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Analysis of Two Peri-Urban Livestock Production Systems in the Valley of San Cristobal De Las Casas, Chiapas, Mexico

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Abstract: The present study's objective was to describe changes in land use and analyze functioning mechanisms and development possibilities of peri-urban livestock production in the Valley of San Cristobal de las Casas (VSNC), Chiapas, Mexico. High demand on land for urban use has led to increase in pasture land prices, reduction in pasture and forest lands, intensification of cattle raising (use of stables) and reduction in sustainability of the Milk and Meat Production (MMPS) and Meat Production (MPS) systems identified. There is a general tendency for the MMPS to be more sustainable from a technical, economic, environmental and social perspective. In this system, herd size, stocking rate, machinery and equipment use, yearlings sold and level of conservation of pastures are significantly greater ($p<0.05$). The Bovine Production Systems (BPS) is preferable ($p<0.05$) with respect to presence of Creole animals and employment of labor. In order to achieve better integration between production and marketing, there is a need for better sanitary control of the milking process. The majority of milk consumers prefer to consume raw cow's milk. Planning for development of ecological peri-urban cattle raising should be oriented toward solving the problem of animal feeding through intensive and efficient cultivation of forage crops in small areas, efficient processing and use of the high volumes of organic residues from the local market as well as technification of cattle management in stables. To achieve this, it is necessary to implement policies of financial support, training and technical advice and assistance in order to obtain high quality competitive animal products.

Key words: Land use, holistic diagnosis, dairy management, sustainability, alternative scenario, BPS

INTRODUCTION

The importance of peri-urban livestock production in many developing nations lies in the growing demand for milk and meat for urban consumption (Rey *et al*., 1993; Hamadou *et al*., 2003). This activity, spreading in many cities, presents serious technical, environmental and social problems related to competition with non-agricultural land use; soil, water and air pollution and public health (Sere and Neidhardt, 1994).

In developing nations, little attention has been paid to food production in peri-urban areas; nevertheless, agricultural activity is constantly increasing in small and medium-sized cities due to migration of rural populations and an increasing demand for healthy food. The contradiction among urban growth, food production in peri-urban areas and public health is a serious problem which should be addressed in a holistic manner. For example, in Southern Mexico city, Alvarez *et al*. (2004) show that milk production in urban stables could disappear in the future due to strong urban pressure which overvalues crop and pasture lands, motivating their sale and reducing their sustainability. Another study of peri-urban areas in Tanzania's Eastern zone (Kavana and Msangi, 2005) reports that dairy farms are in danger of disappearing due to urban growth and lack of financial support and incentives toward achieving sustainability. In the valley of San Cristobal de las Casas, Chiapas, cattle raising has existed for many decades. Initially, this activity was limited to pasturing. However, during the last few decades as the city has grown cattle raising has come to fall within urban or peri-urban areas and due to this urban pressure, surface dedicated to this activity has been reduced. Peri-urban cattle raising complies with the social

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function of providing basic foodstuffs for the population and includes production, processing and marketing of animal products. Furthermore, the demand for natural foods for local and tourist populations is tending to increase. Nevertheless, as is true for cattle raising in other cities worldwide (De Ridder and Wagenaar, 1986; Rey *et al*., 1993; Staal and Shapiro, 1996), several problems must be resolved in order to achieve sustainable development of peri-urban cattle raising.

Little information exists regarding peri-urban cattle raising in Southeast Mexico. In this context, the objective of the present study was to describe changes in land use and analyze functioning mechanisms and development possibilities of peri-urban cattle production in the valley of San Cristobal de las Casas (VSNC), Chiapas.

MATERIALS AND METHODS

The study area: This study was carried out in the urban and peri-urban zones and adjacent hillsides of the valley of San Cristobal de las Casas (VSNC), Chiapas, Mexico. The study area included a quadrangular area of 4,050 ha whose extreme coordinates are 16°76′00′′ to 16°46′00′′N by 92°36′00′′ to 92°67′00′′W. Altitude ranges from 2,117 m in the lower part of the valley to 2,190 m in the hills. According to the Koeppen classification, modified by Garcia (1988), the area has a sub-humid temperate climate with summer rains C (w_2) (w). Average annual temperature is 13.5°C and average annual precipitation is 1,021 mm (CNA, 2003). VSNC has a predominantly mestizo and indigenous urban population of 166,460 (INEGI, 2005). The city of San Cristobal de las Casas is the most important commercial and cultural center of the Chiapas Highlands region.

Sample size, study design and data collection: Key informants (veterinarians, government agency officials and stable owners) were interviewed to obtain a complete list of cattle producers which was later verified and corrected in the field. Producers of all 21 existing ranches (production units) in the VSNC agreed to participate in the study. The study was carried out during 2005 and included three parts; land use; classification, characterization and analysis of Bovine Production Systems (BPS) and hygienic-sanitary management of the milking process. In part 1, two land use maps of VSNC were elaborated, according to two satellite images and then compared in order to observe changes during an 11 year period (1990-2001). One of the maps was based on a LANDSAT TM digital image (1990) (multispectral with 4 bands and a 30 m pixel size). The other was based on a SPOT digital satellite image (2001) (georeferenced with 48 control points in the area studied with a 1 m pixel size). Both images were edited in the Geographic Information Laboratory of the Colegio de la Frontera Sur. Later using UTM coordinates, the BPS were spatially located on the two land use maps with a Geopositioner (GPS). The program Arc Map, Version 8.2 was used to elaborate the maps and the program Arc View GIS, Version 3.0 was used for final map edition. Additionally, changes in land prices were analyzed for the 1990-2005 period based on Suarez's information. To obtain information for part 2, producers were interviewed according to the semi-structured informal interview technique (Vela, 2001) using a questionnaire covering technological, economic, social and environmental aspects of cattle production. Neighbors were also interviewed in order to analyze environmental effects of the stable on the neighborhood. Data from part 3 were obtained by direct observation according to a pre-elaborated list. Furthermore, housewives were interviewed regarding milk consumption (Vela, 2001).

Systemization and information analysis: In part 1, regarding land use information was obtained on land use changes (for forestry, cattle raising and urban use), displacement of BPS by urban use, land price changes, type of land in which BPS were located and producer perspectives. Inflation was eliminated by converting fluctuating land prices in real or constant prices using 1994 prices as a base according to the formula Which uses deflaction:

$$CPI = \frac{fv}{iv} \times 100$$

CPI = The constant price index
fv = The nominal or final value
iv = The initial value or value from the Consumer Price Index (CPI) (SFDF, 1994)

Data on real prices were graphed and used to construct an adjusted curve using an exponential regression model (Zar, 1984).

In part 2, BPS classification and characterization indicators were grouped by technological, economic, environmental and social areas of evaluation (Table 1). Production systems were grouped based on analysis of conglomerates (Manly, 2004) and then the difference between groups was verified using one-way analysis of variance (Infante and Zarate, 2000). Indicators were examined using hypothesis tests based on Student's t distribution in order to determine existence of statistical differences between the two production

Table 1: Indicators and their definitions

Area of evaluation	Indicators	Definition
Technology	Herd size (AU)	Total of animals of all ages and physiological states, standardized in animal units
	Birth rate (%)	Annual percentage of live births in the herd in relation to total reproducing females
	Calf death rate (%)	Annual percentage of calf mortality (during lactation) in relation to live births
	Adult bovine death rate (%)	Annual percentage of mortality of adult cattle (due to illness or accidents) in relation to the average number of adults throughout the year
	Yearlings weaned (%)	Percentage of live births reaching weaning age
	Level of disease control (%)	Percentage of ranches carrying out disease prevention practices: Internal antiparasite injection = 10%; external antiparasite bath = 10%; vaccine against quadriplegic rage = 10%; vaccine (against pneumonic Pasteurelosis, symptomatic carbon and malignant edema) = 30%; vaccination against Brucelosis = 10%; treatment against anaplasmosis and piroplasmosis = 10%; administration of vitamins and reconstituting fluids = 10%; administration of antibiotics = 10%
	Stocking rate (AU ha^{-1})	Average No. of Animal Units (animals of different ages and physiological states) maintained on one hectare of land during 1 year, land owned as well as that rented by the producer was considered
	Forage consumed in stable/AU/year (kg)	quantity (kg) of balanced feed, grains, forage, or cornstalks which one AU consumes in the stable per year. Forage resources produced within the BPS as well as those purchased were considered
	Use of machinery and equipment (%)	Percentage of ranches with special equipment and machinery: sprayer = 20%, forage chopper = 20%, vehicle = 30%, hand tools = 30%
	Infrastructure (%)	Percentage of ranches with special infrastructure: travelable roads = 33.3%, electricity = 33.3% running water = 33.3%
	Presence of Creole animals (or their crosses) (%)	Percentage of animals (of different ages and physiological states) which are Creole or crossed with Creole in relation to total number of animals. En VSNC, breeds crossed with Creole are Holstein, Jersey and Swiss
Economy	Yearlings sold (n°)	Number of weaned calves (female or male) which are sold for fattening, slaughter or replacement
	Sale price of weaned yearling ($)	Sale price in Mexican pesos of weaned calves (destined for fattening, slaughter or replacement). Price is determined by animal size and phenotype, not by live weight
	Production cost per cow ($)	Annual operational expenses (feeding, health, purchase of animals and fuel) and structural expenses (salaries) necessary for ranch and herd management in Mexican pesos, divided by number of reproducing cows
	Net margin /cow /year ($)	Average difference between brute margin (income minus operational expenses) and structural expenses, divided by average annual number of reproducing cows, expressed in Mexican pesos
	Net margin per Family Worker (FW) ($/ FW)	Net margin for the ranch expressed in Mexican pesos divided by average annual number of family workers in the BPS
	Level of integration between production and marketing (%)	Proportion of ranches which practice the following marketing situations: sale of milk or its derivatives and/or meat = 100%; sale of milk and/or meat directly to consumer = 66.6%; sale of milk and/or meat to intermediaries = 33.3%)
Environment	Characteristics of facilities (%)	Proportion of ranches with special types of facilities: corral = 15%; fences dividing pastures = 15%; warehouse = 10%; feed trough = 5%; drinking trough = 5%; water deposit = 10%; appropriate manure management infrastructure = 10%, grass irrigation equipment = 20%, drainage preventing mud formation = 10%
	Level of pasture conservation (%)	Proportion of ranches with pastures in different states of conservation: grassy = 100%, somewhat grassy = 66.6%, overgrazed = 33.3%, eroding = 0.0%
	Level of dependence on external inputs (%)	Percentage of ranches purchasing external inputs; commercial feed concentrate = 10%, common or mineral salt = 10%, vitamins = 10%, vaccines = 10%, internal antiparasite injection = 10%, external antiparasite bath = 10%, antibiotics = 10%, wheat bran = 10%, forage = 20%
Social	Surface of pasture owned (ha)	Surface (ha) destined for pasturing which is property of the rancher
	Surface of pasture rented (ha)	Surface (ha) destined for pasturing which is not property of the rancher but rather used according to a rental agreement
	Producer age (years)	Producer age as indicator of knowledge and cattle raising perspectives
	Years in cattle raising (years)	No. of years the rancher has dedicated to BPS
	Ranches expected to continue into the next generation (%)	Percentage of ranches in which, foreseeably when current producer ceases cattle raising, another family member will continue
	Total labor/100 cows/day (workdays)	Estimated number of workdays required for daily management of 100 cows
	Total beneficiaries in the family (n°)	No. of producer's family members who benefit from BPS including self

systems (Infante and Zarate, 2000). In the evaluation of the stable's effects on the neighborhood, the following indicators were included; disturbances caused by animals, urban landscape, the stable's benefit to the neighbor, competition for public services and health risks. In part 3, regarding hygienic-sanitary management of the milking process, the following indicators were used; number of milkings per day, teat washing before milking, teat sealing, hand washing by the milker, use of special clothing during milking, cleanliness of the milking parlor, type of utensils used, cleanliness of utensils, type of milking (mechanical or by hand), way of distributing the milk, consumer milk-type preference and frequency of purchase. Information from part 3 was analyzed using descriptive statistics with the program SPSS (Statistical Package for the Social Sciences), Version 13.0 (SPSS, 2005).

RESULTS AND DISCUSSION

Land use: Currently, three types of land use in the VSNC are urban (including family patio gardens), animal raising (pastures) and forestry. Comparative cartographic analysis of different land uses for an 11 year time period (1990-2001; Fig. 1, 2) show important changes. In 1990, the urban area occupied 1,222 ha (30%), the forested area 1,955 ha (48%) and the grassland area 871 ha (22%). Eleven years later (2001), the land use configuration showed strong growth in the Urban zone (2,569 ha = 63%) and a reduction in forested areas (1256 ha = 31%) and grasslands (223 ha = 6%).

Forestry is located on sloped areas where pine (*Pinus* sp.) and oak (*Quercus* sp.) is extracted for lumber and manzanilla fruits (*Crataegus pubescens*) are collected. Backyard agriculture is rich in diversity of aromatic herbs (oregano, thyme, rue, rosemary, epazote (*Chenopodium ambrosioides*), mumo (*Piper auritum*); vegetables (lettuce, chard, cabbage, radish, carrots); corn, beans, squash, chayote (*Sechium edule*) and fruit trees such as apple (*Malus pumilla* Mill.), pear (*Pirus communis* L., *Pirus pumilla* Mill.), peach (*Prunus persica*), fig (*Ficus* sp.), plum (*Prunus domestica* L.). Since introduction in colonial times, domestic animal raising of sheep, cattle, horses, pigs and fowl in pastures has fulfilled an important economic, social and cultural function.

In the 1990-2001 time period, grasslands were mainly used for cattle pasturing. As of 2005, 13 of the 21 stables in VSNC had maintained the same location for >25 years. In 1990, 17 stables were located in the peri-urban zone and four within the urban zone. By 2005, 7 continued in the peri-urban zone and the other 14 were surrounded by urban sprawl due to growth of the city on top of pastures and wetlands. Current agricultural land use in VSNC as well as types of animal, forestry and urban use is similar to that of the 19th century. Unlike the slow urban growth of VSNC from the 17-19 century during the 1990-2001 period, growth was greatly accelerated due to factors determining land-use dynamics such as an increase in local and immigrant populations and the foundation of new settlements demanding land and public services. These factors were accentuated in 1995 due to high immigration of indigenous peoples from communities of the Highland region of Chiapas who principally settled adjacent forested slopes.

This situation leads to high demand on land for urban use, competing with animal and forestry uses. As a consequence, the land market has increased exponentially and land values vary in function of location and available public services. In general, lands used for animal raising which are within or near the Urban zone acquire higher prices and have high possibilities of changing to urban use, putting the continuity of BPS at risk. Figure 3 shows price changes of land for animal use in VSNC during the 1990-2005 period. A great increase in real prices (278%) during this period with a biannual rate of 39.5% may be observed. This is due to land invasion by indigenous groups of the greater region after the surge of the Zapatista movement beginning January 1, 1994, resulting in revaluation of these lands.

Classification of the systems: Based on productive orientation (milk and meat or only meat; $F = 11.8$; $gl = 1/19$; $p = 0.003$) and herd size ($F = 65.5$; $gl = 1/19$; $p = 0.001$), two bovine production systems were identified (Fig. 4); the Milk and Meat Production System (MMPS) and the Meat Production System (MPS). This means that classification indicators selected are important predictors of the production system types identified as they allow for validating differentiation in a consistent manner. This procedure has been used by several researchers (Lopez *et al*., 2001; Nuncio *et al*., 2001; Gomez *et al*., 2002) in order to classify animal production systems in different regions. According to Dufumier (1993), the importance of classifying production systems lies in offering the possibility of prioritizing and planning research or development policies oriented toward generating or adapting technologies appropriate to each circumstance. In the same manner, Smith *et al.* (2002) and Alvarez *et al.* (2004) argue that classifying cattle ranches by production system is important to achieving a profound understanding of levels of technical and economic efficiency as well as profitability.

Characterization and analysis of the systems: Indicators characterizing the identified bovine production systems are shown in Table 2-5. Herd size, stocking rate, level of machinery and equipment use, presence of Creole animals, yearlings sold, conservation of pastures and total labor employed were statistically differentiated. The rest of the indicators did not differ ($p>0.05$) by type of BPS, possibly due to aleatory variability of data obtained from existing cattle ranches according to the census of study area (21 producers).

Technological characteristics: Table 2 shows technological characteristics of the BPS. MMPS shows greater ($p<0.05$) or relatively greater ($p>0.05$) values for all indicators with the exception of greater ($p<0.05$) presence of Creole animals in MPS. MMPS tends to show more effective reproductive planning in that some ranches use artificial insemination. In contrast, in MPS breeding is

Table 2: Technological characterization of bovine production systems in the San Cristobal valley

	Production system			
System components	Milk and meat	Meat	SED (CI-D95%)	t (df; p-values)
Average herd size (AU)	24.0	12.0	3.8 (4.4; 20.3)	3.25; 19; 0.004*
Birth rate (%)	31.0	25.0	6.5 (-8.2; 19.2)	0.84; 19; 0.411
Mortality rate (%)	8.0	19.0	10.4 (-34.2;11.4)	-1.10; 12; 0.296
Adult mortality (%)	5.0	9.0	5.1 (-14.4;6.8)	-0.74; 19; 0.467
Weaned yearlings (%)	92.0	81.0	10.4 (-11.4;34.2)	1.10; 12; 0.296
Level of control of animal illnesses (%)	54.0	41.0	0.1 (-0.1;0.3)	1.27; 16; 0.222
Stocking rate (AU/ha)	2.3	1.3	0.5 (-0.03;2.1)	2.04; 19; 0.056*
Forage consumed in stable/cow/year (kg)	85.0	112.0	53.2 (-138.7;84.2)	-0.51; 19; 0.615
Level of machinery and equipment use (%)	73.0	51.0	6.9 (7.4;36.8)	3.21; 14; 0.006*
Infrastructure characteristics (%)	83.0	76.0	14.4 (-22.7;37.8)	0.52; 19; 0.608
Presence of Creole animals in each BPS (%)	22.0	74.0	7.4 (-68.2;-37.0)	-7.05; 19; 0.001*

Table 3: Economic characterization of bovine production systems in the San Cristobal valley

	Production system			
System components	Milk and meat	Meat	SED (CI-D95%)	t (df; p-values)
Sale price per weaned yearling ($)	2,370	2,354	295.5 (-603.1;634.0)	0.05; 19; 0.959
Yearlings sold/ranch/year (heads)	5	2	1.0 (1.8;6.2)	3.97; 13; 0.002*
Production costs/cow/year ($)	2,968	3,278	998.2 (-2398.6;1779.8)	-0.31; 19; 0.760
Net margin of utility/cow/year ($)	3,418	3,087	1780.7 (-3395.3;4058.9)	0.19; 19; 0.854
Net margin/family worker/year ($)	3,281	3,087	1790.7(-3553.3;3942.6)	0.11; 19; 0.915
Level of integration between production and marketing (%)	67 (high)	51 (low)	10.6 (-7.4; 36.8)	1.42; 15; 0.175

Table 4: Environmental characterization of bovine production systems in the San Cristobal valley

	Production system			
System components	Milk and meat	Meat	SED (CI-D 95%)	t (df; p-values)
Characteristics of facilities (%)	55	47	9.2 (-11.1;27.5)	0.89; 19; 0.386)
Level of pasture conservation (%)	87 (grassy)	42 (over-grazed)	10.9 (21.5;67.0)	4.07; 19; 0.001)*
Level of dependence on external inputs (%)	56	57	0.1 (-0.2;0.1)	-0.18; 19; 0.860)

Table 5: Social characterization of bovine production systems in the San Cristobal valley

	Production system			
System components	Milk and meat	Meat	SED (CI-D95%	t (df; p-values)
Surface of pasture owned (ha)	7.0	4.0	2.9 (-2.8;9.4)	1.13; 19; 0.274
Surface of pasture rented (ha)	1.5	2.5	1.5 (-4.2;2.3)	-0.62; 19; 0.544
Producer age (years)	49.0	61.0	7.9 (-28.7;4.2)	-1.56; 19; 0.135
Time in cattle raising (years)	27.0	34.0	8.3 (-24.4;10.1)	-0.87; 19; 0.397
Total labor/100 cows (MWU day^{-1})	7.0	13.0	2.4 (-10.8;-0.8)	-2.46; 17; 0.025*
Total beneficiaries in the family (N°)	5.0	6.0	2.1 (-6.0;2.7)	-0.80; 19; 0.431

*Alfa error ($p<0.05$); SED: Standard Error of the Difference of the means; CI: Confidence Interval; df: Degrees of Freedom

carried out exclusively in a natural manner; the bull remains with the cows constantly and calves are born any time of year. This causes the birthrate and percentage of weaned yearlings to be relatively greater in MMPS. In both systems, yearlings are weaned naturally between 7 and 14 months. MMPS tends to have a greater ($p>0.05$) level of disease control and the main causes of calf mortality are diarrhea and distocic births. In adult animals, carbon fever and distocia are the main causes of death. Average stocking rate for both systems varies throughout the year (0.73-3.60 AU ha^{-1}) in relation to primary productivity of pastures (5,154 kg dry matter/ha/year; Nahed and Lopez, 2000). During the dry season when pasture carrying capacity diminishes, scarcity is compensated by purchased forage, in greater proportion in MPS. Throughout the year, in MMPS during milking, cows consume on average 236 g (±0.30) (a low quantity) of concentrated feed per liter of milk produced.

Tendencies to greater machinery and equipment use as well as better infrastructure are related to greater herd size in MMPS. In MPS, Creole animals predominate with a low presence of animals crossed with Holstein and Swiss while in MMPS, crosses among Jersey, Holstein and Swiss predominate and to a lesser extent, these breeds are crossed with Creole animals. Reproductive management of calves and milk production in MMPS coincide with characteristics of peri-urban stables in

the African city Bobo-Dioulasso as reported by Marichatou *et al.* (2005). Technological development planning of cattle systems should consider intensive and efficient cultivation of forage species in small areas as well as technified cattle management in stables.

Economic characteristics: Table 3 shows economic indicators. MMPS is greater ($p<0.05$) than MPS in terms of yearlings sold and is relatively greater in the other economic indicators. Producers of both systems sold cattle of different ages during any season. However, they prefered to sell weaned male yearlings while female yearlings remain on the ranch to replace unproductive adult cows. Live animals are sold to intermediaries and only three MPS producers are butchers selling meat directly to consumers. MMPS obtain 5 L (±2.7) of milk daily per cow. Only one produces milk products (cheese). These producers sell milk ($6.8 L^{-1}; ±0.78) and cheese ($60.00 kg^{-1}) directly to the consumer, maintaining a high level of integration between production and marketing. Both production systems have the opportunity to better integrate into the productive chain but quality must be improved and greater value-added given to bovine products.

MMPS's tendency to greater productivity observed in greater net margin of utility is due to the lower cost of production of this system as well as to the greater number of weaned yearlings reaching greater size which are sold at better prices and the greater level of integration between production and marketing. These 3 factors allow for greater net margin per family worker.

Environmental characteristics: Table 4 shows environmental indicators evaluated. Clearly, MMPS tends to be better in terms of facilities ($p>0.05$) as well as pasture conservation ($p<0.05$). Nevertheless, both systems show strong dependence on external inputs. This dependence suggests relatively greater economic investment in MMPS which allows for adapting better animal and pasture management strategies in order to reduce direct effects of environmental variation on animal productivity. Thus, MMPS's better facilities (fences and division of pastures) allow for rotational management of pastures and the majority are well conserved.

In contrast, some MPS pastures are over-grazed and others are eroded as a result of greater grazing pressure and lack of fences to divide pastures for better grazing management. Principal forage grasses for both BPS are *Pennisetum clandestinum*, *Cynodon nlemfuensis*, *Bromus carinatus Kook* and *Arn*, *Cynodon dactylon* L. Pers., *Paspalum crinitum* Ch. and *Setaria geniculata* Lamb; legumes (*Trifolium amabile*); cyperaceas (*Cyperus aggregatus* (*Willd*) *Endl* and *Carex schiedeana*) and woody species (*Crataegus pubescens* and *Salix humboldtiana*). During the winter, productivity of these grasses drastically diminishes due to low level of precipitation as well as frosts. This causes greater dependence on external forage (cornstalks, grass bales and rice husks) in order to feed cattle. Ranchers also employ other external inputs such as squash, commercial balanced feed and medicines. In general, dependence on external inputs is high in both systems. MMPS employ greater quantities of medicine and commercial feed and MPS uses more external forage.

As in the Central region of Chiapas (Gomez *et al.*, 2002), in VSNC, forage, milk and meat production vary strongly according to seasonal rain variation. In MPS, this leads to over-grazing which degrades pastures, reduces desirable grass and legume species and compacts and erodes soils as has occurred in other cattle regions in tropical America (Murgueitio, 2003).

From a socio-environmental point of view, the stables affect their neighborhoods and vice versa. This is due to the fact that 40 years ago some families began to establish themselves on property bordering the stables such that currently some stables are surrounded by urban sprawl. In some stables, animals are constantly confined, little affecting the neighborhood. Nevertheless, in other stables, animals are put to graze part of the day during all seasons, in streets or Urban land and frequently block vehicular transit dirty the streets with manure cause odors and in some cases physically harm pedestrians and motorists.

This situation bothers neighbors and the majority consider that stables should be re-located to the city's outskirts as they create unhealthy environmental conditions or because they believe that the cattle reduce San Cristobel's scenic beauty.

According to neighbors of stables, BPS do not provide benefits. Rather, they consider them a health risk. Nevertheless, no cases of zoonotic illnesses have been reported (Celorio, 2005). Existence of BPS in the city does not generate competition with neighbors for water, sewage or electricity according to 80% of neighbors surveyed. However, neighbors recognize that stables in the outskirts or within the city have a high tendency of disappearing due to high demand for land for urban use.

Social characteristics: Table 5 shows some social characteristics related to BPS. MMPS uses less ($p<0.05$) total labor and total family beneficiaries does not differ significantly between BPS, implying that distribution of benefits derived from ranching is similar among family members in both systems. Nevertheless, MPS generates

more employment. The fact that pasture surface owned is relatively greater in MMPS means that this system's producers use less rented land. MMPS producers are younger and have spent more time in ranching than MPS producers. The majority of producers of both BPS expect their children or other family members to continue their cattle business. Therefore, they have thought of adapting their ranches to more reduced terrains, implying that they have a significant capacity for change and innovation. These characteristics of peri-urban BPS coincide with those indicated by Paez *et al.* (2003) in the case of dual purpose ranching in Apure, Venezuela.

Different technological, economic, environmental and social sustainability indicators for animal production were grouped according to the classification by Nahed *et al.* (2006). Results show that pasture stocking rate and number of yearlings sold demonstrate greater productivity and efficiency in MMPS. On the other hand, greater herd size and conservation of pastures show MPS's significant stability while greater presence of Creole animals offers high stability to MPS indicating an important level of resource conservation.

Also, MMPS's significantly greater use machinery and equipment offers this system greater capacity for adaptation, change and innovation. Nevertheless, MPS offers significantly greater employment of labor and benefit distribution. MPS's tendency to greater use of rented pastures and forage consumed in the stable suggest this system's relatively lesser capacity of self-administration compared to MMPS.

Hygienic-sanitary management of the milking process: As milk is easily contaminated, milking management notably influences milk's hygienic-sanitary quality (Arroyo, 1997). In the majority of dairy stables in VSNC, cows are milked once daily; only two ranches milk twice daily. With regard to management practices, teats are washed before milking with water only and one stable does not wash the teats. In 50% of stables before milking, milkers wash their hands with water only and in the remaining 50% hands are not washed. In the majority of the stables with the exception of three cases, the milker uses separate, clean clothing while milking. In none of the stables are the teats sealed after milking in order to reduce mammary gland infections as Timms *et al.* (1997) suggest. Cleanliness of the milking parlor affects milk quality as well as comfort of animals and the milker. Only in half the stables studied are the milking parlors cleaned daily, in two they are not cleaned and two do not have milking parlors rather cows are milked in the open. Utensils (bucket and strainer) are cleaned with water only. These management practices are insufficient to reduce mastitis and maintain hygienic-sanitary quality of milk (Andresen, 2001). Rather, the milker must use separate, clean clothing, wash his/her hands and the cow's teats with soap and water before milking, seal the teats and wash and disinfect the milking parlor after milking as have reported Mungube *et al.* (2005) for milk production systems in Ethiopia. Even with the strictest milking hygiene, bacteria which cause mastitis and contaminate milk are inevitable (Wilson *et al.*, 1995; Lam *et al.*, 1996). In all dairy stables in VSNC, milk management is similar; milking is manual milk obtained from medicated cows is not offered to the consumer; milk is collected in a bucket and deposited in metal jugs; raw milk is transported in metal jugs to the consumer's home by auto, bicycle or tricycle; in order to distribute the milk each day the delivery person covers several city neighborhoods over the course of 3 h and milk is measured with a 1 L metallic recipient after delivery, jugs and measuring recipient are washed with soap and water. Some milk consumers prefer raw milk and purchase, on average, 1.5 L day^{-1} (±0.70) of natural, preservative-free milk at a price of \$6.80 L^{-1}. Other consumers prefer industrialized milk of any of several brands, although the price is higher (\$11.00 L^{-1}) due to the fact that it is easily purchased and does not need boiling since it is pasteurized. The majority of industrialized-milk consumers would prefer raw milk but do not consume it because they do not know how to obtain it and no official certification guarantees its hygienic-sanitary quality.

Regardless of milk type, VSNC families consume on average 4 L (±3.00) per week (although, a significant proportion of the area's population does not consume milk for cultural or economic reasons). There is a potential market for raw cow's milk in the San Cristobal valley, the acceptance of which depends on guaranteeing its hygienic-sanitary quality.

Alternative scenario: According to Mojica (1991), two types of scenarios de evolution of processes may be defined. The probable scenario would be the result of allowing current tendencies in bovine production systems to continue their current trajectory. The other, more desirable would be the result of planned intervention of the system which would modify current tendencies. Taking into account producer perspectives, several elements are lacking in order to achieve a desirable scenario of BPS in VSNC. The greatest threat to sustainability of BPS in peri-urban VSNC is the tendency to reduce pasture lands, leading to productive intensification using stables and high dependence on external forage inputs. In order to confront this loss of self-sufficiency and plan cattle system development, intensive, efficient cultivation of forage species in small

areas as well as technification of cattle in stables should be considered. There is an opportunity to efficiently process and utilize the organic portion of the 40 ton of residues produced daily in local San Cristobal markets for cattle feed. Organic market residues (fruits and vegetables) contain valuable substances such as sugars, protein, vitamins and minerals (Larrauri *et al*., 1994) and therefore, constitute a viable alternative of high quality resources for animal feed. This alternative could prevent the disappearance of peri-urban BPS using stables in VSNC. Nevertheless, a decided policy of technological and economic support by municipal and governmental authorities would be required. There is a need for an organization of producers of both productive systems which would function as a mediator on a government level in order to promote development of cattle ranching. A municipal cattle-raising association would give representation to producers on the municipal council for sustainable development. In this way, producers could participate in decision making (Cartagena *et al*., 2005) and benefit from current public policies supporting cattle-raising. Bovine production systems in VSNC could initiate chains of value of healthy and even organic products distinguishable from industrial products due to their artisan-like qualities. This would require promoting alternative production strategies which maximize efficient resource use such as ranching with low use of external inputs and organic ranching. In order to achieve sustainability of MMPS and MPS, it is necessary to strengthen support-mechanisms-such as technological aspects of production, infrastructure, facilities, equipment (cold tanks and milk pasteurizers) and others at different stages in the productive chain. It is necessary to promote greater integration among production, transformation and marketing of products in order to obtain greater value-added. It is also necessary to establish policies of financial support, training and technical advice and assistance. Particularly necessary is an integral agro-alimentary hygienic-sanitary management policy which would include financing of quality certification and promotion of milk products (such as milk, cheese and yogurt) and meat (such as dried meat and sausage) with artisan like qualities. This would allow for certification of differentiated, competitive bovine products in local, national and international markets.

CONCLUSION

In the valley of San Cristobal, high demand on land for urban use has led to increasing prices for pasture lands, reduction of pasture and forest lands and intensification of cattle raising. Growth of the urban area at the cost of agricultural (pasture) and forest areas reduces sustainability of cattle systems. Maintaining and/or developing sustainable peri-urban cattle raising requires solving the animal-feeding problem derived from reduction in pasture lands. Two systems of peri-urban cattle production predominate: the milk and meat system and the meat system. The milk and meat system tends to be economically, environmentally and socially more favorable.

On the marketing side there is a potential market for raw cow's milk in the San Cristobal valley. Acceptance and consumption depends on guaranteeing the hygienic-sanitary quality of this product. There is a need for implementing policies of financial support, training and technical advice and assistance as well as an integral hygienic-sanitary agroalimentary policy including rigorous quality control in order to obtain quality-certified, differentiated and competitive products.

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