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Original article

Innovation system for the Cuban forestry sector

Sistema de innovación para el sector forestal cubano

Sistema de inovação para o sector florestal cubano

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ABSTRACT

The Cuban forestry sector is not able to respond to the demands of the domestic market, and there are reserves for increased production, greater diversification and relationships between the different actors involved in the innovation process, hampered by a variety of factors, including the lack of effective mechanisms to ensure the generalization of the scientific results obtained and the persistent disconnection between key actors in the process. In this sense, the objective of this research is to propose an innovation system for the sector. For the design of the system, a methodology organized in four stages and eight steps was used, with brainstorming, document review and group discussion as fundamental techniques. The main result obtained was: the structure of the innovation system in subsystems and components. The proposal contributes to the improvement of the innovation process in the sector, as well as to the design and implementation of

policies and strategies to increase its socioeconomic contribution to the country's development with a view to 2030.

Keywords: Innovation process; Forestry sector; Sectoral innovation system.

RESUMEN

El sector forestal cubano no logra solventar las demandas del mercado interno, existiendo reservas para el incremento de la producción, mayor diversificación y relacionamiento entre los distintos actores que hacen parte del proceso de innovación; obstaculizado por disímiles factores, entre los que destacan la inexistencia de mecanismos efectivos que garanticen la generalización de los resultados científicos obtenidos y la desconexión que persiste entre actores clave del proceso. En tal sentido, la presente investigación tiene como objetivo proponer un sistema de innovación para el sector. Para el diseño del sistema se empleó una metodología organizada en cuatro etapas y ocho pasos, como técnicas fundamentales se utilizaron la tormenta de ideas, revisión de documentos y discusión de grupo. Como principal resultado se obtuvo: la estructura del sistema de innovación en subsistemas y componentes. La propuesta contribuye al perfeccionamiento del proceso de innovación en el sector, así como al diseño e implementación de políticas y estrategias para incrementos en el aporte socioeconómico de este al desarrollo del país con vistas al 2030.

Palabras clave: Proceso de innovación; Sector forestal; Sistema de innovación sectorial.

RESUMO

O setor florestal cubano é incapaz de satisfazer as exigências do mercado interno, com reservas quanto ao aumento da produção, maior diversificação e relações entre os diferentes atores envolvidos no processo de inovação, dificultados por uma variedade de fatores, incluindo a falta de mecanismos eficazes para garantir a generalização dos resultados científicos obtidos e a desconexão que persiste entre os atores-chave do processo. Neste sentido, o objetivo desta investigação é propor um sistema de inovação para o setor. Para a concepção do sistema, foi utilizada uma metodologia organizada em quatro fases e oito etapas, com tempestade de ideias, revisão de documentos e discussão em grupo como técnicas fundamentais. O principal resultado obtido foi: a estrutura do sistema de inovação em subsistemas e componentes. A proposta contribui para a melhoria do processo de inovação no sector, bem como para a concepção e implementação de políticas e estratégias para aumentar a contribuição socioeconômica deste sector para o desenvolvimento do país com vista a 2030.

Palavras-chave: Processo de inovação; Setor florestal; Sistema de inovação setorial.

INTRODUCTION

Under the current conditions of the international economy, advantageous insertion depends on producing and trading competitively in the world market. Competitive production requires, among other elements, the sustained generation of innovative goods and services with high added value and products backed or protected by the corresponding intellectual property rights, which implies the availability of research, development and innovation (R+D+I) potential, engineering, quality assurance,

specialized information and human resources training; in other words, it also requires a scientific-technical potential that interacts with a modern productive system and is synergistically linked to it. It is about the conversion of science - and the technology generated from it - as a direct productive force and the modification of this force by the actions of science and technology (Torres *et al.*, 2020).

Innovation activities at any level must be articulated and systemically integrated, so as to generate the necessary synergies between the different actors to promote development and achieve higher levels of income, added value and diversification of production in order to achieve competitive advantages (Torres *et al.*, 2020).

In the case of Cuba, the so-called *supply-side* approach to science has been predominant (Núñez and Montalvo, 2016), with a certain passivity of most enterprises in the face of R+D+I, which should be changing with the updating of the Cuban economic and social model of socialist development that is implemented in the country, based on new policies and mechanisms.

The current context in which the Cuban economy must develop is generally conditioned by the globalization of the economy, the scientific revolution, the forced imposition of the neoliberal model, the impact of the coronavirus pandemic (Lage, Núñez, Triana, Rodríguez and Fernández, 2021), and particularly by the economic blockade, the weak interconnection between the actors of the national Science and Technology System, as well as the low presence of scientific and innovation potential in the Cuban business system (Díaz-Canel, 2021).

A global analysis of the forestry sector shows that its production is decisive for countless sectors and branches of the economy. It also contributes to food security, and also to environmental functions of forests. According to the World Bank (2019) forests annually generate five thousand types of wood products and a gross value added of more than US$600 billion, or about 1 % of the global gross domestic product (GDP).

In Cuba, the contribution of this sector to GDP is low, with an average of 2.8 % per year in the period 1990-2011, decreasing to 2.3 % until 2016 (Torres *et al.*, 2018). Several global and national economic factors, as well as sectoral dynamics have influenced this behavior, among which we can mention the international economic crisis that affects the possibility of obtaining financial resources, the occurrence of climatological phenomena, forest fires and the reduction in the volume of cuttings together with a low effectiveness of plantations that implies losses to the Cuban State and compromises the future development of the forestry sector (Dirección Forestal, Flora y Fauna Silvestres (DFFFS) 2018).

As a consequence of the low diversification of production, the export of its products is mainly concentrated in those of lower added value, generating 155 999.00 thousand USD in the period 2012-2016; conversely, the country imports products of higher added value, reaching a total value of 1 690 762.00 thousand USD, resulting in a trade deficit balance of 1 534 763.00 thousand USD, an issue that reflects a low impact of innovation in products and processes that ensure sectoral development (Torres*et al.*, 2018).

This shows that the forestry sector has not been able to respond the demands of the domestic market, and that there are reserves for the export of some products in the short, medium and long term.

On the other hand, a set of weaknesses are present, including the weak interconnection between the actors involved in the innovation process in the sector, which limits the closure of the R&D&I cycle, due among other reasons to the low absorptive capacity of enterprises, the linear approach to forestry research, the lack of a proper science, technology and innovation (STI) policy and inadequate mechanisms for the implementation of the existing policy in the country, as well as of the Science, Technology and Innovation System established by the Ministry of Agriculture (Torres *et al*., 2018).

By the other hand, the Forestry, Flora and Fauna Directorate (DFFFS) identifies other weaknesses associated with: the use of low quality and uncertified seeds, poor quality seedlings, deficient replacement of failures, no correspondence between planted species and site characteristics, sacrifice of cuttability, little productive diversification, very little value added and a backward and poorly diversified industry (DFFFS, 2018).

The need to develop innovation capabilities in the sector is evident; however, this process is hindered by a set of obstacles such as the lack of effective mechanisms to guarantee the generalization of the scientific results obtained and the disconnection that persists between key actors in the process (Torres *et al.,* 2020). Following this purpose, the general objective of this research was to propose an innovation system for the Cuban forestry sector that would contribute to the improvement of the innovation process and increase its impact on the national economy. This study is a continuity of previous studies conducted by (Torres *et al.*, 2017, 2018 and 2020).

MATERIALS AND METHODS

The methodology for the design of the system took as a reference the methodological proposals presented by Cano Díaz *et al.,* (2019) and Muñoz and Zartha (2019), for the design of conceptual models of innovation management. The proposed methodology was organized by stages and steps, generally based on the premise of learning in action from co-construction through group work.

The development of the stages and steps of the methodology is explained below. In each stage, the general objective was formulated and, likewise, in each of the steps, the description expressing the essence of the steps was made, as well as the specific tools used:

Stage 1. Stakeholder sensitization

Objective: to sensitize stakeholders to the need for an innovation system aimed at solving problems and taking advantage of opportunities.

Step 1. Presentation of diagnostic results

Description: In this step, the main results of the diagnosis of the innovation process in the sector were socialized with the participation of the Group for the Management of Innovation in the Forestry Sector (GGISFC), which includes the Enlarged Board of Directors of the AgroForestry Group (GAF) (Company Directors, Director of the Cuban Agro-Forestry Research Institute (INAF), GAF Directors), the group of researchers, members of the Directorate of Science and Technological Innovation (DCIT) of the Ministry of Agriculture (MINAG) and researchers from the Center for Forestry Studies (CEF).

Methods and techniques: Brainstorming (Hernández *et al.*, 2014).

Step 2. Identification of system components

Description: based on the results discussed in the previous step, with the same group composition, an initial proposal of system components was made, taking as a basis the methodological approach of the Sector Innovation Systems (SIS), the *Network Innovation Model with the Quintuple Helix approach and the Knowledge Networks*, which led to debate and proposals from the participants, and resulted in an initial proposal.

Based on this proposal, an *ad hoc* group was formed for the detailed design of the Innovation System for the Forestry Sector in Cuba (GDSISF), which consisted of: the group of researchers, a member of GAF's Development Directorate, a member of MINAG's DCIT, a member of INAF and a member of CEF; the partial results obtained by the GDSISF were discussed and approved by the GGISFC in socialization workshops.

Methods and techniques: brainstorming, map of components and relationships (Hernández *et al.*, 2014).

Stage 2. Design of the structured system proposal

Objective: to design the structured system proposal for approval.

Step 3. Subsystem design.

Description: The GDSISF prepared the proposal for each subsystem based on the theoretical and methodological references consulted, as well as the strengths and weaknesses of the innovation process in the sector. This result was presented to the GGISFC to be enriched and constitute the final proposal.

Methods and techniques: document review (Hernández *et al.*, 2014).

Step 4. Presentation of the consolidated system proposal.

Description: The GDSISF presented to the GGISFC the consolidated proposal of the system showing the actors, subsystems and their functional interrelationships, as well as the measurement indicators for each of them. The proposal was submitted for approval. Methods and techniques: group work, group discussion and user satisfaction questionnaire (Hernández *et al.*, 2014).

Stage 3. Steps for system implementation

Objective: to determine the steps for the implementation of the innovation management system for the Cuban forestry sector.

Step 5. Identification of the steps for system implementation.

Description: The GDSISF identified the steps for the implementation of the system, appropriate to the conditions of the sector and taking into account the rules and regulations in force, in which the actions to be developed by each actor are proposed, as well as the indicators to measure them, so that each actor plays the role that corresponds to him/her.

Methods and techniques: group work, document review, brainstorming, group discussion (Hernández *et al.*, 2014).

Step 6. Presentation of the steps for system implementation.

Description: the GDSISF presented to the GGISFC the steps for the implementation of the system, for its approval based on new proposals that may arise from the work in the expanded composition of the group.

Methods and techniques: group work, group discussion (Hernández *et al.*, 2014).

Stage 4. Validation of the system and steps for its implementation

Objective: to validate the proposed system from a theoretical, methodological and practical point of view.

Step 7. Validation by the expert judgment method.

Description: The system was validated from a theoretical, methodological and practical point of view, based on the application of questionnaires to a group of selected experts. Each expert was given a synthesis of the system and, as an attachment, a validation instrument, where the qualities to be evaluated were considered.

Methods and techniques: expert judgment, *Delphi* Method, Expert Consensus Index (ICS) (La Fé, 2017).

Step 8. Validation by users

Description: The system and the steps for its implementation were validated by means of a satisfaction survey applied to key stakeholders, in order to have a correct appreciation before implementing them in practice.

Methods and techniques: AIDOV technique adapted to the characteristics of the research, Group Satisfaction Index (ISG) (Pérez, 2019).

RESULTS AND DISCUSSION

1.1 Bases for the design of the innovation system for the Cuban forestry sector

As a result of the application of the first step (Stage 1), the results of the diagnosis were presented. This allowed each actor to visualize their contribution, their responsibilities and how it is reflected in the factors that hinder the innovation process, so that they could contribute to solving them.

In addition, the results were reconciled, through brainstorming a list of three factors in favor and 16 factors against was obtained, which went through a refinement process using the iModeler software where the group evaluated the weight matrix of the identified factors. This was a very important step, as it largely depended on the collaborative disposition of the stakeholders.

The main factors that have a positive influence on the innovation process in the short, medium and long term are: the existence of a network of research centers and universities with the capacity to generate knowledge, a knowledge base accumulated not only in these centers but also in the productive sector, and the implementation of innovation mainly through projects. Among the factors with the greatest negative influence are the nonexistence of a scientific-technical information system that reaches all companies and is disseminated to all workers, the lack of an STI policy contextualized in the sector, and the weak interconnection between the actors involved in the innovation process in the sector.

To determine the components of the system (second step), a study by Torres *et al.* (2020) was used as a reference. This study reveals that the studies consulted on innovation processes in the forestry sector at the international level have focused on the industry, mainly the timber industry; however, aspects related to silviculture have not been addressed, as an important part of the sector, on whose innovations the growth of the industry depends, since it provides the raw material. Neither it isn´t worked on the high potential of non-timber forest products, which from an economic point of view can make important contributions, but which require a great deal of investment and innovation for their processing and marketing.

In the case of studies on the innovation process in the Cuban forestry sector, the introduction and generalization of scientific results (Torres *et al.*, 2017), an analysis of the process and its contribution to the national economy (Torres *et al.*, 2018), the generation of knowledge in the sector (Cala *et al.*, 2020a) and the proposal of components of the innovation system (Torres *et al.*, 2020) are noted as antecedents.

The studies described above have relied on the SIS methodological approach to explain specific aspects of the functioning of the innovation process in the forestry sector, but none of the points of view found and consulted have been used to structure an innovation system, which is the focus of this research.

Based on the above, it was determined that the components that structure the innovation system for the forestry sector are: companies, an essential component to close the innovation cycle, other actors, policy and program generators, decision makers and knowledge generators, knowledge, networks, demand, institutionalism, cooperation processes, complementarity and co-evolution.

1.2 Structuring of the Innovation System for the Cuban forestry sector

As a result of the application of Stage 2 of the methodology used, the innovation system proposal for the forestry sector in Cuba was obtained, which, as a systemic totality, contains the existing dialectic between organization, structure and relationship, which make the system a total of interconnected processes, based on the structure: system-subsystem- components, the description of which is given below.

System description

The Innovation System for the Forestry Sector (SISF) in Cuba is the framework for the planning, organization, generation, dissemination, incentive, financing, control, monitoring and evaluation of innovation in the sector, through the interrelationships that occur between the actors and components of the system, through processes of cooperation and coevolution; whose results generate greater productivity, competitiveness and growth of all participating actors. As shown in Figure 1, the internal functioning of the SISF in Cuba is influenced by a general environment and a particular environment, with which it constantly exchanges information and human, material and financial resources (Figure 1).

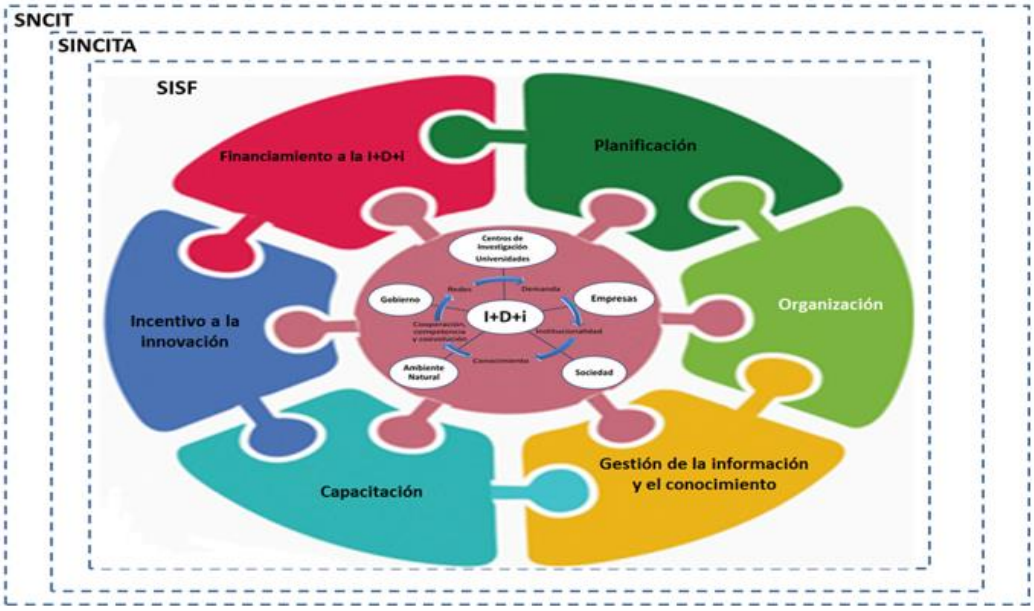

Figure 1. - Innovation system for the Cuban forestry sector
Source: Own elaboration based on Torres *et al.*, (2020).

The SISF in its general environment is subordinated to the policies established by the Ministry of Science, Technology and Environment (CITMA) for all the actors of the National System of Science and Technological Innovation (SNCIT), related to aspects such as: the reordering of its own Science, Technology and Innovation Entities (ECTI) and its relationship with other ECTIs and research-development centers of interest; the creation and implementation of Science-Technology Parks and University-ECTI-Enterprises integration, which allow it to relate to similar experiences at the international level; Ph. D formation; participation in national science, technology and innovation programs, through projects, as well as the remuneration of personnel linked to these.

In its particular environment, the SGISF is methodologically subordinated to the National System of Agricultural Science and Technological Innovation (SINCITA), assuming the policies, norms and regulations on science, technology and innovation established by MINAG, which in turn is subordinated to the general policies established by CITMA.

Internally, the SISF is structured in subsystems and components. The six subsystems are: planning, organization, information and knowledge management, training, incentives and financing; which should channel the efforts of the actors (enterprises, research centers, universities, government and society) in response to the demands of the national and export markets, where technological and knowledge demands are generated.

Through the creation of innovation networks, which in the shortest possible period of time can contribute to the solution of a problem and generate productive linkages, products and services of greater added value; which enhance the use of existing knowledge in the sector and outside it, as well as the creation of new knowledge, from the conversion of tacit knowledge into explicit and vice versa, so as to ensure a greater degree of accessibility, accumulation and access to sources of technological opportunities.

All of the above, based on compliance with the institutional framework of the system, so as to guide the process of design and articulated implementation of short, medium and long term plans; promoting cooperation, competition and co-evolution of these actors, through the articulation among them and with the natural environment, which allows identifying and developing common projects that promote synergies between the capacities of the actors in accordance with the potentialities and common interests.

Overall objective**:** to ensure that innovation becomes the main tool to drive the sector's development.

Specific objectives**:**

1. Promote the active and conscious linkage of companies with research centers and universities to solve the sector's problems.

2. Ensure that all R+D projects developed by ECTIs and universities respond to current and future development demands of the sector.

3. Manage the closure of all the results of the R&D cycle in production and services in the sector, based on permanent communication from the early stages of the innovation process.

4. Guarantee the permanent improvement of the level of preparation of the sector's maneger and workers in order to reach the absorptive capacity of the enterprises that comprise it.

5. Prioritize, in the call for programs and projects, the implementation of R&D&I projects in those areas that generate new or improved products for export and import substitution.

6. Stimulate productive linkages with domestic and/or foreign entities that add value to products and services as a result of innovative activities.

7. Guarantee the necessary financing for the implementation and operation of the SISF.

8. Manage the design, implementation and operation of the innovation management system in all companies in the sector.

Premises

- The existences of a willingness on the part of GAF management to implement, monitor, control and evaluate the SISF.
- Management training in knowledge management and innovation.

Operating principles of the system

- Relevance: the SISF responds to the priorities of the sector and the country, which are reflected in the Economic and Social Policy Guidelines of the Party and the Revolution approved at the VIII Congress of the Communist Party of Cuba and the Economic and Social Development Plan through the year 2030, which in turn are included in the program for the development of the forestry sector in Cuba through the year 2030.
- Systemic approach: the proposal will function as an open innovation system, in which the changes and transformations made take into account how each of the components and subsystems of the SISF are affected by each other and by the environment, so that decision making is integral.
- Sustainability of the Forest Information System: based on the implementation of mechanisms to ensure that the system is sustainable over time, in order to achieve the expected results and contribute to the sustainability of forest systems and resources.
- Cooperation: based on the implementation of mechanisms that encourage cooperation among the actors participating in the system, through teamwork, as a way to obtain positive results for all.
- Flexibility: it must be capable of being updated in the face of changes and conditions of the environment, allowing its sustainability over time.
- Multidisciplinary in project teams: it is based on the multidisciplinary integration of project teams to generate more comprehensive solutions.

Subsystem structure Innovation planning subsystem

Objective: to determine the short, medium and long term objectives of the sector, through the design of the sector's science, technology and innovation policy, strategy and program. Description: This subsystem is responsible for supporting the fulfillment of the sector's mission through the articulated development of short, medium and long term plans for science, technology and innovation. These will be prepared based on the results of the internal and external diagnosis of the country's and the sector's development priorities, the methodological guidelines issued by CITMA (2019) and the Science and Technology

Directorate of MINAG, based on the study of the demands for scientific and technological knowledge derived from the sector's Development Program, to guide the design of STI planning documents, prioritizing the study of international market trends in terms of

export potential and the internationalization of the business system, as the most expeditious way to obtain financial resources in foreign currency to support innovation.

The planning documents to be designed are:

- Science, technology and innovation policy in the sector.
- Science, technology and innovation strategy in the sector.
- Science, technology and innovation program in the sector.

The GDSISF will be responsible for designing the sector's STI policy, strategy and program, which will be submitted to the GGSISF, selected experts and the GAF Technical Advisory Council (TAC) for approval.

In the case of STI projects, they will be approved in the first instance at the level of the Scientific Councils (CC) or CTA of the participating entities and subsequently evaluated by the group of experts of the Program as established by CITMA Resolution 287/2019.

Both the program and the sector's STI projects will be subject to audit through the program's single file and each project's file. All STI projects to be executed must be reflected in the plan and budget of all participating entities as established by the Ministry of Economy and Planning (2019). Depending on the type of project, they must also appear in the sections corresponding to the generalization plan and investment plan of the entity to guarantee not only the financing but also the planned material assurance.

Innovation organization subsystem

Objective: to determine the structure needed to respond to the STI demands of the sector. Description: the response to the demands will be made through STI projects and will be organized through innovation networks that involve a set of actors, so as to add more value to the final product and generate as many productive linkages as possible.

Organization of innovation networks: as many formal networks as necessary will be created to achieve the articulation of actors, so that in a shorter period of time they can contribute to the solution of a problem and generate productive chains and products and services of greater added value. They will be organized on the basis of STI projects as the primary unit. Each project will respond to the demands established in the CTI program, in accordance with the provisions of CITMA Resolution 287/2019. The above will lead to the creation of the sector's portfolio of R&D&I projects, which will respond to the growth and development needs set forth in the sector's strategy.

The following actors will participate in the networks:

- Enterprises: an essential component for generating R&D demands and for closing the R&D&I cycle, it comprises 37 agroforestry enterprises in the sector with an active role within the system, constantly interacting with other actors to generate demands and participate in their solution, so as to favor the innovation approach towards a systemic vision, through the generation and implementation of knowledge.
- Other actors: these include policy makers: DFFFS, CITMA, decision makers: GAF and knowledge generators: INAF, CEF, IBP, UPR, UdG (University of Granma),

UG (University of Guantánamo), UNISS (University of Sancti Spíritus), ECTIs and CITMA Protected Areas. These should strengthen synergistic links with enterprises and among themselves, based on a systemic approach, i.e., they should fulfill their main function and participate in the rest of the functions.

The geographical distribution of the sector constitutes a potential to take advantage of for the development of new networks, since its companies are located in all provinces, which allows fostering links with regional and local actors, in order to respond to the identified demands that are of interest at these levels, taking advantage of the possibilities of association with existing science and technology parks in these areas.

In addition, it can become the space where the interdisciplinary training of collective actors takes shape, based on their relationship with universities, research centers and other actors, through the exchange of information, provision of services, use of infrastructure, development of informal research, which can lead to future projects based on the strengthening of relationships.

Information and Knowledge Management Subsystem

Objective: to provide information on the state of the art and internal knowledge assets that can respond to the identified demands and future developments.

Description: Knowledge and information are two basic elements to carry out innovations; therefore, this subsystem contributes to fulfill the innovation function of enriching the sector's patrimony, through the exploitation and accumulation of knowledge. Exploitation includes different ways of sharing knowledge and information, and will be based on cooperative technological surveillance; and accumulation includes the creation of knowledge within the sector, in order to respond to the identified demands or future developments, through internal solutions within the sector or through external solutions (national or international).

From this subsystem it is possible to determine the type of research project to be carried out, based on whether the possible solution exists or not, which would shorten the response time to each of the demands. This will be carried out in three fundamental parts, information management, cooperative technological surveillance and internal knowledge management. Information management: plays a key role in the subsystem as it supports both the exploitation and the accumulation of internal knowledge. It is in charge of receiving, processing, classifying and transmitting information on innovation to all the actors of the system according to the identified demands.

To develop it, it is necessary to have *hard* technologies (hardware/machines, servers), *soft* technologies (software, computer programs), telecommunication networks (hardware and basic software for voice, data and video transmission), databases (for data support and backup), and computer processes (computing procedures). For the transmission of information, it is proposed to create a forestry technology observatory at GAF where all the knowledge generated internally in the country for the sector and the results of the cooperative technology watch will be made visible and accessible to all stakeholders through the sector's intranet.

Cooperative technology watch: this is based on the principle of cooperation of the knowledge-generating actors in the sector. It is an organized, selective and permanent process of gathering information, both internal and external, on science and technology, selecting, analyzing, disseminating and communicating it, in order to convert it into knowledge to make decisions with less risk and to be able to anticipate changes. It will be carried out through technological surveillance axes, determined by the results obtained in other sectors of the national economy and on an international scale that can respond to the identified demands; it will also incorporate into the inventory those results that, due to their present and future impact, can be generalized; as well as a constant monitoring of the new development trends of the sector. It will provide a real-time consultation platform integrated to the technological observatory, with the results obtained in the sector at the national level, as well as links to other observatories, particularly the Regional Observatory of Forestry Sciences of the University of Pinar del Río, web pages, portals and others of interest at the national and international level.

Internal and external knowledge management: knowledge (scientific and technological, as well as good practices, accumulated experience and everyday knowledge) can be developed in both formal and informal environments, since any of the actors can play an active role in that sense, and is supported by innovation activities, production and the behavior of companies and other actors, the base technologies and inputs, and the technological links and complementarities with other related sectors, both horizontally and vertically (Padilla *et al*., 2013); starting from the conversion of tacit knowledge into explicit and vice versa, from the epistemological to the ontological dimension, through the phases: socialization, externalization, combination and internalization (Nonaka and Takeuchi, 1995).

Training subsystem

Objective: to guarantee the development of human talent through the permanent updating, training, education and continuous development of all the actors involved in the sector. Description: this subsystem will promote the education and training of all stakeholders to ensure the development of production and services; developing lateral thinking through tools that contribute to the creativity and sustainability of the sector.

For the formation of the labor force, advantage will be taken of the geographical distribution of the sector, as a potential for training at different levels, undergraduate and graduate, on a local or territorial scale. The training processes will focus on the formation and/or requalification of skilled workers, middle-level technicians, higher level technicians and university graduates, as well as on professional improvement (courses, training and diploma courses) and academic postgraduate studies (master's, specialty and Ph. D, all with a focus on continuing education and lifelong learning.

Diagnosis of training needs to innovate: this will be carried out by applying basically two techniques proposed by Cuesta (2010, p. 333): the performance evaluation and the questionnaire, the combination of both techniques will allow measuring the existing gap between the labor competencies that each actor has and those required to respond to the proposed projects according to the development priorities of the sector and the country, from the functions that each organization has. The questionnaire can be applied according to the needs of each proposed project, making a selection of the knowledge areas to be evaluated, and the actors can also be stratified by the functions defined in the planning subsystem.

The main competencies to be trained to achieve success in the sector from innovative entrepreneurship are: creative thinking, problem-solving skills, teamwork, R&D&I management, project management and strategic planning (Innogrow, 2016); through the implementation of skills such as: creativity, associative thinking, questioning, observing, networking, experimenting (Moya, 2016).

In topics related to management and administration: in the management area, administrative skills, information technology, industrial safety, quality control, training of competitive skills in the international market, development of new products and processes, internationalization of companies, ways to penetrate international markets, preparation of business plans, attraction and evaluation of external financing, management of national and international value chains, among others.

Training plan: the results generated by the NPD, the responses to the expected demands and the development trends of the sector at the international level, will give rise to training actions that may be general or specific, linked to the training plans of each particular organization, in joint actions that cover all the stakeholders or a significant part of them, training actions by project, or specific actions of the individual development plan of each stakeholder.

Forms of training: Will include technical-professional training in the specialties of the sector and training through continuing education for workers and medium technicians, professional improvement (courses, training and diploma courses) and academic postgraduate (master's, specialty and Ph.D), so that this contributes to achieving higher levels of production, productivity, efficiency and quality of production and services, as well as for the fulfillment of the objectives and development of the sector in the short, medium and long term; the increase of the impact on the preparation for the position and the improvement of the work performance of the manager staff and workers; and the level of incidence in the solution of problems of interest to the sector (Council of Ministers, 2019).

Network of actors: it will promote the use of the training spaces present in each territory, based on the active participation of the actors, such as universities, research centers, technical-professional education centers, among others.

Innovation incentive subsystem

Objective: to promote the culture of innovation by rewarding the results and impacts on the sector, both of organizations and individuals, based on cooperation and linkage between actors.

Description of the subsystem: it contributes to use innovation as a way to respond to the demands of the sector, through the stimulation of both organizations and individuals. Constituting the incentive to increase the connectivity of the network of actors and take advantage of the benefits of the principle of additionality (Moctezuma*et al*., 2017), as well as to make visible the business effort in R&D&I activities. In this sense, the most commonly used mechanisms are tax incentives (United Nations, 2018) and funds for the support of innovation activities (Moctezuma *et al*., 2017). The present research is based on these criteria, as well as the use of non-monetary incentives (CITMA, 2019) that enhance cooperation between actors.

Ways to stimulate institutional innovation:

- Stimulate multidisciplinary integration in projects, conditioning their approval and financing. Funding may range from 5 % per organization that joins up to 70 % of the total project amount, depending on the degree of linkage with other organizations, from the fund created by GAF.

- Conscious employment to stimulate innovation from the application of measures for business improvement in the country: 1) Prioritize the allocation of financial resources to those projects that tax the national industry by virtue of increasing export-bound productions and meeting the demands of intermediate goods of entities that tax exporters; 2) Implement closed financing schemes for exports and import substitution in those companies that are able to execute them; 3) Implement modifications in the established procedure to finance development and research and training activities, from after-tax profits, being considered as investment and not as expenses (MEP, 2020).

Categories for the stimulation of innovation results:

- Annual award for the most innovative company.
- Award for product innovation with the greatest economic impact.
- Award for process innovation with the greatest economic impact.
- Award for product innovation with the greatest social impact.
- Award for process innovation with the greatest social impact.
- Award for product innovation with the greatest impact on the natural environment.
- Award for process innovation with the greatest impact on the natural environment.
- Award for obtaining patents, industrial models and utility models.
- Award for the software with the greatest impact on the sector.
- Award for the broadest and most complete innovation network.

These award proposals are made and the authors are recognized first at the level of the grassroots organizations and go up to the national level where they are evaluated, selected and the most relevant are recognized, with moral and material incentives.

R+D+I financing subsystem

Objective: To guarantee the necessary financing for the development of R&D&I projects, technology transfer processes and technical assistance.

Subsystem description: the R&D&I financing subsystem contributes to enriching the sector's assets by financing innovations, as well as managing funds for organizational and individual incentives and training in innovation, through the establishment of

financing mechanisms that include the enterprises' own sources of financing and other available sources.

Science, technology and innovation development funds are an important instrument for financing innovation, as they allow actors involved in the innovation process to receive direct or indirect support, or both, and to simultaneously use own resources and other sources; these can be designed to achieve complementary policy objectives, such as cooperation and collaboration among various actors (United Nations, 2018).

In view of the above, the mechanisms through which R&D&I will be financed must be evaluated, taking into account the level of risk and the available sources of financing as criteria; the higher the level of risk, the greater the need to implement a scheme that contemplates multiple sources of financing.

Project risk assessment: this assessment will be carried out based on the country's priorities (MEP, 2019), emphasizing the use of the industry to replace imports, increase productive diversification and exports. Based on the determination of the total risk, the possible sources of financing to be managed are established, and the financing mechanism to be used is selected using combined formulas based on the risk and type of project.

Possible sources of financing to be managed: State budget, Science and Innovation Financial Fund (FONCI), bank credit, international cooperation, foreign investment, financing from CITMA's STI programs, GAF fund, territorial contribution for local development, funds for financing local development projects, National Forestry Development Fund (FONADEF) and enterprise profits.

Financing mechanism to be used: they constitute a means to strengthen the relationships between the actors of the system by articulating their interests in terms of project financing. These are usually diverse and can be used in combination. Capote (2018, pp. 103-104) proposes four mechanisms that articulate actors and are considered fundamental for financing management:

- Monofinancing.
- Project co-financing.
- Inter-agency financing.
- Intermunicipal financing.

CONCLUSIONS

The proposed system offers solutions to the shortcomings and insufficiencies of the analyzed background, through the interrelation between subsystems and components; which should channel the efforts of the actors in responding to the demands of both domestic and export markets, through the creation of innovation networks, which in the shortest possible period of time can contribute to the solution of a problem and generate productive chains, products and services with greater added value.

The proposed system is structured in subsystems (Planning, organization, information and knowledge management, training, incentive and financing) and components (Actors, knowledge, networks, demand, institutionalism and cooperation processes, co-evolution and competition), which, as a systemic totality, contains the existing dialectic between organization, structure and relationship, which make the system a total of interconnected processes, based on the structure: system-subsystem-components.

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