EMERGY SYNTHESIS 3:
Theory and Applications of the Emergy Methodology

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Combining Bookkeeping Techniques and Emergy Analysis

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ABSTRACT

This paper proposes the fusion of bookkeeping and emergy analysis to evaluate production systems. The basic idea is to obtain from emergy analysis the values of natural resources that contribute to a specific production and also an estimative of the importance of environmental and social impacts. On the other hand, from the bookkeeping methods side it is necessary to discover where and how the emergy information will be introduced on the Balance Sheet and the Gain and Loss Statement. Finally, it is necessary to observe the behavior of bookkeeping tools after the introduction of emergy values of natural resources and externalities. To illustrate this dual method it was analyzed a water buffalo farm located in Rio Grande do Sul, the southernmost state of Brazil. This farm ("Fazenda Redomão") uses an ecological method for animal husbandry, the Voisin Technique. So far, the proposed combination of methods seems possible but, because the dual method was applied to an ecological system with low negative impacts, we strongly recommend applying it in a non-ecological cattle-growing system, in order to compare and discover new possibilities of improvement. It is possible that negative externalities as well as free contributions from Nature can lead to strong modifications on the bookkeeping results. The combined accounting method may be very useful for holistic management.

INTRODUCTION

Any activity demands and degrades available energy. Every activity has specific open-systems thermodynamics indicators of performance. However, nowadays the enterprises do not use them as criteria for planning and management. But, since economic activities generate important environmental and social impacts, it is necessary to review the forms of measuring value and efficiency.

In this context, emergy method is a precious tool, since it measures the real energy involved in any activity. The Emergy Analysis assigns to every input all the energy that is needed to produce it. In order to make inputs comparable, they are calculated in terms of their equivalent solar energy. On the other hand, Bookkeeping evaluates all the activities of an enterprise through the detailed register of the inventory in order to offer a diagnosis of the economic health of the enterprise. As it has been in use for quite a long time, bookkeeping is accepted internationally as an appropriate tool for administration on general and financial control, in a specific form. The Accounting Community accepts that Bookkeeping can include environmental debts and credits.

Combining both criterions targets a fundamental goal: to offer bookkeeping the possibility of expressing the values of assets and liabilities in terms of emergy and, therefore, to be environmentally meaningful. The idea is to account all the items of a balance sheet by their energy content and quality.

Some of these, whose monetary value is considered inexistent, should be seen as having useful energy and, therefore, capable of performing valuable work.

In South America, cattle-growing is a very important economic activity that requires few employees per area and usually has low costs. Because of that, it spreads out over the countryside. The cattle-growing systems are becoming bigger and concentrate the income in rural areas. This activity creates social and environmental liabilities, not always identified and not charged to the farmers, for instance:

a) Low employment rate (social exodus);
b) Replacement of the virgin forests by pasture;
c) Soil erosion;
d) Water pollution;
e) Extinction of species;
f) Gas emissions that produce climatic changes;

Traditional cattle growers are guided by the logic of diminishing costs through gaining on scale. They acquire political power and use it to avoid law enforcement. Since pasturelands are increasing their price and are no longer fertile, rural activities are striding towards distant woodlands where price of land is cheaper. This raises transport costs, but the financial balance is positive. However, the environmental threaten is obvious. As an alternative, there are systems that combine pasture, forest and animal rotation. These new technologies point towards great improvements in environmental stability and economic profitability. Water buffalo is an interesting option to Latin American countries; they are rustic, docile, adaptable and efficient converters of biomass into many products.

So, the improvement of cattle systems is highly desirable and possible. It is expected that in the future the animal husbandry systems will have integration with agriculture and industrial activities. Naturally, the environmental impacts of the cattle growing activity, that may exist, must be studied and solved. The owners of the cattle project analyzed agreed to contribute with this study.

MATERIALS AND METHODS

In this essay, as shown in Figure 1, the goal is to maintain the standard accounting structure, with its items valued in the traditional way adding, however, a second column in the Balance Sheet (BS) and the Gain and Loss Statement (GLS) where each item receives the emergy value calculated in the Emergy Flows Table. Another additional feature is a line of externalities to be subtracted from the Net Profit at the GLS chart. If externalities are neglected, it means that the producers do not assume

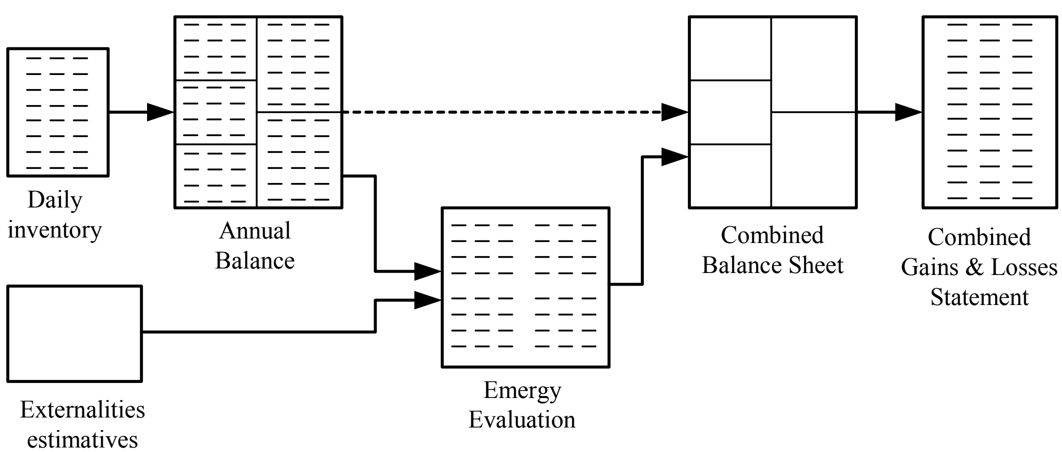


Figure 1. *Accounting procedure including Emergy Evaluation and estimate of externalities.*

social, environmental or economic costs. In short, four scenarios were obtained: monetary and emergy evaluation both with and without externalities.

The combined methods were applied to Redomão water buffalo farm (Figure 2). The productive process of this farm is divided into eight sectors: four sectors are dedicated to milk production and the other three to meat production, in a total area of 307 hectares. In all these sectors, the animal husbandry follows the Voisin method. It establishes that the cattle should stay one up to two days in each paddock, in a quick consumption period, and only comes back after forty days, the period of time necessary for pasture regeneration. The Voisin method doesn't need investments in pasture formation but on paddocks construction and technical training. In the eighth sector the area is devoted to produce the feed (maize and sugar cane) that is supplied to milk producing animals. The farm nowadays obtains the productivity and profitability ratios as shown in Table 1 below:

Table 1. Productivity and Net Profit indicators for the Redomão farm.

Product	Productivity	Medium price US$/unit	Sales US$/ha/year	Expenses US$/ha/year	Net profit US$/ha/year
Meat	228 kg/ha/year	0,60	136.08		
Milk	170 liters/ha/year	1,09	184.92		
Total			**321.00**	**196.56**	**124.44**

Source: Redomão farm, 20/November/2003.

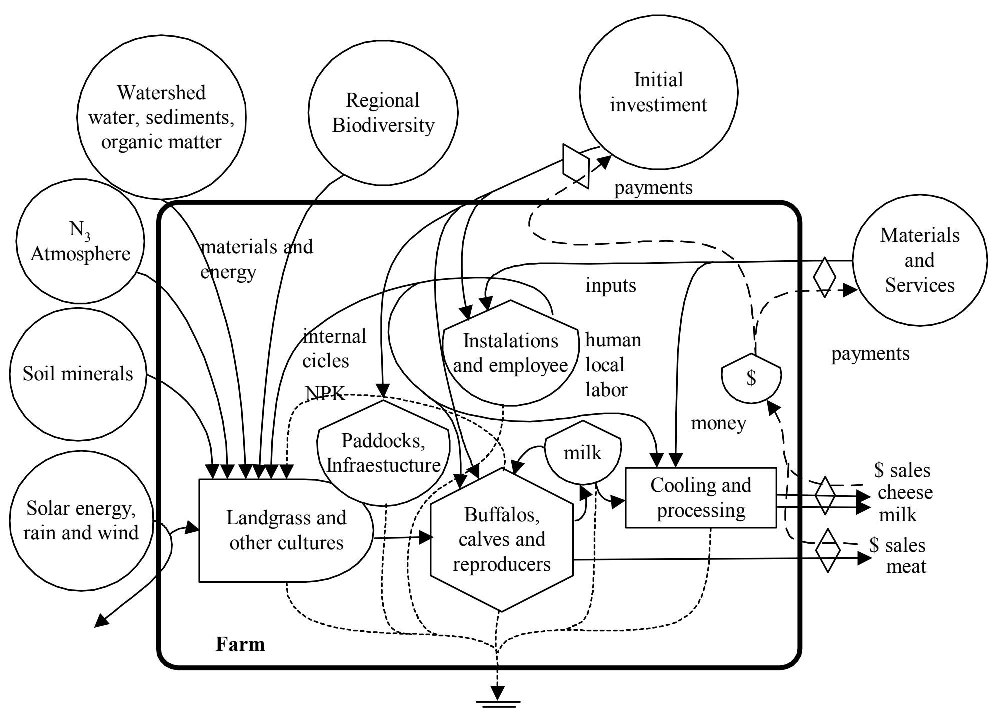
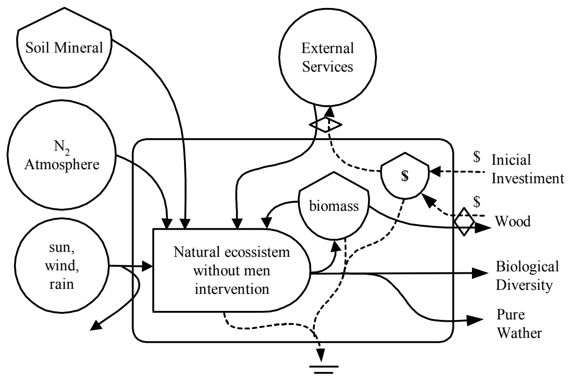


Figure 2. *Emergy Flows Diagram for Redomão ecological farm.*

Diagram Flows and Balance Sheets

For the purpose of this study we need to consider all the stages of the enterprise's development. Through the use of energy flows diagrams and balance sheets in parallel (figures 3 to 6) we show a farm from its beginning until it achieves full production and also to its enclosure. This procedure evidences the environmental passive as well as the ecological debt. Two examples were considered: typical cattle growing and an ecological farm.

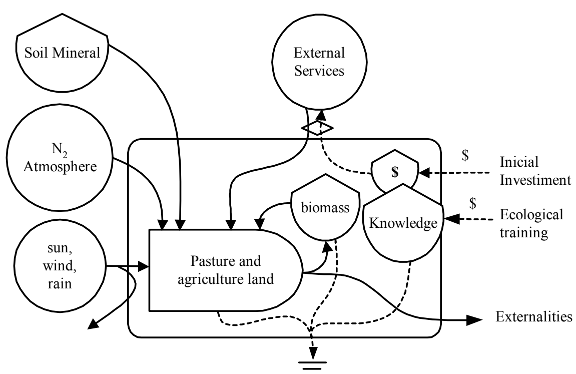
Cattle growing system: Initially, the stakeholders meet to choose the area that will be used and to join the capital to buy it. Nowadays, in Brazil the cattle systems are expanding in lands covered by native forests. The first process is contract external services to extract the wood and after that, they put fire on the residual vegetation. The money obtained from wood sales allows paying part of initial investment. There is an environmental load because the biological diversity decreases and erosion begins. The environmental impact creates a passive to be paid in the future.



Balance Sheet	
Assets	Liabilities
Current Assets *Wood*	Current liabilities
Long Term Assets	Long term liabilities ***Environmental debit***
Fixed Assets	Net worth
Agrarian capital	*Initial Investment*

Figure 3a. *Emergy and Financial views of Cattle Growing System, first step implementation.*

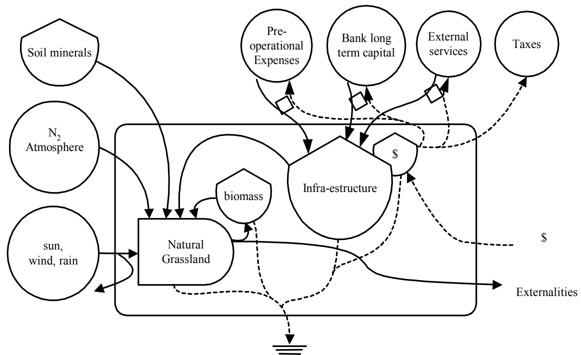
Redomão Voisin Method: The owners decided to buy a land degraded by agrochemical rice culture. The soil fertility was lost and it had a lower price. The enterprise accepted to gradually recover the environmental passive left by previous activity. An important pre-operational investment was the Voisin Method training. This ecological technique demands a high planning and managing capacity.



Balance Sheet	
Assets	Liabilities
Current Assets ***Ecological training***	Current liabilities ***Ecological training costs***
Long Term Assets	Long term liabilities ***Environmental debit***
Fixed Assets	Net worth
Agrarian capital	*Initial Investment*

Figure 3b. *Emergy and Financial views of Redomão Voisin Method, first step implementation.*

In the next stage, the enterprises use land area capital to obtain bank long-term investments to complete the infrastructure: paddocks, equipment, machinery, buildings, etc. This activity can be shown in a unique figure for both systems.

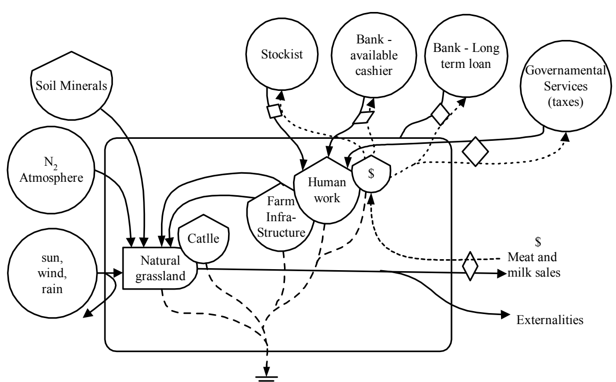


Balance Sheet	
Assets	Liabilities
Current Assets	Current liabilities *Pre operational costs*
Long Term Assets	Long term liabilities *Bank* ***Environmental debit***
Fixed Assets *Infra-structure* *Machinery* *Agrarian capital* *Social register*	Net worth *Initial Investment*

Figure 4. *Emergy and Financial views of the infrastructure implementation in conventional cattle growing system and Redomão ecological farm.*

After the infrastructure implementation, it is possible to start the farm's production. At this stage (Figure 5), the expenses with labor and inputs will begin. The main obligations are salaries, employee's rights, fuel suppliers, electric energy and telephone, payment of the bank interests over third parties capital, taxes and net profit.

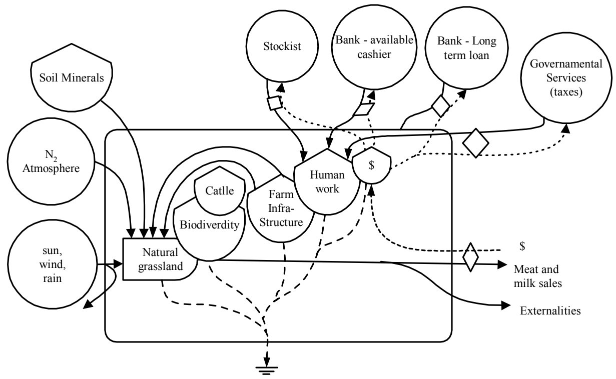
Cattle growing system: This enterprise maintains intense commercial activities with urban economy to buy inputs and to obtain services. Even today the environmental passive is not paid due to several reasons, in the future it will have to be considered in public and private accounting. It is better to be prepared for that moment.



Balance Sheet	
Assets	Liabilities
Current Assets *Available cash* *Cattle Growing* *Consume Stock*	Current Liabilities *Suppliers* *Salary* *Taxes* *Interest*
Long Term Assets	Long Term Liabilities *Banks* ***Environmental debit***
Fixed Assets *Equipment and machines* *Installations* *Agrarian Capital*	Net Worth *Initial Investments* *Net Profit*

Figure 5a. *Emergy and Financial views of full performance conditions in Cattle Growing Systems.*

Redomão Voisin Method: Meat and milk production is carried out with the minimum of external inputs. The animals are fed with several plants that grow on the paddocks under rotation. The milking animals receive a food complement made with sugar cane and corn produced in the farm. The Redomão enterprise is making investments on vegetation recovering: formation of tree corridors, natural diversification of grasslands and soil protection. This farm is gaining an environmental credit, increasing the value of the property and reducing production costs.

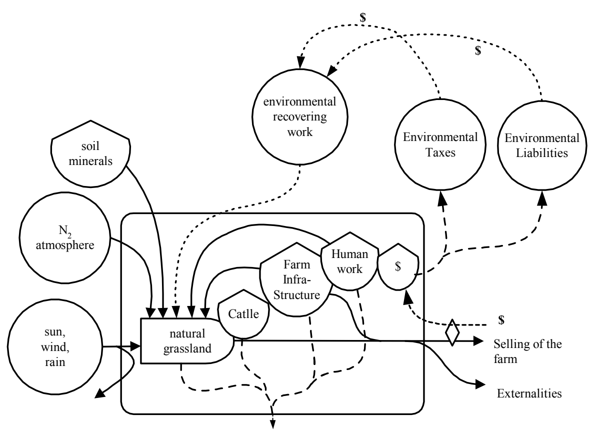


Balance Sheet	
Assets	**Liabilities**
Current Assets	Current Liabilities
Available cash	*Suppliers*
Water Buffaloes	*Salary*
Consume Stock	*Taxes*
	Interest
Long Term Assets	Long Term Liabilities
	Banks
	Net Worth
Fixed Assets	
Water Buffaloes for milk	*Initial Investments*
Equipment and machines	
Installations	*Net Profit*
Agrarian Capital	
Environmental credit	

Figure 5b. *Emergy and Financial views of Redomão Voisin Method in steady state.*

If this farm ends its operation (Figure 6), all the assets should be sold and the result of this sale should meet all the farm's obligations. *Beside the traditional obligations, any company should put apart enough resources to restore the environment to its original conditions.* After having met all these obligations, the owners could keep the remaining assets, if any.

Cattle Growing System: At the end of its operation, the assets will be sold to pay all its liabilities. Our idea is that the ecological debt has to be paid, at least at this final moment. The taxes should be greater for those that do not recover the ecosystem, in such a form that the government could assume the restoration of nature at the end of operations. This tax difference could affect the profit of stakeholders, as shown in Figure 6a:



Balance Sheet	
Assets	**Liabilities**
Current Assets	Current liabilities
	Final payment
Long Term Assets	Long term liabilities
	Environmental recovering reserve
Fixed Assets	Net worth
	Liquid profit of farm sale

Figure 6a. *Emergy and Financial views of end of activities in conventional cattle growing system.*

Redomão Voisin Method: At the end of Redomão activities, the owners will receive additional benefits. There will be no economic neither ecological liabilities. The debt with bank and suppliers will be very low, only some commitments with workers and long-term loans. The ecological recovering will mean better price for the property.

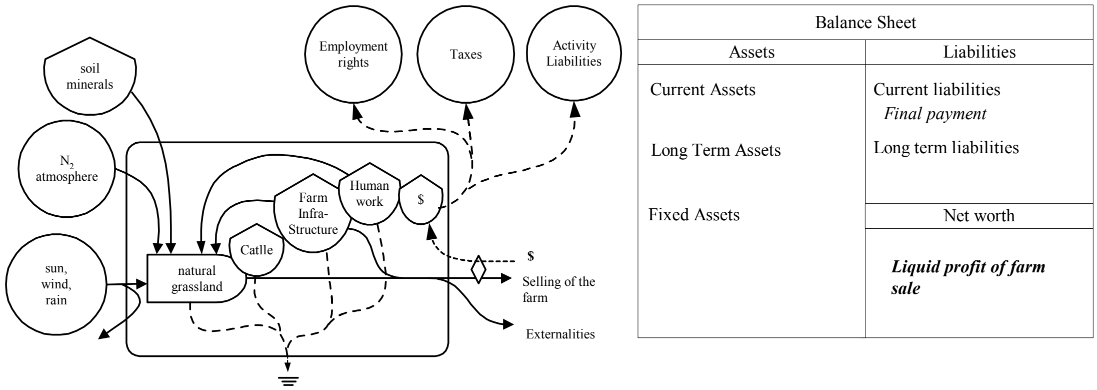


Figure 6b. *Emergy and Financial views of the end of activities in Redomão farm.*

RESULTS

The emergy evaluation of Redomão farm provides the indicators shown in Table 2. See Table 4 in the Appendix for details.

Table 2a. Emergy flows for Redomão farm in 2002.

Aggregated flows	**Emergy flow** x 10^{13} sej/ha/year	**Percent**
Renewable resources (**R**)	278.2	81.8
Non-renewable resources (**N**)	6.3	1.9
Inputs from nature (I)	**284.5**	**83.7**
Materials depreciation (**M**)	12.3	3.6
Materials consumption (**M**)	24.6	7.3
Services (**S**)	13.5	4.0
Additional services (**S'**)	2.3	0.7
Feedback from economy (F)	**52.7**	**15.6**
Total emergy used (Y)	**317.2**	**100.0**

Table 2b. Emergy indicators for Redomão farm in 2002.

Indicators (H. T. Odum, 1996)	**Formulas** (H. T. Odum, 1996)	**Values**	**Remarks** (Brown & Ulgiati, 2000)
Transformity	Tr = Y/(product energy)	1.917.758	Intensive system
% Renewable	%Ren = (R/Y)*100	85%	Highly renewable
Emergy **Y**ield **R**atio	EYR = Y/F	8.1	Very good
Emergy **I**nvestment **R**atio	EIR = F/I	0.14	Low investment
Emergy **L**oading **R**atio	ELR = (N+F)/R	0.17	Low impact
Emergy **E**xchange **R**atio	EER = Y/[(US$ *(sej/US$)]	2.28	Reasonable fair trade

These indicators expose the correctness of the administration patterns adopted by the proprietors and the good environmental behavior of this cattle-growing activity.

Definitions of emergy indicators from Brown and Ulgiati (2000):

Tr: Ratio between the total emergy used and the energy yielded by a process. It is a measure of the ecosystem's efficiency and an indicator of the products position in nature's emergy hierarchy.

%Ren: The renewability shows the ratio of renewable emergy to total emergy used in the production process. Processes with high renewability are sustainable in the long run. The economic consequences to process are low production costs, more competitive products and lower environmental impact.

EYR: The Environmental Yield Ratio provides a measure of the extraction or appropriation of natural local resources by investing economic resources. The lowest possible value is 1, which indicates that a process delivers the same amount of emergy that was provided to drive it, and that it is unable to usefully exploit any local resource. Therefore, a process with EYR equal to 1 or only slightly higher does not provide significant net emergy to the economy and only transforms resources that are already available from previous process.

EIR: The Emergy Investment Ratio measures the ratio of emergy fed back from outside a system to the indigenous emergy inputs (renewable and nonrenewable). It evaluates how much the process is a good user of the emergy that is invested, in comparison with alternatives. For conventional agricultural processes this value goes up to 5-8, for agro-ecological system can be as low as 0,1 to 4. Systems with EIR values higher than 5 are considered dependent of external resources.

ELR: This indicator compares the amount of nonrenewable (N) and purchased emergy (F) to the amount of locally renewable emergy (R). In the absence of external investments, the renewable emergy that is locally available will be driven to the growth of a mature ecosystem and this situation is characterized by an ELR=0. If external investments are made, values lower than 2 indicate low environment impacts (or process that can use large areas of local environment to "dilute impacts"). Values from 3 to 10 mean a moderate impact, while ELR values above 10 indicate high environmental impacts due to large flows of concentrated nonrenewable emergy in a relative small local environment.

A comparison of traditional monetary and emergy Balance Sheets.

Now, switching to accounting procedures, Figure 7 presents two different forms to present the Balance Sheet. The first one is the traditional Annual Balance and the second corresponds to the *Emergy Balance Sheet*. This second form shows the same assets and liabilities in terms of *Em$*.

Monetary Agregeted Values

	Assets	Liabilities	
current	245.991	222.741	current
Long Term	0	**149.030**	Long Term
Fixed	440.613	**314.354**	Net Worth
TOTAL	686.125	686.125	**US$**

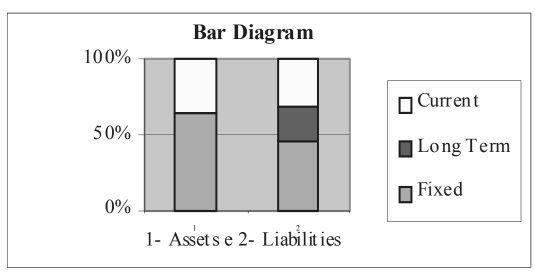


Figure 7a. *Traditional Balance Sheet of Redomão farm in 2003, expressed in US dollars.*

Emergy Agregeted Values

	Assets	Liabilities	
current	262.083	243.272	current
Long Term	0	**149.030**	Long Term
Fixed	411.880	**272.970**	Net Worth
TOTAL	673.963	673.963	**Em$**

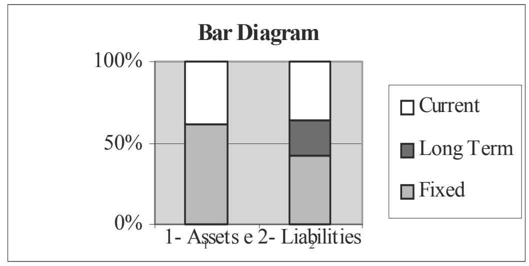


Figure 7b. *Emergy Balance Sheet of Redomão farm in 2003, expressed in Em$.*

It is possible to observe in Figures 7a and 7b that:

(a) **Current Assets**: some items have higher Em$ value than monetary value.
(b) **Current Liabilities:** increase because the inputs in Em$ have a higher value.
(c) **Log term** does not change because correspond to monetary values in both cases.
(d) **Fixed Assets**: monetary depreciations could be higher than the emergy ones (greater time).
(e) **Net Profit**, the more important item of Balance Sheet for stakeholders, decreases when emergy equivalent dollars are used; it changes from 314,354 dollars to 272,970 Em$.

Table 3. GLS in terms of money and Emergy.

Gain and Loss Statement

	US$	Em$
Sales Revenue	101,116.35	101,116.35
Net Revenue	85,768.10	75,541.94
Production costs	18,442.49	17,263.74
Gross profit	67,325.60	58,278.19
Operational costs	7,832.86	7,832.86
Operational Expenses	59,492.75	50,445.33
Financial expenses	13,236.71	13,276.71
Tributary expenses	1,691.79	1,691.79
Depreciation expenses	23,895.88	23,895.88
Earnings before Income Tax	22,360.15	13,312.74
Income Tax	5,590.04	16,770.12
Earnings after Income Tax	16,770.12	9,984.56
Depreciation (+)	23,895.88	23,895.88
Net profit	40,666.00	33,880.44
Social and Environmental externalities	***1,905.43***	***1,905.43***
Net profit after externalities	***38,760.57***	***31,975.01***

Using data from Figure 7 it is possible to prepare the G&LS including, or not, externalities that appear in the system. Table 3 shows GLS in monetary and emergy equivalent dollars, with and without externalities. The last line shows the Net Profit after inclusion of externalities costs.

DISCUSSION

It can be observed that Redomão Farm is a very lucrative enterprise. The value of its current assets allows paying current liabilities. Long-term liabilities can be paid with the Net Profit.

The inclusion of negative externalities can punish the net worth and the non-current liabilities. This punishment, in the case of Redomão is small due to the careful way the owners use to administrate the farm as an ecological unit. Besides that, the technology adopted doesn't generate negative externalities, just the opposite, Voisin Method generates positive externalities.

It was evident that Voisin method as well as Water Buffalo can increase the sustainability and productivity of cattle growing systems in Latin America. The Redomão farm, since its foundation, fifteen years ago, has been constantly improving its performance and the farm environment. Support capacity, self-sufficiency and financial performance get better every year. To attest their success, the farm's support capacity is three times higher (1.5 heads/ha) than the average for the state of Rio Grande do Sul. They are self-sufficient in food supply for the water buffalos. As a result, the farm provides higher return rates than the average for farms of the same region. It can be observed that the social conditions for employees are also better.

Although the ecological path is successful up to now, there are hints that this will become even better, as the owners keep investing in environmental improvements. They expect to increase support capacity up to 3 animals per hectare. Besides that, the farmers expect to duplicate the milk production per milking animal in the next five years. Right now, they are recovering the local vegetation, planting trees and shrubs. Nowadays, the region is mainly covered by degraded pasture without forests. In the South of Brazil the law demands 20% of the farm's land covered by native forest.

CONCLUSIONS

1. The bookkeeping accounting methods (BS and GLS) when applied to Redomão farm provides good indicators of economic behavior, especially in terms of profitability.
2. Emergy evaluation of Redomão farm provides indicators that show the low environmental impact; very good renewability and high emergy yield ratio of the system studied.
3. The combination of both methods demands not only a steady state analysis but also a history of the activities of the enterprise in the region, in order to discover the environmental and social actives and passives.
4. Apparently, the combination of Emergy Evaluation and Bookkeeping is possible. As a result the managers can (a) incorporate environmental supplies, (b) establish environmental assets and debts, (c) introduces the values of negative and positive externalities, (d) planning for the long term.
5. The relevance of the emergy-combined method is out of question and the goal here is cooperation with accounting professionals. Nowadays, there are worldwide important debates among the accountants' organizations on how to measure environmental and social assets and liabilities, and this essay could contribute to the subject.
6. No matter how important this present study could be, it will need verifications, demand adjustments and improvements. Other study cases with more negative impacts will have to be considered and theoretical efforts, as those carried out by Daniel E. Campbell (2004), will have to be taken in consideration.
7. Emergy Accounting is a valuable tool, but in order to be widely used, it has to create an appropriate interface with Bookkeeping, Accounting and Financial Managing; the approach studied could help to face this challenge.

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APPENDIX

1. Externalities:

Negative externalities are costs which producers do not assume and manage to transfer to other systems (society, environment, and employees). In this work, the monetary costs of externalities, as well as their emergy values were inserted in the spreadsheets. The value of "Social and environmental externalities" was subtracted to the "Net Profit" at the end of the "Gain and Profit Statement". To subtract externalities from profit is a form to charge enterprise owners by their omissions or faults.

(a) **Unemployment:** Each biome has a certain capacity to maintain the life of species. In the Amazon jungle, the ecosystem can support 1 human in 20 hectares in a self-sustaining pattern. In the case of a cattle growing that exports products the index could bigger: 1 human in 50 hectares. *From that index, we can estimate the quantity of labor posts that the farm could sustain (307/50 = 6 work places)*. If the farm has 5 workers there is a deficit of 1. It means the wage of a rural worker including social benefits.

(b) Meat contamination:

When a farmer uses toxic chemicals in pastures or animals, such as hormones, or contaminated feed, he is supplying the market with a dangerous product that jeopardizes consumer's health. The effect is an increase of costs of health system and taxes. These costs are difficult to identify and measure because usually are not concentrated. *The farm Redomão does not use toxic substances*.

(c) Milk contamination: Consumer's intoxication is not paid by the farmers but by families or society. *The farm under study has a good milking system and does not produce externalities of this kind*.

(d) Workers intoxication: The family or society pays the medical health treatment of intoxicated workers. Farmers' responsibilities are not assumed neither charged. *The ecological farm does not produce this kind of externalities because doesn't use toxic substances*.

(e) Water contamination: If a rural enterprise uses chemical fertilizers, pesticides and herbicides, part of these substances go to water streams and get the subsoil aquifer. Because it is a diffuse phenomenon the polluters are not charged. There are costs due to water treatment and health treatment. *The system studied does no have this externality*.

(f) Deforestation, soil erosion and Biodiversity loss: Cattle growers use to cut the trees and bushes of the purchased land and, and after that, they put fire. Usually they invest as low as possible, working with low productivity, losing soil's fertility. It is not the case of Redomão; the farmer bought a terrain of natural meadows that did not have forests due to the force of winds and soil was degraded by rice production. *The farmer is recovering grass diversity and seeding trees and bushes in corridors*.

2. Water valuation:

As Active: In order to evaluate the value of the yearly water input of the system, it was obtained the value of rain that hits the region (cubic meters/square meter/year). Multiplying the area with this value allows knowing the water chemical potential, but not all this water is available for photosynthesis; because part of it leaves the land as run-off and another part flows down and leaves the root area without being absorbed. We assume that water is split in three flows: water used or evapotranspiration (85%), run-off (5%) and seepage that get into the aquifer (10%). If there were no rainwater the water would have to be purchased from outside sources in order to obtain the same quantity of biomass. It should be paid at certain price per cubic meter.

As Passive: It was considered the volume of water retired from the well times its cost per cubic meter.

Financial Analysis (active, passive, results) with data from emergy analysis: For each item of Balance Sheet (BS) and Gain and Loss Statement (GLS) the emergy value was included, side by side with the monetary value. *The emergy values were imported from the emergy flows calculation table*.

Procedure to obtain Emergy values used in the BS and the GLS:

1- Each input flow is expressed in terms of its energy or matter flow;
2- These flows are transformed in their equivalent solar emergy Joules through the use of its "transformity". The emergy corresponds to the "real energy cost" of the input, in other words, how much solar energy is needed to produce it;
3- The emergy flows can be expressed in terms of Emergy dollars or "Em$" using an emergy/dollar factor, which is obtained dividing the emergy used in nation's economy by the Gross National Product. We can compare Em$ and Dollars and discover hidden subsidies.
4- The emergy/dollar ratio gives an idea of buying power of a nation's currency.

Depreciation of Permanent Assets in Balance Sheet:

Permanent Assets suffer depreciation during their time of use. This means that, every year, their value is decreased and an amount of money is reserved to be able to substitute them in due time. The traditional accounting due to use of norms of broad field of application establishes very strict parameters to depreciate machinery with excessive safety that led to excessively reduced times to renew equipment. In the emergy calculations we were able to get more close to what happens in real life, therefore we consult the farm owners to verify the most probable life time of each permanent asset, that time is usually bigger than legal depreciation time. Because of that, the emergy depreciation becomes lower than traditional accounting values. In the farm studied we observed good quality equipment and careful use and maintenance of it.

Table 4. Emergy flows of water buffalo system, Guaiba, RS, Brazil.

Ref	Contribution	Value	Units	Tr	Emergy	%	emUS$/	emUS$/y
				sej/dollar	**3.70E+12**			
				sej/unit	sej/ha.year		ha.year	**307 ha**
Renewable resources (R)					**2.78E+15**	**81.8**	**751.8**	**230790**
1	Rain	6.5E+10	J/ha.y	1.82E+04	1.18E+15	34.8	319.7	98157
2	Water from well	2.5E+09	J/ha.y	1.10E+05	2.75E+14	8.1	74.3	22818
3	Nitrogen from air	120	kg/ha.y	4.61E+12	5.53E+14	16.3	149.5	45901
4	Nutrients from soil minerals	69	kg/ha.y	4.37E+12	3.03E+14	8.9	81.8	25128
5	Biodiversity	517	kg/ha.y	9.04E+11	4.67E+14	13.7	126.3	38787
Non-renewable resources (N)					**6.33E+13**	**1.9**	**17.1**	**5256**
6	Arable land erosion	8.6E+08	J/ha.y	7.38E+04	6.33E+13	1.9	17.1	5256
Materials (M): depreciation					**1.23E+14**	**3.6**	**33.2**	**10199**
7	Land and well	10.70	US$/ha.y	3.70E+12	3.96E+13	1.2	10.7	3284
8	Buildings (houses, barn)	4.09	kg/ha.y	2.37E+12	9.68E+12	0.3	2.6	803
9	Stainless steel (milk room)	0.10	kg/ha.y	6.70E+12	6.55E+11	0.0	0.2	54
10	Iron structures	1.21	kg/ha.y	1.35E+12	1.63E+12	0.0	0.4	135
11	Wood structures	2.44	kg/ha.y	3.90E+11	9.53E+11	0.0	0.3	79
12	Grass seeds	0	kg/ha.y	1.48E+12	0	0	0	0
13	Project and training	0.87	US$/ha.y	3.70E+12	3.21E+12	0.1	0.9	267
14	Iron (fetch)	7.03	kg/ha.y	6.70E+12	4.71E+13	1.4	12.7	3910
15	Animals (initial stock)	4.89	US$/ha.y	3.70E+12	1.81E+13	0.5	4.9	1500
16	Plastic (water tubes)	0.10	Kg/ha.y	1.97E+12	1.93E+11	0.0	0.1	16
17	Drinking system (cement)	0.24	Kg/ha.y	1.97E+12	4.81E+11	0.0	0.1	40
18	Machinery)	0.36	US$/ha.y	3.70E+12	1.33E+12	0.0	0.4	111
Materials (M): consumption					**2.46E+14**	**7.3**	**66.4**	**20389**
19	Maintenance (paddocks)	6.34	US$/ha.y	3.70E+12	2.34E+13	0.7	6.3	1945
20	Maintenance (equipment)	5.15	US$/ha.y	3.70E+12	1.91E+13	0.6	5.2	1581
21	Cleaning products	0.66	US$/ha.y	3.70E+12	2.44E+12	0.1	0.7	203
22	Workers consumption	6.33	US$/ha.y	3.70E+12	2.34E+13	0.7	6.3	1945
23	Semen, medicines, vaccines	13.44	US$/ha.y	3.70E+12	4.97E+13	1.5	13.4	4126
24	Fuels	7.53E+08	J/ha.y	6.60E+04	4.97E+13	1.5	13.4	4126
25	Electricity	4.2E+06	J/ha.y	4.00E+05	1.69E+12	0.1	0.5	140
26	Salt with minerals	1.80	kg/ha.y	1.00E+12	1.80E+12	0.1	0.5	149
27	Feed for chicken	0.98	kg/ha.y	2.45E+12	2.40E+12	0.1	0.6	199
28	Lime	72.00	kg/ha.y	1.00E+12	7.20E+13	2.1	19.5	5974
Services (S): yearly expenses					**1.35E+14**	**4.0**	**36.5**	**11192**
29	Local manpower	4.71	US$/ha.y	3.70E+12	1.74E+13	0.5	4.7	1446
30	External manpower	1.72	US$/ha.y	3.70E+12	6.37E+12	0.2	1.7	528
31	Administration	6.75	US$/ha.y	3.70E+12	2.50E+13	0.7	6.7	2071
32	Transport	6.98	US$/ha.y	3.70E+12	2.58E+13	0.8	7.0	2143
33	Technical information	0.50	US$/ha.y	3.70E+12	1.86E+12	0.1	0.5	155
34	Taxes	5.51	US$/ha.y	3.70E+12	2.04E+13	0.6	5.5	1692
35	Animal robbery (8 heads/y)	10.28	US$/ha.y	3.70E+12	3.81E+13	1.1	10.3	3157
Services (S): amortization					**0**	**0**	**0**	**0**
36	Doubt payment	0.00	US$/ha.y	3.70E+12	0	0	0	0
Externalities					**2.3E+13**	**0.7**	**6.2**	**1905**
37	Work posts deficit	6.21	US$/ha.y	3.70E+12	2.3E+13	0.7	6.2	1905
38	Intoxication of workers	0.02	labor/ha.y	0	0	0.0	0.0	0
39	Contamination of milk	169.78	liters/ha.y	0	0	0.0	0.0	0
40	Contamination of meat	227.95	kg/ha.y	0	0	0.0	0.0	0
41	Water pollution	1.800	m3/ha.y	0	0	0.0	0.0	0
	Total				**3.37E+15**	**100.0**	**911.2**	**279731**