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FARMING AT THE EDGE

ECONOMIC AND ENVIROMENTAL SUSTAINABILITY OF FARMS FROM THREE DIFFERENT BRAZILIAN REGIONS

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Abstract: Using the technique of "panels" farms were drawn as representatives from three regions of Brazil: the first was a medium size farm representing the grain production area of Northern Rio Grande do Sul State; the second, a large farm from the grain and livestock production area of Mato Grosso State; the third, a very large farm from the Amazonian livestock production area of Pará State. The long-term cost of production was estimated and the yearly average net income was evaluated for each typical farm. An "emergy" evaluation table, prepared according to procedures described by Odum (1996), was used to estimate each farm process of incorporating energy into its production as a way to evaluate the sustainability of the farms systems. A four quadrant reference system, based on the average measurements for each vector – environmental accounting and net farm income – allowed the plotting of the three farms on the designed quadrants. The null hypothesis indicates that sustainable farms must be plotted on the southwest and on the northeast quadrants. The presence of farms on either of the two non-expected quadrants, the northwest and the southeast, poses long term problems of sustainability and indicates that new development policies are required.

Introduction

There is a big diversity of environmental and economic conditions in Brazil. Environmental legislation requires different farm allowances for preservation areas. For instance, farms in the Amazon are required to maintain 80% of their area as preservation sites. In the Cerrado Region (savannas) and in the Southern temperate region only 20% of the area is required for preservation. Modern agriculture started on the Southern regions, then migrated to the Cerrado region and more recently farming was introduced in the Amazonian region. Land is more expensive in the old areas and less expensive in Amazonian areas. Therefore, present technologies uses more bought inputs in the older areas than in the newer. Also the Southern areas are much closer to the domestic markets for its products and just recently, new commercial channels are being opened for exports of Cerrado and Amazon agricultural production.

The problem addressed by this paper deals with the relative efficiency of farm management in the above mentioned regions. Efficiency was measured for both economic and environmental sustainability. Economic efficiency was evaluated through net income per hectare and environmental efficiency was evaluated through loading ratio per hectare. Loading Ratio is the ratio between the amount of non-renewable resources and the natural renewable resources measured by the emergy flow as defined by Odum (1996). Farm managers are, in general, modeled as profit maximizers. More recently a new objective dealing with environmental conservation was imposed on them. The question is: how convergent are those two forces? As posed by Knight (2002) "all of us in the business of agriculture have seen that these two types of external forces – those involving production and those involving the environment – often act in opposite directions, squeezing profitability in the middle".

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Methodology

Using the technique of "panels" farms were drawn as representatives for the three studied regions of Brazil: the first was a medium size farm representing the grain production area of northern Rio Grande do Sul State (Carazinho); the second, a large farm from the grain and livestock production area of Mato Grosso State (Sorriso); the third, a very large farm from the Amazonian livestock production area of Pará State (Paragominas). Figure 1 shows the location of the three farms.

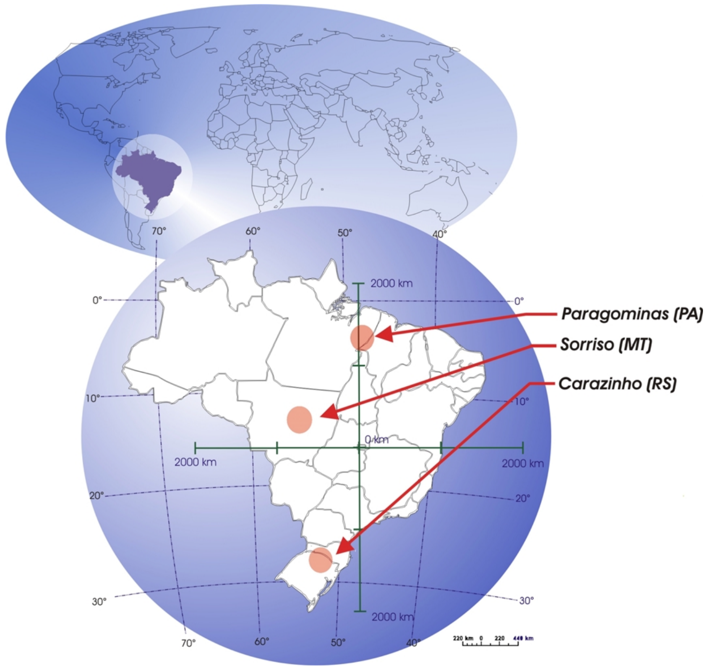

Figure 1. Geographical localization of Paragominas, Sorriso and Carazinho farms.

Six to ten farmers were polled together in the panels to determine the typical farm for each region. For the economic analysis a general budget spreadsheet was estimated for each typical farm containing data on livestock, crop and forest areas, yields, paid and received prices, stocks of invested capital, purchased imputs, machinery, labor and other used services. Net income per hectare was them evaluated for each typical farm.

An emergy analysis was completed to compare the three farms and the effects of land use on sustainability were evaluated by comparing their emergy indices.Emergy, a measure of real wealth, is defined as the sum of the available energy, i.e., the type previously required directly and indirectly through input pathways to make a product or service. The unit of emergy is emjoules. Resourses of nature, agricultural material and service inputs of the farms systems studied were converted into emergy flows (measured as solar emjoules – sej) using the emergy evaluation table of Odum (1996) with transformity corrected by a factor of 1.68 (Odum, 2000).

An emergy evaluation table was prepared with 6 columns with the following headings:

1	2	3	4	5	6
NOTE	ITEM	DATA, UNITS	EMERGY/UNIT	SOLAR EMERGY	EM$

Column number one is the line item number, which is also the number of the footnote in the table where raw data sources are cited and calculations are shown. Column two is the name of the item, which is also shown in the aggregated diagram. Column three is the raw data in Joules, grams, or dollars derived from various sources. Column four is the transformity in solar emjoules per unit (emj/J; emj/g; or emj/$). These are obtained from various studies. Column five is the solar emergy. It is the product of columns three and four. Column number six is the real wealth value in emdollars for a selected year. This is obtained by dividing the emergy in column five by the emergy/money ratio for the selected year. Emdollars was not used in this paper.

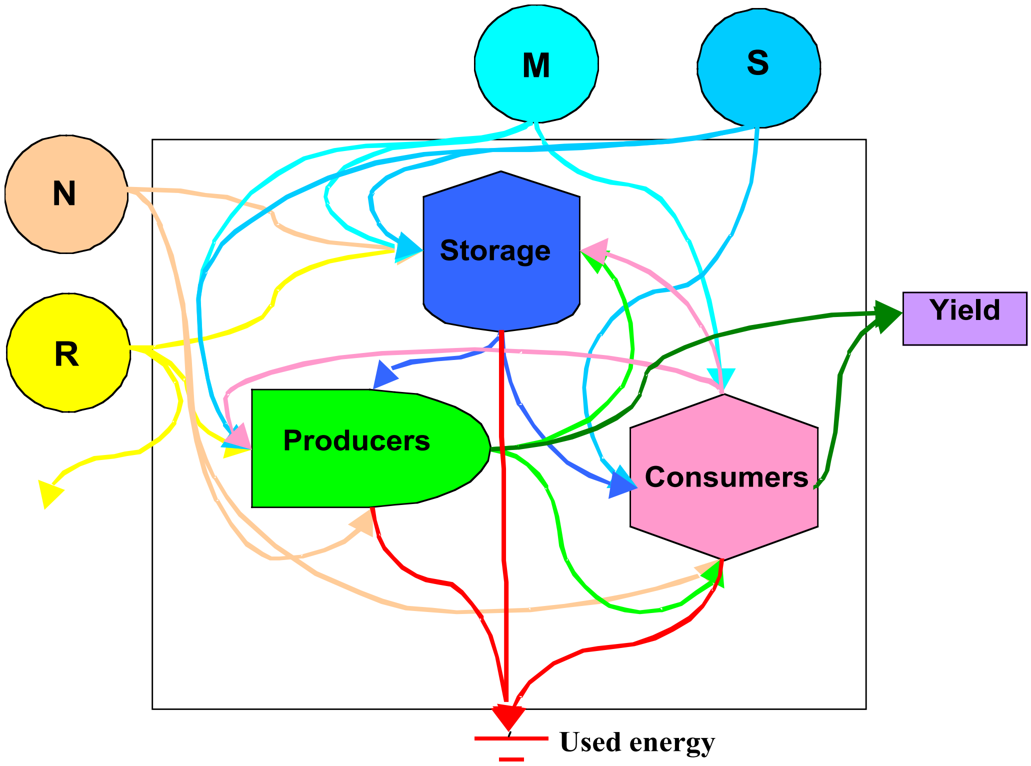

Figure 2 General Emergy Diagram for a Farm

Emergy diagrams for a farm system show the flows of energy between their production processes. The flows are quantified in the emergy evaluation table. In the diagram, R stands for renewable resources (sun, rain, wind); N for non renewable resources (soil): M for material purshased such as oils fuel, fertilizer, chemical pesticides; S for purshased services; Storage for stocks of soil, water, biodiversity; Producers are components of the plant crop process (corn, forage, soybean ,cotton); Consumers the components for the livestock production process; and Yield the output of the productive processess (grain, meat, and others); finally, Used Energy represents the consumed plus the lost energy (entropy).

Results

Panel results show the variability of land usage between the three farm systems, Table 1. Paragominas farm has a high percentage of its total area used as pasture (37%). The Sorriso farm has 34% pastureland and the Carazinho farm has only 14% pastureland. On the other hand, the Paragominas farm has only 3% of cropland, while the Sorriso farm has 46% and the Carazinho farm has 66% of cropland. Although legislation requires 80% forest area in the Amazonian region, the Paragominas farm has only 60% of preserved area. For the other two areas, the required percentage of preserved area are met. Economic results show higher efficiency for Carazinho and Sorriso farms while Paragominas has a lower value of income/hectare.

Table 1. Land use and economic results for typical farms of three regions of Brazil, 2001.

Itens	Paragominas	Sorriso	Carazinho
Pasture (ha)	5711	900	35
Crops (ha)	484	1200	170
Forest (ha)	9293	525	51
Total area	15488	2625	256
Total sales/year (R$)	937,702.17	2,568,312.50	176,952.27
Livestock sales/year	611,092.17	627,000.00	29,052.00
Crop sales/year	326,610.00	1,941,312.50	147,900.27
Total cost/year (R$)	680,022.03	2,213.998.94	86,552.07
Total net income (R$)	257,680.14	354,313.56	90,400.20
Net income/hectare	16.64	134.98	353.13

The emergy analysis was calculated for the tillable agricultural area only, and for all the farm area (agricultural plus florest area). Only the total area result is presented due to the fact that both results are equivalent. The Paragominas farm used more renewable resources due to its

Table 2. Aggregated emergy flows, by sej(solar emjoules)/hectare/year.

Emergy flows (sej/ha/year)	Paragominas	Sorriso	Carazinho
Renewable resources (R)	1.41E+15	1.20E+15	9.14E+14
Non renewable resources (N)	4.46E+13	1.09E+14	7.58E+14
Nature contribution (I=R+N)	1.4546E+15	1.309E+15	1.672E+15
Material inputs (M)	1.3531E+15	5.608E+14	2.1998E+15
Services (S)	1.700E+13	2.506E+13	9.0965E+14
Feedback from economy (F=M+S)	1.354 E+15	5.86E+14	3.11E+15
Total emergy incorporated (Y=I+F)	2.824E+15	1.895E+15	4.78E+15
Produced energy (Ep) in Joules	1.34E+11	7.53E+11	5.88E+12

environmental conditions of rain and of insolation.Carazinho used more non renewable resources due to the intensive use of land with soil erosion. Material resources are higher in Carazinho and Paragominas due to its agricultural tecnology and usage of more chemical and machinery inputs. The values of total emergy incorporated are consistent with the literature. The Carazinho value is typical of developed regions while the Sorriso and Paragominas farms presented, on the other hand, much lower values than those of the developed regions. These last two farms represent new frontier regions that uses less purchased material.

Table 3. Emergy indices.

Emergy indices	Paragominas	Sorriso	Carazinho
Transformity (Tr, sej/J)	21000	2517	812
Net Emergy Yied Ratio (EYR=Y/F)	2.08	3.23	1.54
Non Renewable / Renewable (N/R)	0.03	0.09	0.81
Emergy Invetiment Ratio (EIR=F/I)	0.93	0.45	1.86
Environmental Loading Ratio (ELR)	0.99	0.58	4.23
Renewability (%R=R/Y)	49.9%	63.3%	19.1%

As can be seen in Table 3, Transformity (Tr) is defined as Y/Ep = sum of emergy used/energy of product. Here, Y means the weighted average of the farm products divided by the total area in hectares. The transformity gives a measure of the efficiency for the farms production system. Lower values point to more efficient emergy use when the production systems use equivalent processes. Therefore Carazinho is more efficient, in emergy terms, due to the energetic composicion of it products (corn and weat have higher Ep values).

One is the lowest value for the net emergy yield ratio (EYR) index, which occurs when inputs from nature are null (R+N = 0). The difference above the minimum value (unit) measures the cost-free contribution of the environment to production. The value of net emergy yield ratio (EYR) for the Carazinho farm system is close to one (1.5). Nature contribution is low when compared to resources from the economy. Therefore, its production system is not able to deliver as much net emergy to the external system (the market) due to the fact that most of its inputs are not renewable. The higher values of EYR in Sorriso (3.23) and Paragominas (2.08) indicate its ability to incorporate and use free resources from nature.

The lower the emergy ratio of Non Renewable/Renewable (N/R) the lower is the stress to the environment. Therefore the Sorriso and Paragominas production systems place much less stresses on the environment than the Carazinho system.
Renewability (%R=R/Y) measures the sustainability of the systems, because it represents the proportion of all the resources used that are renewable. In the long run only processes with high %R are sustainable. The Sorriso and Paragominas farm system are more sustainable tham that of Carazinho. In building our four quadrant farm system distribution, renewability is used as a measure for its sustainability.

Emergy investiment ratio (EIR) measures society´s effort to produce a given product in relation to nature´s contribution. It is a measurement of the adequacy of the investment system. A low EIR value means that the environment has a relatively larger contribution to production than the resources of the economy (materials and services), and consequently is more cost competitive. This ratio gives a clear vision of the difference between the systems in relation to the investiment needed for production. The Carazinho farm system value is high (4.23), thus showing an economically fragile agriculture due to its dependence on purchased inputs from other regions. The Paragominas farm has an intermediate value (0.9308) while the Sorriso farm system shows the lowest value (0.579). The last two systems uses resources from nature (free) instead of economic resources (expensive) having lower external investment and, consequently, lower production cost.

Finally, higher values of environment loading ratio [ELR = (N+F)/R] point to greater environmental damage. The Sorriso and Paragominas farms systems presents lower values (0.58 and 0.99) which confirm the greater use of natural renewable resources by their systems than that of Carazinho (4.23). The Sorriso and Paragominas farms have almost the same quantity of emergy from renewable sources as from non-renewable, producing reduced enviromental impact.

As opposed to what is desirable, the three farms were plotted on the Northwest and Southeast quadrant of Figure 3. The separation between the quadrants were drawn on the average value for each axis. Economic sustainability, at the same time as environmental sustainability, would require the farms loci to be on either the Northeast or the Southwest quadrant of the figure.

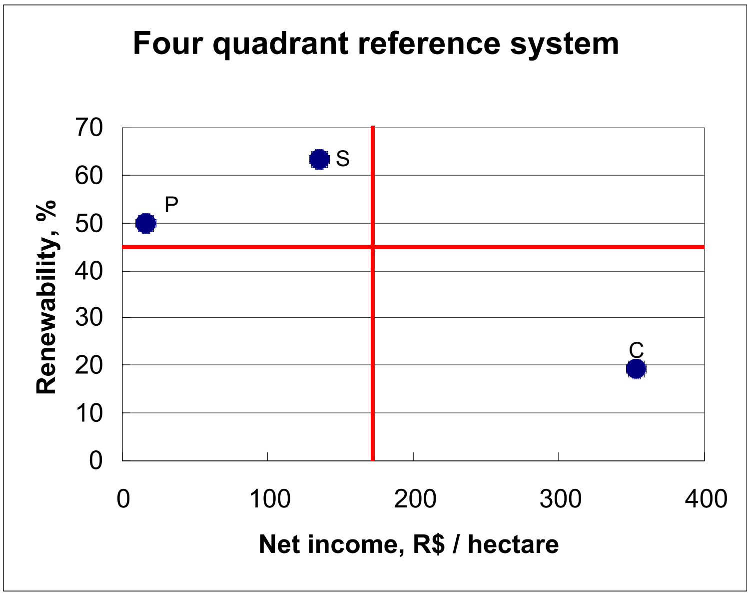

Figure 3. Four quadrant reference system for renewability (%) and net income (R$/ha) for three farms.

Conclusions

The Sorriso and Paragominas farm system has the highest values of EYR, ELR, Tr, %R, and SI, and lowest value of Ep, EIR, and N/R. From this result it may be concluded that the Sorriso and Paragominas farm system are more sustainable than the Carazinho farm system. The Carazinho farm has more efficient use of energy, but its sustainability is lower, because it uses more non renewable resources. The productive part of the Paragominas farm has to pay for the costs of its preservation areas.

While economic sustainability is pointing to the Carazinho type of economic production system as more efficient, environmental sustainability is pointing to the opposite direction. Therefore, new development policies are required to make them compatible in the long run.

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ASSESSING RISK TO ENCOURAGE FARM CHANGE

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Abstract:
Grains Research and Development Council (GRDC) funded project aimed at providing the tools to assess the risks of capital change in a farming enterprise.

The consequences of changes to farming systems and capital structure under risky environments can have a significant impact on farm business viability. Risks to consider include seasonal impacts on production, commodity market fluctuations, financial market risks and the farm business financial position (business health). This project will provide simple to use tools that will help farm businesses perform an initial assessment of the impact of a change to the farming system. A combination of written checklists and computer tools have been developed to assist in this process.

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