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Socio-technical approach to biogas technology: opportunities for local agro-livestock innovation

Enfoque sociotécnico de la tecnología de biogás: oportunidades para la innovación agropecuaria local

Abordagem sócio-técnica à tecnologia do biogás: oportunidades para a inovação agrícola local

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ABSTRACT

The relationship between technology and development is at the center of theoretical and political debates, mediations that today take on new meanings based on energy and its adaptation at the local level. In Cuba, studies on the energy dimension are becoming more important due to the favorable impacts they generate for the environment and people's quality of life. The proposed article had as objective: to describe the socio-technical approach of biogas and its opportunities for local agro-livestock innovation in the Credit and Services Cooperative "10 de Octubre", in Sancti Spíritus municipality. The study is descriptive and is based on qualitative methodology. Participant observation, document analysis, surveys and interviews and participatory dynamics constitute methodological supports of the proposed study. The results obtained reveal gaps and opportunities related to the process of socio-technical adaptation of biogas technology and its impact on the productive sector at local level, as well as the limitations that this social technological process entails.

Keywords: socio-technical approach; local agro-livestock innovation; opportunities

RESUMEN

La relación tecnología y desarrollo se posiciona en el centro de debates teóricos y políticos, mediaciones que cobran hoy nuevos sentidos a partir de la energía y sus adecuaciones a nivel local. En Cuba, los estudios sobre la dimensión energética cobran mayor importancia a partir de los impactos favorables que generan para el medioambiente y la calidad de vida de las personas. El artículo propuesto tuvo como objetivo: describir el enfoque socio-técnico del biogás y sus oportunidades para la innovación agropecuaria local en la Cooperativa de Créditos y Servicios "10 de Octubre", del municipio Sancti Spíritus. Se asume con carácter descriptivo y se sustenta en la metodología cualitativa. La observación participante, el análisis de documentos, las

encuestas y entrevistas y las dinámicas participativas constituyen soportes metodológicos del estudio propuesto. Los resultados obtenidos revelan brechas y oportunidades vinculadas al proceso de adecuación socio-técnico de la tecnología del biogás y su impacto para el sector productivo a escala local, así como las limitaciones que trae aparejado este proceso tecnológico social.

Palabras clave: enfoque socio-técnico; innovación agropecuaria local; oportunidades

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RESUMO

A relação entre tecnologia e desenvolvimento está no centro de debates teóricos e políticos, mediações que hoje assumem novos significados baseados na energia e a sua adaptação a nível local. Em Cuba, os estudos sobre a dimensão energética estão a tornar-se mais importantes devido aos impactos favoráveis que geram para o ambiente e para a qualidade de vida das pessoas. O artigo proposto tinha como objectivo: descrever a abordagem sócio técnica do biogás e as suas oportunidades de inovação agrícola local na Cooperativa de Crédito e Serviços "10 de Octubre", no município de Sancti Spiritus. Assume-se com carácter descritivo e é sustentado na metodologia qualitativa. Observação dos participantes, análise de documentos, inquéritos e entrevistas e dinâmicas participativas constituem apoios metodológicos do estudo proposto. Os resultados obtidos revelam lacunas e oportunidades relacionadas com o processo de adaptação sócio técnica da tecnologia do biogás e o seu impacto no sector produtivo a nível local, bem como as limitações que este processo sócio tecnológico implica.

Palavras-chave: abordagem sócio técnica; inovação agrícola local; oportunidades

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INTRODUCTION

In the world scenario, studies on the energy dimension are considered one of the issues of greatest impact for human life and the environment; a reality that imposes the application of more comprehensive approaches that include both productive processes

and social and cultural aspects of consumption, in the conception of a sustainable energy paradigm at the global and local level.

In this context, energy stands as a phenomenon of nature, essentially socio-technical (Ariztía et al., 2017), thus requiring a detailed understanding of the material, technical, social and cultural aspects that constitute it. Hence, it is necessary to "implement support instruments that encourage the generation and delivery to the grid for individual producers, cooperatives, associations, organizations and institutions that due to the nature of the productive processes have potential for investments in generation or cogeneration processes" (Somoza Cabrera & Betancourt Alayón, 2018).

Despite the complex global socioeconomic, political and environmental scenario, in Cuba there is a strong political will, aimed at the development of Renewable Energy Sources (RES) as an alternative from the legal and regulatory framework, which favors the systematic and accelerated introduction of the results of science, innovation and technology in agricultural production processes and compliance with the established standards of social and environmental responsibility.

Multiple contributions have been made by academic and governmental institutions, political and financial organizations, regarding the benefits, good practices and impacts that the RES have had on local socio-productive development, as represented in the works of Correa, Pérez and Hernández (2017); Martínez and Casas (2017); Ponce de León, Medina and Cardoso (2018); Martínez and Curbelo (2020).

Among those of greater scope and recognition in our country, it can be mentioned: the UNDP/FAO/UN-Environment/GEF Project: Country Partnership Program Support to the National Action Program to Combat Desertification and Drought in Cuba, the Small Grants Program of the Global Environment Facility (GEF)[1], the Local Agro-livestock Innovation Project (PIAL in Spanish), the "Clean Energy Technologies for Rural Areas in Cuba" Project (Bioenergy), the Program to support the strengthening of agro-food chains

[1] It has been in effect in Cuba since 2005 and has experience in issues relevant to food security, such as sustainable land management. It has recently been approved to implement a new climate change adaptation program at the community level

at the local level (Agrocadenas) and the Articulated Platform for Integral Territorial Development.

Mostly driven by the Ministry of Energy and Mines, Electric Union and the National Office for the Rational Use of Energy, in conjunction with other national entities such as the Ministry of Economy and Planning, the Institute of Economic Research, the Institute of Physical Planning and the Ministry of Foreign Trade, and with the financial support of international organizations (European Union, the Global Environment Facility, the Swiss Agency for International Cooperation and the Italian Agency for Development Cooperation), qualitative changes have been generated in the dynamics of the electro-energy sector at the local level.

In parallel, the work carried out by the "Indio Hatuey" Experimental Station of Pastures and Forages in the development of projects aimed at rural energization, based on biomass, stands out. With more than a decade of work in this field and with multiple scientific publications, they have managed to generate local technological alternatives with favorable impacts on economic, social and environmental development in rural areas of the country. From a remarkably diverse and plural vision, they also declare methodologies, models, strategies and intervention actions, conceived in some cases as "balsam of fierabrás" in the approach to such a complex issue.

Thus, based on the policy for the use and prospective development of RES, in the period 2013-2030, the Government Commission creates Group No 6, which under the responsibility of the Ministry of Agriculture, and the Ministry of Energy and Mines, commissions the University of Sancti Spíritus "José Martí Pérez" (UNISS in Spanish) to coordinate the policy proposal for the use and prospective development of forest biomass, windmills, biofuels and biogas as renewable energy resources. In this sense, the National Biogas Program for the period (2016-2030) was drafted, whose subprogram: Implementation and Monitoring of Small-Scale Bio digesters, contributes to the policy proposal for the production and use of biogas in rural areas.

Based on endogenous development, planning, energy supply and consumption matrices, capacity building and the incentive of sustainable technological systems, the province of Sancti Spíritus has positioned energy management in a privileged space in its local

political agenda, which supports the need to address it from a multisectoral dimension: "Energy management is not only exclusive to industrial and service organizations, but encompasses the whole society" (Correa Soto et al., 2017).

In the context of the province, studies on energy production through the use of biomass led by the Center for Energy and Industrial Processes Studies of the University of Sancti Spíritus "José Martí Pérez" stand out. Among the most recent, it can be cited: Barrera, Palmero, Echevarría, Gómez and Isaac (2019); Barrera, Odales, Carabeo, Alba and Hermida (2020). The impacts generated transcend technology to provide new capacities and skills to the executors and the beneficiary population, knowledge in favor of socio-technological change at the local level.

The socio-productive dynamics of the province, associated with the development of pig farming, make it a potential scenario for biogas production. For this reason, some ministries, institutions and non-governmental organizations have developed a group of actions that favor the development of this technology, mainly in rural socio-productive areas.

In this sense, the Credit and Service Cooperative (CCS in Spanish) "10 de Octubre", located in the community of La Sierrita in the municipality of Sancti Spíritus, has achieved during the last 10 years a significant development in the use and management of RES, mainly in the implementation of bio digesters. However, it should be noted that, despite the enormous efforts of some producers and the consolidated work of local actors, biogas technology has not been able to expand to the desired levels.

The initial approach to the problem of renewable energy development at the local level, the policies approved in the country on this issue and the participatory exchange with local actors, reveal some limits to its full development. The scarce information and knowledge that some producers have about the use, management and benefits offered by the technology (biogas), the inexistence of a legal framework that promotes its development on a local scale, the limited access of producers to sources of financing, as well as the inexistence of establishments that provide inputs for its implementation, are determining factors for its meager development in the cooperative.

Therefore, as part of a deeper research process, the proposed article describes the socio-technical approach of biogas and its opportunities for local agro-livestock innovation in the Credit and Service Cooperative "10 de Octubre", in the municipality of Sancti Spíritus.

Socio-technical approach, blurring boundaries

Also conceived as social institutions, science and technology must, in essence, strengthen capacities and consolidate a technological culture that allows for greater articulation of the actors. Awareness that science and technology are not a phenomenon exclusive to scientists is undoubtedly the first and most important step in reversing culturally inherited perceptions.

In socio-technical terms, every technological system incrementally incorporates producers and users, funders and political supports, infrastructures and supplier networks, cultural and regulatory changes, among many other heterogeneous elements. And all this process builds the functioning of these technological systems, their necessity and irreversibility (Thomas et al., 2019).

From both perspectives, an imperative emerges that is oriented to the analysis between the level of the actor and the level of the analyst, building a common sense (far from constituting a nucleus of "good sense") that intrudes into the socio-historical explanations on the processes of technological change and innovation, the dynamics of socio-economic development, the policies and strategies of public policy, the role of the State in the techno-productive sphere, etc.

From the sociological perspective, an important focus of attention on energy issues has been associated with the study of large infrastructures and socio-technical systems and their relationship with different groups and social processes. Somewhat ignored or poorly systematized issues reveal a disparity in the development of energy, taking into consideration its levels of complexity.

Local productive entrepreneurship have been expanding in productive networks, still incipient, in the heat of the updating of the Cuban economic model (Alcázar et al., 2020).

The formation and consolidation of socio-technical networks contribute to democratize decision making, based on knowledge management. Networking responds to the need to deepen the interdisciplinary dialogue that arises from the integration of technologies into daily practices. Its liberating character makes it possible to transcend concrete demands in order to propose innovative models that offer real possibilities of participation to the actors involved.

Problematizing local socio-technical issues invites us to delve into the socio-cultural determinants that have an impact on their development. Overcoming the historical sense of assistance that the processes of construction, appropriation and practice of technology have had, and promoting spaces for participation and effective feedback between equipment and individuals, constitute tasks of the first order for the integrated analysis of these issues.

From this perspective, the social studies of technology are committed to understanding the society-science-technology relationship from increasingly reciprocal optics, in which social transformations can be understood in the light of technological change, but also of the change in the representations that materially and symbolically structure contemporary societies. And it is precisely from this encounter that the research intends, from a concrete experience, to blur the historical-traditional boundaries between technology and society, approaching this phenomenon from a humanistic and transdisciplinary viewpoint.

Betting on socio-technical development, from the principle of democratization as a horizon, implies deepening the democracies of the region, promoting new policies of social inclusion and economic development, a process in which technology is an essential part.

In this context, there are emerging challenges that place science and technology at the center of the governmental agenda and individuals as the main subjects of change. Their liberating character allows us to transcend concrete demands to propose innovative models that offer real possibilities of participation to the actors involved.

Innovation: horizon or path?

The term innovation has its etymological origin in the Latin expression innovare, which means to create something new. Originally, and in a restrictive sense, the term innovation has been related to the technological field and its application in the production of new goods and services (Cornejo Cañamares & Muñoz Ruiz, 2009). Hence, the term was popularized from the thesis of the Austrian economist Joseph Schumpeter who defined it as "any new technological development such as that which takes place in the market and constitutes a monopoly" (Thomas et al., 2019).

Historians, sociologists and anthropologists have noted that innovations, particularly those of a technological nature, follow a path between their conception and their widespread use, hence the multiple approaches and contributions in this regard. Rather than offering a complete perspective on the analysis of innovation processes, our article aims to bring together multiple perspectives on the subject and to draw on the experience of the CCS.

From its social sense, innovation has its origins in the theory of social change, expounded by Ogburn and Thomas (1922), who assures that social change takes place in the interactions between two cultures: the material culture, artifacts and technological projects, and the immaterial culture, rules and social practices. From this position, innovation emerges as a category of analysis that drives the recognition of social rules and practices, with a creative and transforming character.

Thus, social innovation and citizen participation should be understood as systems that favor the processes of social inclusion and development (Alonso González, 2016). Only from this perspective, it will be possible to enhance initiatives, projects and other actions aimed at increasing social welfare and reducing marginalization processes in the local community (Mora Mayoral & Martínez Martínez, 2018).

From this perspective, the development of Technologies for Social Inclusion should be assumed as the strengthening of capacities for the resolution of specific problems, such as food, housing, energy, drinking water, health, transportation, communications, among others (Thomas et al., 2015). Achieving a future of better citizen coexistence

within the framework of sustainable growth and social justice at the national level should be a necessary, although not sufficient, part of a more ambitious plan of true popular protagonism with profound changes at the local level.

As an added value, working from a focus on the construction of integration dynamics in socio-technical systems and processes of re-signification of technologies makes it possible to overcome the limitations of linear conceptions in terms of "transfer and dissemination" (Garrido et al., 2013). Faced with this reality, it is imperative to deepen democratic conceptions and practices with a critical, participatory, proactive and empowering sense of local actors.

Some emancipatory visions of technologies speak of "technology for the people", that is, a type of technology or innovation "coupled to the improvement of the quality of life of all segments of the population throughout the national territory" and that from a constructivist approach to development advocate technological development on a plane of equity, environmental, human, socio-community, based on valuations, "starting from, as much or more, the restrictions that arise from the criticism of the mass production model" (Martínez Crespo & Ruiz-Rivas Hernando, 2018).

From its system approach, innovation encompasses the set of organizations that contribute to the development of innovation capabilities in a country, sector, region, and locality. In particular, Núñez and Alcazar (2016) offer a territorial vision of innovation systems, conceived as:

- The diversity of public and private, entrepreneurial and non-entrepreneurial actors directly involved in the creation, dissemination and use of various types of technological and entrepreneurial innovations, but also in the management of the other types of actors integrated in the system, including in the other relational and institutional elements of the system
- The nature, density and quality of the network relationships of the endogenous territorial and exogenous actors integrated in the dynamics of the system's functioning

- The network of institutions, understood as the formal and non-formalized rules of the game, which have a direct impact on the functioning of the system, and therefore on its performance

The contextualization of innovation systems has great value for the formulation of institutional and development policies, as it proposes to overcome linear models of innovation by strengthening links and interactions with knowledge users, while articulating various actors: governments, enterprises, universities, the media, the educational system, credit institutions, among others. This new proposal promotes the development of science, technology and innovation in dialogue and confrontation with concrete social problems.

Thinking about innovation, based on the particular socio-technical experience, will make it possible to investigate the interrelationships between the system of popular agricultural knowledge and the elements that define rural development at the local level. It is a matter of revaluing the contributions of each of the actors as authentic protagonists of change.

Beyond the theoretical disquisitions around the term, analogies between innovation diffusion and technology transfer, extensions or generalization, the search for effective and sustainable solutions for the integrated management of the entire agricultural production chain is pursued (Martínez Massip, 2018). The aim is to promote innovative processes and the development of the capacities of all actors in rural territories, in a context of social equity and environmental sustainability.

MATERIALS AND METHODS

Going deeper into the work experience of the CCS "10 de Octubre" calls for understanding the system of relationships that structure the innovative processes, seen from an eminently socio-technical approach. Placing at the center of this study the issue of collaborative learning in the development of biogas technology and its impact on agro-livestock innovation required understanding the social practice that, from a concrete and daily reality, allows the proper management of a technology in harmony with the environment.

Therefore, taking into account the scope of the study, from a general dialectical-materialistic methodological foundation, a qualitative research methodological design was applied. The following research methods were used at the theoretical level: historical-logical, analytical-synthetic, inductive-deductive, systemic and dialectical. And as research methods of the empirical level: observation, measurement, phenomenological and case study.

Considering that the single case study design was chosen, there are no established parameters to define the sample size. A non-probabilistic or qualitative research-oriented sample was used, which allows seeking different perspectives and representing the diversity of the phenomenon in a given context. The "snowball" type of sampling was also used, where key informants indicate and facilitate the exchange with other people who are experts in the research topic, who can contribute information and new knowledge until the saturation limit is covered.

The techniques used for the analysis and collection of scientific information were: analysis of documents and secondary data, questionnaire, participant observation, in-depth interview, focus group discussion, participatory techniques and triangulation.

RESULTS AND DISCUSSION

The socio-productive context of the CCS "10 de Octubre", particularities associated with its development

Located in the geographic space of the "La Sierrita" community, of the Colón Popular Council, in the municipality of Sancti Spíritus, the "10 de Octubre" CCS occupies a total area of 15 km2. It extends from the Entronque de Guasimal to La Sierrita, from the Loma de San Isidro to the Jíbaro Highway, bordering the limits of the Zaza Dam (Fig. 1).

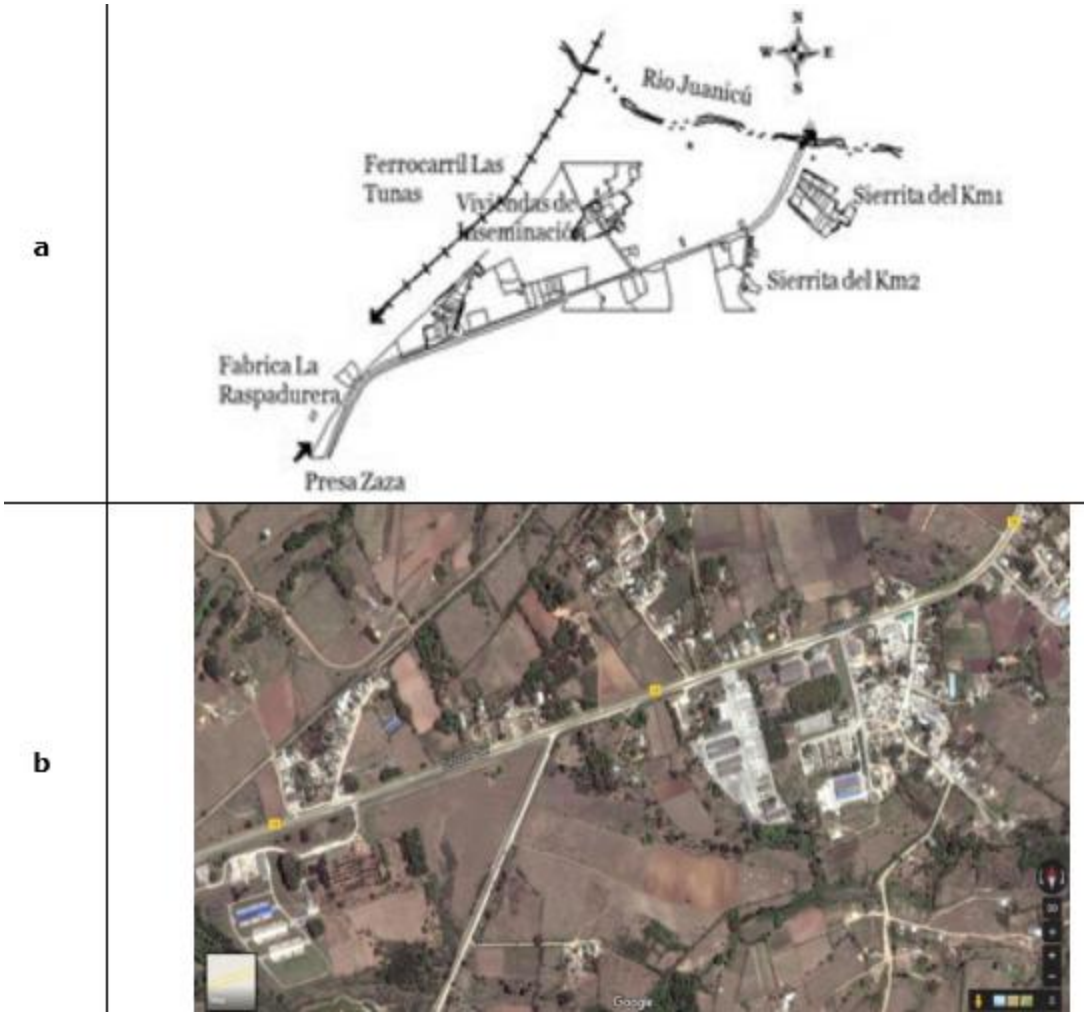


Fig. 1 - Map of the community La Sierrita
a: Geographical limits. **b:** Spatial location
Source: Google Maps

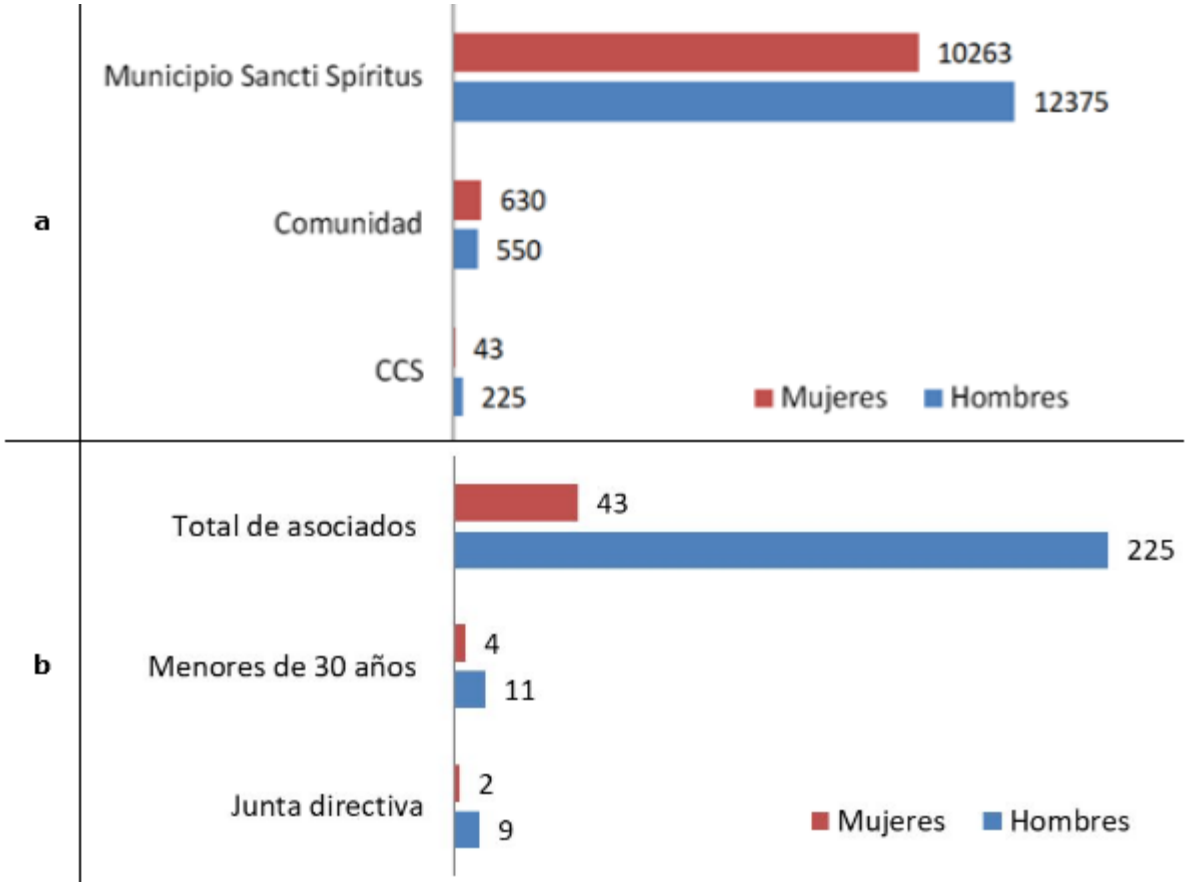
In this area, the flat relief predominates, marked by a semitropical climate, with an average annual temperature that oscillates between 24 and 27 degrees Celsius. The average annual rainfall in the plain is 1,538 millimeters and the number of rainy days fluctuates between 100 and 110 days, the predominant winds are from the north and northeast.

The flora is abundant with a predominance of fruit trees (mango, guava, papaya) and other small fruits such as lemon and coconut. It also contains precious woods, which main reserve is the San Isidro forest, with teak and eucalyptus trees, which belongs to the Sancti Spíritus Municipal Forestry Enterprise. The fauna of the territory is characterized by the presence of tomeguines (*Phonipara canora*), woodpeckers, totíes (*Dives atroviolaceus*) and poultry such as ducks and hens of different species camperas (*Iza Brown*), mountain, Creole and laying hens).

The main access road is the road to Trinidad, located at a distance of approximately 200 meters. The road conditions largely determine the existing means of transportation, such as tractors, cars, horses and bicycles. Route 7 of the local buses, which transports personnel to the municipal capital, is an important means of transportation.

The community of "La Sierrita", where the cooperative's management is located, has several labor establishments such as: "La Raspadurera" Industrial Center, a Military Region, an annexed base, a workshop of the Sancti Spíritus Electric Enterprise, the Agricultural Workshops Enterprise, the Artificial Insemination Center, the Escambray warehouses, the Apiculture warehouses, the offices of the Transit Police and the Forestry Enterprise and the warehouses of the Logistics Enterprise Group of the Ministry of Agriculture, which constitute sources of employment for the inhabitants of the community.

In this context, the CCS "10 de Octubre" is positioned as a dynamic center for the socio-productive development of the locality. Founded in 1994, the cooperative is made up of 268 members, which represents 22.7% of the total population of the community (1180) and 1.18% of the rural population (22638) of the municipality of Sancti Spiritus, for a population density of 32.4 inhabitants per km² (Graph 1a).



Graph 1 - Distribution of associates disaggregated by sex

a: Number of associates with respect to the total population of the community and the rural population of the municipality

b: Number of associates with respect to young people under 30 years of age and members of the board of directors

Source: In-depth interview with CCS directors

The CCS has 225 male and 43 female members, with an average age ranging between 45 and 60 years of age; only 15 members are young people under 30 years of age, for a composition of 11 men and 4 women. Of particular importance for the study is the low presence of women (19.1%) and young people under 30 years of age (6.6%) in the socio-demographic composition of the cooperative entity (Graph 1b), which is one of the most pressing problems in the agricultural sector in Cuba.

Historically, the CCS has stood out for the development of agriculture, livestock and various crops, activities that constitute an important basis of economic support for the majority of the population, mainly independent farmers and associated cooperative members. Currently, the cooperative is working to further develop the diversification of its production, increasing components such as small livestock production (pigs, poultry, sheep, goats) and fruit production.

In view of these efforts, training is an eminently formative process that seeks to enrich people's knowledge, skills or behaviors as a resource for solving specific problems. Within the CCS, most of the training activities have been carried out by projects to which the CCS has been linked, such as the Biomas-Cuba Project, the Local Agro-livestock Innovation Project (PIAL) and the Project to support the strengthening of local agro-food chains (Agrocadenas).

From this experience and in communion with Morales Calatayud (2014, p. 50), we can assure that "the projects obey a sequence of increasing complexity, covering a good range of technical elements and issues, but also social, humanistic and ethical elements, seeking a comprehensive, balanced, formative and liberating training to contribute to the formation of social agents of change".

In parallel, other institutions and enterprises linked to the agricultural sector have accompanied and supported in a timely manner the cooperative management of the CCS, such as the Provincial Enterprise of Pastures and Forages, the Research Institute of Tropical Viands, the Institute of Fundamental Research in Tropical Agriculture "Alejandro de Humboldt" and the Provincial Enterprise of Soils and Fertilizers (Fig. 2).

Fig. 2 - Community Stakeholders Map
Source: Own elaboration based on the results of the field work

Figure 2 shows, on both sides, the role of local actors in the creation, consolidation and strengthening of strategic alliances, the creation of socio-technical networks and collaborative learning. Describing the relationships between decision-makers and local actors, entrepreneurs and families, interveners and beneficiaries, contribute to legitimize the proposal, promote synergies of all kinds and stimulate the emergence of collective solutions.

The cooperative also has strategic allies with whom it establishes collaborative relationships based on shared needs and values. The UNISS and the project of the Faculty of Agriculture and Livestock for teaching collaboration, training and technical advice, especially the PIAL project, are important actors. Also the social and mass

organizations such as the National Association of Small Farmers, the Cuban Association of Agricultural Forestry Technicians, Pastures and Forage, Plant Health, the Union of Young Communists, the Federation of Cuban Women and the Committees for the Defense of the Revolution.

The CCS is one of the most relevant cooperatives in defense of the principles of agroecology[2] in Sancti Spíritus, it has hosted important national and international events and its associates have participated in the four events that have been held so far in Cuba on an international scale, a criterion that the president of the CCS corroborates: "(...) all the associated families practice agro ecology in one way or another, however there are 31 farms that are in the first category and 5 of them have an agro ecological seal".

It is important to highlight the importance of this institutional link for the CCS, as well as the incentive that they have awakened in their associates towards the development and implementation of RES, especially biogas, in addition to the various innovations in which they have ventured and which are now gaining relevance, both at the provincial and national level. In the field of renewable energies, the Biomas-Cuba project has developed a sustained work regarding the use of biogas as an energy resource of great value for the family and the community.

Socio-technical adaptation of biogas in the CCS "10 de Octubre": experiences and opportunities

Food production on a local scale, linked to the need to generate energy without hydrocarbons, is a shared interest of local governments and the CCS "10 de Octubre". Recognized for its innovative results, associated with the production of biogas and biofertilizers, the gasification of biomass to generate electricity, as well as the

[2] Agroecological principles. Spatial and temporal diversification; integration of animal and plant production; maintenance of high recycling rates of animal and plant waste; optimization of the use of space, with an adequate design of the surface area for agricultural use; optimization of the energy balance and integrated production approaches, integrated soil, water and pest management, and agroecological education of technicians and farmers

development and dissemination of beneficial microorganisms, the cooperative contributes to the sustainability of local production systems through the socialization and exchange of good practices.

The presence of intense air currents favorable to the use of windmills and 33 pork-producing members make this cooperative a potential scenario for the development of alternative energy. At present, the cooperative has been able to take firm steps in the development of renewable energy sources as a result of the inventiveness of a significant number of members, so it has a total of 14 windmills, a solar dryer, an aerogenerator and 12 biodigesters; 3 of them, installed by the Biomas-Cuba project (2 of 12 m^3 and 1 of 24 m^3).

With more than a decade of experience in the cooperative, the Biomas-Cuba project promotes "the use of renewable energies, mainly through the reuse and conversion of residual biomass from agriculture into usable energy", with expected benefits for productive yields and the quality of life of families. To this end, it selects a group of producers with favorable conditions for the use of renewable energies, in order to provide them with the necessary technology as part of a pilot experience.

Among the main applications of renewable energy sources, particularly biogas, the cooperative/community uses it for cooking food, as biofertilizer for the treatment of organic waste, electricity generation, vermiculture and, in some cases, in the production of canned food. For those who make use of it, the benefits are associated with the change of mentality or attitude of producers and community members in relation to waste management, the adoption of technologies and alternatives for integrated food and energy production, in addition to the use of agro ecological techniques, among others.

It is evident that the uses and applications are related to the type of technology developed in the cooperative, so it is a priority to strengthen knowledge based on the exchange of experiences and good practices with other producers. In an interview with the president of the CCS, it was confirmed that: "Through the alliances with the projects, the families have learned about the fundamental uses of the bio digesters and have joined the exchange of experiences, workshops and knowledge events inside and outside the community".

Among the benefits are the impact on household chores such as time management and ease of cooking, improvements in women's daily work and increased productivity. There is also evidence that they can satisfy employment demands by generating income for the family and the community.

The development of an agro ecological movement, closely linked to biogas technology, has favored the transmission and exchange of experiences as a factor that stimulates productive development. The transfer of knowledge regarding the management, applications and impacts of the innovations generated from the technology, in this particular case, is a principle for sustainability.

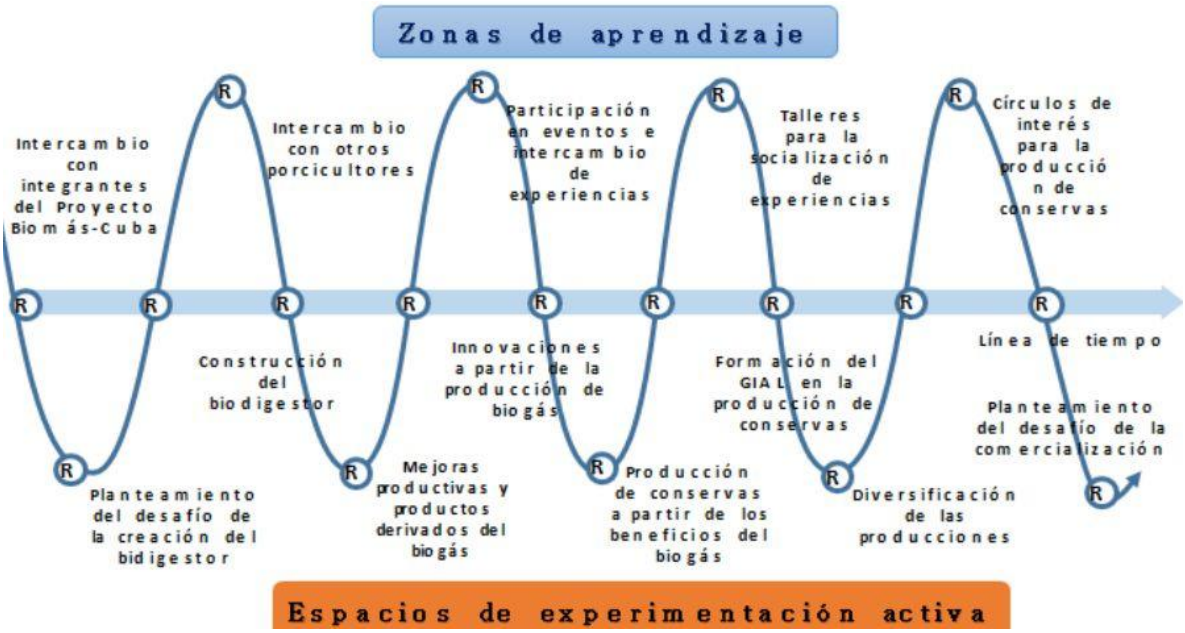
In its beginnings, the Zolenzal family (it is the one with the best conditions) benefits from a 24 m^3 bio digester, designed to supply 24 houses and supplied mainly by pig excreta and cattle excreta on a smaller scale. The effective participation of each of its members in the innovations developed, based on biogas, becomes this family into a reference of family agriculture, with impacts on the economic and cultural development of the community.

As part of the field work, we visited the "Río de Agua Viva" farm (Fig. 3a), owned by the Zolenzal family, which produces various crops such as fruits and vegetables, as well as raising animals (pigs, rabbits, chickens and small livestock). In an interview with Margarita González, Rey Zolenzal's wife, we learned about some of the farm's particularities:

> We have had land for 24 years, but we have only lived on this farm for 12 years. Today we have three hectares of land, two dedicated to grazing and one to the production of various crops, but the production is quite large. I wish all families could have that amount of land to cultivate. On the farm, we only work with 6 people, just the family, even the children participate with us. I can tell you that we all make decisions on the farm according to the needs of the family.

The Zolenzal and Venegas families have the status of agro ecological reference farms, a condition that distinguishes the production of organic food in harmony with

environmental resources. On both farms, there is a demonstration area for sustainable soil management with centers for the production and collection of organic fertilizers, which are applied in the other areas of the CCS to increase agricultural production and yields. These experiences help pave the way for the adoption of other ecotechnologies in an optimal manner, based on learning cycles[3] (Graph 2).



Graph 2 - Learning cycle in the production of canned food from biogas
Source: Interview with family members

Among the agro ecological practices promoted in Rey Solenzal's farm, it can be mentioned the location in paddocks, the live fences, where they intersperse different types of plants, both for fodder and for human or animal food, mulberry (fodder plant), coconut, banana, mango, as food, which is attributed the name of intercropping. They

[3] The learning cycle is defined as a cyclical process of social participation, built from the identification and meaning of challenges in spaces of exchange and agreement. It promotes dialogue of knowledge and experiences among stakeholders, strengthening their innovative capacities for collective action in the management of local agro-livestock innovation systems

also have areas of diversified plants such as soursop, orange, lemon, lime, passion fruit, *hinche* sauce or Inca peanut (omega 3 plant).

Fig. 3 - Reference farm "Río de agua Viva"
a: Entrance to the farm. **b:** Sample of products made by the Zolenzal family
Source: Participant observation at the "Río de Agua Viva" farm

The production of preserves, whether in vinegar, syrup or dehydrated, is one of the main local innovations, as a result of the benefits and impacts of biogas generation (Fig. 3b). The optimal use of the crops and their wastes, the accelerated diversification and the innovative character of their productions, make this family a local potential for the development of a mini-industry, with opportunities for commercialization.

This family is a referent for family farming, not only for the cooperative but also for the municipality. Their agro ecological practices have allowed them to actively participate in several national and international projects. Precisely, there emerges an articulation between demands, identity construction and linkage with the state dynamics, on which the research is focused.

Energy carriers are limiting factors for many productions today, since full development is not always achieved in the agricultural sector, either due to the scarcity or lack of energy or the lack of knowledge that still persists regarding the benefits of this type of resource. This is confirmed by Ernesto L. Barrera Cardoso, director of the Center for Energy and Industrial Processes Studies: "Bio digesters constitute an enormous potential for the development of medium-scale production systems, not only because of the gas for cooking food, but also to use this gas in the development of agriculture (...)".

This issue is fundamentally associated with motivational elements that can be evaluated from a social point of view, with the level and ways of life of the producers, with the perception and degree of acceptance of the technology that is developed. This generates, in the end, an indicator that could be what is called acceptance of the technology in one scenario or another, so it is necessary to evaluate the technology before and after it is installed and in this sense the work must be strengthened.

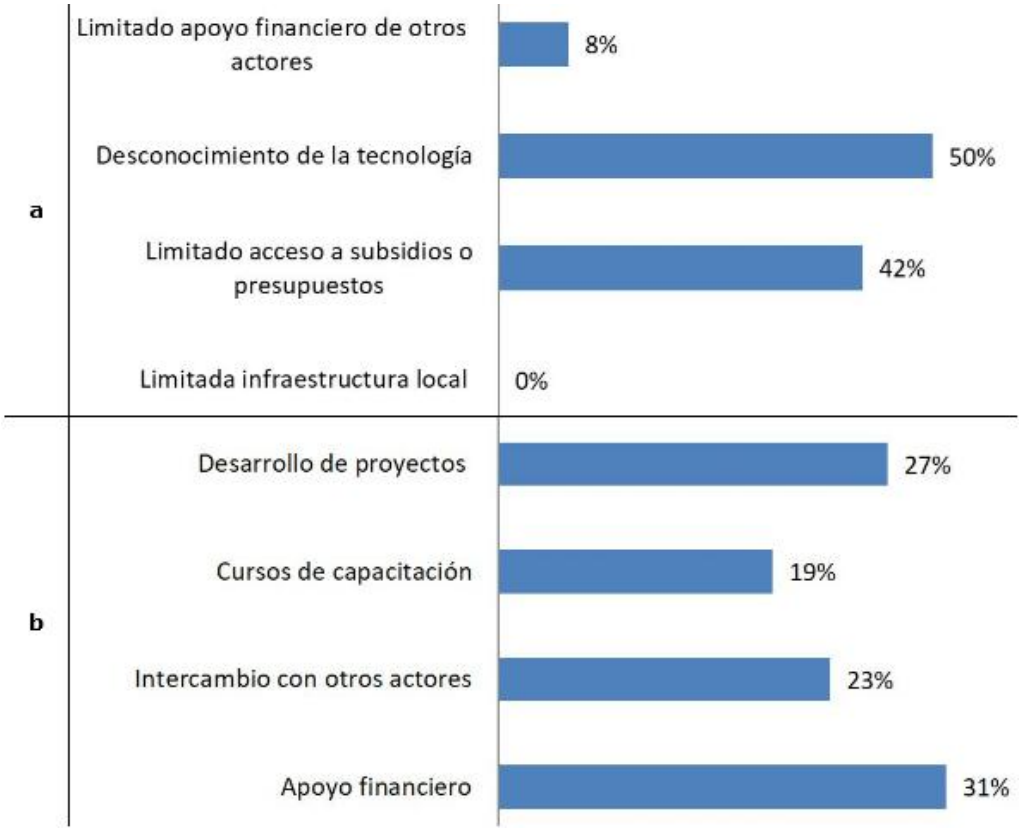
Regarding the level of information, more than 75% of the producers surveyed reported feeling informed about the benefits of biogas. However, the level of information does not ensure a mastery of the multiple applications of this resource for the well-being of the family and the socio-productive development of the community.

Regarding the preparation shown by the surveyed population (associates), it can be seen that 88% of the people do not feel prepared to work with RES, although they are willing

and wish to receive some type of training that will allow them to adequately develop the technology. In the case of producers who make use of it, it can be appreciated a mastery and self-confidence for the use and development of biogas technology, expressed in 83%.

Thus, socio-technical education/training will contemplate not only the value or relevance of the technology, but also the knowledge, wisdom, experiences, conflicts and resistances, fears and uncertainties as a guide for transformative action, participation and sustainability.

Regarding the limitations to develop the technology, the 12 producers who own the biodigester refer to the lack of resources necessary for its maintenance, considering that 10 biodigesters have been in operation for more than 3 years (Graph 3).



Graph 3 - Social perception regarding the development of biogas technology
a: Limitations that hinder its development. **b:** Possible solutions
Source: Survey conducted with partners

These criteria confirm the need to strengthen training actions at all levels, not only for those who work directly with the technology, but also with the beneficiary population. Hence, they propose as possible actions to promote their development: community workshops and training courses.

Among the main innovations are the handicraft and culinary art workshops, where women innovate with certain cooking recipes, mainly with sweets, adding canned foods. The same happens with canned fruits, vegetables, viands and spices. It should be noted that the women of the community have gained a space where exchange predominates. There are also numerous innovations on the part of the producers in terms of agricultural work tools.

Impacting the community's productive systems through RES, specifically the practice of biogas, brings direct benefits to the lives of producers. It is a challenge to continue promoting work from this perspective, creating new habits and ways of doing things that guarantee agricultural development from a healthy and sustainable environment.

The impacts and sustainability of any technology, especially biogas, depend on the processes of social appropriation. It is essential to think about technology, taking into account the structural and functional elements of the context, the knowledge and social perception of the technology and, last but not least, the learning cycles generated around it. Today it is a challenge for local actors to devise a strategy that develops, in a horizontal and dialogic manner, the social factors and technical elements in pursuit of their development at the local level.

Integrating end users in the construction of technological solutions implies, in particular, achieving a better identification of particular and collective needs. "Evaluating potential solutions, taking into consideration the type of socio-productive dynamics to be favored, as well as incorporating the knowledge and cultural practices of the population" (Garrido et al., 2013), emerge as guarantees for a better participation and commitment of the beneficiaries in the processes of change.

Opportunities and limits

The CCS "10 de Octubre" presents an innovative development associated with the development of biogas technology. Pig farming and the strengthening of a participatory agro ecological movement have boosted productive yields in the spirit of family farming. At the same time, it shows a technological and social change with favorable impacts on the environment and people's quality of life. In addition, partnerships have been established with projects that have generated exchange and cooperation and provided inputs and raw materials for the operation of the technology.

Among the main benefits and impacts generated in the CCS, we can mention: the improvement in the quality of life of a significant number of families, the creation of new jobs associated with the technology, training and improvement opportunities associated with project management, the production of biofertilizers, the creation of knowledge networks and the conception of strategic alliances, the strengthening of an energy and environmental culture, and the increase in production yields.

The innovations generated, as well as the strategies implemented, demonstrate the entrepreneurial capacity, the quality of human capital and the flexibility of the productive system that allow peasant producers and other local sectors to contribute to the reduction of food and hydrocarbon imports.

The results obtained allow assuring the need to outline strategies that promote the integral progress of the associates based on the development of innovations that contribute favorably to the cooperative management. The development of biogas, in the agricultural and cooperative sector, requires an integral interpretation from the acquisition, use, intervention and transfer of knowledge that will promote the search for solutions and the expected impact.

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Conflict of interest:

Authors declare not to have any conflict of interest.

Authors' contribution:

Authors jointly designed the study, analyzed the data, and prepared the draft. They reviewed the writing of the manuscript and approved the version finally submitted.