Innovation Ecosystems and Agriculture 4.0: Paths to Socioeconomic Sustainability in the São Francisco Valley

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Summary

The advancement of Agriculture 4.0 has significantly transformed production systems in different regions of the world, introducing digital technologies such as artificial intelligence, big data, remote sensing, and the Internet of Things (IoT) as strategic tools to increase efficiency, traceability, and sustainability in the field. In Brazil, this trend is particularly prominent in the São Francisco Valley, a region that has established itself as a hub for irrigated agricultural production, particularly focused on fruit exports. However, despite the potential for innovation and modernization, challenges remain related to the socioeconomic inclusion of small producers, the democratization of access to technologies, and the reconciliation of technological innovation and agroecological practices. This article analyzes, in light of the literature on innovation ecosystems and territorial development, the opportunities and limitations of Agriculture 4.0 in the São Francisco Valley, considering the role of universities, research centers, the government, private companies, and civil society in establishing collaborative institutional arrangements. The methodological approach is qualitative, exploratory, and descriptive, supported by a bibliographic and documentary review, as well as studies applied to the Brazilian semiarid region. The results discuss how the digitalization of agriculture can contribute to productivity gains, environmental sustainability, and value generation in global supply chains, without losing sight of the need to promote social inclusion and territorial justice. The study argues that only by consolidating strong and integrated innovation ecosystems will it be possible to transform the São Francisco Valley into a living laboratory for Agriculture 4.0, reconciling technological efficiency with socioeconomic sustainability.

Keywords: Agriculture 4.0; Innovation; Territorial Development; Agroecology; São Francisco Valley.

Abstract

The advancement of Agriculture 4.0 has significantly transformed production systems worldwide, introducing digital technologies such as artificial intelligence, big data, remote sensing, and the Internet of Things (IoT) as strategic tools to enhance efficiency, traceability, and sustainability in agricultural processes. In Brazil, this trend has gained particular relevance in the São Francisco Valley, a region consolidated as a hub for irrigated agriculture, especially fruit farming for export. However, despite the potential for innovation and modernization, challenges remain regarding the socio-economic inclusion of small farmers, the democratization of access to technology, and the reconciliation of technological innovation with agroecological practices. This article analyses, in light of the literature on innovation ecosystems and territorial development, the opportunities and limitations of Agriculture 4.0 in the São Francisco Valley,

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considering the role of universities, research centers, the State, private companies, and civil society in shaping collaborative institutional arrangements. The methodological approach is qualitative, exploratory, and descriptive, supported by bibliographic and documentary review, in addition to applied studies in the Brazilian Semi-arid region. The results discuss how agricultural digitalization can contribute to productivity gains, environmental sustainability, and value generation in global supply chains, while highlighting the need to promote social inclusion and territorial justice. It is argued that only through the consolidation of strong and integrated innovation ecosystems will it be possible to transform the São Francisco Valley into a living laboratory of Agriculture 4.0, combining technological efficiency with socio-economic sustainability.

Keywords: Agriculture 4.0; Innovation; Territorial Development; Agroecology; San Francisco Valley.

1. Introduction

The contemporary technological revolution has reached the agricultural sector in a

accelerated, reconfiguring not only productive practices, but also forms of

social and economic organization in rural areas. The so-called Agriculture 4.0 —

inspired by the concept of Industry 4.0 — characterized by the application of technologies

digital technologies such as artificial intelligence, remote sensors, drones, big data, blockchain and

advanced automation systems, capable of generating significant gains in productivity,

efficiency in the use of natural resources and environmental sustainability.

2. Theoretical Framework

Discussion on Agriculture 4.0, innovation ecosystems and agroecology.

3. Methodology

Qualitative, exploratory and descriptive research, based on bibliographic review,

documentary and case study in the São Francisco Valley.

4. Results and Discussion

Analysis of the impacts of Agriculture 4.0 on productivity, inclusion of small

producers and sustainability in the São Francisco Valley.

5. Conclusion

Summary of findings, highlighting the importance of integration between technological innovation,

innovation ecosystems and agroecology in sustainable territorial development.

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