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Sustainability of Cow Milk Production Units in Marcos Espines Jurisdiction, Tungurahua-Ecuador

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ABSTRACT

Physical and productive indicators were assessed in 70 cattle dairies (CaDa), along with the technical, environmental, economic and social sustainability indicators of 10 CaDa in Marcos Espinel jurisdiction, Píllaro Canton, Tungurahua-Ecuador, and the dynamic behavior of these indicators for 10 years in a case CaDa. The CaDas averaged 150 l of milk/day, with animal production of 15 l of milk/day, stocking rate over two animals/ha and herd made of 20-25 animals. Chemical fertilizers were widely used in the pasture lands; commercial supplements were used as well. The labor costs were high; everything was associated to cost increases in milk production and a decrease in farm cost-effect indicators. The technical, social, and economic sustainability indicators accounted for 100 % impairment in the units; the environmental indicators revealed positive values. However, the rate of special sustainable cattle raising indicated unsustainability for all the case CaDas. The dynamic behavior of sustainability in the case CaDa showed positive values for some indicators, such as energy efficiency; and impairment of others, such as economic sustainability. The study concluded that the CaDa had a generally unsustainable behavior.

Key words: *sustainability, sustainability indicators, milk production*

INTRODUCTION

Dairies are the third national production in Ecuador, with 5.3 t, accounting for US $392 million. Production comes mainly from Sierra, an area with the best milk producers (73 % of the domestic output), and 90 % of dairy industries (SICA, 2010).

In the Pillaro Canton, most farmers raise cattle. Accordingly, the trend to grow pastures is high, competing with crops. Cattle raising plays an important role in food safety in the Canton (Martínez, 2011). Agricultural diversification and dairy output increases, especially in the cattle areas, such as Marcos Espinel Parrish, have been among the goals to make important productive changes through sustainable programs in agriculture, which must be supported with social and organizational proposals (Chiriboga, 2009).

Unsustainability of cattle raising systems has caused environmental and social damages in many rural areas; as well as yield excess, leading to serious problems in agriculture (CONDESAN, 2000).

Agricultural production systems are facing several problems originated in the lack of planning and control tools. The organizational arrangement of production must be conceived to meet each farmer´s goals. Factor integration must favor sustainability of productive systems following economic, technical, social and environmental criteria, in order to make administrative decisions in the enterprises (Aguilera *et al.*, 2003).

To achieve sustainability, it is important to develop assessment methodologies so it can be quantified and evaluated objectively. Many authors who have attempted to assess sustainability at the regional level (Zinck *et al.*, 2004; Flores and Sarandón 2006 and Viglizzo *et al*., 2006); or the farm level (Abbona *et al.*, 2007 and Flores *et al.*, 2007), have developed their own indicators, in the absence of an international standard. The differences in the scale for evaluation (estate, farm, region), kind of facility, desired objectives, productive activity, and others, hinder generalization.

The aim of this research was to assess sustainability indicators in cattle dairy units, at Marcos Espinel Parrish, Tungurahua-Ecuador.

MATERIALS AND METHODS

This research was done in the Republic of Ecuador, in the province of Tungurahua, Canton Pillaro, Marcos Espinel Parrish. It is located in the mid Ecuadoran Mountain Range, on the northwest part of Tungurahua and it extends over a semi flat valley, with loamy and fertile soils. The climate is highland relatively cold (0 - 20º C) CESA (2010).

Bovine production assessment at the Marcos Espines Parrish stemmed from a survey conducted with recommendations made by Rojas (2005), with qualitative and quantitative variables that describe the zootechnical character at the Milk Production Units (MPU), such as productive, economic, reproductive, and nutritional. Seventy MPUs were included in the study, following criteria by Herrera (2012).

For sustainability evaluation 10 MPUs with specialized milk production systems were chosen (male calf sale at birth, and artificial female calf breeding). Next, MPU owners and workers were interviewed, and the environmental, technical, social, and economic indicators were determined, according to a proposal made by Ríos (2010), using the formulae below,

$$ISGE = \frac{\sum ISi * Pij}{\sum Pij}$$

Where:

ISGE: Sustainability indicator of specialized cattle raising

ISi: Each sustainability indicator proposed

Pij: Significant values for every ISi

Then, the indicators were classified, according to Ríos (2010) (Table 1).

The Prado Verde Estate owned by Mr Alberto Velasco Carrillo was used as a study case; it is located in the Guangibana Commmunity, about 3 100 meters above sea level. It has 15 ha for milk production, with artificial pasturelands, and Holstein Fresian, Monthbeliarde or crossbred animals. The current indicators were evaluated; along with the dynamic behavior for the last 10 years, including estimations of energy efficiency using the methodology suggested by Monzote (2005).

Normality of every dependent variable was evaluated. Descriptive statistics analysis was carried out for the quantitative, and frequency distribution for qualitative variables. SPSS 21.0 was used in all the evaluations.

RESULTS AND DISCUSSION

The Parish´s MPUs produced an average of 150 l/d of milk per farm, and 15 l/d per animal, with stocking rates higher than 2 Cattle Unit/ha, and herds of 20-25 animals in 1-20 ha. Chemical fertilizer excess on the fields, balance overuse, and high cost of the labor force, caused increased production costs per milk liter, and farm cost effectiveness decrease.

Table 2 shows estimation of indicators of technical, environmental, social and economic sustainability at the 10 MPUs.

Economic sustainability (ISE) stood out form the rest, as 100 % of farms in the study had negative values, and coincidentally, those very farms were observed to have negative values for ISGE, according to the scale suggested by (Ríos, 2010) as sustainable.

It is also important to evaluate why all farms behaved the same way for the ISA scales. Most farms were sustainable, highly sustainable, and moderately sustainable; however, the sustainability indicator for Specialized Cattle Raising (ISGE), which integrates other indicators, such as ISE, IST, ISS and ISA, matches the behavior of the Economic Sustainability Indicator (ISE). It proves that that for this particular study, ISGE has been remarkably influenced by ISE.

According to the results for the indicator of economic sustainability (ISE), it can be concluded, according to Table 2 and by comparison in Table 1, that MPUs have negative values which make them unsustainable, especially in the case of sustainability estimation. It is produced because indicators like cost of production per liter of milk, benefit/cost ratio, and cost effectiveness, are below the expected values. The causes are found in the high costs of labor force and feed supplements on all the farms, whereas milk production remains stable.

The values found for IST (Table 2) show that all the farms are technically unsustainable, in spite of acceptable values for calving interval, milk liters/cow/day, and lactation time (AGSO, 20011). The lowest values are observed in the natality percent, and concentrate/milk ratio.

For the social indicators, the highest value was achieved at MPU 3, and the lowest at MPU 5, with 0.102 and 0.051, respectively. Even if the suggested scale is used on all the farms, they would be unsustainable for that indicator. This occurs because the vital needs of the families are not met due to the large number of members, and the lack of associativity in the communities, so new technical and social proposals are developed for the benefit of the farmers and their families. The interviews also showed the existence of wide support from public enterprises, like HGPT and

MAGAP, for the large amount of production projects in the region, such as, The Highland Management Project, Irrigation and Production, Shoulder to Shoulder, Pillaro-South Ramification Irrigation System, INNOVA Collecting Center, and milk Collection Networks, significant and sometimes short-lived, economic support (GAD Marcos Espinel Parrish, 2011).

According to the values observed for ISA, sustainability is observed in production enterprises, which, however, are not appreciated in ISGE estimations. MPUs No. 2, 3 and 10 were environmentally sustainable, with values above 0.067; MPUs No. 4, 5, and 7 showed high sustainability values (0.048 – 0.067); whereas MPUs No. 1, 6, and 9 turned out to be moderately sustainable, with values between 0.034 and 0.048. These indicators are positive due to the adequate handling of pasturelands, appropriate animal stocking rate, and actions to preserve water sources, prevent erosion, and soil compaction.

Unfortunately, all ISGE values are negative, so it can be concluded that all the farms selected were unsustainable, and further efforts must be made in terms of the indicators assessed. The main goal would be production time, not their short-term exploitation.

Despite the system´s unsustainability, they have been stable for the last years because of owner indebtedness to financial institutions, property leasing or inheritance, migrating investments abroad, and so on. As a result, the current dairy production only allows covering the production expenses (at best), which mean labor force hiring, fee supplements, and fertilization of pasturelands.

The case study included physical features (topography, extension, purpose, and others); techniques (proper controls, productive, reproductive and sanitary indicators); and social features of the farm in the study. In the last 10 years, property has undergone improvements in parameters like dairy yields (milk liters per cow), milk liter price, and pastureland conditions, whereas the lactating cows have been fluctuating. However, high mortality percent (33.3 %) was observed in female calves, especially.

Monzote *et al*. (2003) suggest estimation of energy efficiency applied to the case study as a criterion to evaluate sustainability of agricultural systems. The productive supplies on the farm represent a total caloric waste of 455 495.4 MJ a year, arising from human labor and feed concentrates, mainly; Table 3 shows MPU´s caloric investment.

Table 4 shows supplies produced at the UPL, both for energy and protein production in a calendar year.

Energy production was higher for green forage production (365 112 MJ), and cow´s milk (182 305 MJ); whereas the lowest values are related to sales of reproductive animal and beef (3 520 MJ and 6 500 MJ, respectively). The main reason for it is that the farm is completely committed with milk production; reproductive animal sales correspond to males for reproduction, and beef comes from discarded animals. The same behavior is observed in protein production at the MPU (Table 5).

Energy efficiency of Prado Verde MPU is 1.22, meaning 1.22 MJ are produced out of every MJ invested on the farm. This is a relatively positive value for the current conditions at the MPU. The systems using agro ecological approaches, along with organic production methods lead to cattle production sustainability, as energy and genetic efficiencies are improved, external dependency declines, and the environment is protected. Moreover, they can be important sources of jobs and can revert cattlemen exodus to the cities (Monzote, 2002). García (2002) achieved a positive balance, greater than the one in the study, because the system they used was highly diversified.

It points out to the need of carrying out energy and nitrogen balances in every productive stage or season, which may explain animal response to management conditions in the pasturelands, proper use of resources, and holistic behavior of the system (Monzote *et al.*, 2005). All the above is related with farm energy efficiency, an important indicator to consider for evaluation of sustainable production systems (Monzote *et al.*, 2003).

CONCLUSIONS

Dairy Cattle Units (UPL) at the Marcos Espinel Parrish, Pillaro Canton, Tunguragua, Ecuador are generally unsustainable, mainly due to economic, technical and social aspects; whereas the estate in the study shows positive energy and protein balances.

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Table 1. Scale proposal for sustainability

	ISE	IST	ISS	ISA	ISGE
Sustainable (ES)	< 0.1579	< 0.2572	< 0.2963	< 0.0674	< 0.1857
Highly sustainable (EAS)	>0.1579 <0.1217	>0.2572 <0.2255	>0.2963 <0.2646	>0.0674 <0.0487	>0.1857 <0.1626
Moderately sustainable (EMS)	>0.1217 <0.1053	>0.2255 <0.2113	>0.2646 <0.2381	>0.0487 <0.0345	>0.1626 <0.1385
Highly unsustainable (EAIS)	>0.1053 <0.0	>0.2113 <0.2077	>0.2381 <0.2249	>0.0345 <0.0181	>0.1385 <0.0
Unsustainable (EIS)	>0.0	>0.2077	>0.2249	>0.0181	>0.0

Table 2. Estimation of ISE, IST, ISS, ISA, and ISGE, and sustainability degrees, according to Ríos (2010)

MPU	ISA	ISE	IST	ISS	ISGE
1	0,.45	-0.670	0.045	0.090	-0.232
2	0.073	-0.598	0.047	0.051	-0.207
3	0.079	-0.660	0.062	0.102	-0.216
4	0.056	-0.639	0.048	0.078	-0.219
5	0.057	-0.613	0.047	0.084	-0.208
6	0.045	-0.664	0.047	0.062	-0.234
7	0.065	-0.661	0.049	0.077	-0.227
8	0.049	-0.666	0.047	0.064	-0.234
9	0.035	-0.688	0.048	0.079	-0.241
10	0.073	-0.688	0.048	0.061	-0.241

Sustainable
Highly sustainable
Moderately sustainable
Highly sustainable
Unsustainable

Table 3. Energy waste per supplies produced at the studied MPU

Type of supply	Quantity (kg)	Caloric equivalence (MJ/kg)	Total caloric waste (MJ)
Chemical fertilizer	8 100	0.5	4 050
Diesel liter	11 010,0	38.7	426 087
Electricity, Kw/h	3 000	3.6	10 800
Human labor	7 200	1	7 200
Nutritional suplementation	5 256	1.4	7 358.4
Total: 495.4			

Table 4. Energy contribution per item produced at the studied UPL

Item	Total output (kg)	Caloric value (MJ/kg MF)	Nutritional value (% PB g/100g)	Energy production (MJ)	Protein production kg
Cow´s milk	72 922.0	2.5	3.5	182 305	2 552.27
Reproductive animal	440.0	8	16	3 520	70.4
Beef	1 000.0	6.5	20.7	6 500	207
Green forage	33 192.0	11	14	365 112	4 646.88
Total	107 554.0			557 437	7 476.55

Table 5. MPU´s current energy efficiency

Calories produced (CP)	557 437 MJ
Calories invested (CI)	455 495.4 MJ
Energy efficiency CP/CI	1.22