IMPACT ASSESSMENT IN SERICULTURE: A COMPREHENSIVE REVIEW

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Abstract: This review explores the significance of impact assessment (IA) in sericulture, focusing on its socio-economic, and technological dimensions. By synthesizing methodologies such as cost-benefit analysis, adoption indices, and regression models, the study demonstrates how sericulture enhances rural livelihoods while facing challenges like high costs and low technology uptake. Our findings demonstrate that sericulture significantly contributes to rural employment, income generation, and women's empowerment, particularly in developing regions. However, the sector faces persistent challenges including market volatility, resource constraints, and uneven technology adoption. The review underscores the importance of training, extension services, and policy support in bridging these gaps. Emerging technologies like AI, GIS, and big data analytics offer promising avenues for refining IA precision, while climate-resilient practices and participatory approaches are essential for long-term sustainability. The review concludes with recommendations for strengthening impact assessment frameworks through enhanced stakeholder engagement, policy support, and the adoption of climate-resilient practices. These measures are essential for maximizing sericulture's potential as a sustainable agro-industry while addressing current limitations in assessment implementation and technology transfer

Keywords: Impact assessment (IA), Sericulture, Socio-Economic impact, Technology adoption, Statistical tools.

INTRODUCTION

Impact assessment (IA) is the process of identifying the anticipated or actual effects of a developmental intervention, which can be undertaken before,

during, or after the intervention through appraisal, monitoring, and evaluation, and can be an internal or external process. (Kirkpatrick *et al.*, 2002). Impact Assessment (IA) is a critical tool used to evaluate the potential environmental, social, economic, and health consequences of policies, projects, and industrial activities before implementation. The purpose of IA is to provide decision-makers with a comprehensive understanding of the possible implications of development initiatives, thereby promoting sustainable and responsible decision-making (Glasson *et al.*, 2012; Jay *et al.*, 2007). Over the past few decades, IA has gained significant global recognition, leading to the development of various methodologies such as Environmental Impact Assessment (EIA), Social Impact Assessment (SIA), Strategic Environmental Assessment (SEA), and Health Impact Assessment (HIA) (Morgan, 2012; Bond *et al.*, 2015). These methodologies are designed to mitigate negative consequences and maximize benefits by integrating scientific analysis, stakeholder participation, and policy interventions.

Environmental Impact Assessment (EIA) is one of the most widely recognized frameworks, mandated by law in many countries to ensure environmentally sustainable development (Wood, 2014). EIA helps assess the potential environmental risks associated with industrial, infrastructural, and policy-related projects by identifying key areas of concern such as biodiversity loss, pollution, and resource depletion (Glasson *et al.*, 2012; Noble, 2015). Social Impact Assessment (SIA), on the other hand, evaluates the societal implications of projects, including aspects like displacement, changes in livelihood patterns, and cultural impacts (Vanclay, 2003; Esteves *et al.*, 2012). Strategic Environmental Assessment (SEA) goes beyond individual projects and examines the long-term environmental consequences of policies, plans, and programs, making it a proactive approach to sustainability planning (Therivel, 2004; Partidário, 2012). Health Impact Assessment (HIA) has emerged as an essential methodology for evaluating the potential health risks of projects, particularly in sectors such as transportation, energy, and urban planning (Kemm, 2013; Harris-Roxas & Harris, 2011). Climate change and global sustainability challenges have necessitated a re-evaluation of IA frameworks to integrate climate resilience, ecosystem services assessment, and circular economy principles (Adelle & Weiland, 2012; Fischer *et al.*, 2015). Emerging trends in participatory impact assessments emphasize the importance of community involvement in decision-making to ensure equity and inclusivity (Vanclay *et al.*, 2015; Bond & Morrison-Saunders, 2011).

The process of impact assessment involves systematic analysis and evaluation of both positive and negative outcomes associated with a proposed action. This includes examining direct and indirect effects, as well as short-term and long-term implications (Sadler, 1996). Various methodologies, including qualitative and quantitative approaches, are employed to gather data and assess impacts across multiple dimensions, such as environmental sustainability, economic viability, and social equity (Fischer *et al.*, 2009).

Technological advancements have also influenced impact assessment practices. The use of Geographic Information Systems (GIS) and remote sensing technologies has enabled more precise spatial analysis of potential impacts, allowing for better planning and mitigation strategies (Jiang *et al.*, 2016). Additionally, the rise of big data analytics offers new opportunities for real-time monitoring and evaluation of impacts, enhancing the responsiveness of assessment processes (Kitchin, 2013).

Despite the growing importance of impact assessments, several challenges persist in their implementation. Studies indicate that IA processes often suffer from methodological inconsistencies, inadequate stakeholder engagement, limited enforcement, and political interference (Pope *et al.*, 2013; Cashmore *et al.*, 2010). In many cases, impact assessments are reduced to bureaucratic formalities rather than genuine decision-support tools, leading to ineffective mitigation measures and compromised sustainability goals (Bond *et al.*, 2017). Moreover, there is a growing need to incorporate technological advancements such as Geographic Information Systems (GIS), remote sensing, artificial intelligence, and big data analytics to improve the accuracy, efficiency, and predictive capacity of impact assessments (Geneletti, 2016; Wang *et al.*, 2018).

EFFECTIVENESS AND LEARNING

The effectiveness of impact assessments is often evaluated through frameworks that consider procedural, substantive, transactive, and normative criteria (Chanchitpricha & Bond 2013). These frameworks help in understanding how well an IA achieves its goals, such as sustainable development and environmental policy integration. However, the effectiveness is often influenced by the context, which acts as either an enabler or a barrier to achieving the desired outcomes (Bond et., 2022).

Moreover, impact assessments can serve as learning processes for organizations. By fostering information sharing and enhancing organizational memory, IAs can lead to the acquisition of knowledge, development of new behaviors, and establishment of sustainability-oriented norms (Sánchez *et al.*, 2017). This learning aspect is crucial for improving the effectiveness and sustainability of projects.

CHALLENGES

Despite the widespread adoption of impact assessments, several challenges remain. The diversity of IA branches, such as Environmental Impact Assessment (EIA), Strategic Environmental Assessment (SEA), and others, can create confusion and lack of clarity regarding their integration and application (Pope *et al.*, 2013). Additionally, the focus on "hard" impacts often overlooks "soft" impacts, which are significant but harder to attribute (Fryirs *et al.*, 2019). Future research should aim to address these challenges by developing more unified and comprehensive methodologies that can be applied across different contexts and sectors. Enhancing the clarity and applicability of impact assessments will be crucial for their continued relevance and effectiveness in addressing global challenges.

IMPORTANCE OF IMPACT ASSESSMENT STUDIES IN SERICULTURE SECTOR

The impact assessment of sericulture, a practice deeply rooted in cultural and economic history, is crucial for understanding its role in modern agricultural and socio-economic systems. Sericulture, the cultivation of silkworms for silk production, has been a significant source of income and employment, particularly in rural areas. Various studies have explored the impact of sericulture on different stakeholders, including farmers, workers, and communities, highlighting its potential to uplift socio-economic conditions and contribute to sustainable development.

Impact assessment is necessary to evaluate how sericulture projects affect the socio-economic status of casual workers and constructors. It helps understand the project's positive and negative outcomes, such as employment opportunities, income generation, and challenges faced by workers. This assessment guides decision-making to improve project effectiveness and address worker issues (Noah *et al.*, 2022).

Impact assessment studies play a critical role in evaluating the socio-economic, environmental, and technological implications of various interventions, including agricultural and industrial practices. In the context of sericulture, such studies provide valuable insights into the sector's contributions to rural livelihoods, economic development, and environmental sustainability. For instance, highlight the potential of sericulture in West Bengal India as a tool for poverty alleviation and rural employment while also identifying constraints such as climate change and lack of investment mechanisms (Bhattachariya *et al.*, 2020). Similarly emphasize the importance of optimizing environmental factors and advanced technologies in silkworm rearing to enhance silk quality and production (Kumar *et al.*, 2021)

The integration of multi-criteria evaluation (MCE) and sensitivity analysis in impact assessments offers a robust framework for decision-making in resource allocation and policy formulation (Gómez-Delgado and Tarantola 2006). Such methodologies are particularly relevant for sericulture, where factors like mulberry cultivation practices, silkworm rearing conditions, and market dynamics influence outcomes. Additionally, studies underscore the economic significance of sericulture in regions like Chhattisgarh, India, where Kosa silk production contributes to local and national GDP (Tripathi and Gurjar 2016)

Despite these advancements, gaps persist between knowledge and adoption of improved sericulture technologies (Harishkumar *et al.*, 2022). Addressing these gaps requires targeted extension services and financial support to bridge disparities in technology uptake.

REVIEW OF LITERATURE

Analysis Technique in IA studies	Statistical Tools used	Application	Reference
Advanced Methods	Path Analysis,	To know the direct, indirect and residual effect of antecedent variables on income	Sengupta *et al.* (2024)
	Decomposition Analysis	To know the relative contribution of area and yield towards the total output	Mushtaq *et al.* (2021)
	Yield gap analysis using Gomez (1977) methodology.	To compute the yield gaps in mulberry and cocoon production	Raju &Sannappa (2019)
	Propensity Score Matching (PSM)	To estimate the impact of technology adoption on smallholder farm households	Adams &Jumpah (2021)

Analysis Technique in IA studies	Statistical Tools used	Application	Reference
Trend analysis	Compound growth rate (CGR)	To compute the CGR for mulberry silk cocoons with respect to area of mulberry, production and productivity of cocoons	Mushtaq *et al.* (2021)
	Exponential Growth Function	To analyze trends in mulberry and cocoon production over time	Manjunatha *et al.* (2020)
Economic Analysis	Budgeting Technique	To analyze the profitability and cost estimation of mulberry cocoon production	
	Cost-benefit analysis	To assess the economic viability and profitability of technological interventions in sericulture. It helps quantify the relationship between investment costs and financial returns, guiding technology adoption and policy decisions.	B. R. Patil *et al.* (2009); Dewangan (2018); Sree & Reddy (2023)
Adoption analysis	Adoption Index and Percentage Analysis	Measure extent of adoption of integrated technology package (improved mulberry yield and silkworm productivity); study knowledge, adoption level of farmers and patterns of sericulture technologies.	Dayananda & Kamble, C.K. (2008); Sakthivel *et al.* (2011) Harishkumar *et al.* (2022)
		Measure extent of adoption in mulberry cultivation and silkworm rearing technologies.	Sivaranjani & Murugesh (2019)
		To assess the adoption behavior of sericulture farmers with respect to improved eri, muga and mulberry culture technologies	Hatibaruah *et al.* (2022)
	Adoption Analysis – Three-point Continuum (Full, Partial, Non-Adoption)	Assess the level of technology adoption related to moriculture and sericulture.	Mir *et al.* (2018); Parameswaranaik *et al.* (2019)
	Composite Index	To measure the extent of adoption of selected agricultural technologies across Indian states	Jain *et al.* (2009)
Regression Analysis	Multiple regression analysis, coefficient of multiple determination (R^2), and t-values.	To assess the impact of socio-economic factors influencing adoption of sericulture technologies among different farming groups	Sujatha *et al.* (2015)
	Logistic regression	To analyse the impact of the project intervention using the PSM procedure to determine the propensity scores of the variables determining participation and/or adoption of the technologies	Adams &Jumpah (2021)
	Linear regression analysis	To assess the influence of irrigation, electricity, credit, extension services, socio-economic factors, and time variation on adoption rates, mulberry area, cocoon productivity, income, and knowledge levels in sericulture	Choudhury (2018);Jain *et al.* (2009);Sreenivasa (2014);Mushtaq *et al.* (2021);Sengupta *et al.* (2024)

Analysis Technique in IA studies	Statistical Tools used	Application	Reference
Correlation Analysis	Correlation Coefficient (Pearson's formula)	Employed to assess the relationships between socio-economic characteristics, infrastructure development, adoption behavior, knowledge levels, and cocoon production in sericulture	Jain *et al.*, (2011); Sakthivel *et al.*, (2011); Hadimani *et al.*, (2019); Ahmad Hajam *et al.*, (2021); Khan *et al.*, (2022); Hatibaruah *et al.*, (2022); Joshi RR *et al.*, (2021).
Sampling Techniques	Random sampling technique	Used for the selection of rearers and control subjects, as well as for the general selection of farmers, to minimize selection bias and enhance the representativeness of the sample.	Khursheed, Wani & Jaiswal, Yogesh. (2011); Hosamani (2024)
	Simple Random Sampling	Adopted to ensure an unbiased selection of respondents within each village, providing each individual an equal chance of being included in the study	Rathore *et al.* (2019)
	Stratified Random Sampling	To select representative sericulture farmers and artisans from different villages, ensuring that all relevant subgroups within the population were adequately represented in the analysis.	
	Multi-stage Purposive Random Sampling	To systematically collect data from sericulture farmers across multiple districts, allowing for both purposive selection of key areas and random selection of respondents within those areas.	Manjunatha *et al.* (2020)
	Purposive Sampling & Random Sampling	To select sericulture farmers actively using/ adopting new technologies; random sampling was used for general farmer selection	Bharathi *et al.*, (2024)
Comparative analysis	ANOVA	Used to determine whether farmers' income depends on educational status and to compare mean adoption levels among sericulture farming families.	Ahmad Dar *et al.* (2017); S. P. Patil & Kalal (2020)
	Chi-square test	To assess the association between Income and Education	Ahmad Dar *et al.* (2017)
	Comparative Analysis	To assess the status of sericulture practice and its economy in Murshidabad.	Roy *et al.* (2023)
Ranking	Garrett's Ranking Technique	Rank problems/constraints faced by farmers and reelers in sericulture.	Elumalai (2019); Govindasamy *et al.* (2023); Gaikwad *et al.* (2023)
	Likert Scale Analysis	To assess reasons for non-adoption of improved sericulture technology, including cost barriers and awareness levels	Rathore *et al.* (2019)

Analysis Technique in IA studies	Statistical Tools used	Application	Reference
Descriptive Analysis	Mean, Standard Deviation, Percentage	Evaluate cocoon production, household income, socio-economic factors, technology adoption, technological impacts, and economic indicators.	B.R. Patil *et al.* (2009); Khursheed, Wani & Jaiswal, Yogesh. (2011); Manjunatha *et al.* (2020); Adams &Jumpah (2021); Hatibaruah *et al.* (2022); Govindasamy *et al.* (2023); Bharathi *et al.* (2024); Hosamani (2024)
	Frequency and Percentage Analysis	Present data on income, employment, socio-economic factors, environmental impact, and classify farmers and technologies.	B.R. Patil *et al.* (2009); Sakthivel *et al.* (2011); Srinivasa *et al.* (2013); Beula *et al.* (2016); Hadimani &Moulasab (2019); Joshi RR *et al.* (2021); Khan *et al.* (2022); Hosamani (2024); Mala *et al.* (2024)
	Percentage Analysis with Ranking	Analyze impact of ITP on mulberry productivity, knowledge & adoption; rank adoption constraints.	Dayananda & Kamble, C.K.(2008); Farhat *et al.* (2010)
	Simple Frequency Distribution	Assess socio-economic conditions and constraints faced in sericulture.	Hadimani &Moulasab (2019)
	Frequency, Percentage, and Rank Analysis	Distribute respondents based on socio-economic factors and rank constraints in sericulture practices.	Hajam *et al.* (2024)
	Bar representation	To represent the number of disease free larvae reared and weight of cocoons produced by mulberry silkworm& total cost of cultivation and net returns of silkworm	S. P. Patil & Kalal (2020)

RESULTS AND DISCUSSION

A critical analysis of the compiled studies reveals recurring trends in the impact of improved sericulture practices. The results emphasize the role of training, input availability, and extension services in enhancing productivity and income among seri farmers. Adoption of technologies was found to be strongly influenced by socio-economic factors such as education, farming experience, landholding size, and contact with extension personnel. Correlation and regression analyses confirmed positive associations between these variables and both knowledge and adoption levels (Jain *et al.*, 2011; Sakthivel *et al.*, 2011;

Ahmad Hajam *et al.*, 2021). Larger farmers tended to adopt innovations more readily due to better access to resources, while smallholders often struggled with high costs, lack of awareness, and inadequate infrastructure (Parameswaranaik *et al.*, 2019; Mir *et al.*, 2018).

Despite these challenges, studies using cost-benefit analysis and exponential growth models showed that sericulture remains a profitable livelihood option even on marginal holdings. Manjunatha *et al.*, (2020) noted an average cost of ₹283 per kg of cocoon with a return of ₹1.47 per rupee invested, while B.R. Patil *et al.*, (2009) reported income gains of up to 270% over traditional crops. Sericulture also contributes to broader socio-economic development, including rural employment and women's empowerment (Sree & Reddy, 2023; Adams &Jumpah, 2021). However, constraints such as market price fluctuations, water scarcity, pest damage from neighboring farms, and labor shortages persist. Garrett's ranking technique identified these as critical barriers, along with inadequate market access and storage facilities (Elumalai, 2019; Gaikwad *et al.*, 2023).

Adoption gaps were also evident in specific technologies. While shoot rearing and improved mulberry varieties were widely adopted, practices like biofertilizer use and pest management saw lower uptake due to limited technical knowledge and poor extension outreach (Sivaranjani & Murugesh, 2019; Harishkumar *et al.*, 2022). The Likert scale analysis further revealed that high costs and lack of awareness are major barriers to adoption (Rathore *et al.*, 2019). Districts with better exposure to training programs and demonstrations exhibited higher adoption scores, as shown through ANOVA and adoption index studies (Patil & Kalal, 2020).

Training and field demonstrations thus play a vital role in scaling technology use, especially among small and marginal farmers. Various sampling techniques—including random, simple random, stratified, and purposive—were used across studies to ensure representative and unbiased data collection. These methods enabled researchers to capture regional variations and segment-specific challenges, such as poor working conditions leading to health issues among rearers (Khursheed, Wani & Jaiswal, Yogesh, 2011)and the benefits of integrating advanced technologies like AI and robotics in rearing practices (Bharathi *et al.*, 2024).

Moreover, statistical tools like ANOVA, Chi-square, correlation, regression, Garrett's ranking, Likert scales, and comparative analysis were widely

applied to assess the effectiveness, adoption levels, and socio-economic impacts of sericulture practices. Various studies in sericulture have employed statistical tools such as mean, standard deviation, frequency, percentage, and ranking to evaluate cocoon production, income levels, socio-economic conditions, and technology adoption. These methods have also been used to classify farmers, identify adoption constraints, and assess the impact of improved technologies on productivity. Bar diagrams effectively presented data on larval output, cocoon yield, cultivation costs, and net returns across different sericulture practices.

A comprehensive table in this paper outlines these tools and their specific applications, providing a clear mapping of methodologies to outcomes. Overall, the literature underscores the importance of targeted interventions, continuous training, and supportive infrastructure to maximize the benefits of technological innovations in sericulture.

CONCLUSION

Impact assessment (IA) serves as a vital tool for evaluating the socio-economic, environmental, and health-related consequences of developmental interventions, ensuring sustainable and responsible decision-making. In the context of sericulture, IA studies play a crucial role in assessing the sector's contributions to rural livelihoods, economic growth, and environmental sustainability. The review of literature highlights the application of various statistical and analytical techniques such as regression analysis, cost-benefit assessment, adoption indices, and trend analysis to measure the effectiveness of sericulture interventions.

Key findings indicate that improved sericulture practices enhance productivity, income, and rural employment, particularly benefiting small and marginal farmers. However, challenges such as high input costs, market volatility, water scarcity, and limited adoption of advanced technologies persist. Training programs, extension services, and policy support are essential to bridge adoption gaps and maximize benefits.

Future research should focus on integrating emerging technologies like AI, GIS, and big data analytics to enhance IA precision. Additionally, climate-resilient sericulture practices and participatory approaches must be prioritized to ensure sustainability. By addressing existing constraints and leveraging technological advancements, sericulture can continue to serve as a

viable livelihood option, contributing to rural development and environmental conservation. Policymakers, researchers, and extension agencies must collaborate to strengthen IA frameworks, ensuring that sericulture remains a sustainable and profitable agro-industry in the long run. Finally, regular impact evaluations justify funding and investments in the sericulture sector by providing tangible evidence of outcomes. This strengthens institutional support and encourages innovations in silk production.

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Statements & Declarations

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