Rural Women And Agri-Food Resilience In Boyacá: Agroecological Practices, Community Leadership And Challenges For Sustainable Development

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Abstract
This study analyzes the role of rural women in building resilient agri-food systems in the department of Boyacá, Colombia, through the adoption of agroecological practices and community leadership strategies. The present study was predicated on a mixed-method approach, which entailed the administration of surveys to 38 producers and the conduction of semi-structured interviews with 15 leaders involved in local sustainable production initiatives. The findings indicate that practices such as crop rotation and association, the utilization of organic fertilizers, effective water management, and the conservation of native seeds play a substantial role in ensuring food security and achieving productive autonomy. Concurrently, limitations associated with restricted land ownership, constrained access to financing, and circumscribed coverage of technical training are identified. The study's findings indicate that the empowerment of women's networks and the proactive integration of their organizations into territorial planning are indispensable for the proliferation and fortification of these practices. The results obtained are consistent with the objectives of Sustainable Development Goals 2, 5, 12, 13, and 15. These results provide a foundation for the formulation of public policies that are designed with a gender focus and territorial relevance.
Keywords: agroecology, resilience, rural women, sustainable development, Boyacá.

RESUMEN
Este estudio analiza el papel de las mujeres rurales en la construcción de sistemas agroalimentarios resilientes en el departamento de Boyacá, Colombia, mediante la adopción de prácticas agroecológicas y estrategias de liderazgo comunitario. A partir de un enfoque mixto, se aplicaron encuestas a 38 productoras y entrevistas semiestructuradas a 15 lideresas vinculadas a iniciativas locales de producción sostenible. Los resultados evidencian que la rotación y asociación de cultivos, el uso de abonos orgánicos, el manejo eficiente del agua y la conservación de semillas criollas contribuyen de manera significativa a la seguridad alimentaria y a la autonomía productiva. Asimismo, se identifican limitaciones asociadas a la baja titularidad de la tierra, el acceso restringido a financiamiento y la escasa cobertura de capacitación técnica. Se concluye que el fortalecimiento de las redes de mujeres y la inclusión activa de sus organizaciones en la planificación territorial son condiciones esenciales para escalar y consolidar estas prácticas. Los hallazgos se enmarcan en los Objetivos de Desarrollo Sostenible 2, 5, 12, 13 y 15, y sustentan recomendaciones para el diseño de políticas públicas con enfoque de género y pertinencia territorial.
Palabras clave: agroecología, resiliencia, mujeres rurales, desarrollo sostenible, Boyacá.

INTRODUCTION

The socioeconomic and environmental transformations affecting the Colombian rural sector have underscored the necessity to fortify agri-food systems capable of adapting to climate variability, ensuring food security, and promoting gender equality. In this context, rural women in Boyacá play a central role in combining traditional knowledge, social innovation, and adaptive strategies aimed at sustainability. Their contributions are evident not only in food production and the preservation of natural resources, but also in community cohesion and the transmission of intergenerational knowledge.

A multitude of studies have underscored the efficacy of agroecological practices, including crop rotation and association, the employment of organic fertilizers, and the conservation of native seeds, in enhancing productivity, reducing reliance on external inputs, and fortifying the resilience of rural communities (Altieri & Nicholls, 2017; FAO, 2020). However, structural constraints related to access to land, financial resources, and technical training persist, which hinder the consolidation of these processes (Agarwal, 1997; Duflo, 2012).

The objective of this study is to analyze the role of rural women in Boyacá in the construction of resilient agri-food systems. To that end, the study will first identify the agroecological practices implemented, as well as the factors that enhance or restrict their impact. Then, it will determine the strategies necessary to strengthen their sustainability and scalability.

THEORETICAL FRAMEWORK

Agroecology has been established as a comprehensive approach that combines ecological, social, and economic principles for the design and management of sustainable agricultural systems (Altieri & Nicholls, 2017). This paradigm suggests that productive diversification, the efficient use of natural resources, and the integration of local knowledge serve as mechanisms to reduce dependence on external inputs and increase resilience to climate and market fluctuations.

In Latin America, the concept of agroecology has emerged as a multifaceted approach, transcending its traditional role as a mere production strategy. It has been recognized as a pivotal instrument for social transformation and community empowerment, particularly among rural women (FAO, 2017). The active incorporation of these women in planning and decision-making processes strengthens the social fabric, favors the transmission of intergenerational knowledge, and enhances local innovation (Castañeda & Barrantes, 2020).

The concept of agri-food resilience, as defined by the Food and Agriculture Organization (FAO), refers to the capacity of food production and distribution systems to anticipate, adapt, and recover from shocks, thereby maintaining their functionality and ensuring access to nutritious and culturally appropriate food (FAO, 2020). The concept of resilience is influenced by various factors, including agricultural biodiversity, efficient resource management, access to support networks, and community participation (Nicholls & Altieri, 2019).

A growing body of research has demonstrated that agroecological practices, encompassing crop rotation and association, the utilization of organic fertilizers, sustainable water management, and the conservation of landraces, have the potential to enhance the productivity and stability of agricultural systems. Moreover, these practices can contribute to the promotion of gender equity by acknowledging and recognizing the contributions of women in the agricultural sector (Agarwal, 1997; Duflo, 2012).

In the case of Colombia, research on rural women and agroecology highlights the need for public policies with a gender focus that guarantee access to productive resources, facilitate technical training, and promote cooperation networks among women producers (Escobar & Rodríguez, 2021). This conceptual framework undergirds the importance of examining the experiences of rural women in Boyacá. Such an analysis is pertinent for two reasons. First, it allows for the documentation of their practices and challenges. Second, it provides evidence that can be used to guide the design of sustainable and equitable rural development strategies.

METHODOLOGY

This study employed a mixed approach, combining both descriptive and exploratory methods. It utilized a combination of quantitative and qualitative techniques to obtain a comprehensive understanding of the role of rural women in the agri-food resilience of Boyacá.

Design and participants

The quantitative phase of the study involved the administration of a structured survey to 38 female producers residing in various municipalities of Boyacá. These producers were selected through a non-probabilistic sampling method for convenience. The inclusion criteria were as follows: The population under study must meet the following criteria: (a) they must reside in rural areas of the department, (b) they must actively participate in agricultural activities, and (c) they must have at least two years of experience in agricultural practices. The questionnaire is made up of 28 items distributed in five dimensions: sustainable agricultural practices, productive empowerment, access to resources, community participation, and perception of territorial resilience. The instrument was validated by a panel of specialists in agroecology and gender studies, and it demonstrated a high internal consistency (Cronbach's alpha = 0.89).

In the qualitative phase of the study, 15 semi-structured interviews were conducted with community leaders and representatives of rural women's organizations involved in agroecological production processes and local marketing. The selection was made using the snowball technique, with geographical diversity and productive activities given priority.

Instruments

The survey incorporated both closed and Likert-scale inquiries, with the objective of ascertaining agroecological practices, levels of productive autonomy, and perceptions of climate change. The questionnaire was validated by three experts in the fields of agroecology and gender. The surveys were administered in person during site visits to the participants' farms, thereby ensuring the provision of informed consent and safeguarding the confidentiality of the collected data. The semi-structured interviews were conducted with the objective of addressing the following research questions: first, what are the experiences of participants in the implementation of sustainable practices? Second, what are the characteristics of collaborative networks? Third, what are the characteristics of community leadership? And finally, what are the barriers to accessing productive resources?

Data analysis

The quantitative data were analyzed using descriptive statistics (frequencies, percentages, and measures of central tendency) with the assistance of SPSS software version 26. Thematic analysis was employed to process the interviews, with the assistance of the Atlas.ti version 9 software. This approach facilitated the identification of emerging categories pertaining to agroecological practices, resilience, and community leadership. Despite the implementation of a systematic analysis of the interviews, the qualitative results are utilized solely as inputs to contextualize and complement the information obtained from the surveys.

RESULTS

The following findings are derived from the analysis of surveys administered to 38 rural women from the five horticultural centers of Boyacá. The testimonies obtained from the 15 interviews with community leaders have been incorporated as illustrative material to contextualize the quantitative data. This incorporation is explicit when the testimonies are used to exemplify a finding.

1. Sustainable agricultural practices

The majority of respondents implement actions aimed at improving soil health, optimizing the use of resources, and reducing dependence on external inputs. The most prevalent practice was crop rotation and association (27/38; 71.05%), followed by the production of organic fertilizers (24/38; 63.16%) and rational water management by drip irrigation, ditches, or rainwater harvesting (22/38; 57.89%). However, the study also found that less than half of the participants reported saving native seeds (16 out of 38, or 42.11%) or implementing biological pest control methods without the use of pesticides (15 out of 38, or 39.47%).

Table 1 *Agroecological practices implemented by the participants (n = 38)*

Agroecological practice	**Frequency**	**%**
Crop rotation and association	27	71
Use of organic fertilizers	24	63
Sound water management	22	58
Conservation of native seeds	16	42
Biological pest control (without pesticides)	15	40

Note. *Percentages were calculated on the total number of participants (n = 38).*
Source*: Authors' elaboration based on research data.*

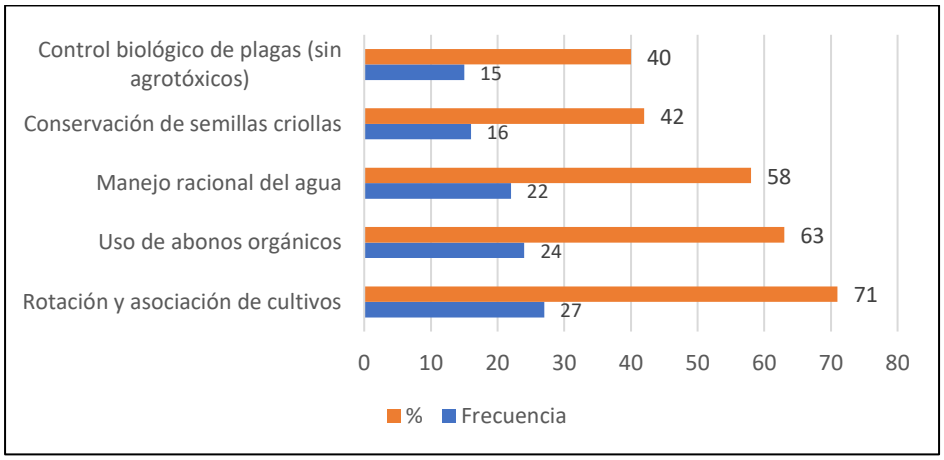

Figure 1. *Percentage distribution of marketing channels used by women farmers (n = 38)*
Note. *The data come from surveys applied in the five horticultural centers of Boyacá.*
Source*: Authors' elaboration based on research data.*

2. Origin of agroecological knowledge

More than half of the respondents (21/38; 55.26%) indicated that their knowledge comes from direct empirical experience**.** 26.32% (10/38) attributed them to family or community networks, while 13.16% (5/38) mentioned institutional training and 5.26% (2/38) indicated formal academic training**.**

Table 2 *Source of knowledge on sustainable practices (n = 38)*

Source of knowledge	Frequency	%
Empirical experience	21	55,3
Family or community networks	10	26,3
Institutional training	5	13,2
Academic background	2	5,3

Note. Absolute and relative frequencies were presented over the total number of participants (n = 38).
Source: Authors' elaboration based on research data.

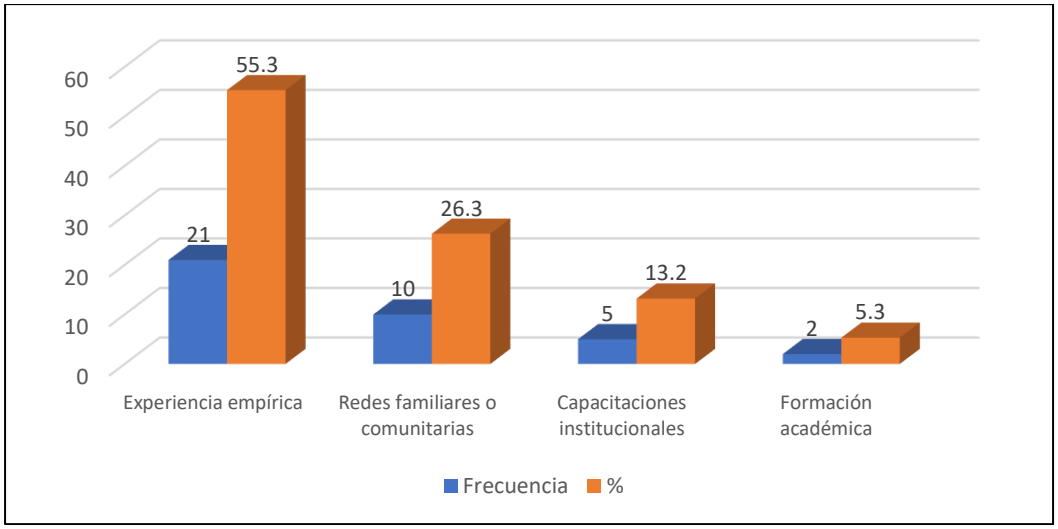

Figure 2 *Sources of knowledge (n = 38)*
Note. *It includes data on land ownership, access to credit and technical training received.*
Source*: Authors' elaboration based on research data.*

3. Access to productive resources

Structural limitations are evident: 68.42% (26/38) do not have a property title, only 26.32% (10/38) have accessed formal agricultural credit and only 11.84% (4/38) received technical training in the last three years. *Qualitative fact*: in the interviews, several leaders pointed out that the lack of property title limits not only access to credit, but also the possibility of entering state support programs.

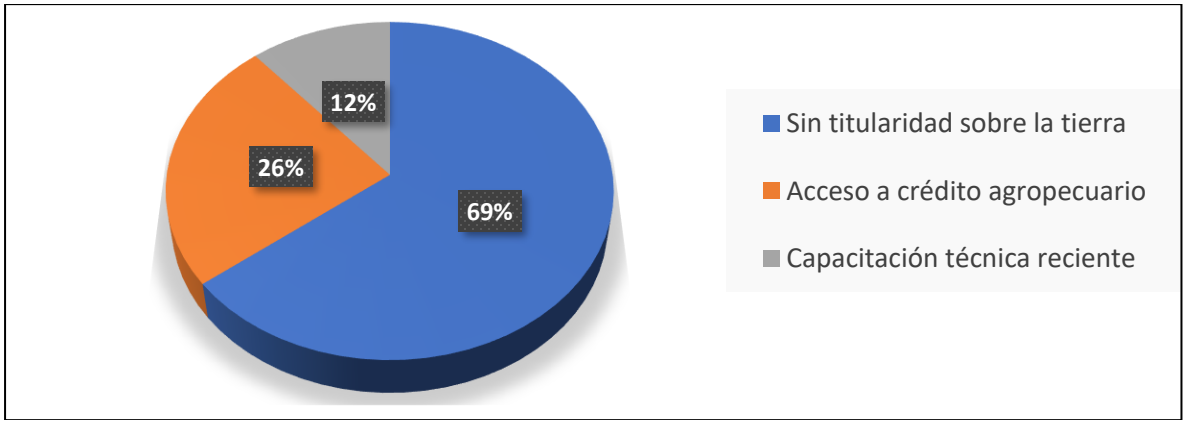

Figure 3 *Access to productive resources in the five study areas (n = 38)*
Note. *It includes data on land ownership, access to credit and technical training received.*
Source: *Authors' elaboration based on research data*

4. Marketing

The predominant channel is direct sales in local markets (65.79%, 25/38), followed by informal orders (21.05%, 8/38) and participation in fairs (10.53%, 4/38). Only one participant (2.63%) reported access to specialized channels. *Qualitative data*: the interviewees emphasized that direct sales allow higher profit margins, but limit the volume marketed and income stability.

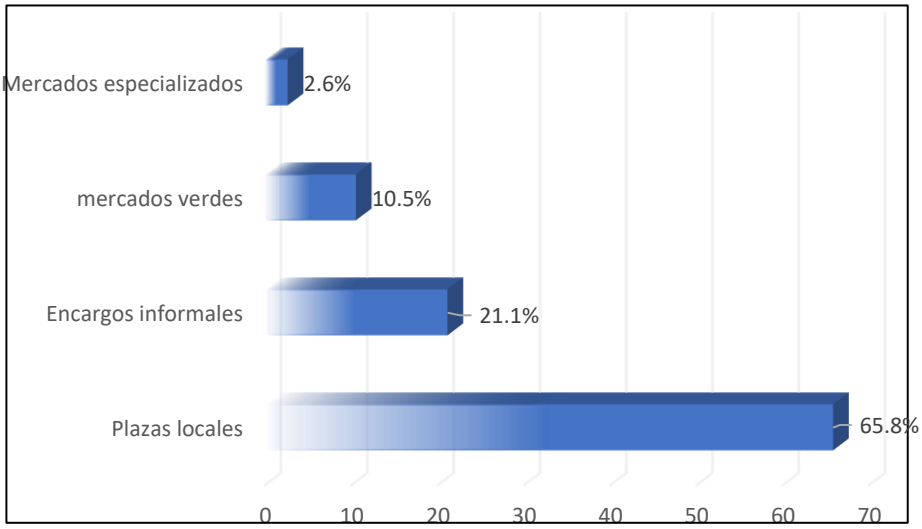

Figure 4 *Marketing channels used by women farmers (n = 38)*

Note. *The predominance of direct sales in local markets over other channels is observed.* ***Source****: Authors' elaboration based on research data.*

5. Community Engagement

Of the total number of respondents, 52.63% (20/38) belong to women's networks or associations, but only 31.58% (12/38) hold leadership positions.

Table 3 Community participation (n = 38).

Indicator	**%**
Membership of networks or associations	52,6
Holding leadership positions	31,6

Note. The predominance of the participation of associations is observed. **Source**: Authors' elaboration based on research data.

6. Perception of agri-food resilience

A significant proportion considers that the sustainable practices adopted have improved their capacity to cope with droughts and shortages of inputs (71.05%, 27/38), have strengthened the food security of their households and communities (65.79%, 25/38) and have increased their productive autonomy (57.89%, 22/38). *Qualitative data*: the interviews reflect that these practices also strengthen women's self-esteem and negotiation skills within their communities.

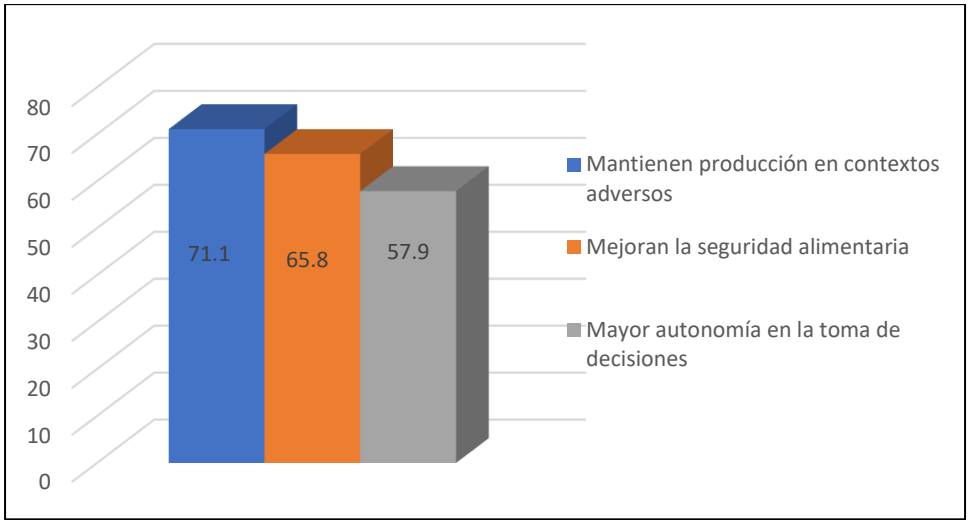

Figure 5 *Participants' perception of agri-food resilience (n = 38)*
Note. *It shows the percentage of women farmers who perceive improvements in food security, autonomy and adaptation to climatic events.*
Source: *Authors' elaboration based on research data.*

Regarding the agroecological practices implemented, crop rotation and association was the most frequent, with 27 out of 38 participants (71.05%), and a 95% confidence interval ranging from 56.63% to 85.47%, indicating that the true proportion in a similar population is likely to be within this range. Regarding the use of organic fertilizers, 24 participants (63.16%) reported applying it, with a confidence interval between 47.82% and 78.50%, reflecting a relatively high level and adequate confidence in the estimate. In relation to the rational management of water, 22 participants (57.89%) implemented this practice, with a wide confidence interval ranging from 42.20% to 73.59%.
On the other hand, the preservation of native seeds was adopted by 16 participants (42.11%), with a confidence interval between 26.41% and 57.80%, which indicates that less than half use it, with moderate confidence. Finally, biological pest control was the least implemented practice, with 15 participants (39.47 %) and a confidence interval between 23.93 % and 55.02 %, which shows a lower adoption and greater uncertainty in this estimate.

Table 3 Agroecological practices implemented and their confidence intervals (n = 38)

Agroecological practice	Frequency	%	95% lower CI	95% higher CI
Crop rotation and association	27.00	71.05	56.63	85.47
Use of organic fertilizers	24.00	63.16	47.82	78.50
Sound water management	22.00	57.89	42.20	73.59
Conservation of native seeds	16.00	42.11	26.41	57.80
Biological pest control	15.00	39.47	23.93	55.02

Note. CI = confidence interval. Source: Authors' elaboration based on research data.

DISCUSSION

The findings indicate that rural women in the horticultural centers of Boyacá play a pivotal role in the adoption and sustainability of agroecological practices. This observation aligns with the conclusions reported by Altieri and Nicholls (2013) and Nicholls and Altieri (2019) regarding

the significance of productive diversity and ecological management in the resilience of agroecosystems. The high frequency of crop rotation and association (71.05%) and the production of organic fertilizers (63.16%) suggest a significant appropriation of techniques that do not depend on external inputs. This has the dual benefits of reducing costs and increasing productive autonomy.

From a gender perspective, the analysis indicates that participation in networks and associations (52.63%) and leadership (31.58%) reflect progress, but also show gaps, in line with what the Food and Agriculture Organization (FAO) (2017) and Quisumbing and Pandolfelli (2010) have pointed out regarding the structural barriers that women face in accessing decision-making positions. The qualitative interviews confirmed that, although community participation is valued, female leadership continues to be conditioned by factors such as domestic burden, unequal access to resources, and the scarce presence of training programs with a gender approach.

With respect to access to productive resources, the high percentage of women without land titles (68.42%) and with limited access to credit (26.32%) aligns with findings from prior studies in Andean contexts (Escobar & Rodríguez, 2021). These studies underscore the role of land tenure conditions in determining access to financing and state support programs. The testimonies of women leaders indicate that this limitation impacts not only the investment capacity of women farmers, but also their social recognition as formal producers.

The positive perception of agri-food resilience, especially in the face of droughts and shortages of inputs, aligns with the concept of resilience proposed by Janssen and Ostrom (2004). This concept is understood as the capacity to adapt and maintain the functionality of the system in the face of shocks. However, the interviews indicate that these capacities are predominantly maintained through community engagement and the exchange of knowledge, rather than through sustained institutional support.

The findings indicate that, while the agroecological practices employed by the women of Boyacá enhance food security and resilience, their expansion and long-term sustainability necessitate more coherent public policies that incorporate access to productive resources, capacity building, and active promotion of female leadership. The combination of productive, organizational, and advocacy strategies could be pivotal in achieving fairer, more resilient, and sustainable agri-food systems in the region.

CONCLUSIONS

The present study demonstrates that rural women in Boyacá assume a pivotal role in the construction of resilient agri-food systems, a feat accomplished through the implementation of sustainable agricultural practices that integrate traditional knowledge, social innovation, and adaptive strategies in the face of climate change. The implementation of practices such as crop rotation, the utilization of organic fertilizers, efficient water management, and the conservation of native seeds has been demonstrated to yield several benefits, including enhanced productivity, strengthened productive autonomy, and enhanced local food security.

The present study explores the role of women's networks and community leadership in the dissemination of agroecological knowledge and social cohesion. Despite the emergence of these factors, structural barriers persist. These barriers include low land ownership, limited access to credit, and limited coverage of technical training. These barriers condition the possibility of scaling up these practices and require comprehensive interventions.

In this context, the findings are directly aligned with the Sustainable Development Goals of the 2030 Agenda, especially SDG 2 (Zero Hunger), by contributing to food security through sustainable food production; SDG 5 (Gender Equality), by making visible and strengthening the role of women in agriculture and territorial management; SDG 12 (Responsible Production and Consumption), by promoting practices that reduce the use of external inputs and optimize resources; SDG 13 (Climate Action), by implementing adaptive strategies in the face of climate variability; and SDG 15 (Life on Land), by protecting agricultural biodiversity through the conservation of native seeds and sustainable management of soil and water.

In light of these findings, it is recommended that public policies aimed at fostering rural development with a gender focus prioritize the enhancement of technical training programs in agroecology and business management for rural women, as well as the establishment of flexible financing mechanisms adapted to family farming. Furthermore, it is imperative to develop strategies for the formalization of land tenure and the active inclusion of women's organizations in territorial planning and climate adaptation plans. To ensure the sustainability of these initiatives, it is proposed that participatory monitoring and evaluation processes be developed. In these processes, farmers themselves can measure the impact of their practices and identify continuous improvements. It is imperative that future research employ longitudinal designs to evaluate the evolution of agri-food resilience over time. Such designs would also facilitate comparative studies between Andean regions, thereby broadening the evidence base and fortifying public policy recommendations.

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