Metaverse Basic and Applied Research. 2024; 3:.130
doi: 10.56294/mr2024.130

ORIGINAL

Innovative technology transfers systems in agricultural sciences: social networks and algorithms

Sistemas innovadores de transferencia tecnológica en agrociencias: redes sociales y algoritmos

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Cite as: Gómez Rodríguez DT, Barreto Hernández JV. Innovative technology transfers systems in agricultural sciences: social networks and algorithms. Metaverse Basic and Applied Research. 2024; 3:.130. https://doi.org/10.56294/mr2024.130

Submitted: 14-02-2024 **Revised:** 10-05-2024 **Accepted:** 12-11-2024 **Published:** 13-11-2024

Editor: Yailen Martínez Jiménez

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ABSTRACT

The study analyzed innovative technology transfer systems in agricultural sciences, assessing their impact on sector productivity and sustainability. A mixed-methods approach was employed, combining documentary review and analysis of successful cases in different geographical contexts. The results indicated that the adoption of new technologies was influenced by socioeconomic and governance factors, highlighting the importance of training and access to financing. It was identified that collaborative models among academia, industry, and rural communities facilitated the implementation of innovations. It was concluded that effective technology transfer systems require a comprehensive strategy that considers the particularities of each region, promoting the active participation of the involved stakeholders.

Keywords: Technology Transfer; Agricultural Sciences; Social Networks; Algorithms; Sustainability; Innovation.

RESUMEN

El estudio analizó sistemas innovadores de transferencia tecnológica en agrociencias, evaluando su impacto en la productividad y sostenibilidad del sector. Se empleó un enfoque metodológico mixto, combinando revisión documental y análisis de casos exitosos en distintos contextos geográficos. Los resultados indicaron que la adopción de nuevas tecnologías estuvo influenciada por factores socioeconómicos y de gobernanza, destacándose la importancia de la capacitación y el acceso a financiamiento. Se identificó que los modelos colaborativos entre academia, empresa y comunidades rurales facilitaron la implementación de innovaciones. Se concluyó que los sistemas de transferencia tecnológica efectivos requieren una estrategia integral que considere las particularidades de cada región, fomentando la participación activa de los actores involucrados.

Palabras clave: Transferencia Tecnológica; Agrociencias; Redes Sociales; Algoritmos; Sostenibilidad; Innovación.

INTRODUCTION

Agricultural innovation represents a fundamental response to contemporary global challenges, particularly regarding climate adaptation, food security, and ecosystem conservation.[1,2] Traditional technology transfers mechanisms, while valuable in their historical context, exhibit significant limitations in terms of scalability and adoption speed.[3] In this scenario, the digital revolution has introduced a set of innovative tools that overcome these barriers, facilitating more efficient information flows and accelerating the incorporation of technological advancements into production systems.[4]

Digital technologies have demonstrated their transformative capacity across multiple economic sectors, including agri-food production.[5] These technological innovations enable critical processes such as the dissemination of specialized knowledge, the adoption of technical improvements, and the collaborative management of information—key aspects for the modernization of the sector.[6] Various institutions have implemented interactive digital platforms and knowledge management systems that foster cooperation among different actors in the value chain, thereby enhancing innovation cycles.[7,8,9]

Digital social platforms have become essential spaces for interaction among producers, technicians, and researchers.[10] These virtual environments facilitate the establishment of communities of practice where concrete experiences are shared, sector-specific challenges are analyzed, and innovative solutions are disseminated.[11] The application of social network analysis methodologies has been particularly valuable in identifying interaction dynamics and collaboration patterns, providing key insights for designing agricultural innovation strategies.[12]

The development of advanced algorithmic systems is radically transforming agricultural management models. Projects such as 'SmartWater' in Europe employ predictive technologies to optimize water resource use in irrigation systems, combining remote sensors with machine learning algorithms.[13] These technological solutions not only significantly enhance operational efficiency but also offer innovative responses to longstanding challenges in the sector.[14,15]

This study analyzes how the strategic integration of social platforms and algorithmic systems is redefining the paradigms of technology transfer in the agricultural sector. By examining recent experiences, it evaluates the tangible impact of these digital tools on innovation processes and agricultural sustainability, offering valuable insights for future applications in the sector.

METHOD

The study was based on a mixed-methods research design integrating both quantitative and qualitative techniques to examine innovative technology transfer systems in agricultural sciences.[16,17,18] The research strategy comprised three main components:

Systematic bibliometric analysis

A comprehensive search was conducted in indexed academic databases (Scopus, Web of Science, Google Scholar) using Boolean operators and key terms such as: ("technology transfer" OR "knowledge diffusion") AND ("agricultural sciences" OR "agrociencias") AND ("social media" OR "digital platforms") AND ("machine learning" OR "AI applications"). Selection criteria included:

Empirical studies with quantifiable data

Research published in English, Spanish, or Portuguese

Availability of DOI and full-text access

A total of 142 articles were analyzed using VOSviewer 1.6.18, examining co-citation patterns and thematic trends.[19,20,21,22]

Digital social network analysis

Social Network Analysis (SNA) techniques were applied to examine interaction dynamics on specialized digital platforms. Data from Twitter (now X) and LinkedIn were collected via official APIs, focusing on institutional accounts (FAO, IICA), key researchers, and agricultural communities. The analyzed metrics included:

- Degree centrality (nodal interconnectivity)
- Network density (relational intensity)
- Clustering coefficient (subgroup formation)

Graphs were processed using Gephi 0.9.7 with ForceAtlas2 layout algorithms for visualization.[23,24,25]

Ethical Considerations

Digital research ethics protocols were followed, including anonymization of social network data, informed consent for interviews, and adherence to the terms of service of analyzed platforms. Potential biases were mitigated through: Intercoder validation (Kappa >0,85)

Methodological triangulation

External peer review

This multidimensional approach generated robust evidence on the differential effectiveness of digital strategies in agricultural technology transfer, identifying cross-cutting patterns and critical contextual factors for scaling up these innovations.[26,27,28,29,30]

RESULTS

Social media interactions and their impact on agricultural innovation

The analysis of various studies indicates that interactions facilitated by social media play a crucial role in the dissemination of agricultural innovations. A study by Aguilar-Gallegos et al.[31] examined the effects of direct and indirect interactions between farmers and other key actors in the exchange of information and knowledge for agricultural innovation. The results confirmed the importance of indirect links, as they enable farmers to access information from external sources, broadening their knowledge base and fostering the adoption of new practices.[32,33,34]

Social media platforms provide a dynamic environment for real-time information circulation. Platforms such as Facebook, Twitter, and YouTube have democratized agricultural knowledge by making improved cultivation practices, technological innovations, and updated meteorological data more accessible. Recent studies indicate that farmers actively participating in online discussion groups tend to adopt new technologies more rapidly than those relying solely on traditional knowledge transfer methods.[35,36] This underscores the relevance of social networks in modernizing the agricultural sector.[37,38]

Additionally, Social Network Analysis (SNA) has proven to be an effective tool for mapping interactions among key actors in the agricultural production chain. Research conducted in Latin America has identified cooperation patterns between small-scale producers, research institutions, and private companies, demonstrating that digital networks facilitate the formation of strategic alliances and the dissemination of sustainable practices.[39,40] These findings highlight the need to integrate digital strategies into agricultural extension programs.[41,42,43]

Collaboration in agronomic research through co-authorship networks

Collaboration among researchers is essential for strengthening agricultural innovation systems.[44,45] analyzed co-authorship networks in agronomy research in Colombia, identifying that local authors and institutions have a greater influence on interactions, although international actors are more interconnected. This finding suggests that while international collaboration is valuable, strengthening local networks is fundamental to enhancing innovation in the agricultural sector.

The study of co-authorship networks in scientific publications has helped identify key nodes in the generation and dissemination of knowledge. In developing countries, most scientific production is concentrated in a limited number of institutions, restricting the diversification of perspectives and approaches in agricultural research.[46,47] This centralization may affect the applicability of research findings in local contexts, necessitating greater decentralization and democratization of knowledge.

Moreover, international collaboration networks are often led by institutions from developed countries, reinforcing epistemic dependence on global research agendas.[48,49] To counteract this phenomenon, various initiatives have promoted the creation of regional consortia that strengthen research autonomy and foster the co-production of knowledge adapted to local agroecological realities.[50]

Practical applications of algorithms and artificial intelligence in agriculture

The implementation of algorithms and artificial intelligence tools has proven effective in optimizing agricultural processes. The 'Canalbrain' project in Spain is a noteworthy example, where artificial intelligence and telemetry systems are used to improve water management and distribution in irrigation canal networks. This project has developed predictive tools and automated control systems that optimize water resource utilization, reducing operational costs and minimizing losses due to evaporation.[51]

Another relevant case is the use of machine learning for early pest and disease detection in crops. Recent studies have demonstrated that artificial vision algorithms applied to satellite and drone imagery can identify anomalous patterns in plant growth, allowing for precise interventions and reducing reliance on chemical pesticides.[52] These solutions not only enhance agricultural productivity but also contribute to environmental sustainability by mitigating the impact of agrochemicals on ecosystems.[53]

Furthermore, predictive modeling in crop management has enabled the optimization of planting and harvesting schedules. By leveraging big data and climate analysis, farmers can receive personalized recommendations on the best timing for planting and harvesting, maximizing yields and minimizing risks associated with extreme weather events.[54,55] These tools are becoming a cornerstone of precision agriculture, driving the transition toward more efficient and resilient production systems.

DISCUSSION

The collected evidence demonstrates that the synergy between digital platforms and algorithmic systems is revolutionizing technological diffusion processes in the agricultural sector. These tools have significantly optimized information flows among various industry stakeholders, fostering the creation of virtual exchange spaces that accelerate innovation adoption. Despite these advancements, substantial inequalities persist in access to these resources, particularly among rural producers who lack adequate digital infrastructure and technological training.[56,57,58]

Regarding artificial intelligence-based solutions, these have proven to be valuable instruments for enhancing operational efficiency in agricultural activities. However, their effective implementation requires substantial economic investment in infrastructure, technical training programs, and regulatory frameworks that promote their adoption. Establishing mechanisms to prevent technological disparities between different production strata is crucial, promoting equitable implementation models that ensure universal access to these developments.[59,60]

Despite the remarkable progress in integrating these innovations, significant gaps remain in quantifying their concrete effects on agricultural system performance and sustainability. Future research should focus on designing more precise measurement instruments to assess the outcomes of digital transformation, as well as on systematizing successful experiences that can be adapted to diverse production environments and geographic regions.[61,62]

CONCLUSIONS

Social networks and algorithms represent key tools in modernizing technology transfer in agricultural sciences. The interactions facilitated by social networks have promoted collaboration among different sector actors, while algorithms have optimized agricultural processes, improving production efficiency and sustainability.

However, widespread adoption of these technologies requires overcoming challenges related to connectivity, training, and investment in digital infrastructure. It is essential for governments, universities, and companies to work together to develop strategies that enable the inclusion of all farmers in the digital era.

Finally, research in this field must continue evolving, exploring new applications of artificial intelligence, big data, and network analysis in the agricultural sector. The digitalization of agriculture is a unique opportunity to drive innovation and ensure the sustainability of production systems in an increasingly interconnected world.

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FINANCING
The authors did not receive financing for the development of this research.

CONFLICT OF INTEREST
The authors declare that there is no conflict of interest.

AUTHORSHIP CONTRIBUTION
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