MODEL AND PROCEDURES FOR THE MANAGEMENT OF TECHNOLOGICAL INNOVATION IN AGRICULTURAL PEASANT ASSOCIATIONS OF COTOPAXI, ECUADOR

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ABSTRACT

The management of technological innovation in community agriculture is essential to improve productivity, sustainability and local development. In the province of Cotopaxi, Ecuador, peasant associations face challenges related to the adoption and management of new technologies. This work proposes an alternative management model of technological innovation for agricultural peasant associations adapted to this region. A qualitative methodology with an inductive-deductive approach was used, based on a systematic review of the literature, interviews with key actors and work with experts using the focus group technique. The findings highlight the importance of considering external factors such as government policies, conditions imposed by the market, and the participation of Quadri-Helix actors: State, Business, Academia and Local Organizations to facilitate the adoption of innovative technologies. It is important to adapt technology transfer to the local culture, promote associativity and ensure adequate resources. The model translates into an application procedure with three stages: 1) technological diagnosis; 2) selection and incorporation of technology; 3) technological impact evaluation. This structured approach provides an adequate and relevant methodological tool as an alternative for the management of technological innovation in the peasant agricultural associations of Cotopaxi, highlighting the importance of a holistic and collaborative approach for success that contributes to sustainable agricultural development, and the strengthening of the local economy.

KEYWORDS: Innovation; Agriculture; Peasant Associations; Quadruple Helix.

RESUMEN

La gestión de la innovación tecnológica en la agricultura comunitaria es esencial para mejorar la productividad, la sostenibilidad y el desarrollo local. En la provincia de Cotopaxi, Ecuador, las asociaciones campesinas enfrentan desafíos relacionados con la adopción y gestión de nuevas tecnologías. Este trabajo propone un modelo alternativo de gestión de la innovación tecnológica para asociaciones campesinas agrícolas adaptado a esta región. Se utilizó una metodología cualitativa con enfoque inductivo-deductivo, a partir de una revisión sistemática de la literatura, entrevistas a actores clave y trabajo con expertos mediante la técnica de grupo focal. Los hallazgos subrayan la importancia de considerar factores externos como políticas gubernamentales, condiciones impuestas por el mercado, y la participación de los actores de la Cuatri-Hélice: Estado, Empresa, Academia y Organizaciones Locales para facilitar la adopción de tecnologías innovadoras. Es importante adaptar la transferencia de tecnología a la cultura local, promover la asociatividad y asegurar recursos adecuados. El modelo se traduce en un procedimiento de aplicación con tres etapas: 1) diagnostico tecnológico; 2) selección e incorporación de la tecnología; 3) evaluación de impacto tecnológico. Este enfoque estructurado proporciona un herramental metodológico adecuado y pertinente como alternativa para la gestión de la innovación tecnológica en las asociaciones agrícolas campesinas de Cotopaxi, destacando la importancia de un enfoque holístico y colaborativo para el éxito que contribuye al desarrollo agrícola sostenible, y al fortalecimiento de la economía local.

PALABRAS CLAVE: Innovación; Agricultura; Asociaciones Campesinas; Quadruple Hélice

INTRODUCTION

Technology and innovation are critical factors for the development of agriculture, especially in rural regions (Monge et al., 2023). Proper management of these elements can significantly contribute to improving productivity and strengthening agricultural peasant associations.

In Ecuador, agriculture is one of the main economic activities, accounting for 8.2% of the Gross Domestic Product (GDP) and employing 27% of the economically active population (Guamán, 2018; INEC, 2020). Ecuadorian agriculture has evolved to include a wide variety of crops, ranging from tropical species in the lowlands to Andean crops in the mountainous regions. Agriculture is not only an industry; it encompasses several value chain links, meeting domestic food needs while also contributing significantly to exports. Nevertheless, the sector faces challenges related to environmental sustainability and technological modernization, which are essential for improving productivity and competitiveness.

Agriculture in Ecuador is divided into Corporate Agriculture (CA) and Family Peasant Farming (FPF). CA encompasses 15% of Agricultural Production Units (APUs), holds 80% of the land, and uses 63% of the irrigation water. In contrast, FPF represents 84.5% of the APUs, owns 20% of the land, uses 37% of the irrigation water, and focuses on subsistence farming to meet basic food needs. Approximately 64% of national agricultural production comes from small-scale producers, with FPF accounting for 60% of the food consumed in Ecuador.

Cotopaxi Province, located in central Ecuador, is characterized by its geographical and cultural diversity. Its main economic activities include agriculture, commerce, and industry (Flores et al., 2023; M. Monge et al., 2021). Manufacturing represents 38% of provincial economic activity, agriculture and livestock 21%, and commerce 12%. Around 40% of the population lives in rural areas, the majority of whom are Indigenous peoples dedicated primarily to agriculture and livestock.

Agricultural peasant associations, led by community leaders, are essential for food production and the strengthening of the local economy. Focused on a variety of crops—ranging from maize to fruits and flowers—these associations also promote sustainable agricultural practices and the joint commercialization of their products. However, they face several challenges that threaten their stability (García, 2019; Massabie et al., 2019; Jácome, 2018), such as limited access to technologies, climate change adaptation, competition in agricultural markets, among others (Merlinsky & Couyoupetrou, 2020).

Despite collaborative projects involving various governmental, non-governmental, and local organizations, the outcomes have not satisfactorily fostered rural agricultural development. Persistent challenges include the incorporation of appropriate technologies in Indigenous communities, access to credit, improvement of rural infrastructure, and training for farmers in the use of new technologies (De Sousa, 2023; Quevedo, 2020).

The efficient management of technological innovation is a key factor for the sustainable development of agricultural peasant associations in Cotopaxi, Ecuador. This research presents a model and its procedures as a pertinent alternative for managing technological innovation in the agricultural peasant associations of Cotopaxi Province, with the aim of boosting rural agriculture and thus contributing to local development.

MATERIALS AND METHODS

A qualitative approach was employed through an inductive-deductive procedure, utilizing various tools such as a systematic literature review, interviews with key stakeholders, and an expert focus group. This approach provided the foundation for proposing a technological innovation management model tailored to the agricultural peasant associations of Cotopaxi, along with its corresponding procedures.

Systematic Literature Review

A review of academic and technical literature related to Technological Innovation Management (TIM) in agricultural peasant associations was conducted. Key concepts and best practices in rural TIM were identified using the PRISMA method (Barrios et al., 2021), structured into three stages: search protocol, review protocol, and data processing protocol.

In the first stage, a detailed methodological strategy was established, including the formulation of research questions, inclusion/exclusion criteria, and search strategies (search equation). The review protocol ensured the relevance of the selected sources based on predefined criteria, promoting transparency and coherence. Finally, the data processing protocol facilitated the extraction and synthesis of information, ensuring consistency and reliability in handling the data derived from the selected studies.

Interviews with Key Stakeholders

This qualitative research technique involved direct interaction between the researcher and relevant individuals associated with the phenomenon under study. Open-ended and specific questions were formulated to gain a deep understanding of the experiences, perceptions, and knowledge of the participants (De la Cruz & Gordillo, 2020). This method enabled the collection of detailed information and meaningful insights from individuals with expertise, experience, or a vested interest in the research topic (Licandro et al., 2019).

The interviews designed for this study followed a semi-structured format, consisting of a series of main and follow-up questions focused on innovation management and technology transfer in the context of agricultural peasant associations in Cotopaxi. Key informants included the Governor of Cotopaxi, a representative of the Indigenous peasant leadership from the Pueblo Igualdad Trabajo (PIT) organization, the Director of the Ministry of Agriculture and Livestock of Cotopaxi, and the Provincial Prefect of Cotopaxi.

Expert Focus Group

This research method involves the deliberate and structured interaction of a selected group of individuals with specialized knowledge in a specific area (Arriola et al., 2018; Geovanny et al., 2019). Participants gather under the moderation of a facilitator to discuss specific issues in a detailed and reflective manner (Pacheco & Salazar, 2020). The group dynamic fosters idea generation, exploration of diverse perspectives, and identification of patterns or consensus on key topics. The focus group was employed to gain an in-depth and contextualized understanding of the subject, drawing on the accumulated knowledge and experience of the participating experts, based on the methodology reported by Betts and Herb (2023).

The implementation of this method followed the steps outlined below:

Step 1: Define the purpose of the focus group, oriented toward obtaining expert insights on the selected topic.

Step 2: Develop a discussion guide based on semi-structured questions addressing critical aspects such as challenges, opportunities, and strategies related to the management of technological innovations in agriculture.

Step 3: Identify experts, including farmers, agricultural technologists, government representatives, and academics, among others.

Step 4: Designate a facilitator to guide the discussion, ensuring comprehensive coverage of the guide and equitable participation.

Step 5: Conduct the focus group session using ethically approved methods, such as audio recordings and detailed note-taking, which were later analyzed and processed by the researchers.

The expert focus group was composed of academic researchers with experience in agricultural TIM, farmers who contributed practical insights and firsthand production experience, innovation management experts who provided knowledge on technology implementation, and public policy experts who contextualized the discussions within the current regulatory framework. This combination ensured a multidisciplinary and enriching discussion, encompassing both theoretical and applied dimensions of the topic under study.

RESULTS AND DISCUSSION

Systematic Literature Review

Based on the systematic literature review, several relevant sources were identified and examined for this research, as briefly summarized in the following paragraphs.

In Europe, several studies highlighted the importance of innovation in the agricultural sector. Iglesias et al. (2019) emphasized the innovation management model in Spain, focused on agricultural technologies to improve production efficiency. Diederen et al. (2020) in the Netherlands and Schmidt and Müller (2018) in Germany also stressed collaboration and staff training for the successful adoption of new technologies. In Italy, Sgroi (2022) presented cases of innovative cooperatives that improved sustainability in their operations by adapting technologies to local conditions.

In Asia, research focused on innovation management models in India, Vietnam, and China. In India, the cooperative “AgriTech” stood out for its focus on agricultural technologies and farmer training (Jammanahalli, 2022). In Vietnam, the “RiceFields” project (Phuc, 2020; Van Nhung, 2021), and in China, the “GreenFields” Farmers’ Association implemented similar

models, highlighting the importance of applied research and farmer collaboration (Chen et al., 2019; Hoan, 2017).

In the Americas, various studies emphasized the implementation of innovation management models in Peru, Argentina, Colombia, and Costa Rica. In Peru, the association "La Esperanza" improved organic coffee productivity through collaboration with research institutions (Guambi, 2018). In Argentina, the agricultural cooperative "San Isidro" adopted efficient irrigation technologies, overcoming financial and technical training challenges (García & Martínez, 2019). In Colombia, the "El Progreso" Farmers' Association promoted crop diversification and agroecological practices through community participation (Hernández & Gómez, 2020; Torres et al., 2019). In Costa Rica, the Agricultural Innovation Network facilitated knowledge exchange among agricultural associations, highlighting the importance of peer collaboration and institutional support (Barboza & Sáenz, 2020).

From the interviews conducted with selected key stakeholders, it can be inferred that all recognized the importance of understanding and addressing various factors to ensure that technological innovations are adequately adapted to local needs and realities.

This not only involves the implementation of technologies but also considers how they interact with the region's socio-economic and environmental context. Furthermore, the active participation of farmers in the innovation process is emphasized, ensuring that technological solutions are appropriate and sustainable within their agricultural practices.

According to the interviewees, it is essential to promote development strategies that foster collaboration among the State, businesses, academia, and local organizations. Each actor plays a fundamental role in driving technological innovation in the rural sector. This synergy is known as the Quadruple Helix (QH) (Cai & Lattu, 2022; Leydesdorff, 2020; Steenkamp, 2019; Urra, 2018).

The State must provide financial support and resources, establish policies and regulations that benefit agricultural peasant associations, and back the adoption of sustainable technologies. The most relevant public actors include the Ministry of Agriculture and Livestock (MAG), the provincial, municipal, and parish-level Decentralized Autonomous Governments (GADs), Agrocalidad (the national agency in charge of plant and animal health and food safety), and all regional offices of the Ecuadorian government.

Academia—represented in the province by the Technical University of Cotopaxi (UTC), the Armed Forces University (ESPE), the Regional Higher Institute of Cotopaxi, the National Institute of Agricultural Research (INIAP), and various educational units—can provide guidance, research, outreach, and technical training to the peasant associations. Collaboration with academia supports the adaptation of technological solutions to local needs and encourages capacity-building in their application.

Enterprises, encompassing all industrial and commercial entities involved in the generation of goods, services, knowledge, financing, and innovation, can contribute to economic and social development. These actors may financially support the implementation of technologies, infrastructure development, and the provision of equipment, supplies, and materials essential to agricultural advancement.

Local organizations—including communities, NGOs, interest groups, associations, cooperatives, and the Church—should also be integrated to ensure community participation and acceptance of the proposed technologies. Additionally, these organizations can oversee the implementation of TIM to ensure equity, promoting inclusion and cultural respect in the technology adoption process.

Interviewees emphasized the importance of technology transfer from various institutions such as universities, research institutes, and INIAP, ensuring accessibility, comprehension, and practical applicability for farmers. They also identified local culture as a crucial factor influencing the acceptance and adaptation of agricultural technologies. Understanding and respecting local practices and beliefs is seen as essential for successful implementation.

Associativity emerges as a vital component to strengthen the model, facilitating collaboration, access to resources, and knowledge exchange, thereby contributing to more effective implementation of agricultural technologies. Financial, technological, and knowledge resources are recognized as critical for the prompt and effective acquisition and deployment of agricultural technologies.

Finally, the need to address external factors—political, economic, social, technological, and legal—that may affect technology transfer and implementation was underscored.

Expert Focus Group

The Expert Focus Group enabled the development of a dynamic and integrative approach based on the specialized knowledge and practical experiences of the participants. This contributed to a holistic analysis of the research problem and the identification of key elements to be emphasized within the agricultural technological innovation management model. The main findings are summarized in Table 1.

Table 1

Summary of Responses from the Expert Focus Group

Evaluated Elements	
	External Factors
	Political, economic, social, and technological factors influencing peasant associations in Cotopaxi were identified, affecting the adoption of agricultural technologies. Examples include: the Law on Popular and Solidarity Economy, Agrarian Development Law, Environmental Law, Science, Technology and Innovation Law, fluctuations in agricultural input prices, and trade policies and agreements.
	Quadruple Helix (QH)
	Participants emphasized the need for strong collaboration between the State, Business, Academia, and Local Organizations to foster technological innovation in rural areas, specifying the roles and specific contributions of each actor.
	Key Elements
	Key aspects such as technology transfer, local culture, associativity, and necessary resources were discussed and listed, highlighting their importance within the technological management model for peasant associations.
	Technology Transfer
	The transfer of technology through an appropriate model can directly impact the adoption and success of agricultural innovations, ensuring their accessibility, comprehensibility, and applicability by local farmers. This process spans internal and external evaluation of the technology, acquisition, incorporation, and monitoring of its use. It includes activities such as: assessment of technological capacities, benchmarking, supplier selection, negotiation, knowledge transfer, and effective use of technological innovation in agricultural management.
	Culture
	The influence of local culture on the acceptance and adaptation of agricultural technologies was analyzed, recognizing its critical role in the success of technological initiatives.
	Associativity
	The importance of strengthening the model through associativity was emphasized, as it facilitates collaboration, access to resources, and the exchange of knowledge.
	Resources
	The critical role of resources in the acquisition, implementation, and deployment of agricultural technologies was highlighted, as they directly affect the likelihood of success of the model to be implemented.

Note. Own elaboration

Main Recommendations from the Expert Group:

- ✓ The model must be capable of identifying external factors and minimizing their impact on the activities carried out by the peasant association.
- ✓ The participation of local actors should be encouraged, and intersectoral collaboration among the State, Business, Academia, and Local Organizations is essential to drive technological innovation in rural areas.
- ✓ The management of technological innovation in agricultural peasant associations should include technology transfer, technological diagnosis, selection and incorporation of technology, and monitoring and evaluation of technological impact.
- ✓ For the model to succeed, processes and procedures must be aligned with local culture. The dynamics of rural communities and peasant associations must be considered and supported.
- ✓ Efficient resource management is a decisive factor in the success or failure of the model.
- ✓ Mechanisms for adaptation to changes must be included (integrated into so-called "continuous improvement processes").

Description of the Technological Innovation Management Model for Agricultural Peasant Associations of Cotopaxi

Based on the previous section, key elements were identified, such as external factors, associativity (Quadruple Helix), key elements, technology transfer, culture, resources, and local development. These elements enabled the establishment of an alternative Technological Innovation Management (TIM) model for agricultural peasant associations in Cotopaxi Province, Ecuador. This model aims to promote the adoption and integration of new technologies as a means of contributing to sustainable local development.

The proposed model, conceptually presented in Figure 1, begins with the assessment of external factors that influence the adoption of agricultural technologies. These have been categorized into political, economic, social, technological, and environmental aspects. This analysis is necessary to understand the context in which innovations will be implemented.

Another critical factor is the integration and interaction of various local actors involved (State, Businesses, Academia, and Local Organizations) to foster rural innovation, supported by appropriate policies, resource allocation, knowledge exchange, and strong community collaboration.

Additionally, the model emphasizes the identification of key elements such as technology management and transfer, cultural considerations (interculturality), resource availability, and the organization of peasant associations, in cooperation with relevant actors (Agricultural

Production Units, farmers, and the diverse entities grouped under Academia, Business, State, and Local Organizations). Addressing these elements adequately can help anticipate potential challenges and create opportunities for the success of technological initiatives in Cotopaxi's agricultural sector.

Figure 1

Conceptual Model for the Management of Technological Innovation in Cotopaxi Province

Note. Own elaboration

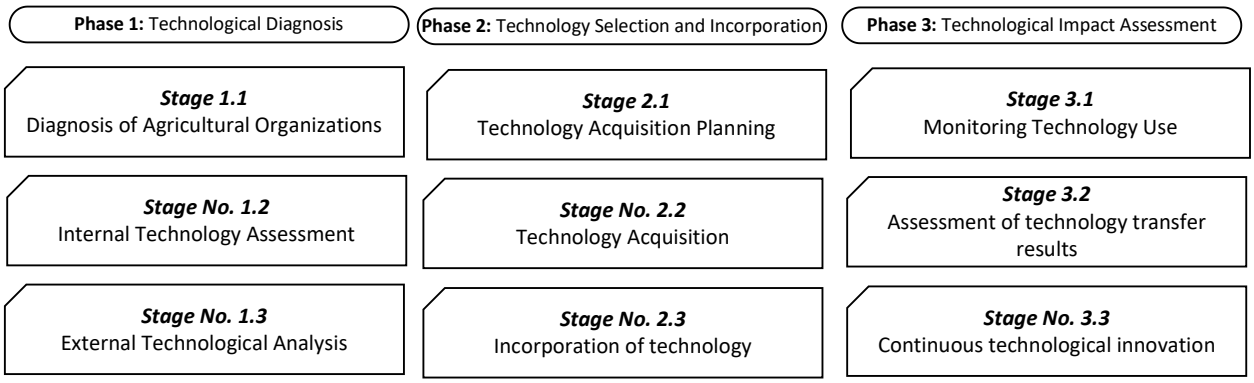
The model presented in Figure 1 was conceived as a dynamic, adaptable, and flexible tool, designed to narrow the "gap" between the current situation and the desired future, aiming to improve productivity, promote greater organizational development, and thereby contribute to sustainable development in the province of Cotopaxi. This ensures the model's relevance and effectiveness within a constantly evolving context.

General Procedure of the Technological Innovation Management Model in Cotopaxi

Based on the elements outlined in the conceptual model shown in Figure 1, a general procedure has been developed for the management of technological innovation in agricultural peasant associations in Cotopaxi. This procedure consists of three phases, described below:

Figure 2

General Procedure for the Management of Technological Innovation in Agricultural Producer Associations of Cotopaxi



Note. The figure is based on the general procedure for the Management of Technological Innovation in the Agricultural Producer Associations of Cotopaxi.
Note. Own elaboration

Phase 1: Technological Diagnosis. It is necessary to assess both internal and external environmental needs, focused on Technological Innovation Management (TIM) within the context of peasant associations. This phase aims to understand the initial situation of peasant associations in Cotopaxi. Its objectives are to evaluate local agricultural conditions, identify existing limitations, and recognize available technological opportunities. Activities include diagnosing agricultural organizations, conducting internal technology assessments, and performing external technological analysis.

Phase 2: Selection and Incorporation of Technology. This phase involves planning the acquisition of technology, taking into account budget, financing, responsible parties, and

timelines. The acquisition is carried out using prioritization and selection methods. This process entails the incorporation of tools, knowledge, and technological practices into the agricultural domain. Ultimately, the selected technology is integrated through processes of transfer, dissemination, and use. This phase ensures that the selected technologies are suitable and beneficial to the specific needs of peasant associations.

Phase 3: Evaluation of Technological Impact. The final phase is dedicated to assessing the technological impact. This process focuses on measuring and analyzing the effects and outcomes of acquiring and implementing agricultural technologies. It includes stages such as monitoring the use of technology, evaluating the results of technology transfer, and continuous innovation (embedded in what is known as the continuous improvement cycle).

The model not only seeks to incorporate advanced technologies but also aims to strengthen community organization, improve agricultural productivity, and contribute to sustainable development in the region. Through collaboration among various stakeholders and the efficient management of resources, it fosters an enabling environment for innovation and the sustainable growth of peasant associations in Cotopaxi.

Discussion

The technological innovation management model developed for peasant associations in Cotopaxi shares similarities with other successful models implemented in various regions. Like the PRESICA initiative in Central America and the Dominican Republic, and the IDIAF project in the Dominican Republic, it emphasizes technology transfer and the strengthening of local capacities through training and the provision of appropriate technologies tailored to specific needs (Brito, 2021; Labarta et al., 2020; Ortiz et al., 2016). It also promotes collaboration with actors embedded in the territory, similar to what is described by Miranda and Vivas (2019) and Ramírez and Gordon (2019), and it shares a cooperative and sustainability-oriented approach as proposed by Yasinski (2022), Villanueva (2022), and Niño (2013), among others.

However, the methodological framework developed for the peasant associations in Cotopaxi distinguishes itself by its specific adaptation to the socioeconomic and environmental context of the province, making it unique when compared to models implemented in other regions. This model includes detailed phases—technological diagnosis, technology selection and incorporation, and impact evaluation—providing a structure that differs in both complexity and depth from other models (Cordovés et al., 2020; Santos, 2018; Viera et al., 2024).

Furthermore, the proposed model places a strong emphasis on the integration of cultural aspects and community cohesion, which significantly sets it apart from more technically oriented approaches, such as those described by Miranda and Vivas (Labarta et al., 2020;

Ortiz et al., 2016; Spyker, 2021). These differences help ensure its effectiveness and sustainability across diverse environments and local communities.

At the same time, the model exhibits general design features that make it suitable for adaptation in other regions with similar characteristics. It incorporates "mechanisms" that allow it to respond to environmental changes, align with local culture, and manage the participatory and timely incorporation of appropriate technologies, according to the needs of its end users (in this case, the peasant associations of Cotopaxi). These features contribute to improved performance and foster local development within the region.

CONCLUSIONS

- ✓ The proposed model presents a detailed and systematic structure that covers all the critical stages of technological innovation management. From the initial diagnosis to the impact evaluation, each phase is designed to ensure the effective implementation and appropriation of new technologies, thereby increasing the likelihood of success in their application.
- ✓ The consideration of local and cultural factors in the implementation of technologies is a key strength of the model. By adapting technological innovations to the specific needs and contexts of Cotopaxi's agricultural communities, it not only facilitates farmer acceptance but also ensures that technologies are used effectively and sustainably.
- ✓ By promoting technologies that improve resource efficiency and reduce environmental impact, the model contributes to more sustainable and resilient agricultural development.
- ✓ The integration of diverse actors—including government entities, businesses, academic institutions, and local organizations—ensures an equitable distribution of the benefits of innovation and strengthens the capacity of peasant communities to face technological and social challenges.
- ✓ The model's ability to adapt to changing environments is essential for its long-term viability. By taking into account external factors such as political, economic, and social changes, the model provides peasant associations with greater resilience to crises and adverse events, ensuring their continuity and development.
- ✓ The inclusion of continuous improvement processes is vital to maintaining its effectiveness. The ability to refine and adjust the model in response to new challenges and opportunities ensures that it remains relevant and efficient in an ever-evolving environment.

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