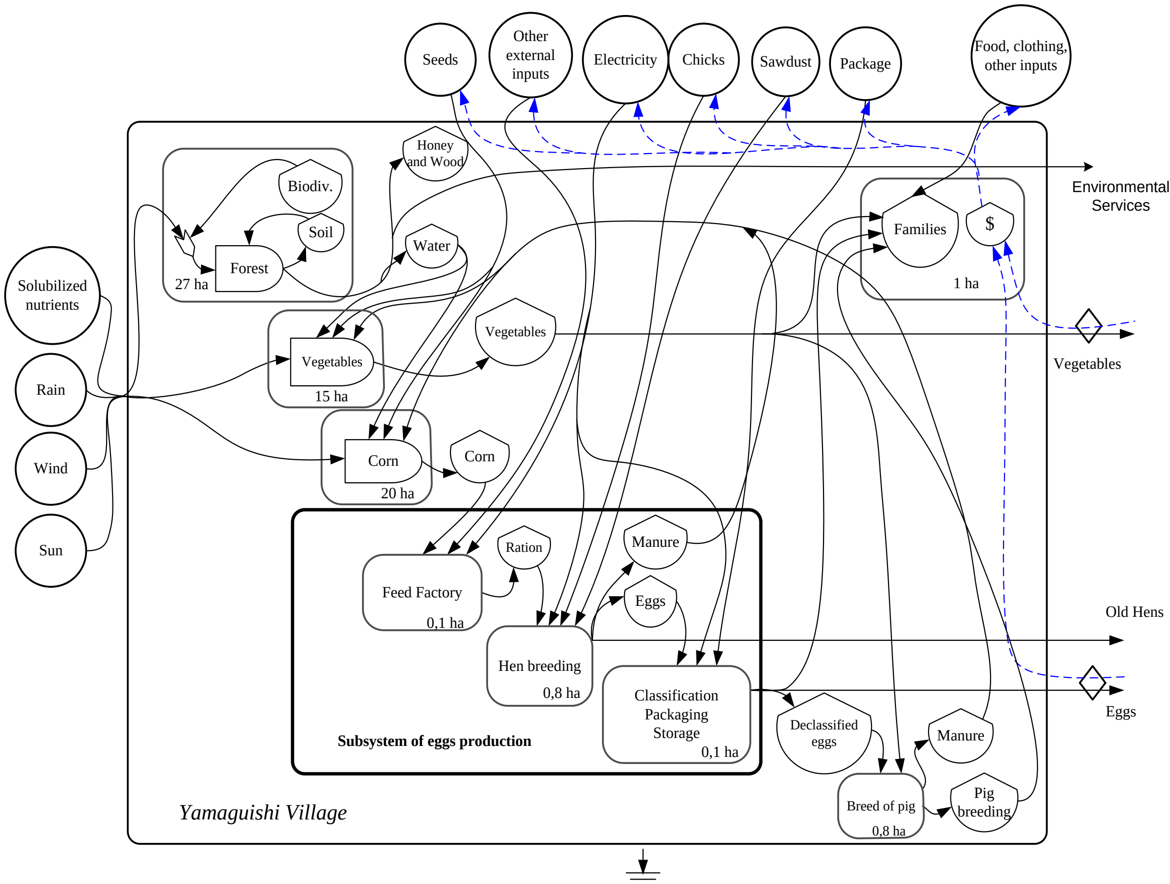

***Figure 6**. Diagram of ecological production in Yamaguishi Village (Takahashi et al, 2008).*

Table 1. Emergy Indices used in this work.

Indices	Equation	Reference
Solar Transformity	Tr = Y/Qp	Odum,1996
Renewability	$R=(R+M_R+S_R/Y)x100$	Ortega et al.,2002
Emergy Yield Ratio	$EYR = Y/(M_N+S_N)$	Ortega et al.,2002
Emergy Investment Ratio	$EIR =(M_N+S_N)/(R+N+M_R+S_R)$	Ortega et al.,2002
Environmental Loading Ratio	$ELR = (N+M_N+S_N)/(R+M_R+S_R)$	Ortega et al.,2002
Emergy Exchange Ratio	EER = Y/(US$ * seJ/US$)	Odum,1996

In the appendix the emergy evaluations are shown in Tables 5 to 9. After these evaluations, the aggregated emergy flows were calculated and the results are shown in Table 2.

Transformity. There was no significant difference in Ibiuna and Jaguariuna systems (the emergy performance is similar in both conventional and organic production). In general for organic production the transformity range is 1,300,000 to 2,500.000 seJ/J. As shown in Figure 7 Joao Dias Farm and Novo Mundo conventional farm had the values above this range. That occurred because the emergy entrance is high and the energy produced is lower than the other sites as seen Table 2. When these data are compared with Nobre Junior's data (Table 3) it is possible to see that the efficiency obtained in the properties evaluated by this author, are higher than those obtained in this study.

Table 2. Aggregated Emergy flows in seJ/J x 1E+13.

	Inputs and services	Ibiuna				Jaguariuna
		Novo Mundo		Joao Dias	Nakajima	Yamaguishi
		Organic	Conventional	Organic	Conventional	Agroecological
R	Renewable natural resources	572	572	1158	583	222
N	Non-renewable natural resources	3	3	3	3	3
I	Nature contributions	575	575	1161	586	225
M	Materials	2044	4521	2619	1253	302
MR	Renewable materials and energy	265	171	717	169	23
MN	Non-renewable materials and energy	1779	4350	1902	1084	279
S	Services	2692	3409	926	2672	1377
SR	Renewable services	1274	685	303	107	795
SN	Non-renewable services	1141	2724	623	2564	582
F	Economy Resources	4735	7929	3545	3924	1680
Y	Total (Y)	5311	8504	4706	4510	1905
	Energy Produced in J	2.15E+10	2.04E+10	1.69E+10	2.14E+10	1.49E+10

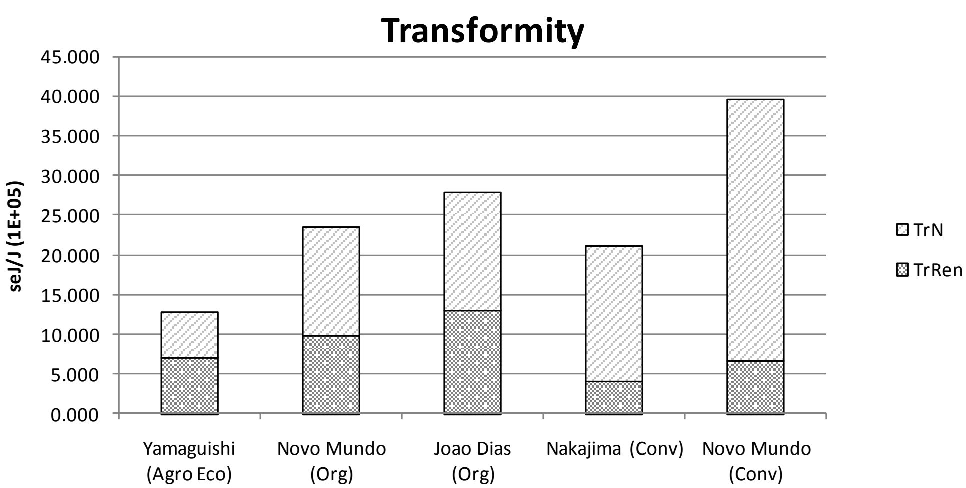

***Figure 7**. Transformity Graphic.*

Table 3. Emergy Indices obtained in this work.

Indicator	Units	Ibiuna				Jaguariuna
		Novo Mundo		Joao Dias	Nakajima	Yamaguishi
		Organic	Conventional	Organic	Conventional	Agroecological
Solar Transformity	seJ/J	2.47E+06	3.96E+06	2.79E+06	2.11E+06	1.27E+06
Emergia específica	sej/kg	3.63E+12	1.06E+13	5.64E+12	7.35E+09	2.81E+12
Emergy Yield Ratio	none	1.82	1.20	1.86	1.24	2.21
Emergy Investment Ratio	none	1.38	4.95	1.16	4.23	0.83
Environmental Loading Ratio	none	1.38	4.96	1.16	4.25	0.83
Renewability	%	40	17	46	19	55
Emergy Exchange Ratio	none	0.98	2.86	0.42	1.03	0.03

Table 4. Emergy Indicators of the studied farming of Highland Area of Rio de Janeiro.

Indicator	Units	Região Serrana Rio Janeiro [1]				
		1	2	3	4	5
Solar Transformity	seJ/J	3.14E+07	1.67E+07	6.27E+06	3.06E+07	#
Emergia específica	sej/kg	1.99E+10	1.59E+10	2.56E+10	2.62E+10	#
Emergy Yield Ratio	none	2.45	5.99	3.48	6.65	7
Emergy Investment Ratio	none	0.69	0.2	0.4	0.18	0
Environmental Loading Ratio	none	0.69	0.2	0.4	0.18	0
Renewability	%	59	83	71	85	#
Emergy Exchange Ratio	none	1.93	6.12	2.29	12.09	8

[1] Nobre Junior (2009)

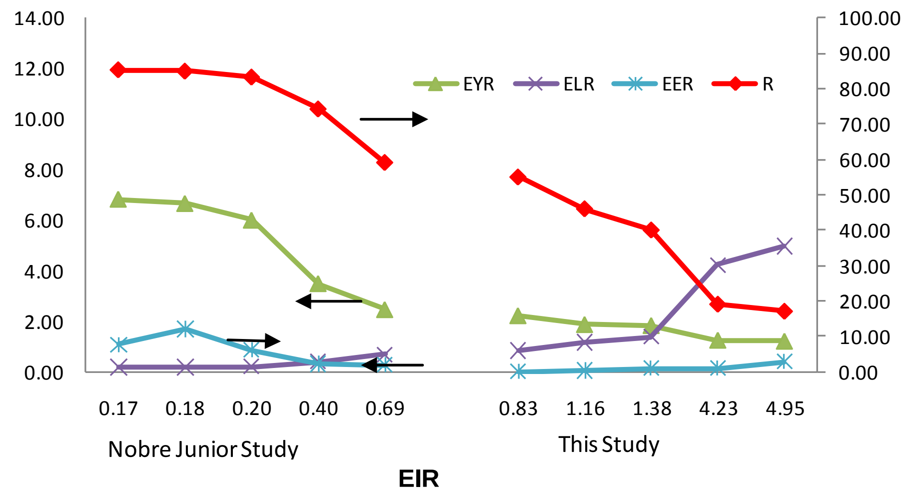

Figure 8. *Comparison of the emergy indices; this study and Nobre Junior (2009) study.*

In Figure 8, it's possible to have the general view about all the systems studied including those studied by Nobre Junior (2009).

When the data from this study is plotted considering also Nobre Junior(2009) data, observe the trends of emergy indices according to the energy intensity ratio of the farms (EIR). Figure 8 shows that some emergy indicators decrease with the energy intensification, a decline is observed in renewability and yield (EYR). On the other hand the loading rate (ELR) increases.

These facts can be explained because the systems studied in Ibiuna and Jaguariuna are very intensive and the organic production still depends on external economy resources. The main difference in the Rio de Janeiro highlands farms studied by Nobre Junior (2009) is that for these farms the dependence on economy resource is little and as the market demand is low, there is no need to increase the productivity to attend it.

In the case of the emergy exchange ratio (EER), Figure 8 allows to discover the behavior in Sao Paulo systems, this value is low (between 0.03 and 2.86) and in Rio de Janeiro system is high (1.93 to 12.09). These values reveal that where the horticulture activity is very intense, the systems are supported by a high trading volume with low prices therefore the farmers are forced to increase the productivity using more chemical these farmers are not using renewable materials inflows. The less intensive systems are ecological and because of that, they are able to obtain renewable material from nature at no cost; they are able to produce using lower quantities of non-renewable resources from economy system. Their products contain more free renewable emergy. The price of products should be higher to balance the exchange (EER=1).

The behavior of horticulture farms indices showed in Figure 8 shows the tendency for sustainability in Southeastern Brazil. To become more sustainable it will be necessary to reduce the dependence from economy inputs with more ecological techniques.

CONCLUSION

This research showed that organic and agroecological systems have better results on environmental performance than conventional agro-chemical farms.

It can be noticed that the sustainability analyzed in terms of renewability has much higher values in the Rio de Janeiro systems, where activity is less energy intensive and production does not dependent on the resources from the economy, than the Sao Paulo systems.

The farms under study in Sao Paulo sell their products to a very structured and big market, on which demand imposes a high productivity to farmers, making them more dependent on the economic system rules. Therefore, in order to improve the renewability it is necessary to use fewer non-renewable resources from the economy and more renewable resources from nature.

In order to achieve a sustainable horticulture production along with a meaningful environmental contribution, it is necessary to discuss, promote and generate public policies which can support organic farming in order to make it more feasible.

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Appendix 1

Unstructured questionnaire for owners.

- Area of property
- Geographic Location.
- Number of people living in the area
- Number of employees
- Wage Employee
- How is the production process
- What are the product
- What is the output of each product.
- What are the inputs that are used for production and the quantity of each.
- The electric power consumption
- Fuel consumption.
- Water consumption and what is the origin
- The infrastructure of the property

APPENDIX 2

Table 5. Emergy Table for Organic Prodution in Novo Mundo Farm.

1	2	3	4	5	6		7			8			9
		Input Data		Renewable Fraction	Flow		Transformity			Emergy Flow			Em$
Note	Item	Value	Unit.ha^{-1}.year^{-1}	Centesimal	Value	Unity	value	seJ.Unit-1	Reference	Renewable	Non Renewable	Total	
I	**NATURAL RESOURCE**												
R	**Renewable**									**2.48E+15**	**0.00E+00**	**5.72E+15**	
1	sun	5.53	kwh	1	6.18E+13	J	1.00E+00	J	Odum,1996	6.18E+13	0.00E+00	6.18E+13	2.29E+26
2	rain	1495	liter	1	7.47E+10	J	3.10E+04	J	Odum et al., 2000	2.32E+15	0.00E+00	2.32E+15	8.57E+27
3	wind	3.72	m/s	1	9.15E+08	J	2.45E+03	J	Odum et al., 2000	2.24E+12	0.00E+00	2.24E+12	8.29E+24
4	river	80	m3	1	1.41E+09	J	6.89E+04	J	Brown e Ulgiati,2004	9.68E+13	0.00E+00	9.68E+13	3.58E+26
5	fixed atmosphere nitrogen	234	kg	1	234	kg	1.30E+13	kg	Brandt-Williams, 2002	3.04E+15	0.00E+00	3.04E+15	1.12E+28
6	soil minerals	234	kg	1	234	kg	8.72E+11	kg	Brandt-Williams, 2002	2.04E+14	0.00E+00	2.04E+14	7.55E+26
N	**Non Renewable**									**0.00E+00**	**3.08E+13**	**3.08E+13**	
7	erosion	275.00	kg	0	2.49E+08		1.24E+05	J	Brandt-Williams, 2002	0.00E+00	3.08E+13	3.08E+13	1.14E+26
F	**ECONOMY RESOURCE**												
M	**Materials**									**2.65E+15**	**1.78E+16**	**2.04E+16**	
8	electricity	54680	Kwh	0.7	1.41E+10	J	2.52E+05	J	Brown and Ulgiati,2004	2.48E+15	1.06E+15	3.54E+15	1.31E+28
9	Organici compost	2730	kg	0.01	2730	kg	9.31E+11	seJ/kg	Brown and Ulgiati,2004	2.54E+13	2.52E+15	2.54E+15	9.40E+27
10	commeal	53	kg	0.01	53	kg	2.18E+12	seJ/kg	Brown and Ulgiati,2004	1.15E+12	1.14E+14	1.15E+14	4.27E+26
11	molasses	18	liter	0.01	18	kg	2.18E+12	seJ/kg	Brown and Ulgiati,2004	3.83E+11	3.79E+13	3.83E+13	1.42E+26
12	rice bran	958	kg	0.01	958		2.18E+12	seJ/kg	Brown and Ulgiati,2004	2.09E+13	2.07E+15	2.09E+15	7.73E+27
13	bone meal	1427	kg	0.01	1427		1.68E+12	seJ/kg	Brandt-Williams, 2002	2.40E+13	2.37E+15	2.40E+15	8.87E+27
14	Potassium	189	kg	0.01	189	kg	2.92E+12	seJ/kg	Odum, 1996	5.51E+12	5.46E+14	5.51E+14	2.04E+27
15	manganese sulphate	15	kg	0.01	15	kg	6.49E+12	seJ/kg	Cuadra and Ryedberg, 200(	9.80E+11	9.70E+13	9.80E+13	3.63E+26
16	zinco sulphate	15	kg	0.01	15	J	7.20E+13	kg	Cohen et al.,2007	1.09E+13	1.08E+15	1.09E+15	4.02E+27
17	bordeaux misture	1	liter	0.01	1	L	8.73E+11	seJ/L	Brown and Ulgiati,2004	6.24E+09	6.18E+11	6.24E+11	2.31E+24
18	depreciation	559	US$	0.01	559	kg	3.30E+12	US$	Coelho et al., 2004	1.84E+13	1.83E+15	1.84E+15	6.82E+27
19	maintenance machine	885	US$	0.01	885	kg	3.30E+12	US$	Coelho et al., 2005	2.92E+13	2.89E+15	2.92E+15	1.08E+28
20	fuel	10280	liter	0.01	3.48E+10	J	9.21E+04	J	Bastianoni et al.,2005	3.21E+13	3.17E+15	3.21E+15	1.19E+28
21	seeds	4	kg	0.23	4		1.68E+12	kg	Ortega, et all. 2002	1.38E+12	4.62E+12	6.00E+12	2.22E+25
S	**Services**									**1.27E+16**	**1.14E+16**	**2.69E+16**	
22	simple labor	5214	hour	0.6	2.94E+08	J	2.80E+06	J	Brown, 2003	4.94E+14	3.29E+14	8.23E+14	3.04E+27
23	technical labor	373	US$	0.6	3.73E+02	US$	3.30E+12	US$	Coelho et al., 2003	7.38E+14	4.92E+14	1.23E+15	4.55E+27
24	adminitrative labor	5796	US$	0.6	5796	US$	3.30E+12	US$	Coelho et al., 2003	1.15E+16	7.65E+15	1.91E+16	7.08E+28
25	telephone	51	US$	0.01	51	US$	3.30E+12	US$	Coelho et al., 2003	1.69E+12	1.68E+14	1.69E+14	6.27E+26
26	light	294	kwh	0.01	1.06E+09	J	2.52E+05	J	Brown and Ulgiati,2004	2.67E+12	2.64E+14	2.67E+14	9.88E+26
27	tax	767.21	US$	0.01	767.21	US$	3.30E+12	US$	Coelho et al., 2003	2.53E+13	2.51E+15	2.53E+15	9.37E+27
28	negative externalities	60.00	US$	0.01	840.00		3.30E+12	US$	Coelho et al., 2003	2.77E+13	2.74E+15	2.77E+15	1.03E+28
Y	**TOTAL EMERGY**											**5.31E+16**	

Table 6. Emergy Table for conventional production in Novo Mundo Farm.

1	2	3	4	5	6	7			8			9
Note	Item	Input data		Renewable fraction	Flow	Transformity			Emergy Flow			Em$
		Value	Unit.ha^{-1}.year^{-1}	Centesimal	Value	Value	seJ.Unit^{-1}	Reference	Renewable	Non Renewable	Total	
I	**NATURAL RESOURCE**											
R	**Renewable**								**5.72E+15**	**0.00E+00**	**5.72E+15**	
1	sun	5.53	kwh	1	6.18E+13	1.00E+00	J	Odum,1996	6.18E+13	0.00E+00	6.18E+13	2.29E+26
2	rain	1495	liter	1	7.47E+10	3.10E+04	J	Odum et al., 2000	2.32E+15	0.00E+00	2.32E+15	8.57E+27
3	wind	3.72	m/s	1	9.15E+08	2.45E+03	J	Odum et al., 2000	2.24E+12	0.00E+00	2.24E+12	8.29E+24
4	river	80	m^3	1	1.41E+09	6.89E+04	J	Brown and Ulgiati,2004	9.68E+13	0.00E+00	9.68E+13	3.58E+26
5	fixed atmosphere nitrogen	234	kg	1	234	1.30E+13	kg	Brandt-Williams, 2002	3.04E+15	0.00E+00	3.04E+15	1.12E+28
6	soil minierals	234	kg	1	234	8.72E+11	kg	Brandt-Williams, 2002	2.04E+14	0.00E+00	2.04E+14	7.55E+26
N	**Non Renewable**								**0.00E+00**	**3.08E+13**	**3.08E+13**	
7	erosion	275.00	kg	0	2.49E+08	1.24E+05	J	Brandt-Williams, 2002	0.00E+00	3.08E+13	3.08E+13	1.14E+26
F	**ECONOMY RESOURCE**											
M	**Materials**								**1.71E+15**	**4.35E+16**	**4.52E+16**	
8	electricity	51650	Kwh	0.7	7.29E+09	2.52E+05	J	Brown and Ulgiati,2004	1.29E+15	5.51E+14	1.84E+15	6.80E+27
9	bordeaux misture	21	liter	0.01	21	8.73E+11	seJ/L	Brown and Ulgiati,2004	1.83E+11	1.82E+13	1.83E+13	6.79E+25
10	pest control	1218	kg	0.01	1218	2.49E+13	kg	Brown and Ulgiati,2004	3.03E+14	3.00E+16	3.03E+16	1.12E+29
14	dolomitic limestone	1200	kg	0.01	1200	1.00E+12	kg	Brandt-Williams, 2002	1.20E+13	1.19E+15	1.20E+15	4.44E+27
15	molasses	16	kg	0.01	16	6.38E+12	kg	Brown and Ulgiati,2004	1.02E+12	1.01E+14	1.02E+14	3.78E+26
16	molibidenium	2	kg	0.01	2	2.04E+15	kg	Martines et al, 2006	3.06E+13	3.03E+15	3.06E+15	1.13E+28
17	nitrogen	124	kg	0.01	124	6.38E+12	kg	Brown and Ulgiati,2004	7.88E+12	7.80E+14	7.88E+14	2.92E+27
18	phosphorus	124	kg	0.01	124	6.55E+12	kg	Brown and Ulgiati,2005	8.09E+12	8.01E+14	8.09E+14	2.99E+27
19	Potassium	124	kg	0.01	124	2.92E+12	kg	Odum,1996	3.61E+12	3.57E+14	3.61E+14	1.33E+27
20	Ammonium sulfate	208	kg	0.01	208	3.80E+11	kg	Cuadra and Rydberg,2000	7.90E+11	7.82E+13	7.90E+13	2.92E+26
21	zinc sulfate	0	kg	0.01	0	7.20E+13	kg	Cohen et al.,2007	2.88E+10	2.85E+12	2.88E+12	1.07E+25
22	potassium sulfate	450	kg	0.01	450	2.92E+12	kg	Odum,1996	1.31E+13	1.30E+15	1.31E+15	4.86E+27
23	chemical feritlizers	35	kg	0.01	35	6.38E+09	kg	Coelho and Ortega, 2002	2.26E+09	2.24E+11	2.26E+11	8.36E+23
24	Depreciatio	193	US$	0.01	193	3.30E+12	US$	Coelho et al., 2005	6.37E+12	6.31E+14	6.37E+14	2.36E+27
25	machines maintenance	885	US$	0.01	885	3.30E+12	US$	Coelho et al., 2005	2.92E+13	2.89E+15	2.92E+15	1.08E+28
26	Fuel	8411	Litros	0	1.56E+10	9.21E+04	J	Bastianoni et al.,2005	0.00E+00	1.44E+15	1.44E+15	5.33E+27
27	seeds	4	kg	0.01	4	1.68E+12	kg	Ortega, et all. 2002	6.00E+10	5.94E+12	6.00E+12	2.22E+25
32	freight	92	US$	0.01	92	3.30E+12	US$	Coelho et al., 2005	3.04E+12	3.01E+14	3.04E+14	1.12E+27
S	**Services**								**6.85E+15**	**2.72E+16**	**3.41E+16**	
33	simple labor	1832	hour	0.6	1.88E+08	2.80E+06	J	Brown, 2003	3.16E+14	2.11E+14	5.27E+14	1.95E+27
34	administrative labor	3182	US$	0.6	3182	3.30E+12	US$	Coelho et al., 2003	6.30E+15	4.20E+15	1.05E+16	3.89E+28
35	telephone	51	US$	0.01	51	3.30E+12	US$	Coelho et al., 2003	1.69E+12	1.68E+14	1.69E+14	6.27E+26
36	light	294	kwh	0.01	1.06E+09	2.52E+05	J	Brown and Ulgiati,2004	2.67E+12	2.64E+14	2.67E+14	9.88E+26
37	tax	480.29	US$	0.01	480.29	3.30E+12	US$	Coelho et al., 2003	1.58E+13	1.57E+15	1.58E+15	5.86E+27
38	negative externalities	250	US$	0.01	6,375	3.30E+12	US$	Coelho et al., 2003	2.10E+14	2.08E+16	2.10E+16	7.78E+28
Y	**TOTAL EMERGY**										**8.504E+16**	

Table 7. Emergy Table for Organic productions in Joao Dias Farm.

1	2	3	4	5	6	7			8			9
Note	Item	Input data		Renewable fraction	Flow	Transformity			Emergy Flow			Em$
		Value	Unit.ha^{-1}.year^{-1}	Centesimal	Value	Value	seJ.Unit^{-1}	Reference	Renewable	Non Renewable	Total	
I	**NATURAL RESOURCE**											
R	**Renewable**								**2.58E+15**	**0.00E+00**	**1.16E+16**	
1	sun	5.92	kwh	1	5.45E+13	1.00E+00	J	Odum,1996	5.45E+13	0.00E+00	5.45E+13	2.01E+26
2	rain	1596	liter	1	7.98E+10	3.10E+04	J	Odum et al., 2000	2.47E+15	0.00E+00	2.47E+15	9.15E+27
3	wind	3.72	m/s	1	9.15E+08	2.45E+03	J	Odum et al., 2000	2.24E+12	0.00E+00	2.24E+12	8.29E+24
4	river	80	m^3	1	7.03E+08	6.89E+04	J	Brown and Ulgiati,2004	4.84E+13	0.00E+00	4.84E+13	1.79E+26
5	water spring	6228	m^3	1	3.11E+10	1.85E+05	J	Consuelo	5.75E+15	0.00E+00	5.75E+15	2.13E+28
6	fixed atmosphere nitrogen	234	kg	1	234	1.30E+13	kg	Brandt-Williams, 2002	3.04E+15	0.00E+00	3.04E+15	1.12E+28
7	soil minerals	234	kg	1	234	8.72E+11	kg	Brandt-Williams, 2002	2.04E+14	0.00E+00	2.04E+14	7.55E+26
N	**Non Renewable**								**0.00E+00**	**3.08E+13**	**3.08E+13**	
8	erosion	275.00		0	2.49E+08	1.24E+05	J	Brandt-Williams, 2002	0.00E+00	3.08E+13	3.08E+13	1.14E+26
F	**ECONOMY RESOURCE**											
M	**Materials**								**7.17E+15**	**1.90E+16**	**2.62E+16**	
9	electricity	20400	Kwh	0.7	1.47E+10	2.52E+05	J	Brown and Ulgiati,2004	2.59E+15	1.11E+15	3.70E+15	1.37E+28
10	seeds	28	kg	0.23	28	1.68E+12	kg	Ortega, et all. 2002	1.08E+13	3.62E+13	4.70E+13	1.74E+26
11	compound materials	403.8	kg	0.7	403.8	9.31E+11	kg	Brown & Ulgiati, 2004	2.63E+14	1.13E+14	3.76E+14	1.39E+27
12	organic fertilizers	23667	kg	0.01	23666.6	1.27E+11	sej/kg	Bastianoni et al., 2001.	3.01E+13	2.98E+15	3.01E+15	1.11E+28
13	dolomitic limestone	1750	kg	0.01	1750	1.00E+12	kg	Brandt-Williams, 2002	1.75E+13	1.73E+15	1.75E+15	6.48E+27
14	pest control	315.8	kg	0.01	315.8	2.49E+13	kg	Brown, and Ulgiat, 2004.	7.86E+13	7.78E+15	7.86E+15	2.91E+28
15	fuel	142	liter	0.01	6.75E+09	9.21E+04	J	Bastianoni et al.,2005	6.22E+12	6.15E+14	6.22E+14	2.30E+27
16	plastic	30.4	Kg	0.01	30.4	5.85E+12	kg	Buranakan, 1998 apud Buranakan and brown, 2002	1.78E+12	1.76E+14	1.78E+14	6.58E+26
17	manure	2000	kg	0.7	2000	2.96E+12	kg	Castelini et al, 2006	4.14E+15	1.78E+15	5.92E+15	2.19E+28
18	Depreciation	358	US$	0.01	358	3.30E+12	kg	Coelho et al., 2004	1.18E+13	1.17E+15	1.18E+15	4.37E+27
19	freight	470	US$	0.01	470	3.30E+12	US$	Coelho et al., 2005	1.55E+13	1.53E+15	1.55E+15	5.73E+27
S	**Services**								**3.03E+15**	**6.23E+15**	**9.26E+15**	
20	simple labor	1752	hour	0.6	3.53E+07	2.80E+06	J	Brown, 2003	5.92E+13	3.95E+13	9.87E+13	3.65E+26
21	technical labor	173	US$	0.6	1.73E+02	3.30E+12	US$	Coelho et al., 2002	3.43E+14	2.29E+14	5.71E+14	2.11E+27
22	administrative labor	1304	US$	0.6	1304	3.30E+12	US$	Coelho et al., 2003	2.58E+15	1.72E+15	4.30E+15	1.59E+28
23	light and telephone	364	US$	0.01	364	3.30E+12	US$	Coelho et al., 2004	1.20E+13	1.19E+15	1.20E+15	4.44E+27
25	tax	633.6	US$	0.01	633.6	3.30E+12	US$	Coelho et al., 2005	2.09E+13	2.07E+15	2.09E+15	7.74E+27
26	negative externalities	60	US$	0.01	300.00	3.30E+12	US$	Coelho et al., 2006	9.90E+12	9.80E+14	9.90E+14	3.66E+27
Y	**TOTAL EMERGY**										**4.706E+16**	

Table 8. Emergy Table for conventional production in Nakajima Farm.

1	2	3	4	5	6	7			8			9
Note	Item	Input data		Renewable Fraction	Flow	Transfomity			Emergy Flow			Em$
		Value	Unit.ha^{-1}.year^{-1}	Centesimal	Value	Value	seJ.Unit^{-1}	Reference	Renewable	Non Renewable	Total	
I	**NATURAL RESOURCES**											
R	**Renewable**								**5.83E+15**	**0.00E+00**	**5.83E+15**	
1	Sun	5.92	kwh	1	5.45E+13	1.00E+00	J	Odum,1996	5.45E+13	0.00E+00	5.45E+13	2.01E+26
2	rain	1596	liter	1	7.98E+10	3.10E+04	J	Odum et al., 2000	2.47E+15	0.00E+00	2.47E+15	9.15E+27
3	wind	3.72	m/s	1	9.15E+08	2.45E+03	J	Odum et al., 2000	2.24E+12	0.00E+00	2.24E+12	8.29E+24
4	river	1124	m^3	1	7.03E+08	6.89E+04	J	Brown and Ulgiati,2004	4.84E+13	0.00E+00	4.84E+13	1.79E+26
5	water well	4.00	m^3	1	2.00E+07	1.85E+05	J	Consuelo	3.70E+12	0.00E+00	3.70E+12	1.37E+25
6	fixed atmosphere nitrogen	234	kg	1	234	1.30E+13	kg	Brandt-Williams, 2002	3.04E+15	0.00E+00	3.04E+15	1.12E+28
7	soil minerals	234	kg	1	234	8.72E+11	kg	Brandt-Williams, 2002	2.04E+14	0.00E+00	2.04E+14	7.55E+26
N	**Non renewable**								**0.00E+00**	**3.08E+13**	**3.08E+13**	
8	erosion	275.00		0	2.49E+08	1.24E+05	J	Brandt-Williams, 2002	0.00E+00	3.08E+13	3.08E+13	1.14E+26
F	**ECONOMY RESOURCE**											
M	**Materials**								**1.69E+15**	**1.08E+16**	**1.25E+16**	
9	electricity	2454	Kwh	0.7	8.84E+09	2.52E+05	J	Brown and Ulgiati,2004	1.56E+15	6.68E+14	2.23E+15	8.24E+27
10	seeds	2	kg	0.23	2	1.68E+12	kg	Ortega, et all. 2002	7.73E+11	2.59E+12	3.36E+12	1.24E+25
11	organic feritilizers	341	kg	0.6	341	1.27E+11	sej/kg	Bastianoni et al., 2001.	2.60E+13	1.73E+13	4.33E+13	1.60E+26
12	chemical fertilizers	46	kg	0.01	46	6.38E+11	seJ/kg	Coelho e Ortega 2002.	2.95E+11	2.92E+13	2.95E+13	1.09E+26
13	ammoniun nitrate	0.68	kg	0.01	0.68	6.38E+12	kg	Bargli and Ulgiati,2003	4.35E+10	4.30E+12	4.35E+12	1.61E+25
14	dolomitic limestone	170.36	kg	0.01	170.36	1.00E+12	kg	Brandt-Willians,2002	1.70E+12	1.69E+14	1.70E+14	6.30E+26
15	nitrogen	398.64	kg	0.01	398.64	6.38E+12	kg	Brown, and Ulgiat, 2004.	2.54E+13	2.52E+15	2.54E+15	9.41E+27
16	phosphorus	398.64	kg	0.01	398.64	6.55E+12	kg	Brown, and Ulgiat, 2004.	2.61E+13	2.58E+15	2.61E+15	9.66E+27
17	potassium	398.64	kg	0.01	398.64	2.92E+12	kg	Odum,1996	1.16E+13	1.15E+15	1.16E+15	4.31E+27
18	fuel	560	liter	0.01	2.65E+10	9.21E+04	J	Bastianoni et al.,2005	2.44E+13	2.42E+15	2.44E+15	9.04E+27
19	pest control	13.25	kg	0.01	13.25	2.49E+13	Kg	Brown and Ulgiati,2004	3.30E+12	3.27E+14	3.30E+14	1.22E+27
20	plastic	59	Kg	0.01	59	5.85E+12	kg	Buranakan, 1998 apud Buranakan and brown, 2002	3.47E+12	3.44E+14	3.47E+14	1.29E+27
30	depreciation	185	US$	0.01	185	3.30E+12	US$	Coelho et al., 2005	6.09E+12	6.03E+14	6.09E+14	2.25E+27
S	**Services**								**1.07E+15**	**2.56E+16**	**2.67E+16**	
31	simple labor	2288	hour	0.6	2.70E+08	2.80E+06	J	Brown, 2003	4.54E+14	3.03E+14	7.57E+14	2.80E+27
32	administrative labor	185	US$	0.6	185	3.30E+12	US$	Coelho et al., 2003	3.67E+14	2.44E+14	6.11E+14	2.26E+27
33	light and telephone	245	US$	0.01	245	3.30E+12	US$	Coelho et al., 2004	8.10E+12	8.02E+14	8.10E+14	3.00E+27
34	tax	98	US$	0.01	98	3.30E+12	US$	Coelho et al., 2005	3.25E+12	3.22E+14	3.25E+14	1.20E+27
35	negative externalities	250	US$	0.01	7,338	3.30E+12	US$	Coelho et al., 2006	2.42E+14	2.40E+16	2.42E+16	8.96E+28
Y	**TOTAL EMERGY**										**4.51E+16**	

Table 9. Emergy Table for organic vegetable production in Yamaguishi Village.

1	2	3	4	5	6	7			8			9
Note	Item	Input data		Renewable Fraction	Flow	Transfomiry			Emergy Flow			Em$
		Value	Unit.ha^{-1}.year^{-1}	Centesimal	Value	Value	seJ.Unit^{-1}	Reference	Renewable	Non Renewable	Total	
I	**NATURAL RESOURCE**											
R	**Renewable**								**2.22E+15**	**0.00E+00**	**2.22E+15**	
1	sun	10.83	kwh	1	9.96E+13	1.00E+00	J	Odum,1996	9.96E+13	0.00E+00	9.96E+13	3.69E+26
2	rain	1.30	m^3	1	6.50E+10	3.10E+04	J	Odum et al., 2000	2.02E+15	0.00E+00	2.02E+15	7.46E+27
3	wind	9.75	m/s	1	2.40E+09	2.45E+03	J	Odum et al., 2000	5.88E+12	0.00E+00	5.88E+12	2.17E+25
4	river	1798.4	m^3	1	1.41E+09	6.89E+04	J	Brown and Ulgiati,2004	9.68E+13	0.00E+00	9.68E+13	3.58E+26
N	**Non Renewable**								**0.00E+00**	**3.20E+13**	**3.20E+13**	
5	erosion	285.00		0	2.58E+08	1.24E+05	J	Brandt-Williams, 2002	0.00E+00	3.20E+13	3.20E+13	1.18E+26
F	**ECONOMY RESOURCE**											
M	**Materials**								**2.31E+14**	**2.79E+15**	**3.02E+15**	
6	electricity	320	Kwh	0.7	1.15E+09	2.52E+05	J	Brown and Ulgiati,2004	2.03E+14	8.71E+13	2.90E+14	1.07E+27
7	seeds	24	kg	0.23	24	1.68E+12	kg	Ortega, et all. 2002	9.27E+12	3.10E+13	4.03E+13	1.49E+26
8	earthworm humus	1000	kg	0.01	1000	9.31E+11	seJ/kg	Brown and Ulgiat, 2004.	9.31E+12	9.22E+14	9.31E+14	3.44E+27
9	coconut shell	1200	kg	0.01	1200	1.90E+04	seJ/J	Brown and Ulgiat, 2004.	2.28E+05	2.26E+07	2.28E+07	8.44E+19
10	manure	8000	kg	0.9	8000	4.12E+07	sej/kg	Castellini, 2006	2.97E+11	3.30E+10	3.30E+11	1.22E+24
11	fuel	200	liter	0.01	9.48E+09	9.21E+04	J	Bastianoni et al.,2005	8.73E+12	8.64E+14	8.73E+14	3.23E+27
12	plastic	152	Kg	0	152	5.85E+12	kg	Buranakan, 1998 apud Buranakan and brown, 2002	0.00E+00	8.89E+14	8.89E+14	3.29E+27
S	**Serviços**								**7.95E+15**	**5.82E+15**	**1.38E+16**	
13	simple labor	39420	hour	0.6	1.59E+08	2.80E+06	J	Brown, 2003	2.67E+14	1.78E+14	4.44E+14	1.64E+27
14	administrative labor	3879	US$	0.6	3879	3.30E+12	US$	Coelho et al., 2003	7.68E+15	5.12E+15	1.28E+16	4.74E+28
15	light and telephone	72	US$	0.01	72	3.30E+12	US$	Coelho et al., 2003	2.38E+12	2.35E+14	2.38E+14	8.79E+26
16	tax	87.71	US$	0.01	87.71	3.30E+12	US$	Coelho et al., 2003	2.89E+12	2.87E+14	2.89E+14	1.07E+27
Y	**TOTAL EMERGY**										**1.90E+16**	