

## Analysis and Comments

# Innovation processes in local food and energy production in Cuban municipalities

Jesús Suárez-Hernández<sup>1</sup>, Julio Ramiro Quevedo-Benquí<sup>1</sup>, Maikel Rodolfo Hernández-Aguilera<sup>2</sup>, Abel Peña-Alfonso<sup>3</sup> and Guillermo González-Telles<sup>4</sup>

<sup>1</sup>Estación Experimental de Pastos y Forrajes Indio Hatuey, Universidad de Matanzas, Ministerio de Educación Superior Central España Republicana, CP 44280, Matanzas, Cuba

<sup>2</sup>Unidad de Extensión, Investigación y Capacitación Agropecuaria, Velazco, Holguín, Cuba

<sup>3</sup>Centro de Desarrollo Local, Gobierno Municipal de Manatí, Las Tunas, Cuba

<sup>4</sup>Filial Universitaria de Martí (Universidad de Matanzas), Martí, Matanzas, Cuba

E-mail: [jesus.suarez@ihatuey.cu](mailto:jesus.suarez@ihatuey.cu)

---

## Abstract

The objective of the work is to make an analysis of the diverse innovation processes in the local integrated food and energy production in Cuban rural areas in the context of the Biomass-Cuba project<sup>1</sup>. For the identification and evaluation of the local innovation process in the integrated food and energy production (IFEP), three questions were established: 1) what innovation processes have been developed or introduced?, 2) What has the link consisted in?, and 3) Which have been the key learnings? The IFEP is promoted for the development of agroenergetic farms, which has been implemented in private farms, cooperatives and state farms, in 22 municipalities of six Cuban provinces. They concentrate two types of innovation: i) sowing and agronomic management of *Jatropha curcas* L. for biodiesel production, and ii) integration of biodigesters in animal and plant production farms. In addition, 176 biodigesters were designed and constructed, mainly fixed-dome ones, and two anaerobic lagoons covered with synthetic geomembrane. In the organizational context there was a link among research centers, municipal universities, governments and local state entities, and professional and farmer organizations. It is concluded that the promotion of local innovation processes in agroenergy, in Cuban municipalities, contributes to a new strategic approach for the IFEP from biomass in rural areas, in the framework of local innovation systems, with high participation of actors, open innovation processes and a science-productive sector-government link.

Keywords: bioenergy, extension, food production

---

## Introduction

At global scale there is a challenge: how to make agroenergy, food security and environmental protection coexist?, in the presence of climate changes, environmental degradation, food crisis and the «biofuels vs. food» contradiction, generated by a senseless policy to obtain the former in large land extensions which were previously dedicated to produce food, something morally rejectable. Nevertheless, biofuels are an ecological alternative to substitute fossil biofuels, in the rural context, and reduce the emissions of greenhouse gases (GHG). This is enhanced in integrated agricultural systems, in which biofuels and food can be produced (Suárez *et al.*, 2011).

This approach to produce, in an integrated way, foodstuffs and biofuels (liquid, gaseous and solid), demands to develop learning and innovation

processes, create a remarkable absorptive capacity in the different involved actors and promote innovation systems and interrelations among the governments, universities, research centers and the productive sector, which constitute important catalysts for a successful implementation of such integrated approach.

In this regard, there are in literature diverse antecedents which approach: learning and construction of technological and innovation capacities (Ramírez *et al.*, 2014), absorptive capacity (Warda and Johansson, 2014; Castellacci and Natera, 2015a), open innovation (West and Lakhani, 2008; West *et al.*, 2014), innovation systems (Castellacci and Natera, 2015b; Wu *et al.*, 2017), local innovation systems (Saldaña, 2014; Guercini and Runfola, 2015), the university-enterprise link (Motoyama, 2014) and the Triple Helix –the relation among the academy,

---

<sup>1</sup> Biomass-Cuba: International project led by the Pastures and Forages Research Station Indio Hatuey (EEPFIH) and funded by the Swiss Development and Cooperation Agency (SDC).

enterprises and Government– (Deakin and Leydesdorff, 2014; Gebhardt, 2015; Leydesdorff *et al.*, 2017).

These approaches configure the national, regional and local environment for innovation, for which the literature on the topic has structured a solid theoretical framework for understanding such processes. However, the large majority of the works have been focused on the experience of manufacturing and service enterprises, and few efforts are still made to understand these issues in the agricultural sector and, specifically, in bioenergy.

For such reason, the objective of the work was to make an analysis of the diverse innovation processes in the local integrated food and energy production in Cuban rural areas in the context of the Biomass-Cuba project.

#### *Integrated food and energy production in the rural context*

The Biomass-Cuba project started in 2009, in a context in which considerable volumes of foodstuffs and fuels were imported, and the use of renewable energy sources (RES) at that time was not a high priority for the Government, unlike food production. Since its conception, the decision was made to focus it on three topics: biodiesel, biogas and gasification, and their production and utilization in the framework of the agricultural systems to contribute to food production, to cost reduction and to the improvement of rural life and environment quality.

In this sense, the project contributed in the integrated production of food and *Jatropha curcas* L. biodiesel; biogas and biofertilizer production from the effluents of biodigesters; biomass gasification to generate energy; evaluation of integrated systems to produce food and energy in Cuba; and the generated economic, social and environmental impact, with a strong link between the communities and decision-makers, as well as a remarkable science-productive sector-government link (Suárez and Martín, 2012). These results were obtained in six Cuban provinces and contributed to improve the quality of life, through the integrated food and energy production (IFEP), in harmony with the environment.

The importance of this experience lies on the promotion of local innovation systems in bioenergy,

based on open innovation processes among multiple actors (researchers, farmers, decision-makers, state institutions and communities), in which a new concept emerges: the agroenergetic farm<sup>2</sup>, new appropriate technologies and applications are disseminated in Cuba, national and international networks are promoted, and incidence is made on public policies, all this supported by the formulation and implementation of local IFEP strategies.

For the identification and evaluation of the integrated food and energy production in Cuba, in the rural context, and for the characterization of the link among the productive sector, the researchers, professors and decision-makers of the government, three questions were established for the analysis of innovation processes:

1. What innovation processes have been developed or introduced?
2. What has the link consisted in?, and
3. Which have been the key learnings?

#### *Innovation processes developed or introduced in the rural context*

The IFEP was promoted through the implementation of agroenergetic farms, located in private farms, cooperatives and state farms, in 22 municipalities of the provinces Guantánamo, Holguín, Granma, Las Tunas, Sancti Spiritus and Matanzas (40 % of the Cuban provinces). In these systems mainly two innovation types are concentrated: i) sowing and agronomic management of food crops in association with *J. curcas*, an adequate shrub for biodiesel production from the seeds of its fruits, and ii) integration of biodigesters in animal and plant production farms.

In that sense, the first model for biodiesel production emerged from the evaluation of a germplasm of non-edible oil plants, such as *J. curcas*, *Ricinus communis* L. and *Aleuritis trisperma*, introduced in the country or collected in rural areas of Cuba, which were established in germplasm banks of three provinces (Machado *et al.*, 2012). This evaluation was complemented by the one carried out along with several farmers in their own farms, which allowed to identify promising materials, mainly of *J. curcas*, for their seed and oil yields. Taking into consideration the aspects reported about *J. curcas* and the physical-chemical characteristics of its oil, it was

<sup>2</sup> Defined as «the productive exploitation where technologies and innovations are developed, improved and evaluated to produce, in an integrated way, food and energy (Suárez *et al.*, 2011).

identified as the most appropriate plant for producing biodiesel in Cuba (Sotolongo *et al.*, 2012).

Planting combinations of *J. curcas* were evaluated and 21 agricultural crops were intercropped between the rows, among which beans, soybean, peanut, corn, cassava, sorghum and rice stood out with the best yields, with the application of survival irrigation and fertilization with biofertilizers (Sotolongo *et al.*, 2012). This experience of intercropping in the *J. curcas* rows proved that it is possible to increase the productivity per hectare with spatial arrangements that allow to produce biodiesel and crops for human consumption.

On the other hand, the reforestation with *J. curcas* was performed in 74 % of the soils not used for agriculture, with diverse degradation conditions –salinity, erosion, low fertility–, in high-fragility areas with environmental affectations and, in some cases, in degraded basins. This generated environmental impacts, because it has been observed that such plantations sequester annually 1 956 000 t of carbon dioxide (CO<sub>2</sub>), an important GHG; *J. curcas*, for example, captures 6 kg of CO<sub>2</sub>/year/tree (Suárez and Martín, 2012).

The second innovation model (biogas and biofertilizer) promotes the construction of biodigesters for the anaerobic treatments of pig and/or cattle excreta, which generate biogas as energy porter and high-quality biofertilizers. In this context 176 biodigesters were designed and constructed, mainly fixed-dome ones (up to 90 m<sup>3</sup> of capacity), besides polyethylene tubular and two anaerobic lagoons covered with high-density synthetic geomembrane<sup>3</sup> of 400 and 5 000 m<sup>3</sup>. These facilities generate remarkable productions, of biogas<sup>4</sup> (which is used in food and feed cooking, refrigeration, generation of electricity and irrigation<sup>5</sup>), as well as biofertilizers<sup>6</sup>, from the biodigester effluents, aimed at the amelioration of degraded soils (Suárez, 2017). In this innovation process the link among several research centers, pig production enterprises and farmers has been essential, which has generated synergies and diverse improvements in the technologies, designs and components of the different biodigester systems.

Another innovation of impact on the quality of life of the inhabitants is the creation of four biogas supply networks, fed by biodigesters, which benefit 53 houses and 272 persons in the Cabaiguán municipality (in the central region of the country), which constitute the first rural communities in Cuba with a gas supply network in food cooking and other usages, annually saving 77,2 MWh of electricity.

The gasification of biomass for energy generation, more efficient process than the traditional combustion, as firewood or charcoal, is also the object of analysis. Two gasifiers and their generators were installed, with capacity of 20 and 40 kW of power, at the Pastures and Forages Research Station Indio Hatuey (EEPFIH), in Matanzas province, and in a sawmill, in Santiago de Cuba province, operated with *Dichrostachys cinerea* (L.) Wight & Arn. branches and trunks and with wastes from the pruning of animal husbandry agroforestry systems and from the processing of timber (bark), respectively (Cepero *et al.*, 2012).

Economic and environmental appraisals were made in order to evaluate the IFEP in different productive scenarios of 15 municipalities. An increase of local food production (vegetables, fruits, milk, meat and eggs) was found, influenced by the above-mentioned innovations, from 1,6 to 27,3 million Cuban pesos (CUP), and the productive items were remarkably diversified. Likewise, between 2013 and 2016 88,7 million CUP were generated, due to the substitution of food, fuel and fertilizer imports for a value of 5,9 million USD –without considering the savings in maritime freights (Suárez, 2017).

In the improvement of the farmer families' quality of life, the following indicators stand out: the creation of 372 new direct jobs, with a mean monthly salary higher than the average salary of the involved provinces, from which 28 % are occupied by women, favoring the family economy.

A positive environmental impact has also been generated associated to the reforestation with 335 000 trees, which favors carbon sequestration; substitution of fossil fuels and decrease of CO<sub>2</sub> and SO<sub>2</sub> emissions due to the management of the pig and cattle excreta; production of biofertilizers, which contributes to improve soil fertility, among others.

<sup>3</sup> Adequate technology for large waste volumes, solving the limitations of uncovered anaerobic lagoons, which emit methane and unpleasant odors.

<sup>4</sup> At present 1 145 317 m<sup>3</sup> of biogas/year are generated (equivalent to 3 460 barrels of oil).

<sup>5</sup> A total of 12 841 people who inhabit rural zones of Cuba is benefitted.

<sup>6</sup> At present, 90 423 t per year are produced; this has allowed to improve 3 874 ha of degraded soils.

A key catalyst of this entire process has been the formulation and implementation of local IFEP strategies in six municipalities, which are integrated to their Local Development strategy, which has allowed to provide their governments with a strategic management tool to promote, in the synergy framework, food security, utilization of RES, waste treatment and utilization, land reclamation, GHG reduction and mitigation and adaptation to the climate change.

### *Importance of the science-productive sector-government link in the innovation processes*

These results were obtained through the promotion of intense open innovation processes by researchers and farmers and between them, to which local decision-makers from the governments and state entities were incorporated, as well as the municipal university centers and campuses. This allowed to create a kind of local innovation systems, in which the participation and inclusion of everyone, individual and organizational learning, and the creation of absorptive and local innovation capacities, are permanent elements.

In the participating municipalities, this link became closer among the Local Operational Committee, Council of Municipal Administration (CMA), Municipal Delegation of Agriculture; municipal directions of Physical Planning, Economy and Planning, Hydraulic Resources and of the National Association of Small Farmers (ANAP, for its initials in Spanish), the Municipal University Center and other projects that act in these territories, with which important synergies are achieved. In this sense, each semester in the CMAs –the local executive power– the implementation of the above-approached Local IFEP Strategies, which exist in six municipalities, is evaluated; while once per year this evaluation is made by the Municipal Assemblies of People's Power –the local legislative power.

The organizational context for the implementation of these innovation processes is shown in a permanent link among research centers, municipal university campuses, producers –with emphasis on farmer men and women–, governments and local state entities and professional and farmer organizations, which more than a Triple Helix is a Four-Helix –enlarged with the civil society–, which has allowed to have incidence on local public policies.

Likewise, the local actors interact periodically with national and sectorial decision-makers, linked to the Ministries of Energy and Mines (Minem),

Agriculture (Minag), Higher Education (MES), Industries (Mindus) and Science, Technology and Environment (Citma), which contributes to have incidence not only on local public policies, but also at ministry and national level. As examples of this interaction the following stand out: i) the Directions of Renewable energy and of Energy Policy of the Minem, ii) several enterprises from the metal-mechanic, chemical and appliances industries to manufacture equipment and components of the biogas and biodiesel systems, and iii) the Entrepreneurial Agricultural, Agroforestry, Animal Husbandry and Labiofam groups, to train their managers and specialists, as well as to implement diverse technologies for bioenergy.

### *Key learnings in the IFEP*

Concerning the lessons learned or under construction, the following stand out:

- The thematic approach focused on the IFEP, with the application of the concept of agroenergetic farm, which has allowed to create in diverse actors a more integrated and systemic conception.
- A wide work in the network among all the actors and synergies at local, territorial and national scale, supported on the participation in multi-institutional and multi-actor platforms, as well as a link among the academic sector and the farmers and decision-makers.
- Intense processes of local agricultural innovation, in the framework of an open innovation model aimed at the achievement of practical results, in which technologies and innovations are developed and improved with wide participation of the beneficiary, for the sustainability of the actions.
- Direct links with the farmers and their families, which has allowed to accompany them in the development of sustainable production processes with community participation.
- The promotion of synergies with other international projects and with institutions (ministries, local governments, enterprises, technical and producers' organizations, and farmers).
- The permanent process of systematization and socialization of results, experiences, good practices, technologies and designs, among others, aimed at direct beneficiaries and project managers, policy decision-makers and at the scientific and academic sector, at local, provincial and national scale.

- Active contribution to the formulation of the national biogas and biodiesel programs.

## Conclusions

The promotion of local innovation processes in agroenergy, in Cuban municipalities, contributes to a new strategic approach for the IFEP from biomass in rural areas, in the framework of local innovation systems, with high participation of actors, open innovation processes and a science-productive sector-government link.

## Acknowledgements

The authors thank the international project Biomasa-Cuba, funded by the Swiss Development and Cooperation Agency (SDC), which contributed with the funding for the implementation of technologies and innovations linked to food and energy production in the Cuban rural context.

## Bibliographic references

- Castellacci, F. & Natera, J. M. Innovation, absorptive capacity and growth heterogeneity: development paths in Latin America 1970-2010. *TIK Working Papers on Innovation Studies No. 20150820*. Oslo: Centre for Technology, Innovation and Culture, 2015a.
- Castellacci, F. & Natera, J. M. The convergence paradox: the global evolution of national innovation systems. *TIK Working Papers on Innovation Studies No. 20150821*. Oslo: Centre for Technology, Innovation and Culture, 2015b.
- Cepero, L.; Recio, A.; Palacios, A.; Iglesias, Y. & Suárez, J. Gasificación de biomasa para la producción de electricidad. En: J. Suárez y G. J. Martín, eds. *La biomasa como fuente renovable de energía en el medio rural: La experiencia de Biomasa-Cuba*. Matanzas, Cuba: EEPF Indio Hatuey. p. 143-149, 2012.
- Deakin, M. & Leydesdorff, L. The triple helix model of smart cities: a neo-evolutionary perspective. In: M. Deakin, ed. *Smart cities: governing, modelling and analyzing the transition*. London: Routledge. p. 134-149, 2014.
- Gebhardt, Christiane. The spatial dimension of the triple helix: the city revisited—towards a mode 3 model of innovation systems. *Triple Helix*. 2:11-14, 2015. DOI: <http://doi.org/10.1186/s40604-015-0024-3>
- Guercini, Simone & Runfola, A. Actors' roles in interaction and innovation in local systems: a conceptual taxonomy. *J. Bus. Ind. Marketing*. 30 (3/4):269-278, 2015.
- Leydesdorff, L.; Etzkowitz, H.; Ivanova, Inga & Meyer, M. The measurement of synergy in innovation systems: redundancy generation in a triple helix of university-industry-government relations. *Working Paper Series SWPS 2017-08*. United Kingdom: Science Policy Research Unit, University of Sussex, 2017.
- Machado, R.; Sotolongo, J. A. & Rodríguez, E. Caracterización de colecciones de oleaginosas útiles para la producción de biocombustible. En: J. Suárez and G. J. Martín, eds. *La biomasa como fuente renovable de energía en el medio rural: La experiencia de Biomasa-Cuba*. Matanzas, Cuba: EEPF Indio Hatuey. p. 41-69, 2012.
- Motoyama, Y. Long-term collaboration between university and industry: A case study of nanotechnology development in Japan. *Technol. Soc.* 36 (1):39-51, 2014. DOI: <https://doi.org/10.1016/j.techsoc.2013.09.001>.
- Ramirez, M.; Bernal, Paloma; Clarke, I. & Hernandez, I. Distinguishing patterns of learning and inclusion through patterns of network formation in developing agricultural clusters. *Working Paper Series SWPS 2014H20*. United Kingdom: Science Policy Research Unit, University of Sussex, 2014.
- Saldaña, A. Integración regional y sistemas locales de innovación: desafíos para las MIPYMES. Una perspectiva desde México. *Espacio Abierto Cuaderno Venezolano de Sociología*. 23 (4):629-642, 2014.
- Sotolongo, J. A.; Suárez, J.; Martín, G. J.; Cala, Marlenis; Vigil, María; Toral, Odalys et al. Producción integrada de biodiésel y alimentos: la concepción de una tecnología agroindustrial apropiada para Cuba. En: J. Suárez and G. J. Martín, eds. *La biomasa como fuente renovable de energía en el medio rural: La experiencia de Biomasa-Cuba*. Matanzas, Cuba: EEPF Indio Hatuey. p. 100-112, 2012.
- Suárez, J. *Informe final del proyecto Biomasa-Cuba Fase II*. Matanzas, Cuba: EEPF Indio Hatuey, 2017.
- Suárez, J. & Martín, G. J., Eds. *La biomasa como fuente renovable de energía en el medio rural: La experiencia de Biomasa-Cuba*. Matanzas, Cuba: EEPF Indio Hatuey, 2012.
- Suárez, J.; Martín, G. J.; Sotolongo, J. A.; Rodríguez, E.; Savran, Valentina; Cepero, L. et al. Experiencias del proyecto Biomasa-Cuba. Alternativas energéticas a partir de la biomasa en el medio rural cubano. *Pastos y Forrajes*. 34 (4):473-496, 2011.
- Warda, P. & Johansson, B. *Knowledge absorption in the development of export products*. Paper No. 368. Estocolmo: Centre of Excellence for Science and Innovation Studies, The Royal Institute of Technology, 2014.
- West, J.; Salter, A.; Vanhaverbeke, W. & Chesbrough, H. W. Open innovation: the next decade. *Res. Pol.* 43 (5):805-811, 2014. DOI: <https://doi.org/10.1016/j.respol.2014.03.001>.
- Wu, J.; Zhuo, S. & Wu, Z. National innovation system, social entrepreneurship, and rural economic growth in China. *Technol. Forecast Soc. Change*. 121:238-250, 2017. DOI: <https://doi.org/10.1016/j.techfore.2016.10.014>.