

**Understanding Farmers' Perception of Integrated Crop Livestock System Through Participatory Modeling Approach**

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### Introduction, purpose and objectives

Integrated Crop Livestock Systems (ICLS) are a type of sustainable agricultural practice (SAP) that promotes mixed farming of crops and livestock and the sharing of farm resources to enhance production and environmental benefits. Environmental benefits include reduction of nitrate leaching (Santos et al., 2023), improvement in overall land productivity and stability of production (de Albuquerque Nunes et al., 2021), enhancement of soil's chemical and biological properties (Valani et al., 2020), and reduction in the intensity of greenhouse gas emissions (de Souza Filho et al., 2019). Producer attitudes and environmental awareness are reported as predictors for the adoption of SAP (Mishra et al., 2018). However, farmers' attitudes and perceptions of ICLS are poorly understood (Garrett et al., 2017; Foguesatto et al., 2020). Understanding the perception of those designing and conducting the interventions as well as the target beneficiaries, is crucial. Pufall Jones et al. (2016) described that the lack of alignment in needs and vision among different levels of the community and collaborative entities results in limited or no social outcomes. Alderkamp et al. (2025) argue that limited or weak social outcomes in ICLS are linked to misalignments that arise as farmers juggle competing operational demands within collaborative arrangements while perceiving institutional policies and support as disconnected from practical realities, leading to communication that does not align with their decision-making processes or address their core concerns. Consequently, these disconnects create friction in collaborative efforts, foster uncertainty, heighten perceived risk, and undermine confidence in the viability of ICLS, ultimately slowing or creating barriers to ICLS adoption.

Nowell (2010) found that not acknowledging a lack of alignment among stakeholders can have harmful effects over time, weakening trust, reducing commitment, and undermining the collective capacity to achieve shared goals. They suggested putting intentional effort into understanding the alignment and misalignment to build a shared framework and ensure conceptualization of an effective and viable program.

Our study aims to understand the similarities and differences in perceptions of ICLS among farmers/ranchers from various sociocultural groups and between farmers/ranchers and agricultural service providers. The specific objectives of the project are to:

1. Examine producers' and agricultural service providers' perceptions of ICLS.
2. Identify similarities and differences in perceptions of ICLS between producers and agricultural service providers

### Methods

This study uses a non-experimental and cross-sectional research design. Participants were recruited using purposive sampling. Crop farmers (n = 3), ranchers (n = 3), facilitators (n = 5), Extension agents and technical support (n = 4), and industry personnel (n=2) participated in the study.

Conceptual Content Cognitive Map (3CM), a method of mental modeling, was used to assess the participants' perception of ICLS. The recommendations from Kearney (2015) were

followed to develop the research instrument, which included positioning participants in a hypothetical scenario, briefly introducing the topic (ICLS in our study), and asking participants to share their unique perspectives by organizing cards with terms related to ICLS. We gave participants a deck of cards and, based on the prompt, asked them to sort the cards following the four steps (Hundemer & Monroe, 2020; Kearney, 2015): (1) to go through each of the cards in the deck and separate them into two piles, one pile included terms that they would use in their response to the prompt, and another pile included terms they would not use (discards); (2) asked participants to add any additional terms that they would include in response to the prompt; (3) to divide the cards into clusters of terms that logically go together; and (4) to assign a name to each group of terms.

The 3CM data was entered into a text file in *Windows Notepad* (Version 21H2; Microsoft Corporation, 2021). Then the file was imported into statistical software *ANTHROPAC* (Version 4.98; Analytic Technologies, 2014) to identify the commonalities in mental maps of stakeholders (Borgatti, 1992). Two separate composite mental maps were created for producers (row crop growers and ranchers) and agricultural service providers (advisors, agents, facilitators, and industry).

### Results/Findings

For producers, profit, risk management, soil health, diversity of income, environmental conservation, and creating opportunities for the next generation were the major motivators for ICLS adoption. The mean for these items was 10 or above, indicating producers assigned 10% or more of the total 100% to these items. For agricultural service providers, profit, soil health, environmental conservation, diversity of income, and risk management were the major motivators, with a mean of 10 or above.

The eigenvalue ratio of producers' mental model was 246.94, and that of agricultural service providers was 29.9. This high eigen ratio indicates internal consensus among stakeholders about important factors to consider for establishing ICLS. The clusters indicate key domains that structure groups' understanding of ICLS. Producers' composite mental model had eight clusters: *regulation, specialized farming, farming support, economics, land structure, infrastructure, production practices, and farming experiences*. Agricultural service providers had 11 clusters: *regulation, climate, specialized farming, economics, trust, market security, technical support, sustainable practices, management practices, infrastructure, and land tenure*. Producers' and agricultural service providers' mental models differ in the way agricultural service providers have a distinct cluster with less overlap than producers. Producers do not recognize climate as a consideration for establishing ICLS.

### Implications

The findings of this study shed light on the differences in perceptions about ICLS among producers of various socio-cultural backgrounds and between producers and agricultural service providers. These findings will provide insight into effective strategies for designing tailored programs to address the existing (mis)perceptions of ICLS. Also, the findings are useful for future researchers to further uncover the reasons behind the existing perceptions and identify the best ways to design effective programs.

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