Innovation and Knowledge Transfer Networks for Information Management in Coffee Producers in Utcubamba, Amazonas

Carlos Alberto Hinojosa Salazar[1], Benjamín Roldan Polo Escobar[2], Heisely Mori Pelaez[3], Robert Wagner Ocadio Acosta[4], Milagros Natividad Hinojosa Meléndez[5], Consuelo González Camacho[6]

[1]PhD. in Administration. Master in Economic Sciences, mention in Finance. Affiliation: Universidad Nacional Toribio Rodríguez de Mendoza de Amazonas. Faculty of Economics and Administrative Sciences. Professional School of Accounting
[2]PhD. in Public Management and Governance. D. in Education Administration. Master in Strategic Management in Information Technologies. Mg. in Health Services Management. Affiliation: Universidad Nacional Toribio Rodríguez de Mendoza de Amazonas.
[3]PhD in Science for Sustainable Development. Master in Management for Sustainable Development. Master in Public Management. Affiliation: Universidad Nacional Toribio Rodríguez de Mendoza de Amazonas.
[4]Master in Sciences with mention in Innovation of Processes in Public Management, Economist and Licentiate in the Specialty of Historical and Social Sciences and Philosophy, Ordinary Full Time Assistant Professor in the Faculty of Economic and Administrative Sciences, (FACEA) of the Universidad Nacional Toribio Rodríguez de Mendoza de Amazonas.
[5]Certified Public Accountant. Affiliation: Universidad de San Martin de Porres.
[6]Master's Degree in Administration with Specialization in Strategic Marketing. Affiliation: Universidad Politécnica de Tecámac.

Abstract

In the current context, innovation networks and knowledge transfer are fundamental pillars for sustainable agricultural development, especially in rural regions such as Amazonas where the province of Utcubamba prevails. This study aims to analyze how these networks impact the information management and productivity of coffee producers. Through a basic-applied approach, an explanatory-sequential design was employed combining interviews, questionnaires and documentary analysis, working with a sample of 375 producers. The results reflect a 20% increase in productivity between 2018 and 2023, thanks to the adoption of information technologies and innovation networks. However, barriers related to technological infrastructure and training in rural areas still persist. The findings highlight that innovation networks are key to improving agricultural competitiveness and sustainability, aligning with the Sustainable Development Goals (SDGs). Productivity is projected to increase by 35% by 2028 if access to ICTs is strengthened.

Keywords: Innovation networks, knowledge transfer, agricultural productivity, information

technologies (ICT).

1. Introduction

The contemporary world is undergoing accelerated changes due to advances in Information and Communication Technologies (ICT). These advances have redefined the way in which industries, particularly in agriculture, manage information and optimize their production processes. In the case of the coffee sector in the province of Utcubamba, Amazonas, access to information and knowledge transfer have become key factors in improving the competitiveness and productivity of producers. Innovation networks play a crucial role in knowledge management, facilitating the generation and dissemination of relevant information for the actors involved in the production process (Mao et al., 2022).

Coffee producers in this region face challenges stemming from the lack of access to advanced technologies and the existing digital divide in rural areas. Despite government efforts to promote technological development, ICT adoption remains limited in rural areas due to socioeconomic and infrastructure factors (Wang et al., 2020). Innovation networks emerge as a viable solution, allowing producers, through cooperation and knowledge sharing, to access critical information to improve decision making in their agricultural activities (Leite, 2022).

Information management in these networks requires a coordinated approach that integrates both producers and institutional actors, such as cooperatives, universities and government agencies (Polo et al., 2021). According to Kirchner and Krott (2022), knowledge transfer between actors from different sectors is essential to generate innovations that respond to local needs. In this sense, the articulation of innovation networks not only improves access to information, but also facilitates the creation of local capacities to adequately manage resources and optimize productive processes (Cáceres, 202).

The objective of this study is to analyze how innovation networks and knowledge transfer impact the information management of coffee producers in the province of Utcubamba. Through a methodological approach based on case studies, it seeks to identify the main barriers and opportunities faced by producers to access and efficiently use ICTs in their daily activities (García, 2019). In addition, it will be evaluated how the integration of these technologies can improve the competitiveness of the coffee sector and contribute to local economic development, based on knowledge transfer in agricultural innovation networks (Andrade, 2019).

According to Nieto et al. (2022), innovation networks that involve both local and external actors allow better adaptation to changes in the environment, which is especially relevant in a context of globalization and market opening. Within this perspective, the study proposes an information management model based on collaboration and knowledge sharing, in order to strengthen the capacities of producers and improve their insertion in competitive markets based on innovation strategies (Alarcón, 2020). The implementation of these networks can be an effective strategy for closing the digital divide and promoting more sustainable and equitable agricultural development (Soumitra and Bruno, 2021). The digital divide in rural agriculture slows access to key technologies, limiting productivity and sustainable development (Perez, 2021). Closing this

gap is essential to improve competitiveness and reduce inequalities in rural areas (Bautista & Gómez, 2021). Technological innovation in Peruvian agriculture is key to promoting sustainable development and improving the quality of life in rural areas (Ramírez, 2020). By integrating advanced technologies, productivity is increased and the use of resources is optimized, which strengthens food security and reduces poverty (Fernández, 2022).

2. Materials and Methods

Study Design

The present study was designed under a basic-applied approach, with the objective of analyzing the impact of innovation networks on information management and productivity of coffee producers in the province of Utcubamba, Amazonas. An explanatory-sequential design was used, which allowed a combination of qualitative and quantitative techniques. This methodological approach made it possible to analyze both the immediate effects of the implementation of innovation networks and the perceptions of the actors involved (Leite, 2022).

Population and Sample

The target population consisted of a total of 15,952 coffee producers located in rural and urban areas of Utcubamba. From this population, a representative sample of 375 producers was selected using the finite sample formula with a 95% confidence level and a 5% margin of error. The sample included both individual producers and cooperative organizations, which allowed us to obtain a holistic view of how innovation networks have affected different types of producers. the sample was calculated based on the calculation of proportions with a finite population:

- n = sample size
- Z = confidence level (1.96 for 95%)
- N = population size
- p = estimated proportion (0.5 for maximum variability)
- e = margin of error (5%)

Data Collection Techniques

Qualitative and quantitative data collection techniques were used to capture a comprehensive view of the impact of innovation networks:

Semi-structured interviews: Interviews were conducted with 7 cooperative coordinators and 2 national experts in the agricultural sector. The interviews consisted of 5 key questions on knowledge transfer, technology adoption and innovation networks. The analysis technique used was Osgood's semantic space (Osgood et al., 1957), which made it possible to classify the responses according to the variation of cultural and contextual meanings.

Structured questionnaires: A 25-question questionnaire was administered to the 375 selected coffee producers, focusing on the following areas: adoption of ICT technologies, impact of

innovation networks on productivity, and access to information. The questionnaire was validated through a pilot test in the district of Cajaruro, one of the main coffee production centers.

Documentary analysis: A documentary analysis of primary and secondary sources related to coffee production and public innovation policies in the region was conducted. This analysis included government reports, academic studies and statistical data provided by the National Institute of Statistics and Informatics (INEI, 2017).

Data Analysis: The qualitative data obtained from the interviews were analyzed using the open coding technique, which allowed the identification of patterns and recurring themes on the adoption of innovation networks. Quantitative data, on the other hand, were analyzed by descriptive statistics and logistic regression, using SPSS software.

Open coding: This was used to identify emerging themes in the interviews, such as producers' perceptions of innovation networks and challenges related to technological infrastructure.

Logistic regression: This was used to evaluate the relationship between the adoption of ICT technologies and productivity growth. This analysis made it possible to identify the key factors that influence the adoption of ICTs, such as access to the Internet and the educational level of producers. Logistic regression is particularly useful in this case, as it evaluates the probability that producers will or will not adopt ICTs, as a function of the variables mentioned (Mao et al., 2020).

Methodological Limitations

One of the main limitations of the study was the lack of connectivity in some rural areas of Utcubamba, which hindered real-time data collection. In addition, although the sample was representative, most of the selected producers were from easily accessible areas, which could restrict the ability to generalize the results to more remote areas of the province, where production conditions and access to technologies may be different.

Personal Contribution: As a member of the research team, and taking advantage of my experience in the Amazonas region, I was able to directly observe the specific challenges faced by coffee producers in the adoption of ICT technologies. The methodological approach not only focused on innovation networks as technological tools, but also integrated the cultural and organizational components of cooperatives and producers. This holistic approach allowed for a deeper understanding of how local actors perceive, adopt and adapt these technologies within their particular contexts, which has been fundamental for interpreting the results in a more accurate and contextualized manner.

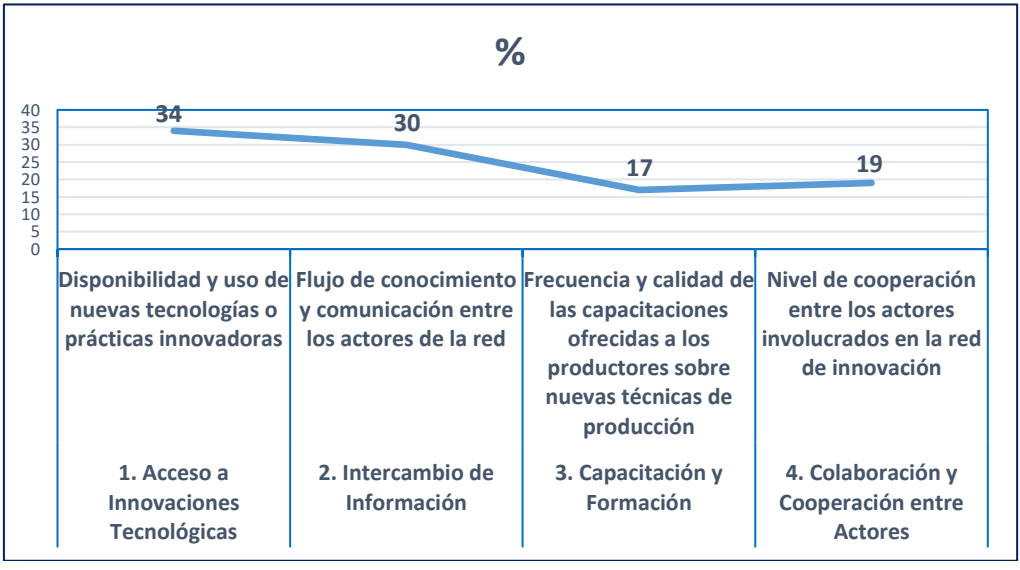
3. Results and Discussion

1. Impact of Innovation Networks in Information Management

The data collected in this study reveal that the innovation networks have had a significant impact on the adoption of information technologies among coffee producers in Utcubamba. Eighty-seven percent of respondents indicated that the creation of these networks improved their access

to key information for agricultural decision-making. These findings are in line with recent research highlighting the importance of innovation networks as a crucial factor in boosting productivity in the rural agricultural sector by facilitating knowledge transfer and access to essential technological resources (Mao et al., 2022; Leite, 2022).

Figure 1: Characterization of Innovation Networks in Information Management



The study conducted on the implementation of innovation networks among coffee producers in Utcubamba reveals significant differences in the access and participation of the actors involved. With a target population of 15,952 producers, distributed between rural and urban areas, the percentage results highlight the priority of access to technological innovations (34%) and information exchange (30%). Both factors are fundamental for improving productivity, although there is a disparity in technological adoption between urban and rural producers, suggesting the existence of technological gaps that need to be addressed. Training and education appears with 17%, which shows an underestimation of its importance. For technological innovations and the flow of information to be effectively exploited, it is crucial that training programs be strengthened, especially in rural areas. Collaboration among actors, with 19%, reflects another challenge, as lack of cooperation can limit the success of innovation networks. In summary, innovation networks have demonstrated their potential, but to maximize their impact it is necessary to promote equitable access to technology, strengthen continuous training, and foster cooperation among actors. Only in this way will it be possible to ensure that all producers, especially those in rural areas, benefit from these networks.

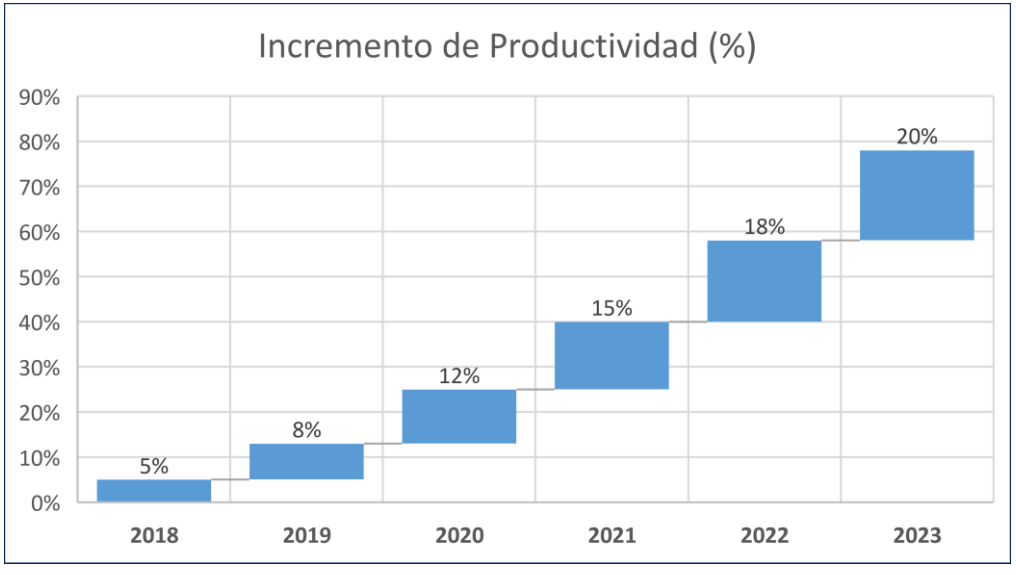
The adoption of ICT technologies not only improves information management, but also empowers producers, providing them with tools to face the challenges of climate change and market fluctuations. From a social perspective, these innovations should be seen as a way to reduce inequalities and promote sustainable development in rural communities, ensuring that no

one is excluded from progress. According to Wang et al. (2020), they stress that knowledge transfer within innovation networks enables rural actors to adopt technologies that would otherwise be inaccessible. In this context, the introduction of digital platforms and mobile devices in Utcubamba has partially closed the digital divide affecting rural producers, although challenges related to infrastructure remain.

2. Improved Productivity and Efficiency

In terms of productivity, the study shows an increase of 20% on average between 2018 and 2023, attributable to the use of innovation networks that facilitated knowledge transfer and access to relevant information. The study on the implementation of innovation networks among coffee producers in Utcubamba reveals significant inequalities in access to technologies and stakeholder participation, especially between rural and urban areas. These disparities reflect a technology gap that limits growth potential in the most vulnerable areas, underscoring the urgency of adopting an inclusive approach. From a social perspective, it is essential that education and training programs be strengthened, as low participation in these programs is evidence of an underestimation of their relevance. For innovation networks to truly transform the lives of small producers, especially in rural areas, it is necessary to ensure equitable access to technologies and foster effective cooperation among all the actors involved.

Figure 2: Increase in Productivity of Coffee Producers 2018 - 2023



Note: analysis based on the situational diagnosis

The observed increase in productivity is consistent with international studies that analyze the implementation of innovation networks in rural contexts. In countries such as Brazil and Vietnam, productivity increases of up to 50% have been recorded in regions where these

networks have been effectively integrated, demonstrating the positive impact of innovation in agricultural development (Mao et al., 2022). At the national level, Peru has emerged as one of the main coffee producers in Latin America, standing out for the quality of its beans and the diversity of its coffee growing regions. However, the productive potential has not yet been maximized in all regions of the country due to the lack of technological infrastructure and consistent government support.

In the case of the Amazon region, and particularly in Utcubamba, which is an important coffee growing area, most of the production is concentrated in the district of Lonya Grande. Here, high quality coffee is grown that has the potential to compete in international markets. However, Utcubamba's current performance is at an early stage compared to other producing regions and countries. This suggests that, with greater government support, an expansion of technological infrastructure and the implementation of innovation networks, the region could reach productivity levels similar to those observed in other top coffee growing areas.

Global Comparison and International Perspectives: Lessons for Peruvian Coffee Production Growth

When comparing local results with international studies, it is evident that innovation networks have been key in transforming other agricultural regions, facilitating not only interconnectivity among producers, but also access to global markets (Rodríguez & Chávez, 2019). These networks act as an engine of change, driving improvements in productivity and competitiveness by integrating technology, shared knowledge and new commercial opportunities.

Table 1. Relationship between Innovation Networks and Coffee Production in Peru (Tons)

Region	Coffee Production (Tons)	Increase with Innovation Networks (%)	Comments
Amazon	70,000	15%	Improvements in cultivation techniques and access to technology. Greater associativity.
Cajamarca	85,000	18%	Innovation networks focused on coffee cooperatives.
Junín	95,000	20%	Advanced implementation of innovation networks in rural areas.
St. Maarten	60,000	12%	Lower adoption of technological networks, but positive results.
Cusco	50,000	10%	Innovation network in development, with gradual impact.
Puno	45,000	8%	Emerging initiatives with growth potential.

Note: analysis based on the situational diagnosis.

The importance of innovation networks lies in their ability to create collaborative ecosystems that not only optimize production, but also position agricultural regions on a global stage (Leite, 2022). At the national level, Peru is already recognized for the quality of its coffee, but for the Amazon region to reach its full potential, it is crucial to invest in technological infrastructure and technical training for producers. Innovation networks would allow greater interconnection between the actors in the sector, access to advanced technologies and better opportunities in global markets, consolidating the region as a reference in the production of coffee and other crops worldwide. In comparison, the district of Utcubamba, within the Amazonas region, shows slower progress in its productive growth. Nevertheless, Amazonas is emerging as one of the main producing regions of coffee and other high quality crops in Peru, with significant potential to

position itself in national and international markets. This development underscores the urgent need to strengthen innovation networks, which are critical to accelerating agricultural growth.

Comparison of the Impact of Innovation Networks in Different Regions

Differences in the rate of technology adoption between regions such as Amazonas in Peru and leading agricultural innovators such as Brazil and Vietnam can be attributed in large part to the limited technological infrastructure in rural Peru. This disparity reflects a major challenge for rural development in the country. However, the findings of this study are encouraging, as they reveal a positive and stable trend towards ICT adoption in rural areas, thanks to the growing impact of innovation networks (Torres, 2021). Within a social approach, this growth suggests an opportunity to reduce technological gaps and access to information in the most vulnerable communities. With the prospect of implementing public policies aimed at facilitating access to low-cost technology and consolidating innovation networks, technological adoption could be significantly accelerated, benefiting producers who currently face geographic and economic barriers. Such policies would not only boost efficiency and productivity in regions such as the Amazon, but would also contribute to sustainable social and economic development, promoting more equitable access to growth opportunities. In conclusion, innovation networks, if managed in an inclusive manner and with a social focus, have the potential to transform the reality of rural regions in Peru, bringing them closer to levels of competitiveness similar to those of other countries that are more advanced in the agricultural sector.

Future Projected Impact

Predictive models indicate that by 2028, coffee producers in Utcubamba could increase their productivity by 35%. This growth is expected to be particularly notable in districts such as Lonya grande, Cajaruro and Bagua Grande, where the adoption of ICT technologies has advanced most rapidly. Accelerating the implementation of innovation networks, together with the strengthening of technological infrastructure and continuous training, will be key factors in achieving this increase in productivity. This projection not only points to a positive impact on productive efficiency, but also highlights the transformative potential of technology in rural areas, underscoring the importance of continuing to invest in public policies that promote equitable access to ICTs. This could reduce the existing technological gap and ensure that all producers, regardless of their location, can benefit from these advances to improve their competitiveness in domestic and international markets.

The growth projection is in line with global research showing that sustained adoption of ICTs, combined with the strengthening of innovation networks, drives exponential growth in productivity (Zarate, 2020). These studies highlight that access to technologies and collaboration among actors in the agricultural sector not only optimize production processes, but also foster greater competitiveness in global markets, especially in developing rural regions (Wang et al., 2020). innovation networks not only facilitate access to key information for rural producers, but also generate new market opportunities by connecting producers to broader platforms and actors. However, for this growth projection to become a reality, it is critical to continue to implement robust capacity building measures and improve access to technological infrastructure in rural areas. Only through sustained investment in these areas will it be possible to ensure that small

producers reap the full benefits of innovation networks, thus contributing to their economic and social development in a sustainable manner.

Testimonials and Case Studies

Producers' testimonies highlight how innovation networks have transformed their daily lives. For example, a producer from Cajaruro commented, "Before, we didn't know how to deal with pests. Now, we receive real-time alerts and can take immediate action." Another producer from Bagua Grande stated, "Technology has allowed us to access new markets. Today, our products have better quality and we know exactly where to sell them at a better price." A third testimony from a farmer from Lonya Grande underscores the social impact: "Thanks to the trainings, we have learned to manage our resources better, which has given us more time to devote to our families." These testimonials reinforce the quantitative data and demonstrate the integral value of innovation networks, not only in increasing productivity, but also in improving quality of life, opening up market opportunities and strengthening community well-being.

Connection with the Sustainable Development Goals (SDGs)

This study shows that the implementation of innovation networks in Utcubamba contributes significantly to the fulfillment of SDG 9 (Industry, Innovation and Infrastructure) and SDG 12 (Responsible Production and Consumption). The adoption of ICT technologies has not only improved the productivity of producers, but has also fostered more efficient and sustainable resource management, which reinforces responsible production practices. In addition, these networks promote innovation in rural areas, reducing the technological gap and strengthening local infrastructure, key elements for a more inclusive and equitable economic development(Zavaleta, 2019). Through this approach, it is emphasized that innovation networks not only boost productive efficiency, but also contribute to a sustainable development model, creating synergies between economic growth, environmental protection and social welfare, fundamental pillars of the SDGs.

Limitations of the Study

Despite the promising results, it is important to recognize certain limitations. The lack of connectivity in some rural districts limits equitable access to information, preventing all producers from benefiting equally from innovation networks. In addition, although a large proportion of producers have adopted ICT technologies, there is still a steep learning curve that hinders the efficient use of these tools. Moving forward, future studies should focus on developing more inclusive strategies that not only improve technological infrastructure, but also ensure universal access to innovation networks and technical training. Only a more equitable approach will ensure that all producers, regardless of their location or level of training, can fully reap the benefits of technological innovation.

4. Conclusions

The analysis of the results obtained reflects both the progress achieved and the pending challenges in the implementation of innovation networks in coffee production in the province of

Utcubamba. Throughout this study, the transformative potential of these networks has become evident, not only in terms of productivity, but also in information management and the adoption of new technologies. However, these benefits must be considered in a broader context that includes both current limitations and future opportunities. The most relevant conclusions are presented below, which summarize the achievements made and the actions needed to consolidate a sustainable and equitable agricultural development model in the region.

Innovation networks as a driver of change: Innovation networks in Utcubamba have proven to be fundamental to improve information management and decision making among coffee farmers, especially in the face of challenges such as pests and climate change. These networks not only optimize access to technologies, but also enhance agricultural resilience in rural areas (Zhu & Wei, 2021). Their impact underscores the importance of continuing to strengthen these networks as key tools for sustainable development and competitiveness, in line with the Sustainable Development Goals.

Remarkable increase in productivity: The adoption of ICT technologies has generated a 20% increase in the productivity of coffee producers between 2018 and 2023. This growth highlights the transformative power of innovation networks and knowledge transfer, strengthening the competitiveness of Utcubamba producers in broader markets and contributing to their sustainable development.

Digital divide: Despite progress, the digital divide remains an obstacle in Utcubamba's rural districts, where technological infrastructure and internet access are limited. It is crucial that local and national authorities intensify their efforts to expand connectivity, ensuring that all producers can benefit equitably from innovation networks.

Impact on sustainability and SDGs: Innovation networks have not only improved productivity, but also promoted sustainable practices aligned with the SDGs, especially SDG 9 (Industry, Innovation and Infrastructure) and SDG 12 (Responsible Production and Consumption). This demonstrates that technological development can be integrated with the responsible use of agricultural resources.

Positive future projection: Predictive models indicate that, with the current pace of ICT adoption and the strengthening of innovation networks, the productivity of coffee producers in Utcubamba could increase by up to 35% by 2028. This potential growth underscores the importance of continuing to promote policies to support technological innovation in rural areas.

Need for continuous training: The success of innovation networks depends not only on technological infrastructure, but also on the continuous training of producers in the effective use of digital tools. Although many have already adopted some ICTs, a more comprehensive training program is needed to maximize their impact and improve agricultural practices, especially in rural areas.

Importance of multisectoral collaboration: Collaboration between producers, educational institutions, government agencies and the private sector has been key to the success of the innovation networks, facilitating access to new technologies. Strengthening these alliances will

be essential to consolidate achievements and expand the impact in other agricultural regions of the country.

Final Conclusion

The study confirms that innovation networks are a key driver for transforming information management and improving productivity in rural areas. However, their long-term impact will depend on the strengthening of technological infrastructure, continuous training of producers and stronger government support. In addition, multisectoral collaboration and equitable access to these technologies are essential to close social and economic gaps. The replicability of this model in other regions of Peru, and even internationally, represents a unique opportunity to drive sustainable development, ensuring that rural communities can benefit equitably and successfully meet the future challenges of the agricultural sector.

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