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Sustainable sericulture certification: Extension approaches for organic and ethical silk production

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Abstract

Sericulture offers vital income opportunities for rural communities, yet it is increasingly challenged by environmental pressures, social inequities, and economic vulnerabilities faced by smallholder farmers. Conventional practices often rely on chemical inputs, exploit undervalued labour, and lack mechanisms for fair market access, making the sector vulnerable to sustainability and ethical scrutiny. Certification schemes such as GOTS (Global Organic Textile Standard), OEKO-TEX, and Fairtrade have emerged as important tools to align sericulture with organic, fair, and environmentally sound standards, while offering access to premium markets. However, their adoption among smallholder producers is constrained by technical, institutional, and financial barriers. This review synthesizes recent research on certification frameworks, extension approaches, and global case studies in sericulture. Evidence highlights the role of farmer training, demonstration plots, participatory community models, and Information and Communication Technology (ICT) based advisory tools in enabling certification adoption, supported by institutional and policy interventions. Case studies from India, China, and Southeast Asia demonstrate that certification succeeds when technical innovation, farmer aggregation, by-product valorisation, and market traceability are integrated. The paper concludes that certification provides the incentive and standards for sustainable silk production, while extension supplies the practical means for adoption. Future priorities include rigorous impact evaluations, cost-sharing mechanisms, and digital traceability systems to scale certified sericulture sustainably.

Keywords: Certification schemes, organic silk production, ethical silk, farmer extension, premium markets

1. Introduction

Sericulture provides rural people with significant income prospects, but the environmental and social effects of this industry are heavily influenced by post-cocoon processing, the dynamics of silk supply chains, and farm-level activities including host plant farming and silkworm breeding. Sericulture plays a key role in rural economies by providing steady, year-round employment across multiple stages, from mulberry cultivation to silk reeling, especially for women and marginalized communities ^[1].

However, traditional sericulture frequently depletes natural resources, uses chemicals, and might not follow fair labour standards; therefore, a move towards more ethical and sustainable techniques is necessary. Organic cultivation and integrated pest management help reduce environmental damage, while agroforestry and efficient resource use bolster ecological health ^[2].

Certification has emerged as a vital mechanism for addressing these concerns. By validating eco-friendly practices and ensuring traceability, certification schemes enhance both consumer trust and producer income. Labels such as organic, fair-trade, and geographical indications are increasingly applied to silk, enabling rural producers to gain access to premium markets sensitive to sustainability and ethical sourcing ^[3]. For many farmers, certification represents long-term resilience by aligning production with environmental stewardship and social responsibility.

However, achieving certification is not straightforward. It demands technical knowledge, infrastructure, investment, and institutional support, elements often beyond the reach of smallholder silk producers. Extension services help bridge this divide, offering training, demonstration programs, farmer field schools, and digital advisory platforms. These interventions build farmer capacity, foster collaboration, and

guide communities toward meeting standards and unlocking sustainable silk markets ^[4].

Moreover, a comprehensive 2025 review highlights how integrating organic sericulture with recognized certification schemes, such as India's National Programme for Organic Production (NPOP) and the Global Organic Textile Standard (GOTS), can significantly enhance environmental outcomes and open up premium market access. The authors discuss ecological improvements, such as healthier mulberry soils, reduced chemical residues, and better silkworm resilience, while linking these gains to growing consumer demand for certified, sustainable silk products ^[5]. This transition is summarized in Figure 1, which shows how certification functions as the pivotal bridge between conventional sericulture challenges and sustainable outcomes.

In this review, we explore the role of certification in embedding sustainability and ethical values within silk production, and examine how targeted extension strategies can empower rural producers to meet these standards in a changing socio-environmental landscape.

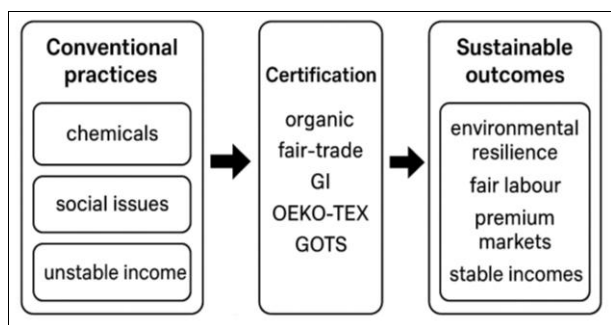


Fig 1: Pathways from conventional sericulture challenges to certified sustainable outcomes.

2. Sustainability Challenges in Conventional Sericulture

Traditional sericulture is a major source of income in rural areas, but it is also linked to economic, social, and environmental issues that threaten its long-term viability. Recent research has brought attention to these strains, which are covered in the section that follows.

2.1 Environmental issues: chemicals, soil health, biodiversity

Mulberry cultivation and cocoon production often rely on chemical inputs such as synthetic fertilizers, fungicides, and insecticides to sustain leaf yield and quality. These inputs can leave residues on mulberry leaves, disturb soil microbial communities, and cause both sublethal and lethal effects in non-target organisms, including the silkworm itself, which is highly pesticide-sensitive ^[6, 7]. Research shows that pesticide residues on mulberry leaves can reduce larval growth, impair silk gland development, and lower cocoon and silk quality ^[7, 8].

Repeated agrochemical applications also degrade soil structure, suppress microbial biomass and enzyme activity, and diminish biodiversity within the mulberry ecosystem. This erosion of soil health and ecological balance weakens system resilience to pest outbreaks and climate stress ^[6, 8]. The result is a negative feedback loop: declining soil and

leaf quality drive farmers toward heavier chemical use, further intensifying risks for both the ecosystem and human health ^[6, 7, 8].

2.2 Social and ethical issues: child labour, fair wages, gender equity

Sericulture is labour-intensive and often carried out in household and cottage-industry settings. Studies show that the sector disproportionately depends on women's labour, especially in rearing, cocoon handling, and reeling activities, yet these roles are often low-paid and undervalued compared to men's participation in marketing or farm management ^[9]. Gender inequities are reinforced by limited access to training, credit, and extension services for women, which constrains their ability to benefit fully from sericulture as an income-generating activity ^[10].

Beyond gendered disparities, concerns about labour ethics persist in conventional sericulture systems. Reports highlight instances of child labour and informal employment practices in parts of Asia and Africa, raising questions about compliance with international standards of decent work ^[9, 10]. These social and ethical dimensions not only affect the welfare of rural households but also influence market perceptions of silk, where global consumers are increasingly demanding certified products that guarantee fair wages and ethical labour conditions.

2.3 Economic limitations for small farmers

Smallholders dominate mulberry-based sericulture, but they face recurring economic barriers such as limited access to quality seed/eggs, disease-resistant silkworm strains, and affordable credit. Weak market linkages and sharp cocoon price fluctuations further reduce profitability, leaving farmers with narrow margins and high vulnerability to shocks ^[11, 12]. Without assured premiums for certified or higher-quality silk, the short-term economics often discourage adoption of organic or labor-intensive sustainable practices ^[9]. Recent field studies also show that women, who form a large share of the workforce, face additional constraints in marketing and value-chain participation ^[13]. These findings highlight the need for cooperatives, policy support, and stable market mechanisms to make sustainable sericulture financially viable ^[14].

Together, these environmental, social and economic problems show why certification and extension matter. Certification can create market incentives, premiums, traceability and buyer commitments, that offset costs of sustainable practices. But for certification to reach smallholders it must be paired with strong extension: technical guidance on organic pest and soil management, capacity building for quality control, and support to meet labor-standards documentation and audit requirements. The peer-reviewed literature therefore points to a combined approach: technical, social and economic support delivered through extension alongside market mechanisms to make certified sericulture viable at scale ^[6, 9]. A summary of these interlinked sustainability issues is illustrated in Figure 2, highlighting the environmental, social/ethical, and economic pressures that together threaten the long-term viability of conventional sericulture.



Fig 2: Triple Challenges in Conventional Sericulture. Environmental, social/ethical, and economic pressures converge to threaten long-term viability.

3. Certification Frameworks for Sustainable Silk

Certification schemes give buyers and consumers a provable signal about environmental and social performance along a textile value chain. For silk, the most relevant schemes are those that target fibre-level integrity, for example organic standards such as GOTS, restricted-substance and product testing, for example OEKO-TEX Standard 100, and social or economic fairness, for example Fairtrade. Reviews of

textile ecolabels note that each scheme has a different scope and verification pathway. Some focus on agricultural practices such as input restrictions and organic cultivation, while others emphasize industrial processing, chemical residues, labour standards, or broader socio-economic outcomes. Matching a certification’s scope with the specific stages of silk value chains is therefore essential ^[15].

3.1 Overview of major textile certifications and what they cover

GOTS integrates organic fibre production with downstream processing requirements and social criteria in processing units. It therefore covers mulberry cultivation (if organic inputs are required) and textile processing steps, but it requires traceability and chain-of-custody systems that can be demanding for small, fragmented suppliers ^[15, 16].

A product-level test for banned compounds, OEKO-TEX Standard 100 is helpful in ensuring that finished silk textiles adhere to chemical safety restrictions, but it does not independently certify organic agricultural or labour practices ^[15]. Price floors or premiums, worker/producer organisation, and fair purchasing practices are all specifically targeted by Fairtrade and related social standards programs. These can directly address labour and income issues in sericulture clusters, but they also require producer-group organisation and record-keeping, which many smallholders lack ^[15]. The key aspects of these certifications are summarized in Table 1, which compares the scope, strengths, and limitations of major certifications relevant to silk.

Table 1: Major certifications relevant to silk production, their scope, strengths, and key limitations.

Certification	Scope	Strengths	Gaps/limitations
GOTS	Organic, Processing, social	Strong integration	Costly, traceability heavy
OEKO-TEX	Product chemical safety	Market access	No labour/agricultural coverage
Fairtrade	Social equity, price fairness	Improves wages	Needs co-ops and record-keeping

3.2 Applicability to sericulture

Silk’s production chain has distinct nodes: mulberry cultivation, silkworm rearing, cocoon collection, reeling/degumming, dyeing and weaving. Some certifications map neatly onto these nodes while others leave gaps. For example, GOTS can be applied where mulberry is grown organically and where downstream processing meets its chemical and social criteria; it therefore delivers a vertically integrated claim but requires chain-of-custody systems and certified processing partners. OEKO-TEX® (Öko-Tex Standard) can give buyers assurance about chemical residues in finished silk products, which is valuable for market access, but it tells little about upstream agrochemical use or labour ^[15]. Life-cycle analyses of silk and comparative Life Cycle Assessment (LCA) work suggest that upstream agricultural practices, including mulberry cultivation, inputs, and water use, as well as wet-processing chemistry, both materially affect environmental footprints, meaning certification that addresses only one part of the chain will leave other impacts unaddressed, according to Gonzalez et al., 2023 ^[17].

3.3 Barriers to adoption in developing regions

Peer-reviewed work on certification adoption across commodity value chains highlights repeatable barriers that apply strongly to sericulture in developing countries: fragmented production with many smallholders, weak farmer organisation, high transaction and audit costs, lack of access to certified processing facilities, limited technical capacity to meet standard requirements, and the absence of clear price premiums or predictable buyer commitments ^[15, 18]. These issues are magnified in silk because the sector includes both agricultural (mulberry) and industrial (degumming, dyeing, reeling) steps that often occur in different geographies and under different ownership, which complicates traceability.

Additional, sector-specific barriers include the technical sensitivity of silkworm rearing, which can be disrupted by small deviations in leaf quality or residues, and the need for clean degumming and wet-processing technology to comply with downstream chemical limits. Reviews of green processing for silk show that low-cost, scalable alternatives exist, but adoption at scale requires investment and training that many small clusters lack ^[19].

3.4 Opportunities and practical pathways

The literature suggests several pragmatic approaches to make certification feasible for smallholder sericulture clusters. First, group certification or group chain-of-custody models reduce audit costs and lower administrative burden per farmer ^[15]. Second, combining product-level testing (OEKO-TEX) with farm-level organic claims (GOTS) or social premiums (Fairtrade) can create stacked value propositions that appeal to buyers seeking both chemical safety and ethical sourcing ^[15, 17]. Third, targeted investments in cleaner wet-processing, such as green degumming can unlock compliance with downstream chemical standards without changing upstream farming immediately ^[19]. Finally, local pilot projects and buyer-producer long-term contracts can underwrite the transition costs and build trust in markets for certified silk ^[3].

3.5 Implication for extension

Because certification requires both technical compliance and administrative records, extension interventions must be multi-dimensional: technical training on organic mulberry cultivation and integrated pest management; on-farm quality assurance for leaf handling and cocoon hygiene; support for group formation and record keeping; and facilitation to link producers with certified processors and buyers. Reviews of ecolabel adoption emphasise that technical assistance, financing mechanisms, and market facilitation are the three pillars that convert certification potential into real uptake among smallholders ^[15, 18].

4. Extension Approaches for Promoting Certification

In sericulture, a comprehensive extension strategy is necessary to successfully promote certification. This strategy should combine innovative Information and Communication Technology (ICT) tools, participatory models, traditional methods, and solid policy assistance to make sure smallholder farmers can access, understand, and use sustainable practices.

4.1 Traditional Extension: Farmer Training and Demonstration Plots

Traditional extension methods, such as farmer training programs and demonstration plots, remain foundational in disseminating knowledge about sustainable sericulture practices. These methods facilitate hands-on learning and provide farmers with practical experience in implementing new techniques. Studies have shown that such direct engagement leads to improved adoption rates of sustainable practices among smallholder farmers ^[20]. However, the effectiveness of these methods can be limited by factors such as geographical barriers and the scalability of outreach efforts.

4.2 ICT and Digital Tools: Enhancing Reach and Efficiency

The integration of Information and Communication Technology (ICT) has revolutionized agricultural extension by providing scalable solutions to reach a broader audience. Mobile applications, online advisory services, and digital platforms like mKisan in India have been instrumental in delivering timely information on pest management, weather forecasts, and market trends ^[21]. These tools enable farmers

to make informed decisions, thereby enhancing productivity and sustainability. However, challenges such as digital literacy and internet connectivity in rural areas can hinder the widespread adoption of ICT-based extension services ^[22].

4.3 Participatory and Community-Based Extension Models

Participatory extension approaches involve farmers in the decision-making process, ensuring that the solutions are context-specific and culturally appropriate. Community-based models, where farmers collaborate in groups to share knowledge and resources, have proven effective in promoting sustainable practices and certification adoption. These models foster a sense of ownership and accountability among farmers, leading to more sustained and impactful outcomes ^[23].

4.4 Policy and Institutional Support

Supportive policies and institutional frameworks are crucial for the success of certification initiatives in sericulture. Government policies that incentivize sustainable practices, provide subsidies for certification costs, and facilitate access to markets can significantly enhance the adoption of certified sericulture practices. Additionally, strengthening institutional support through training programs for extension agents and establishing certification bodies can streamline the certification process and build trust among farmers ^[24].

5. Case Studies and Best Practices in Certified Sericulture

Many regions have adopted sustainable and certified sericulture using different strategies, offering important insights for wider adoption. These initiatives serve as examples of how silk manufacturing systems can simultaneously fulfil social, economic, and environmental objectives. Additionally, they emphasise how crucial it is to combine technical innovation, farmer participation, and policy support in order to guarantee market competitiveness and long-term sustainability.

5.1 India: Cluster-Based and Heritage Approaches

In India, the Karnataka Silk Cluster serves as a leading example. The state has promoted sustainable practices through Farmer Producer Organizations (FPOs), which support organic mulberry cultivation, ethical silkworm rearing, and improved market access. These FPOs provide training, aggregate cocoons for better pricing, and facilitate access to certification programs, thereby enhancing both environmental sustainability and farmer livelihoods ^[25].

Similar impacts have been reported under the Central Silk Board's Cluster Promotion Programme (CPP) in Andhra Pradesh. The CPP combined inputs such as disease-free layings (DFLs), chawki rearing centres, and local facilitation with training and extension support. In Kalyandurg cluster, this approach led to significant improvements in bivoltine cocoon yield and raw-silk output, while also providing livelihood opportunities to marginalized farming households ^[26]. The programme demonstrates how targeted technical and institutional support can move rural families toward profitable sericulture within a relatively short span.

On a different axis, the Sualkuchi silk cluster in Assam illustrates how heritage-based branding contributes to sustainability. Here, artisanal weaving, cultural identity, and local branding reinforce the value of silk products. A recent study found that while product quality and heritage appeal remain strong, gaps in technology adoption, distribution networks, and online market presence hinder competitiveness. Addressing these gaps through certification and traceability could elevate the cluster's sustainability profile and global reach ^[27].

5.2 China: Technical and Policy Innovations

China provides a contrasting but complementary set of lessons. At the technical-ecological end, recent reviews show how mulberry-silkworm systems are being managed for both production and environmental remediation. Mulberry has been studied as a phytoremediation crop in heavy-metal contaminated lands and, when combined with careful monitoring and varietal selection, can expand cultivation into degraded areas without creating unacceptable food-chain risks; such ecological strategies help make certified silk more credible from an environmental-safety perspective ^[28]. At the policy and market level, analyses of China's silk trade stress that scaling sustainability requires attention to value-chain traceability, environmental standards, and export governance, all areas where integrated technical and institutional reforms are needed to maintain competitiveness while lowering environmental impacts ^[29]. Taken together, Chinese experience underlines that technical innovation (breeding, phytomanagement), strong traceability, and trade policy must work hand-in-hand to achieve certified, sustainable silk ^[28, 29, 30].

5.3 Southeast Asia: Certification, Branding, and Local Identity

Southeast Asia offers examples of how certification, branding, and heritage assets can be combined. In Thailand, a case study of Khon Kaen province shows that certification labels (organic, GI, local certification schemes) can raise producer incomes and support local identity but uptake depends on the fit between the certification's requirements and producers' capacity, and on whether certifications are supported by collective marketing and processing capacity ^[3]. This mirrors findings from other regional reviews showing that certification programs succeed when they are embedded in producer organizations, accompanied by training, and connect producers to premium markets ^[9, 31].

5.4 Success Factors Across Cases

Across these cases several recurring success factors appear. First, institutional aggregation, FPOs, cooperatives or producer associations is critical to access certification, aggregate quality output, and reduce transaction costs ^[30]. Second, context-appropriate technical packages matter: disease-free layings, chawki rearing centres, integrated pest management and phytomanagement (e.g., mulberry for degraded soils) reduce inputs and increase environmental credibility ^[28, 31]. Third, by-product valorisation, especially sericin recovery and use in cosmetics, biomedical materials and value-added bioproducts, both reduces waste and creates new revenue streams that strengthen the economics

of certified systems ^[32, 33]. Finally, market linkages and traceability from seed to finished textile are required to capture premiums for certified silk and to convince buyers that social and environmental claims are real ^[29, 30].

5.5 Lessons for Transferability

Lessons for transferability are clear but conditional. Institutional models (FPOs, cluster programmes, producer cooperatives) are transferable when adapted to local governance, land-use patterns and social norms; technical packages must be tailored to local mulberry varieties, pest pressures and climate; and market interventions must match the scale and orientation of local value chains. In places where English-language peer-reviewed studies for a specific province (for example, Lam Dong, Vietnam) are sparse, reliable transfer requires combining the peer-reviewed evidence base summarized above with high-quality local technical reports and stakeholder consultations so solutions are adapted, not copied. In short, certified sericulture scales where institutional support, technical fit, by-product valorisation, and market access are aligned ^[3, 9, 28, 30, 32].

6. Conclusion and Future Directions

Certification can be a powerful lever for making silk production more sustainable, transparent and fair. When certification standards cover both farm practices such as mulberry cultivation and silkworm rearing and downstream processing including reeling, degumming and dyeing, they create a measurable pathway to reduce chemical inputs, improve soil and ecosystem health, and give consumers traceable assurances about environmental and social claims. ^[15] Certification can also open access to premium markets and finance the extra costs that sustainable practices often require, turning short-term income sacrifice into longer-term value for producers ^[34]. However, certification by itself is not a magic bullet: its benefits only materialize when standards are realistic for smallholders, buyers pay consistent premiums, and the whole value chain maintains chain-of-custody and audit rigor ^[15, 34].

Extension sits at the centre of that translation from standard to practice. Effective extension builds farmer capacity to meet certification criteria: it trains farmers on organic soil fertility, integrated pest management, record keeping, worker welfare documentation and traceability procedures. Reviews of agricultural extension show that technology adoption is far more likely when extension is context-sensitive, pluralistic (public/private/community), and sustained rather than one-off ^[35]. In sericulture specifically, extension that combines demonstration plots, local facilitator networks and digital advisory for timely pest and husk management has been highlighted as a practical route to scale sustainable practices while protecting silk quality ^[35, 36]. Certification creates the target and the market incentive, but extension creates the capability to hit that target.

Looking forward, there are clear, actionable research and program priorities. First, rigorous, peer-reviewed impact evaluations of fully certified sericulture pilots, such as pre/post or controlled comparisons, are needed to determine which certification models actually deliver measurable environmental, social and economic gains for smallholders. The literature currently contains many conceptual reviews and programme descriptions, but relatively few long-term,

high-quality impact studies in certified silk clusters ^[15, 34]. Second, more operational research is needed on cost-sharing and finance models that make certification affordable for small farmers: blended finance, group certification through cooperatives or FPOs, and buyer-led purchase guarantees look promising but require formal testing. Third, applied research into locally appropriate technical packages, organic soil amendments, biological pest control and low-impact post-cocoon processing will make certification standards easier to meet; recent reviews show biological control and other low-chemical approaches are technically feasible but need field validation in different agroecologies ^[36]. Fourth, the design and evaluation of digital traceability systems tailored to smallholder sericulture remain underdeveloped; research should pair technology pilots with social and economic studies to ensure uptake and data integrity ^[35]. Certification defines what “sustainable silk” looks like, extension supplies the how, and both must be coupled with realistic finance, market commitments and rigorous impact measurement to succeed at scale. Policymakers and donors should therefore fund integrated pilots that combine standards, extension, cooperative aggregation and buyer engagement, and require peer-reviewed evaluation so the field can learn what truly works for smallholders and for the environment ^[15, 34, 35, 36].

References

- Sharma R, Kumar U, Lavanya V, Chavan P. Role of sericulture in rural development: Employment generation, economic growth, and sustainability. *South Asian J Agric Sci*. 2023;3(1):169-78.
- Pavithra A, Rajashekar J, Saikrishna K, Shreya B, Pramod Kumar M, Thanuja A, *et al*. The evolution of the sericulture industry in India: from tradition to modernity. *J Sci Res Rep*. 2024;30(9):282-91.
- Numata M, Srisutham M, Suzuki A. Impact of agricultural certification for silk farmers: Case study of Khon Kaen Province, Northeast Thailand. *Int J Environ Rural Dev*. 2024;15(1):120-5.
- Amarnatha N, Narmada M, Sangreskop H, Gowda S. Challenges and adoption of bivoltine hybrid silkworm rearing in Karnataka's south-eastern dry zone, India. *J Exp Agric Int*. 2024;46(9):1201-9.
- Fatimaa S, Isharb AK, Jeeva PS, Devi HD, Rajeswari SU, Kumari B. Recent innovations in sericulture: A comprehensive review of advancements in silk production and quality enhancement. *Uttar Pradesh J Zool*. 2024;45(23):75-83.
- Baciu ED, Baci GM, Moise AR, Dezmiorean DS. A status review on the importance of mulberry (*Morus* spp.) and prospects towards its cultivation in a controlled environment. *Horticulturae*. 2023;9(4):444.
- He Z, Fang Y, Zhang F, Liu Y, Wen X, Yu C, *et al*. Toxic effect of methyl-thiophanate on *Bombyx mori* based on physiological and transcriptomic analysis. *Genes*. 2024;15(10):1279.
- Hazarika S, Jekinakatti B, Bharathi BK, Charitha K, Rahman T. Impact of novel insecticides in mulberry ecosystem and its residual effect on silkworm growth and productivity. *J Exp Agric Int*. 2024;46(9):37-44.
- Altman GH, Farrell BD. Sericulture as a sustainable agroindustry. *Clean Circ Bioecon*. 2022;2:100011.
- Hosamani V, Yalagi M, Sasvihalli P, Hosamani V, Nair KS, Harlapur VK, *et al*. Constraints and economics of sericulture. *Int J Chem Stud*. 2020;8(1):746-50.
- Halagundegowda GR, Kantharaju BM, Kumaresan P. Time series forecasting of price volatility of bivoltine cocoons: An application of GARCH process and artificial neural network. *Int J Curr Microbiol Appl Sci*. 2019;8(11):840-50.
- Soundarya SR, Kumar B, Singh RK. Economics of marketing silkworm cocoons and marketing constraints faced by farmers in Kolar district of Karnataka. *J Farm Sci*. 2022;35(3):366-9.
- Madhu DM, Irfan SM, Prakash S, Sinha DK, Singh KM. Value chain analysis of cocoons, constraints faced by women in production and marketing of mulberry silk in Chikkaballapur district of Karnataka, India. *Asian J Agric Ext Econ Sociol*. 2023;41(5):36-43.
- Hussain MA, Rasid SS, Hussain SA, Sut R. Sericulture in Assam: A decade of trends, challenges, and opportunities. *Int J Entomol Res*. 2024;9(8):71-6.
- Plakantonaki S, Kiskira K, Zacharopoulos N, Chronis I, Coelho F, Togiani A, *et al*. A review of sustainability standards and ecolabeling in the textile industry. *Sustainability*. 2023;15(15):11589.
- Global Standard. GOTS annual report 2023. Stuttgart: Global Standard; 2024. Available from: https://global-standard.org/images/resource-library/documents/GOTS-Annual-Reports/GOTS_Annual_Report_2023.pdf
- Gonzalez V, Lou X, Chi T. Evaluating environmental impact of natural and synthetic fibers: A life cycle assessment approach. *Sustainability*. 2023;15(9):7670.
- Aziz NF, Chamhuri N, Batt PJ. Barriers and benefits arising from the adoption of sustainable certification for smallholder oil palm producers in Malaysia: A systematic review of literature. *Sustainability*. 2021;13(18):10009.
- Zhu L, Lin J, Pei L, Luo Y, Li D, Huang Z. Recent advances in environmentally friendly and green degumming processes of silk for textile and non-textile applications. *Polymers*. 2022;14(4):659.
- Meena MS, Singh KM, Swanson B. Indian agricultural extension systems and lessons learnt: A review. *J AgriSearch*. 2015;2(4):281-5.
- Khan RP, Gupta S, Daum T, Birner R, Ringler C. Levelling the field: A review of the ICT revolution and agricultural extension in the Global South. *J Int Dev*. 2025;37(1):1-21.
- Mukherjee S, Padaria RN, Burman RR, Velayudhan PK, Mahra GS, Aditya K, *et al*. Global trends in ICT-based extension and advisory services in agriculture: A bibliometric analysis. *Front Sustain Food Syst*. 2025;9:1430336.
- Addorisio R, Spadoni R, Maesano G. Adoption of innovative technologies for sustainable agriculture: A scoping review of the system domain. *Sustainability*. 2025;17(9):4224.
- Darjee DK. A review on policy initiatives, institutional mechanism and support for organic farming in India with special reference to north-east states: An exploratory study. *Int J Res Anal Rev*. 2023;10(4):193-211.

25. Prem SM, Kiran N, Manjunatha B. Sericulture in Karnataka: Revitalizing through farmer producer organizations. *Int J Agric Environ Biotechnol*. 2024;17:417-25.
26. Kumar KK, Sudhakar P, Naidu BV, Teotia RS. Cluster promotion programme (CPP), a novel method for the upliftment of socio-economic conditions of schedule caste and schedule tribe farming community. *Innov Farming*. 2020;5(3):123-30.
27. Tiwari S, Rosak-Szyrocka J, Bharali D, Akoijam SL, TA B. Demystifying the sustainable competitive advantage of Sualkuchi silk products: Perspectives of buyers and sellers. *Sustainability*. 2023;15(2):1110.
28. Fan W, Kong Q, Chen Y, Lu F, Wang S, Zhao A. Safe utilization and remediation potential of the mulberry-silkworm system in heavy metal-contaminated lands: A review. *Sci Total Environ*. 2024;927:172352.
29. Lu F, An M, Liang Q. The sustainability of China's silk trade: Analysis of growth effect and the influencing factors. *Front Sustain Food Syst*. 2025;9:1521229.
30. Giora D, Marchetti G, Cappellosa S, Assirelli A, Saviane A, Sartori L, *et al*. Bibliometric analysis of trends in mulberry and silkworm research on the production of silk and its by-products. *Insects*. 2022;13(7):568.
31. Jaiswal KK, Banerjee I. Recent trends in the development and diversification of sericulture natural products for innovative and sustainable applications. *Bioresour Technol Rep*. 2021;13:100614.
32. Silva AS, Costa EC, Reis S, Spencer C, Calhelha RC, Miguel SP, *et al*. Silk sericin: A promising sustainable biomaterial for biomedical and pharmaceutical applications. *Polymers*. 2022;14(22):4931.
33. Liu J, Ge X, Liu L, Xu W, Shao R. Challenges and opportunities of silk protein hydrogels in biomedical applications. *Mater Adv*. 2022;3(5):2291-308.
34. Hăbeanu M, Gheorghe A, Mihalcea T. Silkworm *Bombyx mori*—sustainability and economic opportunity, particularly for Romania. *Agriculture*. 2023;13(6):1209.
35. Becerra-Encinales JF, Bernal-Hernandez P, Beltrán-Giraldo JA, Cooman AP, Reyes LH, Cruz JC. Agricultural extension for adopting technological practices in developing countries: A scoping review of barriers and dimensions. *Sustainability*. 2024;16(9):3555.
36. Kishore SM, Khajuria M, Shalini KS, Saini A, Srivastav S, Manideep KS, *et al*. Advancing sustainable sericulture: A review on biological control agents in managing pests and diseases of mulberry and silkworms. *J Exp Agric Int*. 2024;46(9):1139-46.