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EMERGY ANALYSIS AND BOOKKEEPING ACCOUNTING OF CONVENTIONAL AND ORGANIC COFFEE PRODUCTION IN BRAZIL

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ABSTRACT

Emergy, economic and social analyses were conducted in two different farms located in the northeast of Sao Paulo State, Brazil, that used different systems of coffee production. The farming systems studied work according to two opposing agricultural models: organic and conventional. The comparison between both systems showed that the organic system is capable of improving the economic results in small properties. These improvements were possible because the organic system made a large use of the free natural resources in the agro ecosystem. The use of these natural resources enable farmers to obtain lower costs with material inputs and have better number for permanent employment per area and also promote the recovery of the environment. The emergy analysis was able to discover that organic farm uses more natural resources and this fact allowed more economic benefits.
Key words: Coffee production, Emergy, Ecological Economy.

1. INTRODUCTION

The recent decline of prices of coffee in the international market, coupled with the lack of public policies for planning and management of coffee production, as well as the continuous increase of chemical inputs price in agriculture are factors that contribute to profitability reduction in coffee farming. As consequence, many small coffee producers have been forced to abandon farming. In recent years, some measures to increase productivity as mechanization, irrigation, and high density planting have been implemented in coffee farming, but all of them give support of the more capitalized coffee producers. On the other hand, small coffee producers generally have limited access to these technologies as well as to financial resources due to their small production scale.

The organic production system is an alternative for the small producers because of the ability of this agricultural technology of using free natural inputs instead of purchased chemicals. In order to evidence this fact, in this study it is combined the traditional bookkeeping accounting with emergy analysis.

2. MATERIAL AND METHODS

Field studies were conducted in two farms that use different systems of coffee production (organic and conventional). The conventional system is characterized by the use of chemical pesticides, herbicides, fertilizers and petroleum fuel. The organic system is intensive in the use of natural inputs, organic materials and permanent workers.

These field studies were conducted to evaluate:

a) Improvement the income of small producers;
b) Employment generation;
c) Ecological efficiency using emergy analysis;

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d) "Net Emergy" and Economic profitability after accounting the environmental externalities;

The first farm, considered to be of medium size, is called Barrinha farm and is located in the municipal district of Santo Antonio do Jardim in the state of Sao Paulo. It occupies a total area of 190 hectares, and it has 150 hectares planted with conventional coffee cultivars.

The second farm, considered to be of small size, is called Terra Verde and is located in the city of Albertina in the state of Minas Gerais. It occupies a total area of 56 hectares, with 25 hectares of organic coffee cultivars and the remaining area is used with several cultures for internal consumption and milk production.

For the analysis of employment it was registered the number of permanent and temporary employees and their respective economic income. These values were divided by farm area.

The field research made it possible to obtain the production cost data for the 2003/2004-year crop as well as the emergy values. The sale price for the coffee was the medium value in the State of Sao Paulo (AGRIANUAL, 2004) [1].

The Gain and Loss Statement (GLS) was used to obtain total revenue, production costs and expenses and overall profitability of the systems.

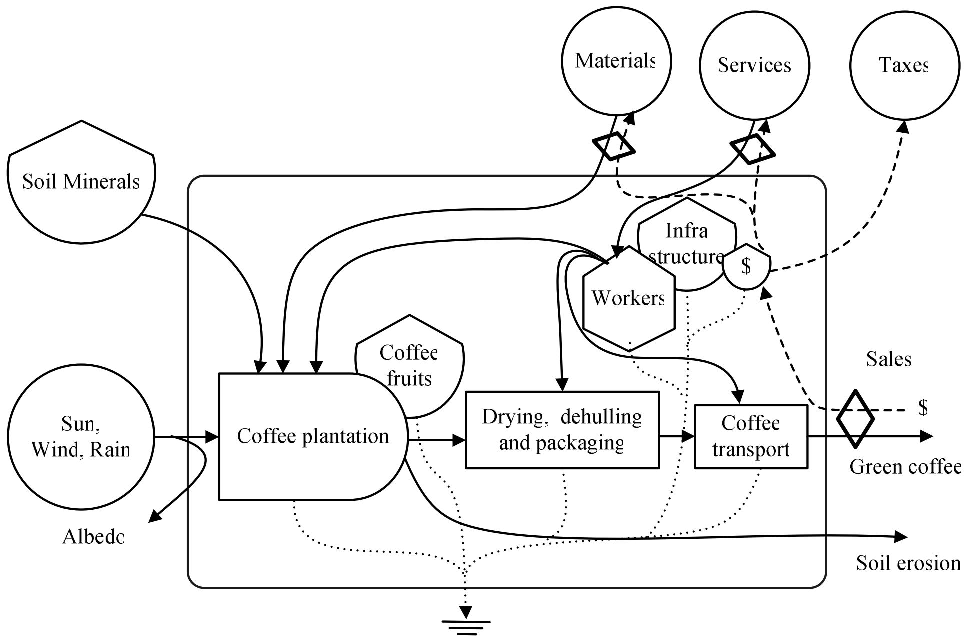
It was applied the emergy accounting methodology (ODUM, 1996) [2], as well as a graphical emergy indicators tool proposed recently by Giannetti *et al* (2005) [3].

Finally, this study compares an economic accounting table (Gain and Loss Statement) with its respective emergy table (Aggregated Emergy Flows) with appropriated sequence. This work gives continuity to the first effort accomplished recently in this field by ORTEGA *et al* (2004) [3] where emergy analysis was integrated with bookkeeping on a buffalo farm in Rio Grande do Sul, Brazil.

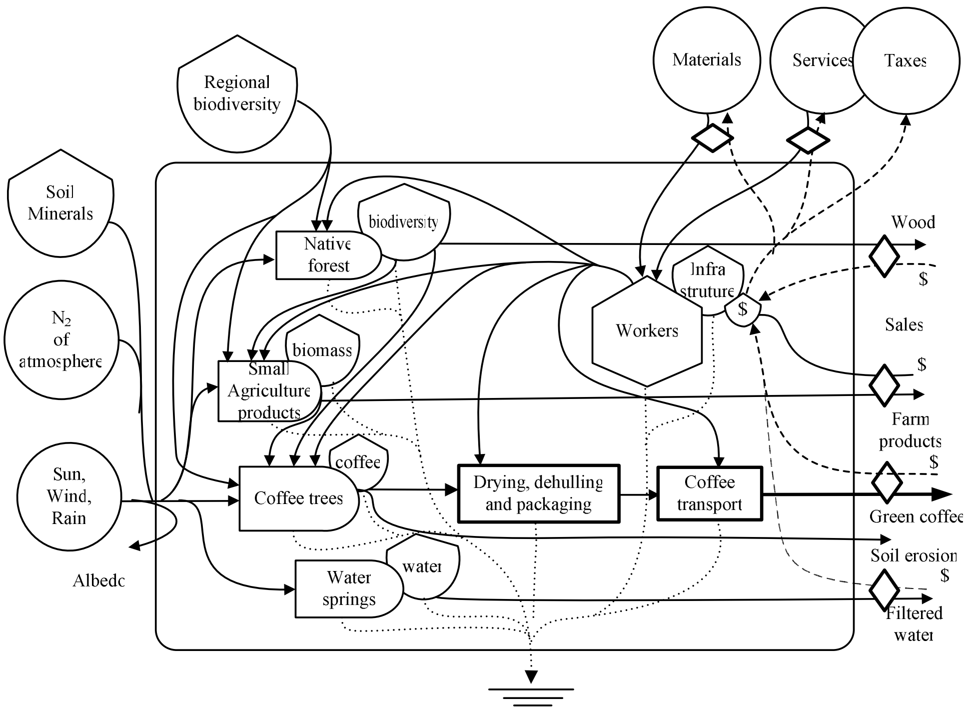
3. RESULTS

Emergy diagrams allow a better understanding of the farms. The natural inputs are shown on the left; at the top right side appear the materials and external services. At the right are the outputs and their exchange for money. At the bottom is placed the degraded energy.

The conventional farm (Figure 1a) shows a small internal interactions and great dependence on external resources. The organic farm, Figure 1b, has larger interaction among the internal stocks. This fact contributes to a self-sufficiency and efficiency.



1a: Conventional coffee production emergy diagram, Barrinha farm



1b: Organic coffee production emergy diagram, ranch Terra Verde

Figure 1: Emergy diagrams of energy flows in both studied systems
Source: Adapted from ORTEGA, E. “Emergy Methodology”. www.unicamp.br/fea/ortega/. (Accessed in 15/03/2004)

Table 1. Coffee inputs: quantities and costs; for the year-crop 2003/2004

	CONVENTIONAL SYSTEM		ORGANIC SYSTEM	
MATERIALS	Unit/ha.year	US$/ha.year	Unit/ha.year	US$/ha.year
Calcareous rock	1000.0	14.5	0	0
Super phosphate	330.0	47.8	0	0
Zinc sulphate	4.8	2.4	0	0
Acid boron	6.0	5.2	0	0
Fertilizer 20-00-15	2000.0	448.3	0	0
Green fertilizer	0	0	3000.0	51.7
Composite fertilizer	1000.0	27.6	1 7600.0	275.9
Herbicide	9.0	40.8	0	0
Insecticide	3.5	30.1	0	0
Fungicide	1.5	54.7	0	0
Cement*	23.7	-	35.7	-
Fossil fuel	47.0	27.6	14.0	8.3
Iron*	11.6	-	58.0	-
Wood and its products*	21.0	-	17.8	-
Steel /9depreciation)*	4.7	-	5.4	-
Machinery maintenance	-	9.6	-	10.3
Equipments**	-	5.2	-	6.9
Coffee bags	-	32.8	-	17.4
SOBTOTAL (A)		**746.6**		**370.5**
SERVICES	US$/ha.year		US$/ha.year	
Temporary labor	86.9		86.9	
Permanent labor	41.8		70.9	
Technical assistance	11.6		11.6	
Labor rights	7.6		12.9	
Technical bookkeeping	20.7		33.1	
Administration work	33.1		20.7	
Governmental taxes***	518.8		586.7	
Capital costs****	92.0		58.7	
Storage costs	8.8		7.7	
SOBTOTAL (A)	**821.3**		**889.2**	
Simple economic cost (A+B)	**1 567.9**		**1 259.7**	

* Depreciation of wood, steel and cement: 20 years. For iron we used 10 years depreciation.

** Electricity and telephone expenses.

*** Government taxes: ICMS (18%), ITR (1. 4%), FUNRURAL (2%) e Revenue (27. 5%).

**** Interest rate 9.5% year on production costs, administrative expenses, sales and stocks.

Table 2. Gain and Loss Statement (total sales, production costs, taxes, capital costs) per hectare in two coffee production systems, US$/ha/year

CONVENTIONAL SYSTEM US$ 64.00 per 60 kg		ORGANIC SYSTEM US$ 100.00 per 60 kg*	
Total sales proceeds (S)	**1 884.0**	**Total sales proceeds (S)**	**1 800.0**
(-) Sales taxes (18%)	339.1	(-) Sales taxes (18%)	324.0
(-) Production costs	860.6	(-) Production costs	511.0
(-) Operational expenses	107.8	(-) Operational expenses	106.7
(-) Capital costs	92.0	(-) Capital costs	58.7
(-) Taxes (Funrural/ITR)	64.0	(-) Taxes (Funrural/ITR)	59.1
(-) Income taxes	102.2	(-) Income taxes	203.6
Total production expenses(E)	**1 565.7**	**Total production expenses (E)**	**1 263.1**
Net profit (S-E)	**318.3**	**Net profit (S-E)**	**536.9**
Profitability (S-E/S)	**16.9%**	**Profitability (S-E/S)**	**29.8%**

Source: AGRIANUAL 2004. “Benefited coffee prices received by the producers in Sao Paulo, Brazil”. p.208 * The value of the organic coffee in the ranch Terra Verde was US$ 100.00 per 60 kg of green coffee, (using an exchange rate of R$ 2.90 / US$ 1.00).

The values of the aggregated emergy flows are shown in Table 3. The complete Emergy Balance Tables are presented in appendixes 2a and 2b.

Table 3. Emergy flows for studied coffee production cases

Aggregated emergy flows	**Abbreviation**	**Conventional ($x10^{14}$)**	**%**	**Organic ($x10^{14}$)**	**%**
Materials	**M**	143	*46*	17	*1.5*
Services	**S**	88	*28*	86	*7.8*
Renowable resources	**R**	64	*21*	1000	*90*
Nonrenewable resources	**N**	14	*5*	4	*0.4*
Renewable + **N**onrenewable	**I=R+N**	79	*26*	1004	*90.4*
Feedback	**F=M+S**	231	*74*	103	*9.6*
Emergy output	**Y=I+F**	309	*100*	1107	*100*

Sources: Field research data (05/03/2004).

In Table 4 the emergy values presented in appendixes 2a and 2b are used to obtain emergy indicators.

Table 4. Emergy Indicators of ecological sustainability collected in analyzed coffee production systems

Emergy Indicator	**Abbreviation**	**Conventional**	**Organic**
Product Emergy (j/ha.year)	**EP**	1.99E+7	1.06E+7
Transformity	**Y/EP**	1.55E+9	1.05E+10
Emergy **I**nvestment **R**ate	**EIR**	2,91	0.10
Environment **L**oad **R**ate	**ELR**	3,75	0.11
% System **R**enovability	**%R=(R/Y)*100**	21.1%	90.4%
Emergy **Y**ield **R**ate	**EYR**	1.33	10.7

Sources: Ecological Engineering Laboratory spreadsheets – FEA/UNICAMP, 05/03/2004.

4. DISCUSSION

4.1 Social and Economic aspects

The results of Table 1 show that organic production uses more permanent labor. In the conventional system the rate of employment is 1 worker for 24 hectares, in the organic system it is 1 permanent worker for 14 hectares. If the same analysis is made in terms of income, the permanent work cost considering employment rights and governmental taxes in conventional system is US$ 49.4 per hectare/year while the organic system is US$ 83.8 per hectare/year. In the conventional coffee production the most intensive labor activities (crop picking and fertilization) are realized with use of machineries or accomplished by external temporary hand labor. In this last case the majority of workers are contracted for short periods of time generating social problems.

Table 2 shows that the organic coffee growing uses a lower quantity of chemical inputs enabling more protection against the variation in coffee prices. The main cost in organic coffee farming is related with labor rights, technical attendance, financing costs and taxes. It is observed that labor payments represent an additional expense to the organic system of US$ 34.4 per hectare/year. On the other hand, the conventional system displayed an additional cost related to the purchase of chemical defensives and fertilizers, whose costs are US$ 125.6 and US$ 208.2 per hectare/year.

In the coffee market there is, indeed, a great price variation. The price is affected by climatic factors which affect the crop forecast and subsequently its price. Investors use this information to speculate in the market producing daily price oscillations. This volatility in price highlights the importance of self-sufficiency in small coffee farms. In the case of big farms, the producers are able to deal with price oscillation through negotiations to obtain special financing conditions. The coffee market has shown in recent years a great variation in the price of the product. Between 1998 and 2002 the coffee price was, on average, US$ 66.7 per bag. A bag has 60 kg of coffee beans. In 1999 the highest price registered was US$ 89.5 per bag. However, in 2001 the lowest price registered was US$ 39.7 per bag (AGRIANUAL, 2003) [4]. Therefore it is impossible for the farmer to protect himself because climatic factors are uncontrollable. Then the strategy of rural administration should focus on making reductions in their direct costs of production.

The external inputs dependence of conventional farm forces the acquisition of capital to finance their purchase, establishing dependence between producers and banks. This financial expense increases the cost of production considerably (ASSIS *et al*, 2002) [6]. In organic farming, the biodiversity of the native forest enables the control of pests and preservation of water springs and soil. Coffee grows with green manure and wood, citric fruits, banana, papaya, latex. All this allows better economic return.

4.2 Emergy Indicators

The analysis of table 3 demonstrates that the conventional system needs approximately nine times more purchased resources and five times more nonrenewable natural resources than the organic system. The organic system uses sixteen times more renewable natural resources than the conventional.

EYR: This indicator analyzes the total contribution of nature to the production process. It is calculated through the division of total emergy used (Y) by the total of material resources (F). Values closer to 1 represent a minimal contribution by nature while the larger values represent more support of to human economy.

- Conventional: **1,33**
- Organic: **10,7**

%R: This is an indicator of ecological sustainability that shows the renewable natural resources as a percentage of total resources used in the production system. Systems with a larger percentage obtain larger amounts of renewable energy, smaller direct costs of production and larger competitiveness in the market.

- Conventional: **21,1%**
- Organic: **90,4%**

EIR: This is an indicator that measures the competitiveness of the system. It is the ratio between purchased inputs divided by natural resources used in the production system. Values close to zero indicate that the environment has a high contribution to production; in this case the lower monetary costs of ecological production increases its competitiveness.

- Conventional: **2,91**
- Organic: **0,10**

ELR: This indicator represents the pressure exercised by the productive system on the ecosystem where it is located. It is calculated through the division of the total nonrenewable natural resources by the total renewable natural resources. Values close to zero indicate smaller environmental load of the activity and larger ecological sustainability of the production process over time.

- Conventional: **3,75**
- Organic: **0,11**

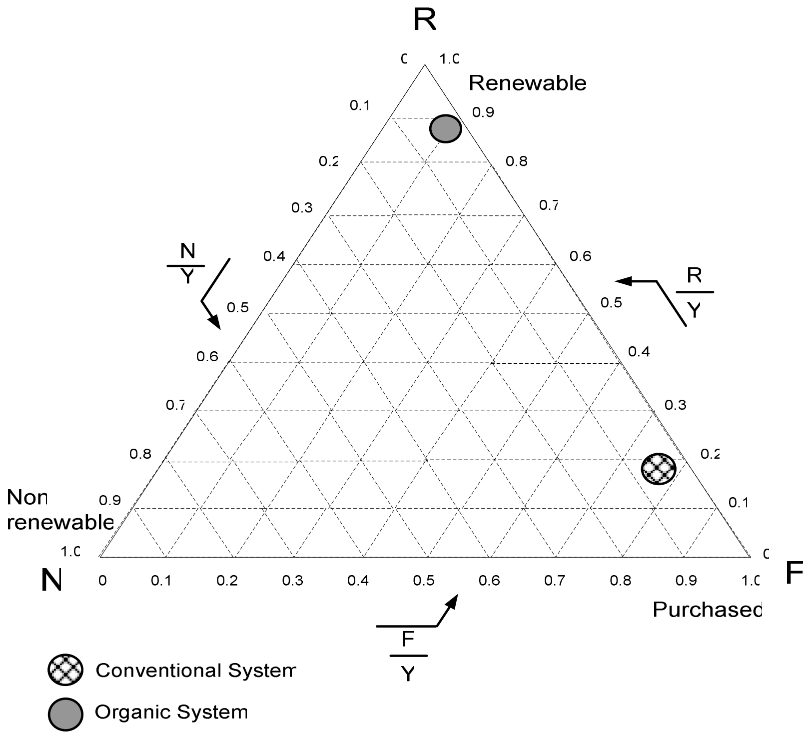


Figure 2. Ternary Diagrams of systems analyzed results

The ternary graphic used in this study enable us to differentiable the characteristics of the systems. The organic system is the renewable area and the conventional system in the area that depends of purchased inputs.

A methodology that combines bookkeeping with emergy analysis to obtain the "net Emergy" produced by the system is shown in Table 5.

Table 5. Gain and Loss Statement observed with emergy values

Utilized resources	Abbreviation	Conventional System ($x10^{14}$)	Organic System ($x10^{14}$)
Emergy output	Y	309	1107
Materials	M	143	17
Services	S	88	86
Nonrenewable resources	N	14	4
Externalities	E	5	0
Total nonrenewable resources	M+S+N+E	250	107
"Net Emergy"	**R**	**50**	**1000**

Source: Emergy Gain and Loss Statement (GLS) of ranch Terra Verde and Barrinha farm. Ecological Engineering Laboratory – FEA/UNICAMP, 05/03/2004.

This table uses the structure of Gain and Loss Statement (GLS) with the aggregated emergy flows. We also include externalities (unemployment, water springs pollution, river pollution) in this analysis.

Table 5 shows that the "net Emergy" is directly related with "profit". The enterprise benefit corresponds to the renewable natural resources that can be driven to farm production with almost no cost. The organic system is more intensive in the use of free natural resources and it obtains a much larger "net Emergy". In the case of small coffee growing farms this may contribute to preserve their economic profitability.

5. CONCLUSIONS

This paper demonstrated that, in the two studied farms, better economic results could be achieved when the small coffee producers made larger use of their renewable natural resources. In terms of public policies, organic coffee growing is the best alternative for small-scale coffee producers, enabling them to maintain their economic profitability.

The characteristics of the organic farms enable small producers to practice coffee growing with 90% natural resources, representing lower costs of production and a consequent increase in their competitiveness in the coffee market. Small conventional producers should take the opportunity offered by increasing international demand and start using the organic techniques that protect growers against the volatility in price.

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Appendix 1a

The table below shows energy flow analysis for conventional coffee production in 2004 in Barrinha farm, which has 190 hectares of total area. The coffee cultivation area is 150 hectares and contains 4.400 plants per hectare, which are between 4 and 18 years old.

1. RENEWABLE NATURAL RESOURCES

Rain = 1.5 m3/m2/year x 1.000 Kg/m3 x 10.000 m2/ha x 5.000 J/Kg = **7,5E10 J/ha.year.** 1.5 m3 rain index for this region, 1,000 Kg rain density, 10,000 m2 = 1 hectare area, and 5,000 J potential energy of rain. (Ortega, 2002)
Soil minerals = **20 Kg/ha.year** (Ortega, 2002)
N_2Atmosphere = **70 Kg/ha.year** (Ortega, 2002)
Biologic control = **0**
Compost = **1,000 Kg/ha.year**
Subsistence agriculture = **30,000 Kg/ha.year** (cattle, chickens, pigs, vegetables and fruit)

2. NONRENEWABLE RESOURCES

Loss of soil = 20.000 Kg/ha/year x 0.04 Kg organic material/12g soil x 5.400 kcal/Kg mat.org. = 6,48E6 kcal/ha/year; Conversion = 6,48E6 kcal/ha/year x 4.186 J/kcal = **1,79E10 J/ha.year**
Loss of Biological Control = **3,07E8 j/ha.year** (Ortega, 2002)
Loss of nutrients = **15,00 Kg/ha.year** (Ortega, 2002)

3. MATERIALS

Calcareous rock = **1000,00 Kg/ha.year** (Agrianual, 2002)
Single super phosphate = **330,00 Kg/ha.year** (Agrianual, 2002)
Fertilizer 20-00-20 = **2000,00 Kg/ha.year** (Agrianual, 2002)
Zinc sulfate = **4,80 Kg/ha.year** (Agrianual, 2002)
Boric acid = **6,00 Kg/ha.year** (Agrianual, 2002)
Chemical Herbicides = **9,00 Kg/ha.year** (Agrianual, 2002)
Chemical Pesticides = **3,50 Kg/ha.year** (Agrianual, 2002)
Chemical Fungicides = **1,50 Kg/ha.year** (Agrianual, 2002)
Cement = 40.000 Kg (seat farm) + 30.000 Kg (2 employee houses) + 20.000 Kg (coffee yard 750 m2) / 20 years (depreciation) / total area 190 hectares = **23,68 Kg/ha.year** (Ortega, 2002)
Petroleum fuel = 50 liters/ha.year = 47 Kg fuel/ha.year x 10.000 Kcal/Kg x 4.186 J/Kcal = **5,86E8 j/ha.year** (Ortega, 2002)
Iron = tractor 25.000 + 2 dryers 7.500 Kg + coffee bag machine 4.000 Kg = 44.000 Kg / 190 hectares / 20 years (depreciation) = **11,57 Kg/ha.year** (Ortega, 2002)
Wood and its products = 40.000 Kg / depreciation 10 years / 190 ha = **21,05 Kg/ha.year** (Ortega, 2002)
Steel = 6000 Kg (tractor) x 3 / 190 hectares / 20 years (depreciation) = **4,73 Kg/ha.year** (Ortega, 2002)
Machinery and equipments maintenance = **28,00 US$/ ha.year** (Ortega, 2002)
Other equipments (electricity e telephone) = **15,00 US$/ha.year** (Ortega, 2002)
Coffee bags = US$ 2,80 unit x 34 bags/ha.year = **95,20 US$/ ha.year**

(Ortega, 2002)

4. SERVICES

Temporary workers (picking, drying and processing) = 30 men x 60 days x US$ 21.00 man/day/150 hectares = **252,00 US$/ha.year** (Agrianual, 2004)
Permanent workers = US$ 240.00 x 8 men x 12 months / 190 hectares = **121,30 US$/ha.year**
Technical assistance = US$ 350 / month x 12 months / 150 ha = **33,60 US$/ha.year** (Agrianual, 2004)
Accountant = US$ 450 /month x 12 months / 190 ha = **60,00 US$/ ha.year** (Agrianual, 2004)
Fixed employment rights = 240 x 8 x 219% / 190 = **22,13 US$/ha.year**
Governmental taxes = **1.410,5 US$/ ha.**
Capital costs = **38,40 US$/ ha.year** (0,96%/month)
Storage costs= 0.005% x 34 bags x US$ 150.00= **25,5 US$/ha.year**

Appendix 1b

The table below shows energy flow analysis for conventional coffee production in Terra Verde ranch, which has 56 hectares of total area. The coffee cultivation area is 25 hectares and contains 4.400 plants per hectare, which are between 4 and 18 years old.

1. RENEWABLE NATURAL RESOURCES

Rain = 1.5 m3/m2/year x 1.000 Kg/m3 x 10.000 m2/ha x 5.000 J/Kg = **7,5E10j/ha.year.** 1.5 m3 rain index for this region, 1,000 Kg rain density, 10,000 m2 = 1 hectare area, and 5,000 J potential energy of rain. (Ortega, 2002)
Soil mineral = **30,00 Kg/ha.year** (Ortega, 2002)
Air nitrogenous = **70,00 Kg/ha.year** (Ortega, 2002)
Organic Fertilizer = **17.600,00 Kg/ha.year** (Ortega, 2002)
Green fertilizer = **3.000,00 Kg/ha.year;** implement of other cultures on coffee crop area, example: beans, soybean, corn e shrubs (Ingá e Leucena). (Ortega, 2002)
Self-maintenance cultures = **20.000,00 Kg/ha.year**; vegetables, milk, chicken, swine (Ortega, 2002)
Biologic control = **3,07E8 j/ha.year** (Ortega, 2002)

2. NONRENEWABLE RESOURCES

Loss of soil = 5.000 Kg/ha/year x 0.04 Kg organic material/12g soil x 5.400 kcal/Kg mat.org. = 6,48E6 kcal/ha/year; Conversion = 6,48E6 kcal/ha/year x 4.186 J/kcal = **4,52E9 j/ha.year** (Ortega, 2002)
Loss of nutrients = **3,00 Kg/ha/year** (Ortega, 2002)

3. MATERIALS

Calcareous rock = **0**
Single super phosphate = **0**
Fertilizer 20-00-20 = **0**
Zinc sulfate = **0**
Boric acid = **0**
Chemical herbicides= **0**
Chemical pesticides = **0**

Chemical fungicides = **0**
Cement = 30.000 Kg (2 employee houses) + 10.000 Kg (coffee yard 250 m2) / 20 years (depreciation) / total area 56 hectares = **35,71 Kg/ha/year** (Ortega, 2002)
Petroleum fuel = 15 liters/ha.year = 14 Kg fuel/ha.year x 10.000 Kcal/Kg x 4.186 J/Kcal = **5,86E8 j/ha/year** (Ortega, 2002)
Wood = 10.000 Kg / depreciation 10 years / 56 ha= **17,85 Kg/ha.year** (Ortega, 2002)
Iron = tractor 25.000 + dryer 7.500 Kg = 32.500 Kg / 56 hectares / 10 years (depreciation) = **58,03 Kg/ha.year** (Ortega, 2002)
Steel = 6000 Kg (tractor) / 56 hectares / 20 years (depreciation) = **5,35 Kg/ha.year** (Ortega, 2002)
Equipments and machinery maintenance = **30,00 US$/ha.year** (Ortega, 2002)
Other equipments (electricity e telephone) = **20,00 US$/ha.year** (Ortega, 2002)
Coffee bags = US$ 2.80 per bag x 18 bags/ha.year = **50.40 US$/ha.year**

4. SERVICES

Temporary workers (picking, drying and processing) = 5 men x 60 days x US$ 21.00 man/day/25 hectares = **252.00 US$/ha.year** (Agrianual, 2004)
Fixed workers = US$ 240.00 x 4 men x 12 months / 56 hectares = **205.71 US$/ha/year**
Technical assistance = **33.60 US$/ha/year** (Agrianual, 2004)
Accountant = **60.00 US$/ha.year** (Agrianual, 2004)
Fixed workers rights = 240 x 4 x 219% / 56 = **37,40 US$/ha.year**
Government taxes = **1.423,40 US$/ha.year**
Capital costs = **28,80 US$/ha.year** (crop area) (0,96% month)
Storage costs = 0.005% x 18 bags x US$ 250.00 = **22,50 US$/ha.year**

Appendix 2 . Barrinha farm and ranch Terra Verde production system characteristics.

Managerial Model	Crop area	System production characteristics						Risks of system
Conventional monoculture	150 ha (medium size)	Chemical fertilize and pests control	Large scale production	High Mechanization	High energy (fuel) and capital costs	Intensive in temporary hand labor	Coffee sale as comodity	Soil erosion; loss of biological diversity; social exclusion.
Organic System	25 ha (small size)	Natural fertilize, biological control of pests and subsistence culture	Small scale production	No mechanization	Small energy and capital costs	Intensive in permanent and familiar hand labor	Specialty coffee sale direct to consumer	Lose of competitiveness if organic coffee sale price will low

Source: Ecological Engineering Laboratory, FEA/UNICAMP

Appendix 3a – Emergy Balance of Barrinha farm, 190 hectares.

NOTE	ITEM	UNITY		VALUE	TRANSFORMITY		EMERGY FLOWS	
		VALUE	UNITY	J/year.ha	VALUE	UNITY	VALUE	UNITS
NATURAL RESOURCES								
R1	Rain	1,50E+00	m3/ha.year	7,50E+10	1,82E+04	Sej/j	1,37E+15	Sej/ha.year
R2	Soil minerals	2,00E+01	Kg/ha.year		4,37E+12	Sej/Kg	8,74E+13	Sej/ha.year
R3	Atmosphere N2	7,00E+01	Kg/ha.year		4,61E+12	Sej/Kg	3,23E+14	Sej/ha.year
R4	Biologic control	0,00E+00	Kj/ha.year		3,07E+08	Sej/Kg	0,00E+00	Sej/ha.year
R5	Organic fertilization	1,00E+03	Kg/ha.year		4,78E+12	Sej/Kg	4,78E+15	Sej/ha.year
R6	Subsistence agriculture	3,00E+04	Kg/ha.year		1,52E+07	Sej/Kg	4,56E+11	Sej/ha.year
NONRENOVABLE RESOURCES								
N1	Soil erosion	2,00E+04	Kg/ha.year	1,79E+10	7,38E+04	Sej/j	1,32E+15	Sej/ha.year
N2	Biologic control loses	3,07E+08	J/ha.year	3,07E+08	7,40E+04	Sej/j	2,27E+13	Sej/ha.year
N3	Nutrients loses	1,50E+01	Kg/ha.year		4,37E+12	Sej/Kg	6,56E+13	Sej/ha.year
MATERIALS								
M1	Calcareous rock	1,00E+03	Kg/ha.year		3,80E+12	Sej/Kg	3,80E+15	Sej/ha.year
M2	Single super phosphate	3,30E+02	Kg/ha.year		3,80E+12	Sej/Kg	1,25E+15	Sej/ha.year
M3	Fertilization 20-00-20	2,00E+03	Kg/ha.year		3,80E+12	Sej/Kg	7,60E+15	Sej/ha.year
M4	Zinc sulphate	4,80E+00	Kg/ha.year		3,80E+12	Sej/Kg	1,82E+13	Sej/ha.year
M5	Acid Boric	6,00E+00	Kg/ha.year		1,48E+13	Sej/Kg	8,88E+13	Sej/ha.year
M6	herbicides	9,00E+00	Kg/ha.year		1,48E+13	Sej/Kg	1,33E+14	Sej/ha.year
M7	pesticides	3,50E+00	Kg/ha.year		1,48E+13	Sej/Kg	5,18E+13	Sej/ha.year
M8	fungicides	1,50E+00	Kg/ha.year		1,48E+13	Sej/Kg	2,22E+13	Sej/ha.year
M9	Cement	2,37E+01	Kg/ha.year		3,30E+13	Sej/Kg	7,81E+14	Sej/ha.year
M10	Petroleum fuel	1,40E+01	Kg/ha.year	5,86E+08	6,60E+04	Sej/j	3,87E+13	Sej/ha.year
M11	Iron (machinery, tractor)	1,16E+01	Kg/ha.year		1,35E+12	Sej/Kg	1,56E+13	Sej/ha.year
M12	Wood and it products	2,11E+01	Kg/ha.year		3,90E+11	Sej/Kg	8,21E+12	Sej/ha.year
M13	Steel (depreciation)	4,73E+00	Kg/ha.year		1,80E+12	Sej/Kg	8,51E+12	Sej/ha.year
M14	Machinery and equipments maintenance	2,80E+01	US$/ha.year		3,70E+12	Sej/US$	1,04E+14	Sej/ha.year
M15	Other equipments (telephone, electricity)	1,50E+01	US$/ha.year		3,70E+12	Sej/US$	5,55E+13	Sej/ha.year
M16	Coffee bags	9,52E+01	US$/ha.year		3,70E+12	Sej/US$	3,52E+14	Sej/ha.year
SERVICES								
S1	Temporary workers	2,52E+02	US$/ha.year		3,70E+12	Sej/US$	9,32E+14	Sej/ha.year
S2	Permanent workers	1,21E+02	US$/ha.year		3,70E+12	Sej/US$	4,49E+14	Sej/ha.year
S3	Technical assistance	3,36E+01	US$/ha.year		3,70E+12	Sej/US$	1,24E+14	Sej/ha.year
S4	Managerial work	9,60E+01	US$/ha.year		3,70E+12	Sej/US$	3,55E+14	Sej/ha.year
S5	Accountant	6,00E+01	US$/ha.year		3,70E+12	Sej/US$	2,22E+14	Sej/ha.year
S6	Fixed employees rights	2,21E+01	US$/ha.year		3,70E+12	Sej/US$	8,19E+13	Sej/ha.year
S7	Union taxes	1,41E+03	US$/ha.year		3,70E+12	Sej/US$	5,22E+15	Sej/ha.year
S8	Capital costs	3,84E+01	US$/ha.year		3,70E+12	Sej/US$	1,42E+14	Sej/ha.year
S9	Store costs	2,55E+01	US$/ha.year		3,70E+12	Sej/US$	9,44E+13	Sej/ha.year

Appendix 3b – Emergy Balance of ranch Terra Verde, 56 hectares.

NOTE	ITEM	UNITY		VALUE	TRANSFORMITY		EMERGY FLOWS	
		VALUE	UNITY	J/ha.year	VALUE	UNIDADES	VALUE	UNITY
NATURAL RESOURCES								
R1	rain	1,50E+00	m3.year	7,50E+10	1,82E+04	Sej/j	1,37E+15	Sej/ha.year
R2	Soil Minerals	3,00E+01	Kg/ha.year		4,37E+12	Sej/Kg	1,31E+14	Sej/ha.year
R3	Atmosphere N2	7,00E+01	Kg/ha.year	3,10E+12	4,61E+12	Sej/j	3,23E+14	Sej/ha.year
R4	Organic fertilization (N+C)	1,76E+04	Kg/ha.year		4,78E+12	Sej/Kg	8,41E+16	Sej/ha.year
R5	Green fertilization	3,50E+03	Kg/ha.year		4,78E+12	Sej/Kg	1,67E+16	Sej/ha.year
R6	Subsistence agriculture	2,00E+04	Kg/ha.year		1,52E+07	Sej/Kg	3,04E+11	Sej/ha.year
R7	Biologic control	3,07E+08	J/ha.year	3,07E+08	7,40E+04	Sej/j	2,27E+13	Sej/ha.year
NONRENOUVABLE RESOURCES								
N1	Soil erosion	5,00E+03	Kg/ha.year	4,52E+09	7,38E+04	Sej/Kg	3,34E+14	Sej/ha.year
N2	Nutrients loses	3,00E+00	Kg/ha.year		4,37E+12	Sej/Kg	1,31E+13	Sej/ha.year
MATERIALS								
M1	Calcareous rock	0,00E+00	Kg/ha.year		1,48E+13	Sej/Kg	0,00E+00	Sej/ha.year
M2	Single super phosphate	0,00E+00	Kg/ha.year		1,48E+13	Sej/Kg	0	Sej/ha.year
M3	fertilization 20-00-20	0,00E+00	Kg/ha.year		3,80E+12	Sej/Kg	0	Sej/ha.year
M4	Zinc sulphate	0,00E+00	Kg/ha.year		1,48E+13	Sej/Kg	0	Sej/ha.year
M5	Acid Boric	0,00E+00	Kg/ha.year		1,48E+13	Sej/Kg	0	Sej/ha.year
M6	Herbicides	0,00E+00	Kg/ha.year		1,48E+13	Sej/Kg	0	Sej/ha.year
M7	Pesticides	0,00E+00	Kg/ha.year		1,48E+13	Sej/Kg	0	Sej/ha.year
M8	Fungicides	0,00E+00	Kg/ha.year		1,48E+13	Sej/Kg	0	Sej/ha.year
M9	Cement	3,57E+01	Kg/ha.year		3,30E+13	Sej/Kg	1,18E+15	Sej/ha.year
M10	Petroleum fuels	1,40E+01	Kg/ha.year	5,86E+08	6,60E+04	Sej/j	3,87E+13	Sej/ha.year
M11	iron (machinery, tractor)	5,80E+01	Kg/ha.year		1,35E+12	Sej/Kg	7,83E+13	Sej/ha.year
M12	Wood and it products	1,78E+01	Kg/ha.year		3,90E+11	Sej/Kg	6,94E+12	Sej/ha.year
M13	steel (depreciation)	5,35E+00	Kg/ha.year		1,80E+12	Sej/Kg	9,63E+12	Sej/ha.year
M14	Machinery and equipments maintenance	3,00E+01	US$/ha.year		3,70E+12	Sej/US$	1,11E+14	Sej/ha.year
M15	Other equipments (telephone, electricity)	2,00E+01	US$/ha.year		3,70E+12	Sej/US$	7,40E+13	Sej/ha.year
M16	Coffee bags	5,04E+01	US$/ha.year		3,70E+12	Sej/US$	1,86E+14	Sej/ha.year
SERVICES								
S1	Temporary workers	2,52E+02	US$/ha.year		3,70E+12	Sej/US$	9,32E+14	Sej/ha.year
S2	Permanent workers	2,06E+02	US$/ha.year		3,70E+12	Sej/US$	7,61E+14	Sej/ha.year
S3	Managerial work	9,60E+01	US$/ha.year		3,70E+12	Sej/US$	3,55E+14	Sej/ha.year
S4	Technical assistance	3,36E+01	US$/ha.year		3,70E+12	Sej/US$	1,24E+14	Sej/ha.year
S5	Accountant	6,00E+01	US$/ha.year		3,70E+12	Sej/US$	2,22E+14	Sej/ha.year
S6	Fixed employees rights	3,75E+01	US$/ha.year		3,70E+12	Sej/US$	1,39E+14	Sej/ha.year
S7	Union taxes	1,42E+03	US$/ha.year		3,70E+12	Sej/US$	5,27E+15	Sej/ha.year
S8	Capital costs	2,88E+01	US$/ha.year		3,70E+12	Sej/US$	1,07E+14	Sej/ha.year
S9	Storage costs	2,25E+01	US$/ha.year		3,70E+12	Sej/US$	8,33E+13	Sej/ha.year