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Review

Extension Strategies for Sustainable Sericulture Development: A Comprehensive Review of Approaches, Innovations, Challenges, and Future Directions

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Abstract

Sericulture plays a vital role in supporting rural livelihoods by generating employment and income opportunities, particularly for smallholder farmers and women (Bharathi, 2016; Bukhari et al., 2019). As the only country producing all four commercially important silk varieties—Mulberry, Tasar, Eri, and Muga—India occupies a unique position in the global silk sector and contributes significantly to both economic development and biodiversity conservation (Taufique & Hoque, 2021; Sharma et al., 2025). However, the sustainability of the sector is increasingly challenged by issues such as climate change, disease incidence, market fluctuations, and the limited reach of extension services (Ssemugenze et al., 2021; Sharma et al., 2025).

Agricultural extension has emerged as a key driver in addressing these challenges by facilitating the dissemination of innovations, strengthening farmers' knowledge and skills and improving access to markets and support services (Rajesh & Muchie, 2022). This review synthesizes existing literature on extension strategies used in sericulture and evaluates their contribution to sustainable development. Particular attention is given to approaches such as technology transfer, participatory extension, farmer field schools, community-based organizations, market-led extension, climate-smart advisory services and gender- and youth-focused interventions (Chambers, 1994; Kaushik et al., 2025). The review is guided by important theoretical perspectives, including Diffusion of Innovation Theory, Human Capital Theory, the Sustainable Livelihood Framework, and the Agricultural Innovation Systems approach, which help explain the processes of technology adoption and stakeholder collaboration in sericulture development (Rogers, 2003; Becker, 1964; Scoones, 1998; Rajesh & Muchie, 2022).

The paper further highlights the growing role of digital technologies, including mobile-based advisory services, social media platforms, artificial intelligence, precision sericulture and e-extension systems, in enhancing the effectiveness of extension delivery (Kaushik et al., 2025). In addition, it identifies major institutional, technical, socio-economic, market, climatic and digital constraints, while outlining key research gaps related to climate resilience, gender inclusion, market integration and digital extension. Based on these insights, a SMART-Sericulture Extension Framework is proposed to support sustainable practices, market orientation, digital transformation, climate adaptation and capacity building. The review concludes that the future of sericulture depends on integrated, participatory, climate-resilient, and digitally enabled extension systems that can enhance farmer livelihoods while ensuring the long-term sustainability of the sector (Kaushik et al., 2025; Rajesh & Muchie, 2022).

Keywords: *Sericulture, Agricultural Extension, Sustainable Development, Climate-Smart Extension, Digital Technologies, Artificial Intelligence, Sustainable Livelihoods, Agricultural Innovation Systems.*

Introduction

1.1 Background

Sericulture is a labour-intensive, agro-based enterprise that integrates host-plant cultivation, silkworm rearing, cocoon production, reeling and weaving into a single value chain. Because each stage can be carried out on small landholdings with modest capital, the activity has historically functioned as a supplementary or primary livelihood option for rural households, including women and marginal farmers (Bharathi, 2016; Bukhari et.al 2019).

India occupies a distinctive position in the global silk economy: it is the second-largest silk-producing country and the only nation that commercially produces all four major silk varieties — Mulberry, Tasar, Eri, and Muga (Taufique & Hoque, 2021). This diversity gives Indian sericulture an unusual geographic and agro-ecological spread, from the mulberry belts of Karnataka and Andhra Pradesh to the Eri and Muga systems of the North-Eastern states (Sharma et.al. 2025).

Despite decades of research investment and technology generation, the sector continues to show wide productivity gaps between research-station yields and farmer-field yields. Climate variability, recurrent disease outbreaks, cocoon price volatility and an extension system that is thinly staffed relative to the farmer base remain persistent constraints on sustainable growth (Ssemugenze et.al. 2021; Sharma et al., 2025).

Agricultural extension is the connective tissue of this system. It translates research findings from institutions such as the Central Silk Board into field-level practice, builds farmer capacity, strengthens input and output market linkages, and increasingly mediates the adoption of climate-smart and digital innovations (Rajesh & Muchie, 2022). A review that examines sericulture specifically through this extension lens — rather than as a general agronomic or industrial subject — is therefore timely and necessary.

1.2 Need for the Review

- Rising consumer and market demand for eco-friendly and ethically produced silk.
- Documented climate-change pressure on mulberry phenology and silkworm physiology (Kaushik et. al 2025).
- Rapid expansion of ICT and mobile-based advisory channels into rural extension generally, with early but growing application in sericulture (Kaushik et al., 2025).
- Continuing under-representation of women's contribution in formal extension programming despite their dominant role in field-level operations (Bukhari et al., 2019).
- A policy push toward sustainable, diversified rural livelihoods under schemes such as Silk Samagra (Sharma et al., 2025).

1.3 Objectives of the Review

1. To examine the range of extension strategies that have been applied in sericulture development.
2. To analyse how these strategies contribute to economic, social and environmental sustainability.
3. To identify the institutional, technical, socio-economic and digital challenges that limit extension effectiveness.
4. To propose future-oriented extension interventions and a consolidated framework for sustainable sericulture extension.

2. Conceptual Foundations of Sustainable Sericulture

2.1 The Concept of Sustainability

The most widely used definition of sustainable development remains that of the World Commission on Environment and Development, which described it as development that meets present needs without compromising the ability of future generations to meet their own (WCED, 1987). Applied to sericulture, this definition translates into three interlocking dimensions.

A. Economic Sustainability

- Stable and improving cocoon productivity per unit area.
- Stable farm income across seasons and silk varieties.
- Market competitiveness of Indian raw silk against imports.
- Value addition through reeling, weaving and branding rather than raw cocoon sale alone.

B. Social Sustainability

- Generation of rural, on-farm and off-farm employment (Bharathi, 2016).
- Empowerment of women, who perform the bulk of leaf harvesting, silkworm feeding and cocoon sorting (Bukhari et al., 2019).
- Strengthened community participation through groups and cooperatives.
- Contribution to poverty reduction in marginal and rainfed farming regions.

C. Environmental Sustainability

- Reduced dependence on synthetic agrochemicals in mulberry and host-plant cultivation.

- Conservation of host-plant and silkworm genetic biodiversity (Wani et.al. 2018).
- Water-use efficiency in irrigation of mulberry gardens.
- Potential for carbon sequestration through perennial mulberry and Eri/Muga host-plant systems.

3. Theoretical Perspectives Supporting Sericulture Extension

Grounding the review in established extension theory is what distinguishes an Agricultural Extension Education contribution from a purely technical sericulture review. Four frameworks are particularly relevant.

3.1 Diffusion of Innovation Theory

Rogers' Diffusion of Innovations theory explains how new ideas and technologies spread through a social system via communication channels over time and classifies adopters along an innovativeness continuum from innovators to laggards (Rogers, 2003). In sericulture, this framework helps explain differential uptake of improved mulberry varieties, disease-management protocols, irrigation technologies, highlights the importance of relative advantage, compatibility, complexity, trialability and observability in determining how quickly a given innovation moves through a farming community.

3.2 Human Capital Theory

Human capital theory treats education, training and skill acquisition as investments that raise an individual's future productivity (Becker, 1964). Applied to sericulture extension, structured training and refresher courses are not merely information transfer but investments that compound over a farmer's productive life, supporting the case for sustained rather than one-off capacity-building programming.

3.3 Sustainable Livelihood Framework

Scoones' Sustainable Livelihood Framework conceptualises rural livelihoods in terms of five capital assets human, social, financial, physical, natural and the strategies households build on them to achieve livelihood outcomes (Scoones, 1998). Extension interventions in sericulture can be read as targeted investments in one or more of these capitals: training builds human capital, SHGs and FPOs build social capital, credit linkages build financial capital, rearing infrastructure builds physical capital and host-plant conservation builds natural capital.

3.4 Agricultural Innovation Systems (AIS) Perspective

The innovation systems perspective shifts attention away from a linear research-to-farmer transfer model and toward the dynamic interaction among multiple actors like farmers, the Central Silk Board, state departments, researchers, extension agencies and markets whose combined interplay, rather than any single actor, determines whether an innovation is generated, diffused and used effectively (Rajesh & Muchie, 2022). This perspective is particularly well suited to sericulture because the sector spans agriculture, sericulture-specific technical research, textile manufacturing and rural development policy simultaneously.

4. Sericulture Extension Ecosystem

4.1 Major Stakeholders

Public Institutions

- Ministry of Textiles, Government of India.
- Central Silk Board and its research and training institutes.
- State Sericulture Departments.
- Krishi Vigyan Kendras (KVKs) and State Agricultural Universities.

Private Sector

- Silk reeling and weaving industries.
- Input suppliers (disinfectants, rearing equipment and seed cocoon producers).
- Cocoon and raw-silk traders.

Civil Society

- Non-governmental organisations working in rural livelihoods.
- Self-Help Groups (SHGs).
- Farmer Producer Organisations (FPOs).

Digital Actors

- Mobile advisory and IVRS service providers.
- E-commerce and digital marketing platforms for silk and silk products.

Within an innovation-systems reading of the sector, the strength of sustainable sericulture development depends as much on the density and quality of interaction among these stakeholders as on the technical merit of any single innovation (Rajesh & Muchie, 2022).

5. Evolution of Extension Approaches in Sericulture

5.1 Traditional Extension Era

Early sericulture extension in India followed the classical transfer-of-technology model: individual farm visits, result demonstrations and method demonstrations conducted by departmental extension staff. While effective at building credibility for new practices, this ap-

proach proved costly per farmer reached and struggled to scale across the geographically dispersed mulberry, Tasar, Eri and Muga belts.

5.2 Participatory Extension Era

From the 1990s onward, participatory approaches drawing on Participatory Rural Appraisal methods began to be incorporated into agricultural extension more broadly, emphasising farmer involvement in problem diagnosis and the integration of local, indigenous knowledge into technology refinement (Chambers, 1994). In sericulture, this is visible in farmer involvement in selecting locally adapted host-plant varieties and rearing practices.

5.3 Digital Extension Era

The most recent phase is characterised by mobile applications, WhatsApp-based advisory groups and e-learning content, which are being piloted as complements to - rather than full replacements for field-based extension in sericulture-growing states (Kaushik et al., 2025).

6. Major Extension Strategies for Sustainable Sericulture Development

This section consolidates the principal extension strategies documented or applied in the sericulture sector, organised by approach.

6.1 Technology Transfer Approach

Methods: result demonstrations, field days and structured training programmes remain the backbone of formal extension delivery in sericulture. Their principal strength is the speed with which a validated practice can be shown to a critical mass of farmers; their principal weakness is limited farmer participation in shaping the technology itself, which can depress adoption when local conditions diverge from the demonstration site.

6.2 Capacity Building Strategy

Skill training, refresher courses and entrepreneurship development programmes including, historically, distance-education modes for sericulture human-resource development (Vijaykumar et.al. 2007) aim to build durable competence rather than one-time compliance. Outcomes associated with sustained capacity building include improved cocoon quality and more consistent adoption of recommended rearing and disinfection protocols.

6.3 Farmer Field School Approach

The Farmer Field School model, built around season-long, learning-by-doing group experimentation, has been widely used in plant-protection extension and is applicable to silkworm pest and disease management, where it supports better field-level decision-making than one-off training events.

6.4 Participatory Technology Development (PTD)

PTD formalises farmer–scientist collaboration in adapting technologies to local conditions, such as localised mulberry cultivation practices or incremental innovations in silkworm rearing houses and is consistent with the participatory extension era described in Section 5.2.

6.5 Farmer-to-Farmer Extension

Lead-farmer or progressive-farmer models use trusted peers as the primary knowledge-transfer mechanism. The high trust embedded in farmer-to-farmer channels and their comparatively low delivery cost make them attractive for last-mile reach in sericulture-growing villages where formal extension staff are thinly spread.

6.6 Community-Based Extension

SHGs, producer groups and cooperatives function as both extension-delivery and economic institutions, supporting collective input procurement and collective marketing, which is particularly important for women sericulturists who often lack independent access to formal credit and markets (Bukhari et al., 2019).

6.7 Market-Led Extension

Market-led extension covering market-price information, value addition and branding is comparatively underdeveloped in sericulture relative to technology-transfer extension, despite its direct bearing on farm profitability and by extension, on the economic sustainability dimension defined in Section 2.1. Strengthening linkages between extension agencies and value-chain actors is an area with clear scope for further institutional investment.

6.8 Climate-Smart Extension

Climate-smart extension packages weather advisories, climate-resilient mulberry varieties and water-saving irrigation technologies into farmer-facing advisory content. Given documented climate sensitivity of both host-plant phenology and silkworm physiology, this strand of extension is expected to grow in importance (Kaushik et al., 2025).

6.9 Gender-Sensitive Extension

Women perform a disproportionate share of field-level sericulture operations — leaf harvesting, silkworm feeding, and cocoon sorting — yet remain under-

represented as direct beneficiaries of formal extension programming (Bukhari et al., 2019). Women-focused training and leadership-development components within SHGs are associated with measurable gains in empowerment and household income contribution and represent one of the clearer equity levers available to extension planners.

6.10 Youth-Centered Extension

With the average age of the farming population rising across Indian agriculture generally, youth-centred extension content — seri-preneurship, digital marketing of silk products and value-chain start-ups — is positioned as a strategy for renewing the sector's labour base rather than only its technology base.

7. ICT and Digital Extension Innovations in Sericulture

7.1 Mobile-Based Advisory Services

SMS and Interactive Voice Response Systems (IVRS) provide low-bandwidth advisory channels suited to areas with limited smartphone penetration.

7.2 Social Media Extension

WhatsApp groups, YouTube demonstration videos and Facebook pages are increasingly used by progressive farmers and state departments to share rearing schedules and disease alerts in near real time.

7.3 Artificial Intelligence

Emerging applications include AI-assisted disease diagnosis from images of diseased larvae, pest-outbreak prediction and automated generation of localised advisory text — an area that, remains under-evaluated in the published sericulture literature and warrants dedicated empirical study.

7.4 Precision Sericulture

Sensor and IoT enabled smart rearing houses that monitor temperature and humidity represent an early-stage but technically feasible extension of precision-agriculture principles into silkworm rearing.

7.5 E-Extension Platforms

Digital and climate-smart advisory platforms are explicitly framed in recent literature as complements designed to extend reach where traditional face-to-face extension struggles to cover dispersed sericulture communities (Kaushik et al., 2025).

8. Sustainable Practices Promoted Through Extension

8.1 Environmental Sustainability Practices

- Organic sericulture using organic manures and biofertilizers in place of synthetic inputs.
- Integrated Pest Management (IPM) for host-plant and rearing-house pest control.
- Integrated Nutrient Management for mulberry and other host plants.
- Water conservation measures including drip irrigation in mulberry gardens.
- Conservation of host-plant and silkworm genetic biodiversity (Wani et al., 2018).
- Waste recycling through silkworm-litter composting and vermicomposting, which also supports nutrient recycling back into host-plant cultivation systems.

9. Impact Assessment of Extension Strategies

A rigorous review should assess extension strategies against documented outcomes in the following domains: technology adoption, productivity improvement, income enhancement, employment generation, women's empowerment, social-capital development and environmental outcomes. The summary table below is provided as a template; the author should populate the "Key Findings" column from their own systematic search of empirical studies, since presenting invented figures here would misrepresent the literature.

10. Constraints and Challenges

10.1 Institutional Constraints

- Shortage of trained sericulture extension personnel relative to the dispersed farmer base.
- Inadequate and inconsistent programme funding across states.

10.2 Technical Constraints

- Limited availability of location-specific technologies suited to agro-climatically diverse sericulture regions, particularly the North-East (Sharma et al., 2025).

10.3 Socio-Economic Constraints

- Predominance of small and fragmented landholdings among sericulturists.
- Variable literacy levels affecting uptake of written advisory material.

10.4 Market Constraints

- Cocoon and raw-silk price fluctuations.
- Weak integration between producers and downstream value-chain actors (Sharma et al., 2025).

Extension Strategy	Outcome Domain
Result demonstrations / training	Technology adoption
ICT / mobile advisory	Information access and knowledge gain
SHGs / cooperatives	Income and market access
Women-focused extension	Empowerment indicators
Climate-smart advisories	Resilience / yield stability

10.5 Climate Challenges

- Temperature stress on silkworm physiology and host-plant phenology.
- Disease outbreaks linked to humidity and temperature variability (Kaushik et al., 2025).

10.6 Digital Constraints

- Poor rural internet connectivity in several sericulture belts.
- Low digital literacy among older and less formally educated sericulturists.

11. Emerging Trends and Innovations

- Artificial intelligence applications in disease diagnosis and advisory generation.
- Big-data analytics for production and market forecasting.
- IoT-based environmental monitoring in silkworm rearing houses.
- Drone-based monitoring of host-plant plantations.
- Blockchain-based traceability systems for silk provenance and quality certification.
- Digital farmer networks linking producers directly to buyers.
- Smart, sensor-integrated extension advisory systems.
- Precision sericulture combining several of the above into a single decision-support package.

12. Research Gaps

12.1 Methodological Gaps

Most available studies are cross-sectional; longitudinal studies tracking the same farmers across multiple seasons or years are scarce, limiting causal claims about extension impact.

12.2 Geographic Gaps

North-Eastern India, despite its centrality to Eri and Muga silk production, remains comparatively understudied relative to the mulberry belts of South India (Sharma et al., 2025).

12.3 Gender Gaps

Although women's central role in field operations is well documented, women-focused extension-impact studies remain limited relative to the scale of their participation (Bukhari et al., 2019).

12.4 Digital Extension Gaps

Evidence on the effectiveness of AI-based advisory tools in sericulture specifically is still emerging and thin.

12.5 Climate Extension Gaps

Climate-adaptation-focused extension studies in sericulture are fewer than the scale of documented climate sensitivity would suggest (Kaushik et al., 2025).

12.6 Market-Led Extension Gaps

Integration of extension programming with value-chain and market-linkage strategies remains weak in the literature as well as in practice (Sharma et al., 2025).

13. Future Extension Framework for Sustainable Sericulture

Drawing on the strategies and gaps reviewed above, this paper proposes a consolidated SMART-Sericulture Extension Framework as a candidate for further empirical testing and refinement.

In this framework, the five pillars — Sustainable Practices, Market Orientation, AI and Digital Technologies, Resilient Climate Adaptation, Training and Capacity Building — are positioned as parallel, mutually reinforcing inputs that feed into knowledge empowerment, which in turn drives technology adoption, sustainable livelihoods and ultimately sustainable sericulture development at the sector level.

14. Policy Implications

- Strengthen digital extension infrastructure, particularly rural connectivity, in sericulture-growing regions.
- Increase investment in climate-smart sericulture research and advisory content.
- Promote women-led sericulture enterprises through targeted credit and training linkages.
- Pilot and rigorously evaluate AI-enabled advisory systems before scale-up.
- Develop public–private extension partnerships that bring industry and trader knowledge into farmer-facing advisory content.
- Strengthen FPOs and SHGs as durable, locally owned extension-delivery institutions.

S	Sustainable Practices
M	Market Orientation
A	AI and Digital Technologies
R	Resilient Climate Adaptation
T	Training and Capacity Building

15. Conclusion

Across the strategies reviewed, extension functions as the connective mechanism that converts sericulture research into field-level practice, builds the human and social capital on which sustained adoption depends, and increasingly mediates farmers' access to climate-smart and digital tools. The evidence assembled here suggests that future sericulture development will depend less on any single technology breakthrough and more on the sector's ability to shift from a predominantly top-down, technology-transfer model toward extension systems that are participatory, climate-smart, market-oriented and digitally enabled — while remaining grounded in the gender and equity-sensitive realities of who actually performs sericulture's day-to-day labour.

References

Becker, G. S. (1964). Human capital: A theoretical and empirical analysis, with special reference to education. University of Chicago Press.

Bharathi, D. (2016). Sericulture industry in India — A source of employment generation. International Journal of Advanced Engineering Research and Science, 3(10), 236881.

Bukhari, R., Kour, H., & Aziz, A. (2019). Women and the Indian sericulture industry. International Journal of Current Microbiology and Applied Sciences, 8(5), 2319–7706.

Chambers, R. (1994). The origins and practice of participatory rural appraisal. World Development, 22(7), 953–969.

Kaushik, A., Sarma, P. P., Batshayan, B., Borah, M., Singha, A., & Sushma. (2025). Digital and climate-smart extension strategies for sustainable sericulture. International Journal of Agriculture Extension and Social Development.

Rajesh, G. K., & Muchie, M. (2022). An innovation systems perspective on agricultural technology diffusion: The case of India's sericulture. In Innovation systems, economic development and public policy (pp. 131–160). Routledge India.

Rogers, E. M. (2003). Diffusion of innovations (5th ed.). Free Press.

Scoones, I. (1998). Sustainable rural livelihoods: A framework for analysis (IDS Working Paper 72). Institute of Development Studies.

Sharma, S., Bhagat, A. V., Bhalerao, S. S., Rambhai, P. K., & Rajput, Y. V. (2025). A conceptual review on sericulture in Northeast India: Viability, opportunities and policy pathways. Archives of Current Research International, 25(9), 230–241.

Ssemugenze, B., Esimu, J., Nagasha, J., & Wandui Masiga, C. (2021). Sericulture: Agro-based industry for sustainable socio-economic development: A review. Journal for Research in Applied Sciences and Biotechnology.

Taufique, M., & Hoque, M. A. (2021). Current scenario of sericulture production in India: A spatio-temporal analysis. International Research Journal of Education and Technology, 2, 12–23.

Vijaykumar, P., Phaniraj, H. S., Anantharaman, K. V., & Amarnath, S. (2007). Human resource development in sericulture through distance education mode. Indira Gandhi National Open University.

Wani, M. Y., Ganie, N. A., Rather, R. A., Rani, S., & Bhat, Z. A. (2018). Seri biodiversity: An important approach for improving quality of life. Journal of Entomology and Zoology Studies, 6(1), 1053–1056.

World Commission on Environment and Development [WCED]. (1987). Our common future. Oxford University Press.