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Characterization of environmental management in three dairy production units from Instituto de Ciencia Animal

Caracterización de la gestión ambiental en tres unidades de producción lechera del Instituto de Ciencia Animal

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The dairy sector represents a key activity in Cuban agriculture, although it faces significant environmental challenges due to the use of natural resources and the generation of wastes. The study focused on characterizing environmental management in three dairy production units from Instituto de Ciencia Animal to diagnose their performance and identify areas for improvement. To this end, two separate questionnaires were applied, one directed at workers and the other at managers and experts, complemented by direct observation. The results revealed a workforce with low stability; only 11 % of workers received environmental training. Weaknesses were identified in the management of natural resources: extensive use of land without organic fertilization, 33 % reported poor water quality, and no cases with consumption measurement. In waste management, in two units, solid wastes are burned and liquids are dumped without treatment. Of the managers and experts, 84 % are aware of the existence of the institutional environmental strategy, but low implementation is perceived. The gender perspective is not well integrated, and there is a perceived disconnect between managers' knowledge and their practical experience. It is concluded that a weak operational environmental culture predominates, with little application of regulations and low use of natural resources. The institutional environmental strategy requires greater implementation, a territorial focus, and a gender perspective. It is recommended to implement continuous training programs, main projects with renewable energies and the establishment of indicators for environmental monitoring in dairy units.

Key words: *assessment, dairy unit, environmental management, sustainability*

El sector lechero representa una actividad clave en el ámbito agropecuario cubano, aunque enfrenta importantes desafíos ambientales, debido al consumo de recursos naturales y la generación de residuos. El estudio se centró en la caracterización de la gestión ambiental en tres unidades de producción lechera del Instituto de Ciencia Animal para diagnosticar su desempeño e identificar áreas de mejora. Para ello, se aplicaron dos cuestionarios diferenciados, uno dirigido a trabajadores y otro a directivos y expertos, complementados con observación directa. Los resultados relevaron una fuerza laboral con baja estabilidad, solo 11 % de los trabajadores recibió capacitación ambiental. Se identificaron debilidades en el manejo de recursos naturales: uso extensivo del suelo sin fertilización orgánica, 33 % reportó mala calidad del agua, y ningún caso con medición de consumo. En gestión de residuos, en dos unidades los desechos sólidos se queman y los líquidos se vierten sin tratamiento. De los directivos y expertos, 84 % conoce de la existencia de la estrategia ambiental institucional, pero se percibe baja implementación. La perspectiva de género no está bien integrada, y se percibe una desconexión entre el conocimiento de los directivos y su experiencia práctica. Se concluye que predomina una débil cultura ambiental operativa, con escasa aplicación de normativas y bajo aprovechamiento de recursos naturales. La estrategia ambiental institucional requiere mayor implementación, enfoque territorial y perspectiva de género. Se recomienda implementar programas de capacitación continua, proyectos piloto con energías renovables y el establecimiento de indicadores para el monitoreo ambiental en las unidades lecheras.

Palabras clave: *evaluación, gestión ambiental, lechería, sostenibilidad*

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Introduction

Dairy production is a key activity for food security in Cuba. However, as an intensive agricultural system, it entails a significant demand for natural resources and a constant generation of wastes, which poses important environmental challenges (Ritter *et al.* 2020). Globally, there is a growing trend towards establishing mandatory sustainability parameters in livestock. However, in Latin America and the Caribbean, productive, environmental, and human capacity gaps persist, hindering this transition (Mahecha-Ledesma *et al.* 2022).

Environmental management stands as the main tool to guide the transformation processes towards resilient and environmentally responsible agricultural systems. According to Rodríguez-Sánchez (2021), this management should be analyzed with a multidimensional approach to evaluate how economic activity influences on the conservation of the natural and social environment where goods and services are produced.

According to Gutiérrez Peña *et al.* (2019), the implementation of the indicators revealed that farms with better environmental management also tended to be more profitable in the long term. This provides a framework of specific indicators to operationalize the environmental management variable. Each of the selected indicators can be adapted to systematically characterize and compare the study units.

While studies such as those by Valentí *et al.* (2023) have addressed dairy environmental management, there is a lack of comprehensive characterizations that combine qualitative and quantitative indicators in production units with a research mandate such as those of the Instituto de Ciencia Animal (ICA), where technology transfer is a key component.

The ICA develops researchers focused on animal nutrition and sustainable agroecological systems. However, there is no environmental and systematic characterization of their own milk production units. This lack of internal diagnosis limits effective environmental management, the application of its own researchers in the territory it occupies, and alignment with the national strategies of the Ministry of Science, Technology and Environment (CITMA).

The objective of this study was to characterize the environmental management in three dairy production units from ICA, in order to identify specific problems and evaluate existing capacities. The results will provide a main baseline for decision-making and the implementation of more sustainable practices in the Cuban institutional dairy sector.

Materials and Methods

The study was conducted in three dairy units from ICA ("Vaquería B", "Genético III" and "Genético IV"). The Institute is located on the Havana-Matanzas plain, between 22° 53' north latitude and 82° 02' west longitude, at an altitude of 80 m o. s. l. It belongs to San José de las Lajas municipality, Mayabeque province, Cuba. The area has a stationary, humid tropical climate, with average total rainfall in the rainy and dry season was 1320 mm, a maximum temperature above 27 ºC and a minimum temperature of 15 ºC (Herrera *et al.* 2018).

These units were selected using non-probabilistic purposive sampling, based on the following inclusion criteria:

- Institutional representativeness: units that combine production and research activities
- Productive diversity: different scales and management systems existing in ICA
- Accessibility: availability for data collection and direct observation
- Strategic relevance: importance in the institute's research and production programs

The research type is descriptive. Theoretical methods (analytical-synthetic, inductive-deductive) and empirical methods (surveys, direct observation) were used. Two questionnaires were designed: one for the workers of the units (9 people) (total of workers directly involved in production) and another for managers and experts according to the link of their position or experience with milk production and environmental management (19 individuals) (6.05 % of the total workers and 100 % of the managers and experts). The total sample of 28 participants is considered adequate for a mixed-methods qualitative case study, allowing for information saturation and triangulation of perspectives.

Instrument characteristic

First questionnaire: Structured, with closed and open questions, consisting of 52 questions. It was carried out in person with the support of the researcher through meetings with working groups. The dimensions explored included job profile, resource use, environmental perception, gender, waste, regulations, and training. The research study of González *et al.* (2017) was used as a reference.

Second questionnaire: Structured with closed and open questions, consisting of 12 questions, in order to evaluate the level of knowledge and experience, perception on the institutional strategy and training and improvement priorities on the environmental management of the dairy units from Instituto de Ciencia Animal. The Training Manual for Comprehensive Environmental Assessments and Examples of Good Practices in Comprehensive Environmental Assessments in Latin America and the Caribbean (PNUMA 2010) was used as a basis. In addition, studies by Acosta Gutiérrez *et al.* (2018) and Mateo Rodríguez *et al.* (2024) were used as references. The Google Forms platform was applied.

Statistical analysis: The Excel program and the statistical program ComparPro version 1 were used (Font *et al.* 2007).

The following tests were applied (comparison of proportions (Chi square) and Duncan (1955) test ($p<0.05$)) to establish relations and differences where necessary.

Results and Discussion

Profile of surveyed: The average number of workers is 3 per unit, for a total of 9 people. The workers have a secondary and pre-university level of education. Of those surveyed, 72 % are male and the rest are female. There is gender inequality, where the role of women is perceived as limited to milking by 100 % of the workers. This result is consistent with what was reported by Benítez *et al.* (2021) regarding the masculinization of the Cuban agricultural sector. These challenges show the relevance of moving towards a gender-sensitive approach to development, focused on power relations, that questions traditional roles and promote equitable participation, which in turn incorporates new perspectives and skills into the management of units.

Of the workers, 67 % have an average age between 35 and 65 years and 33 % are workers under 35 years of age (table 1, figure 1). Therefore, regarding the relation between education and age of the farmer, it can be observed that older farmer tend to have lower levels of education, and consequently, the process of adopting technology and sustainable practices becomes more complex; although some older farmers have experience, innovation does not come easily, as showed by Ojeda Carrasco *et al.* (2020), who highlight that younger farmers tend to have higher levels of education. Therefore, younger generations will have more years of schooling compared to their predecessors.

Figure 2 shows that 44.44 % of the workers have been engaged in cattle rearing for more than 20 years, while 55.56 % have been working in the unit for less than five years. Staff instability makes difficult the accumulation of specific experience and long-term commitment to the unit's environmental improvement. There is no family tradition; the economic factor plays a role, considering that the workers do not receive additional pay and are looking to improve their living standards. These data differ from those reported by Ojeda Carrasco *et al.* (2020), who believe that there will be transmissibility in the following generations.

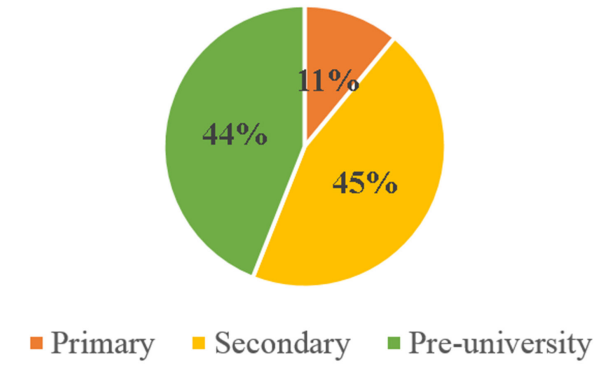

Figure 1. Educational level of the workers in the three dairy production units

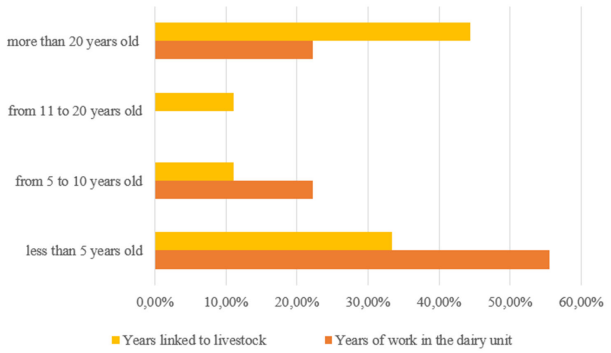

Figure 2. Performance of years linked to livestock and years of experience in the dairy unit

In the case of managers and experts, 74 % are female and 26 % are male. An 84.21 % hold doctorates in science and 15.79 % hold master's degrees in science. Of the managers and experts, 42 % had less than 20 years of experience in environmental management, coinciding with the rise of this field starting in the 1990s. From its beginnings, the aim has been to conserve natural resources and contribute to ecologically sustainable development (figure 3).

Vidal and Asuaga (2021) point out that environmental management is a strategy through which activities that affect the environment are organized, in order to achieve an adequate quality of life, by mitigating and promoting environmental problems.

Table 1. Distribution of workers in dairy units

Units	Sex		Education level			Age range		
	M	F	Primary	Secondary	Pre-university	Under 35 years old	From 35 to 50 years old	From 51 to 65 years old
Vaquería B	3		1	1	1	3		
Genético 3	3			2	1		1	2
Genético 4	2	1	1		2		1	2

It should be highlighted that there is no professional in the environmental field, which is evidenced by the lack of experience and the slow dynamism of activities.

Natural resources management: Extensive land use without organic fertilization practices was identified. The absence of conservation practices such as the incorporation of organic matter or systematic crop rotation in two of the three units constitutes a risk factor for their degradation in the medium term. This result aligns with the warnings of Gerber *et al.* (2013) on how inadequate agronomic management in dairy systems can exert constant pressure that degrades the state of the soil resource, affecting its future productivity.

Regarding water resources, 33 % of workers reported poor water quality. The reliance on tanks and wells, coupled with the lack of consumption measurement, reflects a reactive rather than a proactive approach to water management. The perception of poor water quality from the aqueduct in a unit suggests vulnerabilities in the infrastructure. This situation is common in livestock systems with technological limitations, where water management is not usually prioritized until a crisis occurs (FAO 2019).

Moderate drought conditions and irregular rainfalls have been identified, with differentiated climatic influence between units in the last five years. This performance is due to the location of the units; being far apart, they have different microclimates. Ponvert-Delisles Batista (2016) highlights that variations in climatic conditions have had a negative impact on agricultural activity. The rise in temperature has been accompanied by a reduction in total annual rainfalls of 10 to 20 %, with rainfall decreasing during the rainy season and increasing during the dry season. The different responses regarding the presence of flooding are due to differences in the relief and soil type where the units are located, because they have been subjected to constant changes in the last 30 years, so there is greater runoff in the first two, according to what was stated by Álvarez *et al.* (2012).

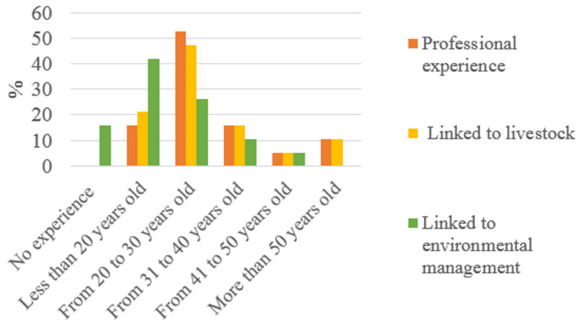

Figure 3. Years of professional experience, years linked to livestock and environmental management of the surveyed

Another environmental problem affecting the units in recent years is the impact on biodiversity, which indicates invasive plants as the main cause. Because of this situation, measures should include the implementation of programs to recover the land that was not being used, which would allow for more area to be available for grazing and forage production. According to Acosta Gutiérrez *et al.* (2018), the presence of invasive species affects the productivity and quality of grasslands, by occupying areas dedicated to this purpose, and also establishes competition for water, light and nutrients, issues necessary to ensure the efficiency and sustainability of livestock systems.

Regarding the status and use of energy, 100 % of the workers in the units responded that they have electricity in the unit and that they do not use renewable energy sources. Despite this, managers and experts recognized the potential of technologies associated with renewable energy sources to ensure the stable operation of dairy units (table 2).

Of the variables that make up the model, solar panels are a technology that predominates for developing the different services mentioned. However, those surveyed did not consider the use of windmills in the study areas.

Table 2. Perception regarding the use of technologies associated with renewable energy sources for the stable operation of dairy units (%)

Renewable energy source technologies / Energy service	Photovoltaic panels	Solar waters heaters	Windmills	Biodigesters	Not respond	SE and Signif.
Electric fence	84.21^{a}	5.26^{b}	0^{b}	5.26^{b}	5.26^{b}	±9.18, p=0.001
Mechanized milking	73.68^{a}	5.26^{b}	0^{b}	15.79^{b}	5.26^{b}	±9.18, p=0.001
Water pumping	36.84^{a}	5.26^{b}	52.63^{a}	0^{b}	5.26^{b}	±9.18, p=0.001
Lighting	57.89^{a}	15.79^{b}	0^{b}	26.32^{b}		±9.93, p=0.001
Water heating and cleaning	5.26^{a}	89.47^{b}	0^{b}	5.26^{b}		±9.93, p=0.001
Grass and forage preparation	52.63^{a}	0^{b}	21.05^{b}	5.26^{b}	21.05^{b}	±9.18, p=0.001
Cooking food	10.53^{b}	10.53^{b}	0^{b}	68.42^{a}	10.53^{b}	±9.18, p=0.001
Refrigeration	36.84^{a}	5.26^{b}	0^{b}	42.11^{a}	15.79^{ab}	±9.18, p=0.01

$^{a, b}$ Different letters in rows show significant differences at p<0.05 (Duncan 1955), SE: Standard Error

Rosas Leutenegger and Villasana López (2022) describe that the adoption of technologies in production systems in the agri-food sector requires an understanding of the phenomenon with a view to improving the efficiency of the processes. The economic factor influences on the decision-making process for technology implementation, as proposed by Cerón-Muñoz *et al*. (2022). Consequently, collaboration between the organization, workers, and local government creates demonstration spaces to build trust in the use and operation of these technologies.

Waste management: In two of the three units, solid wastes are burned, and the liquids go down the drain without previous treatment. It does not handle hazardous waste. This situation can affect animal health, with the consequent implications for the human environment. The dumping of waste water can cause contamination of surface and groundwater, given that these units are located on the Mayabeque River basin. Vélez-Castro *et al*. (2014) argue that this productive sector bears a great responsibility, not only in relation to the possible effects on the health of consumers and the environment in which it develops. A change of attitude is urgently needed regarding the management of the system and all its components, including its interrelation with the economic and social chain. Among the most relevant aspects, there is a regulation that demands change in the sector and the repayment of the economic benefits that have been received with respect to the accumulated social and environmental debt, which at this time is essential to face for the good of society.

Institutional environmental management: Table 3 shows the level of knowledge and experience of managers and experts in topics related to environmental management. The responses ranged from sufficient to acceptable, showing preparation in the topics, but the lack of experience highlights the limited connection to the development of researches in these areas, such as renewable energies, which helps to prioritize training. This coincides with reports by González-Mejías *et al.* (2018), who suggest that the gap between technical knowledge and practical application is common in dairy systems in developing countries, where the availability of resources limits effective implementation. Furthermore, there is evidence of greater experience in animal welfare, which confirms what Rueda *et al*. (2017) stated, who indicated that training in environmental topics tends to focus on immediate productive aspects, leaving aside innovative technologies.

Of the managers, 84 % are aware of the ICA's environmental strategy, but perceive low implementation, little link with local development and a lack of projects. Limited training, weak risk perception, and limited access to technological solutions are noted. The strategy does not clearly address value chains, circular economy, or women's empowerment. This represents a significant gap, according to the author. Closing this gap is not only fair, but also contributes to a competitive and resilient economic model. Additionally, having spaces for debate can promote innovative practices. Also, gender equality and the empowerment of women are established as one of the three universal values that guide the Sustainable Development Goals (SDGs). Therefore, gender equality represents an integral component for achieving inclusive and sustainable development. In this sense, the circular economy can be considered an enabler and a tool for achieving several SDGs. When analyzing the institution's strategy's contribution in certain dimensions, the survey revealed significant differences in all cases, as shown in the following table (table 4).

The results reveal an environmental strategy perceived as moderately effective, but with weaknesses in its technological implementation and social integration, validating the research hypothesis that management limitations are more than technical. The perception of managers and experts suggests that a review of the operational mechanisms of the environmental strategy is required to achieve the desired impacts on dairy sustainability.

Training needs: Of the workers, 11 % have received environmental training. Roca Cedeño (2022) mentions that all types of agricultural activities generate alterations to environmental assets. Therefore, training for farmers forms a fundamental pillar for the development of good practices, whether agricultural, environmental, social, or related to production. None of the workers from the units described the topics they would like to be trained in, which shows a lack of knowledge on the subject.

Table 3. Level of knowledge and experience of managers and experts topics related to environmental management

TOPIC	Knowledge sufficient/acceptable	Experience sufficient/acceptable
Wastes use	68.43 %	52.63 %
Water management	63.15 %	57.89 %
Renewable energy	68.42 %	36.84 %
Animal welfare	84.21 %	78.94 %
Agroecological practices	89.48 %	73.68 %

Table 4. Perception of managers and experts regarding the contribution of the environmental strategy in key dimensions (%)

Topic	Contribute significantly	Contribute moderately	Contribute little	Does not contribute	I have no opinion	SE and Signif.
Water	21.05[ab]	36.84[a]	31.58[ab]	5.26[b]	5.26[b]	±9.18, p<0.05
Energy	21.05[ab]	36.84[a]	36.84[a]	0[b]	5.26[b]	±9.18, p=0.01
Stimulating the circular economy	15.79[ab]	26.32[ab]	0[b]	42.11[a]	15.79[ab]	±9.18, p<0.05
Focus on gender equality and women's empowerment	31.58	36.84	15.79	10.53	5.26	±9.18, p>0.05

[a, b] Different letters in rows show significant differences at p<0.05 (Duncan 1955), SE: Standard Error

Table 5. Priority of training on environmental issues according to the criteria of managers and experts (%)

Topics	Levels			
	Significantly priority	Moderately Priority	Low priority	Signif.
Waste management	84.21[a]	10.53[b]	5.26[b]	p=0.001
Waste treatment (technical and operational processes)	73.68[a]	21.05[b]	5.26[b]	p=0.001
Rational use of soil	78.95[a]	21.05[b]	0[b]	p=0.001
Controlled grazing	57.89[a]	42.11[a]	0[b]	p=0.001
Water management	73.68[a]	21.05[b]	5.26[b]	p=0.001
Animal welfare	68.42[a]	26.32[b]	5.26[b]	p=0.001
Biodiversity conservation	68.42[a]	31.58[b]	0[c]	p=0.001
Agroecological practices	68.42[a]	31.58[b]	0[c]	p=0.001
Renewable energies (solar thermal, photovoltaic, wind)	89.47[a]	10.53[b]	0[b]	p=0.001
Renewable energies (Bioenergy)	78.95[a]	15.79[b]	5.26[b]	p=0.001
Reduction of GHG emissions	73.68[a]	21.05[b]	5.26[b]	p=0.001

Standard Error: ±10.81, [a,b,c] Different letters in rows show significant differences at p<0.05 (Duncan 1955)

Managers and experts considered all the topics listed in table 5 to be of significant priority. The success of an organization increasingly depends on the knowledge, skills and abilities of its managers (Almaguer Álvarez 2017). Therefore, training must be carried out systematically, in a planned and permanent manner, due to the demands imposed by the constant changes in the national and international environment and to achieve the purposes of the state and government in the management of organizations.

Conclusions

The study allowed to characterized the environmental management in three dairy units from ICA, identifying strengthens and weakness. A weak operational environmental culture predominates, with little application of regulations and low use of natural resources. The institutional environmental strategy requires greater implementation, a territorial focus, and a gender perspective. It is recommended to implement continuous training programs, main projects with renewable energies and the establishment of indicators for environmental monitoring in dairy units.

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