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# Socio-Technical Dynamics of Mexican Rural Extension: Systematizing Productive, Organizational, and Psychoeducational Shifts

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**Abstract**

Research on rural development in Mexico has paid limited attention to the systematization of technical assistance within a socio-technical systems framework. This study critically evaluates the productive, economic, organizational, and psychoeducational impacts of rural extension programs in Mexico during 2022–2026, examining interactions among actors, institutions, and technologies. A qualitative systematic literature review with a structured documentary design examined eight peer-reviewed studies alongside institutional datasets published between 2022 and 2026. Evidence was extracted using thematic matrices and analyzed through content analysis and descriptive synthesis of reported econometric findings, including results from generalized additive models for location, scale, and shape and Bayesian additive regression trees. The reviewed evidence indicated a transition from linear technology transfer toward interactive socio-technical systems. Reported economic outcomes included an average 21% increase in smallholders' net income and a 15% reduction in production costs. The synthesis also identified improvements in collective organization and gender equity, with women representing 58.2% of active program beneficiaries. These findings contribute to socio-technical transition theory and agricultural innovation systems by highlighting the interactive and multidimensional character of rural extension. The study concludes that extension programs should integrate multidisciplinary expertise, psychoeducational support, and financial components. Policy implications include securing sustained financing, revising university agronomy


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curricula, and strengthening territorial cooperatives to support long-term food sovereignty.

**Keywords:** Rural Extension; Socio-Technical Systems; Agricultural Innovation; Smallholder Agriculture; Mexico

## INTRODUCTION

The Mexican agricultural sector is characterized by profound structural heterogeneity and vast biocultural diversity, playing a strategic role in national food sovereignty and the sustenance of rural livelihoods. However, this sector faces persistent and multidimensional structural challenges that severely limit its sustainable development. Among these critical issues, the most prominent are the low productivity of small- and medium-scale farming units, the accelerated degradation of natural resources, the fragmentation of value chains, asymmetric market power, and historical barriers to accessing technical services and financial resources tailored to local conditions. In this context of heightened socio-environmental vulnerability, which has been exacerbated by the global impacts of climate change, rural extension has historically emerged as a fundamental instrument of public policy to induce technical change, promote socio-productive innovations, and strengthen the resilience of rural communities.

Historically, rural extension services in Latin America, and particularly in Mexico, have been simplistically conceptualized as linear technology transfer mechanisms. Under this traditional paradigm, the primary goal was to disseminate closed, pre-packaged scientific knowledge and chemical-heavy technological packages developed in central academic laboratories directly to passive farmers. However, contemporary research on agricultural innovation has demonstrated that these linear, diffusionist, and highly vertical models are fundamentally inadequate for addressing the complex socio-ecological realities of rural production. Linear transfer models assume cognitive passivity on the part of the producer and systematically dismiss the rich corpus of traditional peasant knowledge. This mismatch has historically resulted in extremely low technology adoption rates and a systematic disconnect between proposed innovations and the real, territorialized needs of smallholders. In response to these limitations, recent literature (2022–2026) proposes a paradigm shift, reconceptualizing extension through the lens of socio-technical systems. This perspective views extension as an interactive process of co-design, knowledge co-production, and innovation network construction where scientific, empirical, and traditional knowledge

interact horizontally.

Over the past few decades, the institutional design of rural extension policies in Mexico has experienced severe programmatic oscillations. Following the dismantling of state-run, centralized technical assistance services during the neoliberal reforms of the late twentieth century, the government progressively outsourced extension services to market-based models. These private models relied on temporary subsidies granted to private professional service providers, which severely fragmented the continuity of technical support and eroded relationships of trust with smallholders. Recently, under national guidelines aimed at rescuing the agricultural sector and achieving domestic food self-sufficiency, public policy has attempted to build a new paradigm of state-supported extension. These contemporary strategies prioritize dialogue of saberes (knowledge dialogue), agroecological transition, and the strengthening of rural associativity. Nevertheless, intense debates persist regarding the consistency of their impacts, actual territorial coverage, scientific evaluation, and the institutional tensions arising from their implementation in highly diverse territories.

The scientific literature from the 2022–2026 period has documented these transformations in a fragmented manner. While some studies focus on quantitative, econometric evaluations of economic impacts and yield increases derived from technical support, other investigations of a sociological, institutional, and psycho-educational nature explore how these interventions trigger changes in mindset, community cohesion, and social capital. Despite these contributions, a significant research gap persists: the lack of systematic, integrative reviews that synthesize the scientific evidence generated under a socio-technical transition framework. Most available analyses are limited to regional, short-term case studies or descriptive sectoral reports, lacking a critical synthesis that links technical changes to broader socio-institutional and psychological dynamics. This gap limits the ability of policymakers to identify common success factors, institutional bottlenecks, and evidence-based policy implications at the national level.

To address this gap, this study offers a substantial novelty by conducting a systematic review of the peer-reviewed scientific literature and institutional evaluations published over the last five years (2022–2026). By using the theoretical framework of Socio-Technical Innovation Systems and the Multi-Level Perspective (MLP), this framework allows us to unravel how interactions between social components (networks of producers, cooperative organizations, extension agents, and gender dynamics) and technical components (bio-

inputs, soil conservation, and financial credit) configure protected niches of innovation. These niches, in turn, have the potential to challenge and transform the dominant, unsustainable agricultural socio-technical regime in Mexico. By integrating and coding qualitative and quantitative data from cutting-edge empirical research, this systematic review provides an integrated macro-perspective that transcends the geographic and thematic limitations of individual studies.

Therefore, the main objective of this article is to critically analyze the role of rural extension in Mexico during the 2022–2026 period as a socio-technical catalyst for innovation and sustainable agricultural development. Specifically, the study aims to: (1) systematize the economic and productive impacts of extension reported in contemporary literature; (2) identify the dynamics of technology appropriation, rural associativity, and gender inclusion promoted by participatory models; (3) discuss the institutional, cultural, and training bottlenecks that limit or enhance the success of these programs; and (4) propose strategic guidelines for the design of future agricultural extension policies in the Mesoamerican and wider Latin American context.

## METHODS

To ensure scientific rigor, reproducibility, and transparency, this research was designed as a Systematic Literature Review (SLR) in strict accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, adapted for the social and agricultural sciences. This systematic approach minimizes selection bias, structures an exhaustive database search, and facilitates a critical synthesis based on validated scientific evidence. The study focuses specifically on peer-reviewed literature published between January 2022 and July 2026, capturing the most recent socio-technical, methodological, and public policy dynamics within Mexican rural extension.

### Search Strategy and Information Sources

The systematic literature search was conducted between May and June 2026 across major scientific databases relevant to the Latin American agricultural context, including Google Scholar, Redalyc, SciELO Mexico, and the Institutional Repository of the National Council of Humanities, Sciences and Technologies (CONAHCYT). Google Scholar was utilized as a primary search engine due to its proven capacity to index high-quality regional literature, technical institutional reports, and journal articles that are often omitted from

commercial, Anglo-centric databases but represent the vanguard of rural sociology and agricultural development in Mexico.

The search strings were constructed using Spanish and English keywords combined with Boolean operators (AND, OR). The core search terms included: *"extensionismo rural"*, *"asistencia técnica agrícola"*, *"sistemas sociotécnicos"*, *"innovación agrícola"*, *"desarrollo rural sustentable"*, *"asociatividad"*, *"México"*, *"rural extension"*, *"socio-technical systems"*, and *"agricultural innovation"*. A representative example of the search equation adapted for database engines was:

("extensionismo rural" OR "asistencia técnica") AND ("sistemas sociotécnicos" OR "innovación") AND "México"

with temporal filters applied to restrict results to the 2022–2026 period.

**Inclusion and Exclusion Criteria**

To build a highly robust and thematic corpus, strict inclusion (IC) and exclusion (EC) criteria were defined:

- **IC-1:** Peer-reviewed scientific articles, scientific book chapters, or formal technical reports from recognized agricultural development organizations (such as FAO).
- **IC-2:** Empirical or theoretical studies directly addressing rural extension, technical training, socio-technical innovation, or associativity within the Mexican agricultural sector.
- **IC-3:** Documents published exclusively between 2022 and 2026.
- **IC-4:** Studies presenting a clear and explicit methodological framework (quantitative, qualitative, or mixed-methods).
- **EC-1:** Opinion pieces, editorials, book reviews, newspaper articles, or any literature lacking rigorous peer review.
- **EC-2:** Research conducted outside of Mexico, unless it included a comparative analysis where the Mexican case was clearly disaggregated.
- **EC-3:** Publications dated prior to 2022.

**Selection and Screening Process**

The document selection process was structured into four sequential phases, aligned with the systematic screening workflow:

1. **Identification:** Compilation of all database records retrieved using the search strings. A total of 184 potential records were identified.

2. **Deduplication:** Removal of duplicate citations using Mendeley reference management software, resulting in 112 unique sources.

3. **Screening:** Title and abstract screening of the 112 sources against the inclusion and exclusion criteria. This step led to the exclusion of 68 documents that discussed general agricultural topics but lacked a direct, explicit link to technical assistance, extension models, or socio-technical transitions.

4. **Eligibility and Final Selection:** Full-text reading of the remaining 44 documents. During this stage, documents that did not match the strict validity criteria or were determined to be untraceable in indexation databases were excluded. Ultimately, a final corpus of 8 highly rigorous, fully verified scientific sources was selected for data extraction, coding, and qualitative-quantitative synthesis.

**Data Extraction and Analysis**

To process the selected 8 sources, a structured digital extraction matrix was developed, capturing the following variables: (a) Author(s) and publication year; (b) Geographic scope/Mexican state of study (e.g., Veracruz, Oaxaca, Chiapas, Hidalgo, etc.); (c) Methodological approach (qualitative, quantitative, or mixed); (d) Scale of analysis and sample size (number of farmers involved); (e) Typology of analyzed innovations (technological, organizational, agroecological, psycho-educational, financial); (f) Main reported empirical findings (economic, productive, and gender-related impacts); and (g) Primary institutional bottlenecks identified.

Thematic content analysis was performed using a combined inductive-deductive coding strategy grounded in socio-technical systems theory. Quantitative impact data reported in the empirical studies (such as crop yield increases, adoption rates, and financial margins derived from econometric models) were systematically tabulated and weighted to identify national trends. Qualitative data were categorized using thematic synthesis, highlighting emerging patterns of transition within family farming, such as cultural resistance to change, dialog of saberes, associative structures, and female empowerment. The triangulation of diverse methodologies—comparing rigorous econometric evaluations with ethnographic case studies and institutional monitoring databases—guaranteed the internal validity and scientific reliability of the synthesized findings.

## RESULTS

The systematic analysis of the selected 8 scientific sources (2022–2026) reveals that rural extension in Mexico has undergone a profound structural reconfiguraton. The country is transitioning from traditional, linear, and chemical-intensive technology transfer models toward participatory, socio-technical networks focused on interactive and sustainable innovation.

### Categorization of Selected Literature and Methodological Frameworks

The 8 analyzed studies cover a diverse national geography, with a clear concentration in the central, southern, and southeastern states (such as Veracruz, Oaxaca, Chiapas, Puebla, Hidalgo, and the State of Mexico). These regions concentrate the highest density of small-scale family farming and communities experiencing high rates of socioeconomic marginalization. Table 1 presents the classification of the analyzed literature based on methodological approaches, analytical scale, and the types of innovation evaluated.

**Table 1. Categorization of Selected Scientific Literature (2022–2026)**

| Study Category | Common Methodological Approaches | Priority Regions and Scale | Analyzed Innovations | Key Reference Authors |
|---|---|---|---|---|
| Econometric Impact Evaluation | Multiple Linear Regression (OLS), GAMLSS (Pareto II distribution), Bayesian BART models, Propensity Score Matching. | National scale; Multi-regional coverage (Chiapas, Veracruz, Jalisco, Puebla, Hidalgo). | Technical changes, soil management, production costs, crop yields, net profitability. | Benigno-Cruz et al. (2024); Domínguez Torres et al. (2023) |
| Socio-technical & Component Analysis | Actor mapping, component characterization, Multi-Level Perspective, socio-ecological qualitative analysis. | Central and Southern Mexico (Oaxaca, Chiapas, Veracruz). | Technology appropriation, basic components of technical support programs, agroecological transition. | Vilaboa-Arróniz et al. (2023); Morales Muñoz et al. (2022) |
| Associativity and Social Capital | Case studies, qualitative analysis of cooperatives, participatory action-research (PAR) methodologies. | Coffee and horticultural regions (Chiapas, Veracruz, Puebla). | Collective input purchasing, joint marketing plans, social capital, value chain integration. | Mendoza Álvarez et al. (2023) |

| Study Category | Common Methodological Approaches | Priority Regions and Scale | Analyzed Innovations | Key Reference Authors |
|---|---|---|---|---|
| Psycho-educational and Gender Dimensions | Mixed-methods, attitudinal surveys, FAO gender-sensitive indicators, qualitative analysis of mindset transformation. | National and regional studies (Hidalgo, Veracruz, Oaxaca). | Female empowerment, collective learning dynamics, attitude changes, household food security. | FAO (2023); Torres-Mena et al. (2024) |
| Financial & Credit Evaluation | Quantitative analysis, credit guarantee evaluation, institutional policy analysis. | National scope; Agricultural development funds. | Agricultural credit, technical assistance special funds, financial services. | Banda Ortiz et al. (2024) |

**Socioeconomic Profile of Beneficiaries and Structural Inequality**

The synthesized empirical evidence reveals that contemporary public policies for rural extension in Mexico have successfully reoriented their target population toward small- and medium-scale producers, specifically focusing on municipalities with high and very high marginalization indexes. On average, the farmers participating in the analyzed programs manage smallholdings ranging between 1.5 and 5.0 hectares. These units are dominated by subsistence family farming, primarily producing staple crops (maize, beans, squash) under the traditional Milpa system, or small-scale commercial crops such as shade-grown coffee and seasonal vegetables.

The application of non-parametric Bayesian Additive Regression Trees (BART) in the reviewed econometric studies consistently demonstrates that farmers in conditions of high social and economic vulnerability exhibit a highly positive response and a greater propensity to participate in technical assistance programs. This finding strongly challenges the historical assumption that marginalization is a natural barrier to technical change. From a socio-technical perspective, this indicates that when extension services eliminate entry fees and adopt participatory methodologies, appropriate technologies are perceived as highly valuable tools for stabilizing household income and mitigating environmental risks in vulnerable agroecosystems (Benigno-Cruz et al., 2024).

**Development and Appropriation of Sustainable Technologies**

A major finding across the analyzed publications is the high rate of technology appropriation among participating farmers. On average, over 90% of the producers integrated into the contemporary extension networks adopted at least one sustainable innovation on their farms during the program's cycle (Benigno-Cruz et al., 2024).

Unlike previous decades, where innovation was restricted to rigid Green Revolution packages (hybrid seeds, chemical fertilizers, and highly toxic pesticides), the innovations adopted during the 2022–2026 period focused primarily on low-cost, agroecological practices with high local relevance, such as:

1. Local production of bio-inputs, including fermented organic fertilizers (bocashi), vermicompost, bio-fertilizers enriched with local microorganisms, and mineral broths for pest control.

2. Soil and water conservation practices, such as contour farming, narrow-base terraces, live and dead barriers, and conservation tillage.

3. Participatory breeding, selection, and *in situ* conservation of native maize varieties, which significantly reduces dependence on commercial patented seeds.

The literature demonstrates that these technologies are highly compatible with the socioeconomic rationality of smallholders because they minimize cash-flow requirements and rely on locally available natural resources and family labor.

**Economic Impacts: Income Growth and Production Cost Reduction**

The studies applying quantitative econometric methods report highly significant economic improvements derived from systematic technical accompaniment. To formalize and isolate these impacts, several studies utilize multiple linear regression models structured around the following generalized income determination equation:

$$\Delta Y_i = \beta_0 + \beta_1 T_i + \beta_2 X_i + \epsilon_i$$

Where:

$\Delta Y_i$ represents the variation in net income or profitability of the agricultural unit of producer $i$.

$T_i$ is a dummy treatment variable that takes the value of 1 if the farmer received systematic extension services, and 0 otherwise.

$X_i$ represents a vector of socioeconomic and productive control variables (such as age, education, farm size, access to irrigation, and agricultural credit).

$\beta_1$ estimates the net impact of the rural extension program on the farmer's income.

$\epsilon_i$ represents the random error term capturing unobserved factors.

The coefficients estimated by Benigno-Cruz et al. (2024) and Domínguez Torres et al. (2023) confirm that the treatment variable *T* is statistically significant (*P<0.01*). On average, farmers receiving socio-technical extension experienced a 21% increase in their net monthly income compared to non-beneficiaries. This increase in profitability is not merely driven by increases in physical crop yields (which showed stable increases ranging from 12% to 18%), but rather by a substantial 15% reduction in overall production costs. This cost reduction is directly linked to the substitution of expensive synthetic inputs (which suffered from high global price volatility during the analyzed period) with on-farm produced bio-inputs.

Furthermore, public cost-benefit estimations show a highly favorable return on investment. For every Mexican peso invested by the state in deploying extension agents to the field, an average net economic benefit of 2.4 pesos was generated in additional income for the participating families (Benigno-Cruz et al., 2024). This demonstrates that rural extension is a highly profitable social investment rather than an assistance-based public expenditure.

**Dynamics of Associativity, Social Capital, and Gender Inclusion**

Beyond economic and technical metrics, the systematic review shows that contemporary rural extension acts as a powerful catalyst for social capital and territorial organization. Participatory extension methodologies (such as peasant learning communities, field schools, and peer-to-peer knowledge exchanges) have allowed individual, isolated smallholders to transition toward robust associative structures (Mendoza Álvarez et al., 2023).

This organizational strengthening has led to the consolidation of local cooperatives and regional networks that successfully manage:

- Bulk purchasing of agricultural tools and permitted inputs at competitive prices.
- Collective post-harvest processing to add value (e.g., wet and dry coffee processing, vegetable packaging, and processing native maize into specialized flours).
- Insertion into short supply chains and alternative fair-trade markets, bypassing exploitative local intermediaries (*coyotes*).

One of the most profound socio-technical shifts identified in the recent literature is the rapid inclusion of female producers in extension programs. Systematic monitoring data show that 58.2% of active beneficiaries registered in public technical assistance programs were women (Benigno-Cruz et al., 2024). This high participation rate represents a major structural change in the Mexican countryside, which has historically been dominated by patriarchal land tenure systems and highly unequal access to public agricultural resources.

Econometric models utilizing the BART approach confirm that female gender correlates positively and significantly with the probability of adopting multiple sustainable innovations and participating in associative planning (Torres-Mena et al., 2024). Women have assumed leadership roles in running community bio-factories, managing agrobiodiversity in family homegardens, and leading the administrative structures of local cooperatives. This participation directly enhances household food security and fosters broader gender equity in rural territories (Morales Muñoz et al., 2022).

## DISCUSSION

The results of this systematic literature review show that rural extension in Mexico between 2022 and 2026 has transitioned from a linear technology transfer mechanism to an interactive, socio-technical process. This transformation has generated measurable impacts on productivity, income, and social organization, while highlighting critical institutional challenges that must be addressed to ensure the sustainability of these transitions.

### Reconceptualizing the Transition: From Transfer to Socio-Technical Systems

The high technology adoption rate (exceeding 90%) and the positive impact on net household income (+21%) validate the theoretical shift toward socio-technical systems of innovation. This paradigm contrasts with the classic diffusionist model of the Green

Revolution, which assumed that innovation flowed unilaterally from scientific laboratories to fields, ignoring the local biocultural contexts and resources of smallholders.

By analyzing extension through the lens of socio-technical systems, it becomes clear that technical change does not depend solely on the biophysical performance of a technology, but on the alignment of social, institutional, and cultural factors. The contemporary public extension initiatives in Mexico have functioned by creating "protected socio-technical niches" at the community level. These niches, represented by peasant learning communities and field schools, shield smallholders from market pressures of synthetic input suppliers. This allows agroecological practices (such as bio-fertilization and native seed selection) to stabilize through collective learning, dialogue of saberes, and social reflexivity.

**Convergence with International Sustainable Agriculture Theories**

The empirical evidence from Mexico aligns with international theories of agroecology and rural sociology, which argue that participatory and dialogical extension is more effective for long-term sustainable development than top-down technical assistance. Scholars in Latin America have argued that transitioning to sustainable agriculture requires developing critical thinking and self-monitoring capacities among farmers rather than distributing rigid technological recipes (Morales Muñoz et al., 2022).

The Mexican studies reviewed (Benigno-Cruz et al., 2024) show that low-cost, locally sourced inputs reduce production costs by 15%, reducing smallholders' economic dependency on imported synthetic fertilizers. This socio-technical resilience, co-produced through horizontal interactions between extension agents and farmers' traditional knowledge, leads to long-term technology appropriation. This ensures that adopted practices persist even after public subsidies or formal extension programs end.

**The Psycho-Educational and Associative Dimensions of Extension**

A key contribution of the 2022–2026 literature is the integration of psycho-educational and community social capital analyses into the study of extension. Incorporating psycho-educational interventions to transform producers' mindsets (as discussed by Torres-Mena et al., 2024) is crucial for overcoming deep-seated barriers such as cultural resistance to change, mistrust of government institutions, and lack of motivation for collective action. Adopting agricultural innovations is not a purely rational-economic decision; it is a complex social process shaped by risk perception, self-esteem, peasant identity, and community trust.

The development of associative networks and the active integration of women (who represent 58.2% of beneficiaries) show that contemporary extension in Mexico transforms rural social structures. Associativity acts as a socio-technical multiplier, enabling smallholders to achieve economies of scale in input purchasing and negotiate better terms in the market, bypassing exploitative intermediaries (Mendoza Álvarez et al., 2023). Furthermore, women's leadership in community bio-factories and value-added cooperative projects democratizes household and community decision-making, contributing to social and gender justice in highly marginalized areas (FAO, 2023).

**Institutional Bottlenecks and Policy Implications**

Despite the documented positive impacts, the systematic review reveals critical structural and institutional challenges that limit the long-term sustainability of rural extension in Mexico:

1. **Operational Discontinuity and Budgetary Uncertainty:** Many public extension programs operate under rigid annual fiscal cycles and bureaucratic regulations. This often interrupts technical support in the field during critical stages of the crop cycle (Benigno-Cruz et al., 2024). Technical change and cooperative consolidation are long-term social processes that cannot be forced into annual administrative cycles.

2. **Technical-Productivist Bias in Professional Training:** Most extension agents deployed in rural areas have been trained in traditional agronomy curricula that focus almost exclusively on biophysical aspects of production, lacking training in rural sociology, adult education (andragogy), and business management. This limits their capacity to facilitate complex social organization and resolve community conflicts.

3. **Weak Institutional Coordination:** There remains a disconnect between formal agricultural research institutions (such as universities and national research institutes) and the public agencies operating extension services in the field. This gap reduces the practical relevance of academic research and limits the flow of scientific innovations to smallholders. Additionally, the interface between financial services, agricultural credit guarantees, and technical assistance must be reinforced to provide smallholders with the necessary liquidity to adopt sustainable technologies (Banda Ortiz et al., 2024).

To address these challenges, Mexico must transition toward long-term state policies for rural extension that guarantee multi-year funding and operational continuity. It is highly recommended to reform agricultural university curricula, integrating multidisciplinary

approaches that combine agronomy with rural sociology, participatory andragogy, and gender studies (Torres-Mena et al., 2024). Furthermore, establishing territorialized platforms for horizontal co-creation of knowledge is essential to link scientific research, extension field services, and traditional peasant knowledge, thereby supporting national food sovereignty (Domínguez Torres et al., 2023).

### Limitations of the Systematic Review

This systematic review is subject to certain limitations. Because it relies on peer-reviewed scientific literature and formal technical reports published between 2022 and 2026, the validity of the findings depends on the quality of the primary sources. A potential publication bias exists, as field research documenting successful interventions or statistically significant positive impacts is published more frequently than programs that reported null or negative results. Future empirical research should utilize long-term longitudinal research designs to monitor the persistence of technical and organizational innovations after state funding and formal extension services are withdrawn from the territories.

## CONCLUSION

This systematic literature review (2022–2026) demonstrates that rural extension in Mexico has undergone a major paradigm shift, transitioning from linear technology transfer models toward interactive, socio-technical innovation networks.

The compiled empirical evidence shows that participatory and dialogical technical support, tailored to local territorial contexts, is highly effective for sustainable rural development. This approach has achieved a 21% average increase in smallholders' net income, driven by a 15% reduction in production costs through the adoption of agroecological practices and local bio-inputs.

Furthermore, contemporary extension acts as a social catalyst, strengthening social capital and cooperative structures that reduce dependency on exploitative intermediaries. The paradigm has also promoted gender equity, with women constituting 58.2% of active participants and leading community-based sustainable innovations.

To sustain this transition, policymakers must address critical bottlenecks, including operational discontinuity, weak institutional coordination, and the traditional technical-productivist bias in agronomic training. Implementing long-term state policies with multi-

year funding, reformulating university curricula to integrate social sciences, and fostering platforms for horizontal knowledge co-creation are essential to support long-term national food sovereignty.

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