CO-INNOVATION AS A METHODOLOGICAL TOOL TO HELP IMPROVE ECONOMIC, ENVIRONMENTAL, AND SOCIAL RESULTS IN FAMILY FARMING

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1. Relevance of the topic

Agriculture faces multiple challenges, including a) supplying the growing demand for nutritious food at affordable prices; b) contributing to the energy matrix while maintaining quality, increasing resilience and preserving the capacity of natural resources to meet the needs of future generations; and c) achieving an equitable distribution of benefits among all those involved in the production process, especially family farmers.

The sustainable development of family farming is strongly conditioned by the economic, social and institutional context in which it is carried out, but also by factors specific to production units themselves. The latter include not only limitations with respect to the quality and quantity of resources, but also the manner in which the production system is organized and functions in order to meet its objectives.

Under current conditions, the productive, economic, social and environmental results achieved by most family farming systems fall below their potential. This is due to serious deficiencies in the management of natural resources (water, soil and agrobiodiversity) and in the organization of the production system. There are certain issues inherent to the size of farms, as well as limitations with respect to technical assistance and access to technologies due to their geographic and social isolation. Additionally, solutions based on existing technologies are not always adapted to the local context of family farmers.

It is possible to increase the productivity of family farming systems by adjusting their management and, at the same time, increasing their resilience to climate variability, without this involving an increase in costs. This has been demonstrated, for instance, by co-innovation processes carried out by the National Agricultural Research Institute (INIA) of Uruguay for the family livestock farms of organizations tied to the National Commission for Rural Development (CNFR) of Uruguay (Aguerre and Albicette 2018).

The technologies that allow for achieving these results must be financially viable, socially acceptable and evaluated in specific environments, based on a reduced set of quantifiable objectives. From this point of view, agricultural research contributes to society by revealing the "facts and the technological options" that exist. It is often forgotten that social inequity and the inadequate management of natural resources are issues generated by human behavior, and that any effective contribution to overcoming them will depend on the interaction between multiple stakeholders in a negotiation and social learning process (Dogliotti 2012).

Even so, research institutions have an important role to play in agricultural innovation, provided they have long-term strategies, adequate budgets, qualified personnel and effective connections with producers and other stakeholders involved in agrifood systems. Given that much of the budget available for agricultural research for change is allocated to projects, the manner in which these projects are carried out is a key determinant of the pace of transitions towards sustainability. The effective disruption of unsustainable practices through project interventions requires rethinking linear cause-effect relations to include project governance and management approaches based on complex adaptive systems thinking, social learning settings, and monitoring geared to adaptation and learning (Rossing et al. 2021).

2. Background

Traditionally, a linear outlook on the sources and direction of technological change has persisted, with knowledge and technology generation being attributed exclusively to researchers outside of the agricultural system, who design technological solutions that are then transferred by extension workers and adopted by farmers as the result of a linear process (Dogliotti 2012). Under this lens, producers are mere consumers of technologies (Aguerre and Albicette 2018).

This linear model has led to a limited use of many improved agricultural technologies and has been severely questioned. Moreover, it has been partially replaced by systemic approaches under which producers are considered important stakeholders in the knowledge generation process.

It is important to acknowledge the key importance of learning in innovation processes, both "learning by doing" (during the creation process) and "learning by using" (during the use of technology); this fosters a better understanding of research results among producers. At the same time, these exchanges generate new research questions for researchers. Likewise, producers' feedback based on their

use of these technologies in practice, as well as their perception of opportunities and limitations, improve the research process. All of this facilitates innovation processes, in which new solutions to technological issues are co-produced by various stakeholders in an interactive learning process. ***It is important to shift the focus from "technology transfer" to improving farmers' capacity to learn and experiment*** (Dogliotti 2012).

This new paradigm must recognize the tremendous diversity that characterizes farmers, in terms of their access to resources, the conditions under which they must produce, the strategies they prefer to use and the objectives they seek to achieve. Therefore, research and development methods must be able to adapt to this diversity, by creating viable alternatives for different situations, and straying away from a "prototype" or optimal "package" whose message to farmers is "take it or leave it" (Dogliotti et al. 2005).

3. The co-innovation approach

Despite the wealth of analytical knowledge available regarding factors and processes that delay or hinder the transition towards sustainability in various sectors of society, researchers often lack guidance on how to develop knowledge that supports positive change and sustainability. We know that research is carried out within the context of innovation, which is understood to mean the application of knowledge to achieve desired social, ecological or economic outcomes. This knowledge can be acquired through learning, research or experience and can come from a variety of sources and stakeholders; however, it can only be considered an innovation until it has been applied (Aguerre and Albicette 2018).

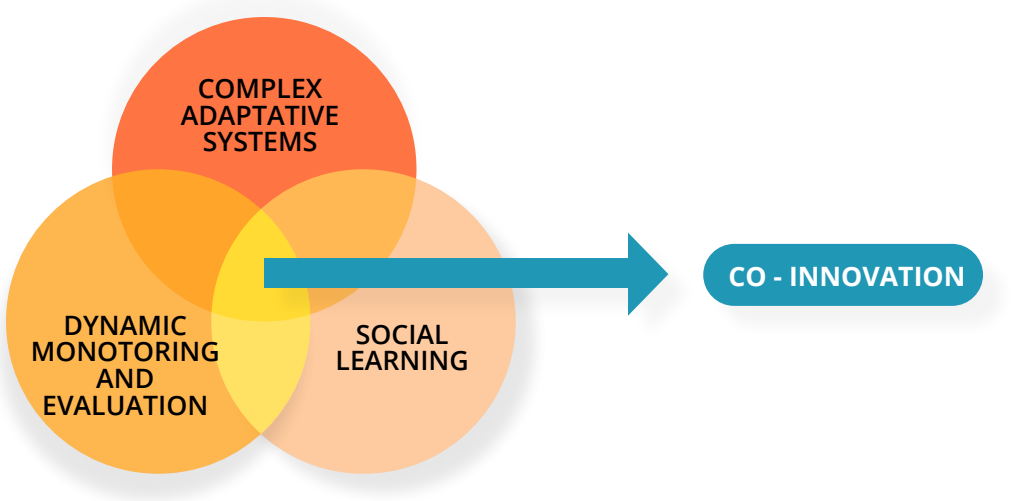
Under the Agricultural Innovation Systems (AIS) approach, innovation is understood to mean the result of a networking and interactive learning process among a heterogeneous group of stakeholders that includes producers, input suppliers, processors, traders, researchers, extension workers, government officials and civil society organizations (Aguerre and Albicette 2018).

In 2007, co-innovation emerged as an approach to governance and the management of change-driven projects, combining three areas: a) a complex adaptive systems perspective, b) a social learning environment, and c) dynamic monitoring and evaluation (Rossing et al. 2021). In co-innovation, cyclical processes of planning, doing, observing and reflecting enable innovation to emerge from interactive learning among stakeholders (Coutts et al. 2016, cited by Aguerre and Albicette 2018).

3.1 The three pillars of the co-innovation approach

From a theoretical standpoint, the co-innovation approach is the result of a combination of three domains (Figure 1): **the complex adaptive systems theory, social learning, and dynamic monitoring and evaluation.** It involves a collective learning process (social learning), within an intentionally designed context (monitoring and evaluation dynamics) and considering a vision of complex adaptive systems (Aguerre and Albicette 2018). This section provides a brief explanation of each of these domains.

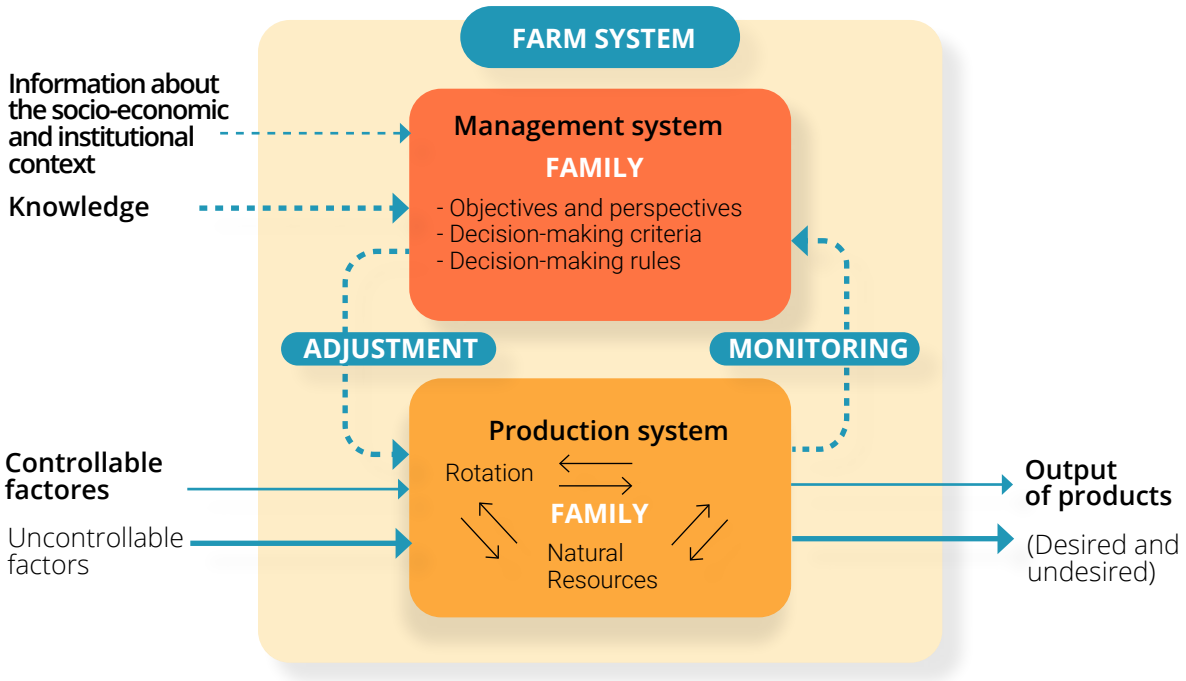
FIGURE 1. The three pillars of the co-innovation approach



Source: Aguerre y Albicette 2018.

Under the co-innovation approach, farms and their context are considered **Complex Adaptive Systems (CAS)**. They comprise multiple components of interconnected systems (farmers, stakeholders, entities), with the capacity to change and learn from experiences, as well as make things happen through their interaction with other stakeholders (Dogliotti 2012). At the farm level, this approach involves an analysis that takes into account two subsystems and their relationship with the environment: a) the management subsystem, which involves the family, its objectives and decision-making processes, and b) the production subsystem, which involves economic, productive and environmental aspects (Aguerre and Albicette 2018).

FIGURE 2. Qualitative model of a family farm



Source: Dogliotti 2012, adapted from Sorrensen and Kristensen 1992.

At the regional level, it implies a broader vision of agricultural innovation, understood as the result of multiple interactions between the components of production systems, supply chains and economic systems, the political context and social systems. This reflects the idea that innovation is the result of the actions of an AIS (Klerkx et al. 2012, cited by Aguerre and Albicette 2018).

Social learning is understood to mean a process that facilitates individual and collective learning through interaction with other individuals or stakeholders to solve a problem. During that process, stakeholders themselves acquire new technical and social skills, produce knowledge and develop relationships. Likewise, the organization of social learning bodies among the various stakeholders (researchers, producers and organizations) makes it possible to generate an appropriate environment in which innovation can occur (Dogliotti 2012). Within this framework, researchers can play a role in supporting stakeholder learning, while also learning themselves.

Learning for innovation involves cognitive learning; that is, learning about "things you previously didn't know about". It also enables mental frameworks to provide a foundation for the search for more creative, collective solutions. In this manner, stakeholders engage with a new technology, develop evolutionary cycles of selection and, through their interactions, combine ideas and experiences in new ways that result in innovations. Successful learning is dependent on all stakeholders coming together early on, enjoying equity and participating fully, without limitation,

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as well as on efforts to facilitate the process. The design and implementation of a social learning process involves thinking, designing and organizing group dynamics, as well as reporting on progress and results (Aguerre and Albicette 2018). That is, the process requires planning, follow-up and monitoring that is conducive to learning.

In co-innovation processes, ***dynamic monitoring and evaluation*** is primarily used to foster learning during the implementation of a program or project, as well as to facilitate accountability and management (Aguerre and Albicette 2018).

In order for the monitoring and evaluation system to contribute to stakeholder learning, stakeholders must periodically reflect on the validity of impact hypotheses and the results achieved not only at the end of the process, but throughout the project's implementation. This allows for incorporating lessons learned in real time, as the process moves forward (Dogliotti 2012). In other words, it is advisable to define, from the outset, the theory of change on which the project will seek to generate an impact, as well as assumptions and monitoring indicators.

The analysis of impact pathways is associated with the development of strategies that provide a "preview" of the project's expected results by working together with the users who will subsequently utilize them. This is the project's theory of change. The expected results serve as the basis for the dynamic monitoring and evaluation process.

To activate reflection processes, it is necessary to facilitate the creation of a learning environment, considering the various stakeholders, their interactions and feedback. In addition to providing opportunities for dialogue, it is also important to

carefully facilitate group processes that allow for addressing the needs of all stakeholders and that enable them to engage in negotiations with one another (Aguerre and Albicette 2018).

3.2. The nine principles for applying the co-innovation approach

Based on the context in New Zealand, Coutts et al. (2014), cited by Aguerre and Albicette (2018), note that co-innovation is context-specific and adaptive; in other words, the manner in which co-innovation is implemented must be tailored to the particular situation, which will also change over time. Nine principles that can facilitate co-innovation have been identified, and are listed below (Coutts et al. 2017, 2016; cited by Aguerre and Albicette 2018):

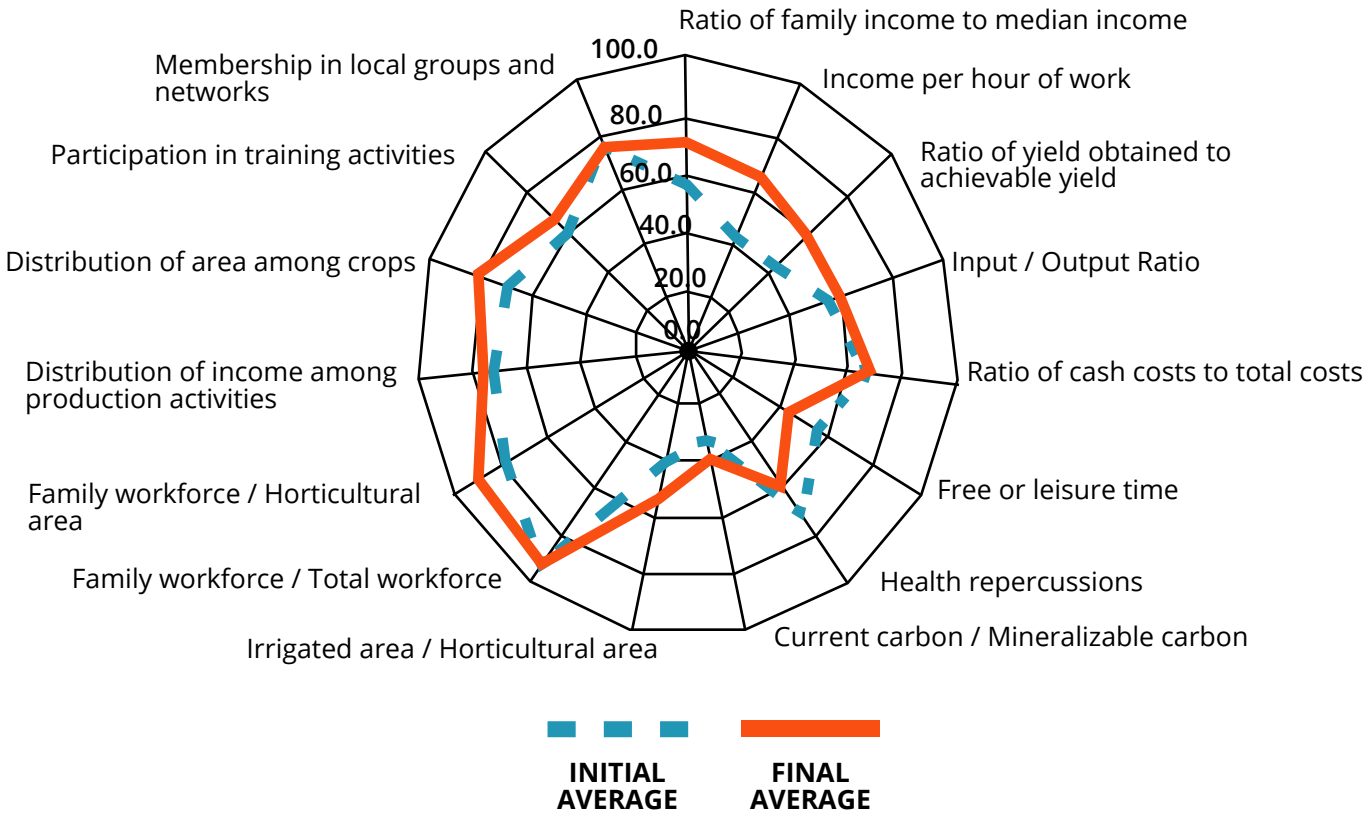
1. **TAKE TIME** to understand the problem from many different views.
2. **BE INCLUSIVE** – ensure everybody is present who needs to be there in order to understand the problem, its causes and to develop workable solutions.
3. **ENGAGE** with and value all sources of knowledge – seek new insights and take the time to listen to all the different perspectives.Mantener la visión compartida o la "ambición de cambio", refrescándola periódicamente.
4. **STRIVE** to learn from each other by actively listening and understanding – be open to new ideas by being willing to let your own understanding and perspectives evolve.Tener en cuenta el contexto más amplio del problema y cualquier cambio real o potencial que pueda ocurrir.
5. **KEEP SIGHT** of the shared vision or 'ambition for change' and update it periodically.
6. **BE HONEST**, open and constructive in your interactions with other participants.Seguir el proceso de coinnovación a pesar de las frustraciones.
7. **BE AWARE** of the wider context of the problem and any actual or potential changes which may occur.
8. **BE FLEXIBLE** and adaptable.
9. **STICK** with the co-innovation process despite its frustrations.

4. Results achieved by applying the co-innovation approach

The European Latin-American Project for Co-Innovation of Agro-ecosystems (EULACIAS), which focused on fostering the strategic reorientation of 16 family horticultural and horticultural-livestock farms as part of three case studies in Latin America, set a relevant precedent for projects designed under the co-innovation approach. One of the case studies of the project involved horticultural and livestock producers in Uruguay (Dogliotti 2012).

The case study in Uruguay demonstrated the potential of co-innovation to improve certain farm sustainability indicators. For instance, organic matter in soil increased by an average of 26%, the ratio of yield obtained versus achievable yield improved by 39%, family income rose by 51%, and family productivity grew by 53% (Dogliotti 2016). These and other impacts are summarized in Figure 3.

FIGURE 3. Impact on sustainability in farms



Source: Dogliotti 2016.

Between 2012 and 2015, Uruguay's INIA adopted this methodology in its coordination efforts with producers' organizations such as CNFR, which is primarily comprised of family farmers. The joint efforts, which focused on seven family livestock breeding farms in regions vulnerable to climate change, yielded positive results in terms of redesigning the production systems.

Among the noteworthy results of this experience in the seven farms in Rocha is an average 23% increase in meat production, a 56% increase in net income (at 2014-2015 prices) and a 25% reduction in animal and pasture management tasks (Albin 2016). Meat production increased in all but one farm. From an environmental standpoint, considerable increases in forage height were observed on natural fields in all cases, with the exception of the farms that already had more forage available. From a social standpoint, relevant improvements were achieved in the use of proposed technologies, as well as in assessments and planning (Aguerre and Albicette 2018).

Subsequently, a project was carried out together with the government of New Zealand and organizations in that country to exchange experiences related to co-innovation in livestock farming. The Uruguayan government is currently implementing its Climate-Smart Livestock Farming project (GEF), while CNFR is implementing its Resilient Family Livestock Farming project (Euroclima+EU), with a view to scaling up co-innovation in livestock farming. Both projects, in which INIA is involved as a partner entity, have achieved excellent progress thus far.

Rossing et al. (2021), in turn, highlight recent progress achieved in New Zealand through the Primary Innovation project, which applies the co-innovation approach to address the current challenges of modern agriculture. This approach has been gaining momentum in recent years as a way to foster innovation and learning in agriculture and in natural resource management.

In general, all of these experiences allow for asserting that (Rossing et al. 2021):

The most significant contributions to the transition towards sustainability were associated with in-depth project planning, an approach applied at the farm level rather than at the crop or field level, connections established throughout the course of the project with stakeholders involved in the regional innovation system, and the facilitation of frequent interaction between the project and stakeholders to reflect on results, the broader implications of the system, and the management of the project.

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