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Original article

Integrated procedure to manage knowledge and innovation in Cuban agroforestry companies

Procedimiento integrado para gestionar conocimiento e innovación en empresas agroforestales cubanas

Procedimento integrado para gerenciamento de conhecimento e inovação em empresas agroflorestais cubanas

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ABSTRACT

Separate management of knowledge and innovation limits the capacity of agroforestry companies to convert experience, scientific information and productive learning into economic, environmental and social results. Therefore, the objective of this investigation was to design an integrated procedure to manage knowledge and innovation in Cuban state-owned agroforestry companies. For its execution, the qualitative investigation methodology was used as part of this, the systemic method and concrete modeling were

applied, in the techniques of document analysis and content analysis. As a result, a procedure is obtained that is structured in 7 stages and 32 steps: governing; diagnose; learn to identify opportunities; manage ideas and portfolio; develop projects and solutions; generalize; and improve. As a main conclusion, it is demonstrated that the integrated procedure connects problems and opportunities with critical knowledge, projects, adoption, protection, impact and learning, offering a comprehensive, gradual and compatible architecture with the management systems of agroforestry companies.

Keywords: agroforestry company; innovation management; knowledge management; management of knowledge and innovation.

RESUMEN

La gestión separada del conocimiento y de la innovación limita la capacidad de las empresas agroforestales para convertir experiencia, información científica y aprendizaje productivo en resultados económicos, ambientales y sociales. Por esto el objetivo de esta investigación fue diseñar un procedimiento integrado para gestionar el conocimiento y la innovación en empresas estatales agroforestales cubanas. Para su ejecución se empleó la metodología de la investigación cualitativa como parte de esta se aplicó el método sistémico y de modelación concretada, en las técnicas de análisis documental y análisis de contenido. Como resultado se obtuvo un procedimiento que se estructura en siete etapas y 32 pasos: gobernar; diagnosticar; aprender a identificar oportunidades; gestionar ideas y cartera; desarrollar proyectos y soluciones; generalizar; y mejorar. Como principal conclusión, se demuestra que el procedimiento integrado conecta problemas y oportunidades con conocimiento crítico, proyectos, adopción, protección, impacto y aprendizaje, ofreciendo una arquitectura trazable, gradual y compatible con los sistemas de gestión de las empresas agroforestales.

Palabras clave: empresa agroforestal; gestión de la innovación; gestión del conocimiento; gestión del conocimiento y la innovación.

RESUMO

A gestão separada do conhecimento e da inovação limita a capacidade das empresas agroflorestais para converter experiência, informação científica e aprendizagem produtiva em resultados econômicos, ambientais e sociais. Por isso, o objetivo desta investigação foi projetar um procedimento integrado para gerenciar o conhecimento e a inovação em empresas agroflorestais estatais cubanas. Para sua execução foi empregada a metodologia da investigação qualitativa; como parte disso, se aplicou o método sistêmico e de modelagem concreta, nas técnicas de análise documental e análise de conteúdo. Como resultado se obtuvo um procedimento que se estrutura em sete etapas e 32 passos: gobernar; diagnosticar; aprender a identificar oportunidades; gerenciar ideias e carter; desenvolver projetos e soluções; generalizar; e melhor. Como conclusão principal, demonstra-se que o procedimento integrado conecta problemas e oportunidades com conhecimento crítico, projetos, adoção, proteção, impacto e aprendizagem, oferecendo uma arquitetura viável, gradual e compatível com os sistemas de gestão das empresas agroflorestais.

Palavras-chave: empresa agroflorestal; gestão da inovação; gestão do conhecimento; gestão do conhecimento e da inovação.

INTRODUCTION

Agroforestry companies make decisions under the simultaneous pressure of production, climatic, environmental, technological and social demands. Its prolonged biological cycles, territorial dispersion of operations and exposure to fires, plagues and hydrometeorological phenomena make technical, scientific, traditional and organizational knowledge especially valuable. Technological, social and institutional innovation is indispensable to transform the forestry sector and expand its contribution to sustainable development (Organización de las Naciones Unidas para la Alimentación y la Agricultura 2024). However, acquiring technology is not enough. For this to produce results, it requires skills, learning, collaboration networks and mechanisms capable of converting needs and opportunities into usable solutions.

Digitalization opens up new possibilities for inventory, tracking, prediction and traversability using sensors, remote sensing, geographic information systems and data analytics. An example of this is technologies known as Bosque 4.0 *(Forest 4.0),* which on the ground are oriented towards the digitalization of the forest, but constitute a paradigm shift in connected, automated and data-driven forestry, which seeks to balance production with the conservation of the ecosystem. (Damaševičius *et al.,* 2024; Ehrlich-Sommer *et al.,* 2024). But the value of digital infrastructure depends on its integration with management processes, the interpretation of context and collective learning.

Knowledge management is defined as the deliberate conduct of processes to identify, acquire, create, validate, organize, protect, share, apply and renew relevant knowledge. Innovation management, on the other hand, guides opportunities, ideas and projects towards solutions that generate value. Both capabilities maintain a recursive relationship, knowledge supports the identification of problems and the design of solutions; Experimentation and adoption produce new learning. In agri-food systems, this articulation strengthens innovative capacity when linked to strategy, networks and decision-making (Gardeazabal *et al.,* 2023; Ureña-Espaillat *et al.,* 2023). Simismo, scalable management of knowledge allows integrating scattered information and making it reusable between actors and territories (Short *et al.,* 2023).

In Cuban state agroforestry companies, technical and traditional knowledge, accumulated experience in dispersed units, movement and aging of specialists, resource restrictions and unequal connectivity converge. When knowledge is reduced to the archive of documents and innovation to the record of initiatives, problems are formulated without sufficient evidence, ideas are not compared with common criteria, tacit knowledge falls away and successful results have difficulties in transferring or generalizing. These barriers coincide with international evidence on agroforestry adoption, which highlights the interaction of technical, economic, institutional and sociocultural factors (Tranchina *et al.,* 2024).

The Cuban normative framework reinforces the need to overcome this fragmentation. The General Law of Science, Technology and Innovation establishes the need to achieve the articulation of actors, programs, projects, human potential, scientific information, intellectual property and impacts (Asamblea Nacional del Poder Popular 2025).

Resolution 2/2025 regulates the management of programs and projects, while NC 1307:2022 establishes national requirements for research, development and innovation systems (Ministerio de Ciencia, Tecnología y Medio Ambiente 2025; Oficina Nacional de Normalización 2022). At the international level, the ISO 56001:2024 standard provides the requirements of the innovation management system and the ISO 30401:2018 standard, which corresponds to knowledge management (International Organization for Standardization 2018, 2024).

Models of knowledge creation, absorptive capacity, dynamic capabilities, open innovation and ecosystems explain the decisive dimensions of the phenomenon. However, isolated employment does not resolve the need to conduct, through the same business sequence, the transition from the problem and the knowledge available to adoption, the impact and the learning. The investigation took care of this loophole: insufficient functional and bringable articulation of knowledge management with the innovation cycle in Cuban agroforestry companies.

The objective of the work was to design an integrated procedure to manage knowledge and innovation in Cuban state-owned agroforestry companies, aligned with international trends, the national technical-legal framework and the process approach. The investigation formed part of the project PS211LH008-019 "Innovation management system for the Agroforestry Group", belonging to the program "Science, technology and innovation management for sustainable development".

MATERIALS AND METHODS

A qualitative, applied and non-experimental investigation was carried out. The analysis unit understood the business process through which it identified and mobilized knowledge to formulate, select, develop, implement, protect, transfer and evaluate innovations in Cuban state-owned agroforestry companies. The systemic-structural method allowed us to establish components and their relationships; The model is used to represent the sequence, decision points and feedback mechanisms.

The foundations were formed through an intentional demonstration supported by thematic relevance and the authority of the source. Between September 2024 and June 2026, Google Scholar, Crossref and the official portals of the International Standards

Organization, the United Nations Organization for Food and Agriculture and the Official Gazette of the Republic of Cuba were consulted. Arbitrated articles, standards and provisions directly related to knowledge, innovation, forestry sector, digitalization, sustainability and business management are included. Publications from 2021 to 2026 were prioritized, without foregoing seminal works necessary to explain the foundations of the procedure.

If you use the combinations «knowledge management» AND innovation AND (forestry OR agroforestry), «innovation management system» AND enterprise, «digital forestry» AND knowledge and their equivalents en spanish . Duplicates, promotional texts, records without verifiable origin and documents without direct contribution to a decision on the procedure will be eliminated. For each source, authorship, year, type, theoretical contribution or requirement and methodological expression will be registered.

The content is examined using a matrix that relates the basis of the requirement, problem addressed, methodological implication, activity, responsibility, input, tools, evidence, indicator and decision criteria. In a first reading, the codification followed the common categories of management systems: context, leadership, planning, support, operation, evaluation and improvement. A second reading incorporated the agroforestry particularities that were not explained by these categories. When ambiguities arise, the primary source is turned and the design decision is contrasted with another theoretical, normative or contextual referent.

The procedure is modeled on input–transformation–output logic, the plan–make–verify–act cycle and decisions by control points. Each step is accepted when it shows a contribution to the objective, identifiable input and output, main responsibility, verifiable evidence and link with a risk or decision. The sequence was refined to avoid duplications with the quality systems, human capital, document management and projects.

Internal consistency was examined through the triangulation of four groups of sources (Table 1): theoretical foundations, international standards, national provisions and needs of the agroforestry context. The bringability matrix links foundation, problem, component, activity, tool, result and indicator. It was also verified that each stage will have purpose, inputs, activities, outputs and advancement criteria. The study did not

include empirical validation; Therefore, the results are interpreted as evidence of coherence and predicted applicability, not as demonstration of effectiveness (Table 1).

Table 1. - *Sources and criteria used in the methodological design*

Source	Content analyzed	Incorporation criteria
Scientific literature	Relationship between knowledge and innovation, learning, networks, digitalization and sustainability.	Explanatory support and recent evidence.
Management standards	Requirements, principles, tools, measurement and systems integration.	Conversion of the requirement into activity, control or evidence.
Cuban regulatory framework	CTI, projects, files, PI, advice and innovative participation.	Obligation or guideline applicable to the state company.
Sectoral experience	Structures, practices, restrictions, networks and generalization of results.	Agroforestry relevance and feasibility.

Source: own elaboration.

RESULTS AND DISCUSSION

The analysis allowed us to specify that the management of knowledge and the management of innovation are mutually necessary, but they fulfill different functions. The first step is to ensure that relevant knowledge is available, validated, protected and in use; the second leads to opportunities, ideas and projects that generate value. The link between both is visible in concrete decisions: the problem bank defines knowledge needs; surveillance provided evidence; ideas combine internal and external knowledge; the projects produced learning; the transfer supports the adoption; and the evaluation returned these learnings to the memory and the portfolio of ideas and projects.

The procedure is based on a systemic, socio-technical and contextual perspective. The strategy, the leadership, the people, the processes, the technologies, the resources and the environment will be treated as related elements, not as independent variables. This position avoids giving technology a capacity for autonomous transformation, its contribution depending on the skills, culture, routines and conditions of each company and territory.

The creation of knowledge justifies social interaction, the explanation of tacit knowledge, documentary integration and learning through practice (Nonaka 1994). The absorption capacity sustains the search, assimilation, adaptation and application of external knowledge (Cohen and Levinthal 1990). Organizational memory is operationalized through knowledge maps, files, lessons learned, tutoring and transfer before the movement or recruitment of specialists.

Dynamic capabilities provide three functions: perceiving changes and opportunities, mobilizing resources to take advantage of them and transforming routines (Teece 2007). The open innovation justifies the map of actors and agreements on contributions, data, confidentiality, ownership and benefits. The evidence on forest innovation ecosystems confirmed that its effects on green productivity depended on institutional and territorial conditions (Huang *et al.*, 2024).

Sustainability was incorporated as a selection criterion and not as an automatic consequence. Each initiative values economic benefits, environmental effects, security, learning and social contribution. Climate uncertainty, input availability, user acceptance and financial continuity will also be considered. This decision responded to the need for inclusive and resilient forestry innovations (Organización de las Naciones Unidas para la Alimentación y la Agricultura 2024).

The normative framework translates into operational requirements. The ISO 56001:2024 standard provides the structure of the innovation system and ISO 30401:2018, the knowledge processes (International Organization for Standardization 2018, 2024). In Cuba, Law 182, Resolution 2/2025 and NC 1307:2022 sustain the articulation between actors, project portfolio, scientific information, intellectual property, impact assessment and territorial linkage (Asamblea Nacional del Poder Popular 2025; Ministerio de Ciencia, Tecnología y Medio Ambiente 2025; National Standardization Workshop 2022).

Structure and operating logic of the procedure

From this theoretical-normative integration came the procedure for knowledge management and innovation in agroforestry companies (PGCI-EAF), organized in 7 stages and 32 steps (Table 2). Its application begins in the face of a production problem, an opportunity, a normative change, a technological or commercial alert, the risk of

losing critical knowledge or a strategic priority. The process does not conclude with the administrative close of the project. It is necessary to decide whether the result should be standardized, generalized, protected, transferred, adjusted or abandoned, and which learning should be incorporated into the memory of the organization.

Even though the steps establish a working order, the sequence is not rigid. At each decision point you can move forward, return the initiative to complete evidence, keep it on hold or close it down. If the tests revealed that the problem had been formulated in an insufficient way, that there was a lack of knowledge and that the context had changed, the process returned to the corresponding stage. This possibility of return responds to the inherent uncertainty of innovation and avoids converting the procedure into a bureaucratic succession of formats.

For governance, existing structures will be considered. The Management Council assesses policies, objectives, resources and portfolio; the Technical Advisory Board, the knowledge and innovation management committee, coordinates diagnosis, prioritization and follow-up; project managers are responsible for results and learning; and the legal, quality, human capital, economics, IT, environment and document management areas participate according to the risk. A matrix of responsibilities, approval, consultation and information requires the rendering of accounts.

The territorial dimension is integrated into the management system through a map of relationships between municipal governments, municipal university centers, universities, scientific entities, production forms, providers, customers and communities. To generate each collaboration, the shared problem, the contribution, the responsibilities, the information rules and the expected benefit are defined. This configuration allows you to connect the business portfolio with employment, climate resilience, ecosystem services, import replacement and local development.

Tools are selected according to complexity and risk. The best locals can use brief files and causal analysis, while strategic projects require feasibility studies, surveillance, intellectual property evaluation, pilot tests and impact analysis. Documentation is established as evidence to decide and learn, not as an administrative purpose.

Table 2. - *Stages, purpose, steps and output of control*

Step	Purpose and main steps	Control output
1. To govern	Establish governance; raise awareness; approve policy and objectives; assign resources; organize documents.	Governance and approved resources.
2. Diagnose	Analyze context and actors; value chain; maturity; critical knowledge; problem bank.	Baseline and priorities.
3. Identify	Define needs; capture and validate information; share; formulate opportunities; mobilize networks.	Sustained opportunities.
4. Manage ideas and portfolio	Generate ideas; preselect; evaluate value, risk and PI; prioritize; approve card.	Authorized wallet.
5. Develop projects	Formulate project; plan knowledge; pilot design; execute and learn; check results.	Result confirmed.
6. Generalize	Prepare adoption; protect; empower and transfer; deploy; generalize or commercialize.	Result in use and scalable.
7. Improve	Measure performance and impact; later revision; recognize; review system; plan improvements.	Impacts, lessons and improvements.

Source: own elaboration.

Operational content of the steps

Step 1. Prepare and govern. At this stage, the scope, structures, roles, politics, objectives, resources and documentary rules are defined. Sensitization links the procedure with real problems and clarifies that the management of the system corresponds to senior management, while technical coordination facilitates its execution.

Step 2. Understand the context and diagnose. This stage has the purpose of analyzing the environment, interested parties, value chain, capabilities and maturity. The knowledge map identifies critical knowledge, location, carriers, level of documentation, risk of loss and treatment actions. Evidence, effects, probable causes, affected and responsible process are recorded in the problem database.

Step 3. Watch, learn and identify opportunities. At this stage, priorities are transformed into intelligence questions about technologies, climate, markets, standards, financing and partners. The sources of information are evaluated by their authority, timeliness,

relevance and corroboration. The challenges are translated into business implications and opportunities with beneficiaries, needs, value, restrictions and missing knowledge.

Step 4. Manage ideas and portfolio. At this stage, ideas are generated and refined with the participation of workers. The alternatives are compared according to their alignment, economic, environmental and social value, feasibility, available knowledge, time, risk and generalization potential. An initial intellectual property review is carried out to identify background, operating freedom and protection options. Finally, the management examines a portfolio of ideas and projects that balance incremental improvements and exploratory options.

Step 5. Develop projects and solutions. During this stage, prioritized ideas are formulated as projects with objectives, scope, deliverables, achievements, assumptions, responsibilities and indicators. In the knowledge acquisition plan, it is necessary to acquire, create, document, protect and transfer. Before authorizing the execution of pilot tests, safety, environment, resources, data and success criteria must be checked, and during execution the tests, errors, decisions and adjustments are recorded.

Step 6. Implement, protect, transfer and generalize. At this stage, possible users are planned, process changes to be made, skills, infrastructure, maintenance and supply necessary to implement solutions. The protection strategy values which protection option is most convenient in each case (patent, utility model, copyright, secret, trademark, publication or contractual transfer). During implementation, training is combined with demonstrations, supervised practice and monitoring of real use. Generalization is only authorized when transferability, minimum conditions, risks, costs and support for the receiving unit are demonstrated.

Step 7. Measure, review and improve. To develop this stage, a set of indicators for inputs, processes, products, results and impacts is defined. Systematic and final revisions contrast expectations, evidence, deviations, unforeseen effects and lessons. The Management Council must periodically evaluate the portfolio of ideas and projects, risks, resources, alliances, maturity and compliance, and approve actions to correct practices or review system assumptions.

Decision points, tools and records

Five decision points were established. El Punto 0 authorizes the idea when there is a relevant problem or opportunity, minimal evidence, responsibility and strategic alignment. Point 1 decides on the incorporation into the portfolio after comparing value, feasibility, risks, knowledge and intellectual property. Point 2 authorizes the pilot test when the protocol, resources, safety, environment, data and success criteria are defined. El Punto 3 decides to implement the scale according to performance, acceptance, sustainability and support. El Punto 4 initiates the process when results, impacts, transfer, lessons and final disposition are documented.

The procedure is supported by 20 editable records and 16 indicators. The records document governance, problems, critical knowledge, surveillance, ideas, projects, risks, intellectual property, transference and lessons. The indicators combine compliance, the use of knowledge, the conversion of opportunities into solutions, the advancement of projects, the adoption, the generalization and the impacts.

The contribution of the PGCI-EAF does not reside in bringing together tools and knowledge, but in ordering its connections within the same flow of decision where problems, critical knowledge, vigilance, opportunities, portfolio, projects, intellectual property, adoption, transfer, impact and learning, dejaron de treated as separate activities. Gardeazabal *et al.* (2023) highlighted the importance of formalizing the flows of knowledge in agri-food systems; The proposed procedure is operationalized by assigning responsibilities, evidence, indicators and decision points. Likewise, the relationship observed between knowledge, creativity and innovation in agribusiness (Ureña-Espaillat *et al.,* 2023) is expressed in a sequence where a single idea acquires the condition of innovation after being tested, adopted and evaluated.

The network configuration responds to the territorial distribution of actors and agroforestry knowledge. Knowledge ecosystems can support the transformation of small organizations when they rely on intermediation and situated links (Marinelli *et al.,* 2024); In the forestry sector, its results vary according to institutional and territorial conditions (Huang *et al.,* 2024). For this reason, the procedure does not consider the formal existence of an agreement sufficient. Each collaboration must be associated with

a need, a contribution, a responsibility, a rule of access to information and an expected benefit.

Digitalization occupies an instrumental place in the process and management of companies. Sensors, connectivity and analytics expand observation and traversability in the forestry sector (Damaševičius *et al.,* 2024; Ehrlich-Sommer *et al.,* 2024), but it does not replace technical judgment in the learning organization. The procedure involves data, with information, interpretation, decision, action and learning. In companies with uneven connectivity, this logic allows you to combine digital and conventional support, planned synchronization and version control, instead of depending on platforms whose complexity exceeds available capabilities.

The sustainability and generalization of results will be examined from the formulation of each initiative. The barriers to agroforestry adoption encompass technical, economic, political and sociocultural factors (Tranchina *et al.,* 2024); Therefore, the value case is not limited to productivity and income. It also includes effects on soil, water, biodiversity, security, learning and the community. Generalization is conceived as an adaptation process, not as an automatic reproduction of an experience. This decision coincides with studies that recommend planning scaling and its conditions throughout the innovation cycle (Rivera *et al.,* 2025).

The articulation of the ISO 56001:2024 standard with the ISO 30401:2018 allows us to avoid parallel systems, one dedicated to documenting knowledge without converting it into value and the other focused on projects that do not preserve their learning. The procedure translates to the business level the logic of the Government Management System Based on Science and Innovation, which starts from identifying priority problems, resorting to scientific advice, articulating actors, organizing projects and introducing results (Díaz-Canel Bermúdez 2021). In turn, the continuation of the implementation of the innovation system of the Cuban forestry sector to integrate surveillance, transfer and generalization in a common sequence (Torres Cala *et al.,* 2021).

CONCLUSIONS

The triangulation of scientific, technical and legal references allows us to support a procedure with a systemic and contextualized structure for Cuban state-owned agroforestry companies, methodologically overcoming the problem of separating the identification of problems, the movement of knowledge, the development of solutions and organizational learning, present, in the way in which these companies manage knowledge and innovation.

The main contribution of the elaborated procedure was to establish bringability in problem solving, from strategic priority to adoption, through protection, transfer, generalization of innovative solutions to impact assessment, support in existing business structures and proportional controls at risk.

An empirical validation in the context of the agroforestry companies participating in the project is recommended, before generalization at national level.

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Authors' contribution:

The authors have participated in the writing of the work and analysis of the documents.

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