

International Journal of Agriculture Extension and Social Development

Volume 8; Issue 11; November 2025; Page No. 06-10

Received: 09-08-2025

Accepted: 11-09-2025

Indexed Journal

Peer Reviewed Journal

Sericulture-based agroforestry systems in India: Farming models for Economic and environmental sustainability

¹Samarpan Chakraborty, ²Tamalika Mondal, ¹Ritam Dhar, ¹Sujan Biswas and ³Debabrata Basu

¹Dhaanyaganga Krishi Vigyan Kendra, Ramakrishna Mission Vivekananda Educational and Research Institute, Murshidabad, West Bengal, India

²Sericultural Extension Economics and Management Division, Central Sericultural Research and Training Institute, Berhampore, Murshidabad, West Bengal, India

³Uttar Banga Krishi Viswavidyalaya, Pundibari, Coochbehar, West Bengal, India

DOI: <https://www.doi.org/10.33545/26180723.2025.v8.i11a.2613>

Corresponding Author: Samarpan Chakraborty

Abstract

Sericulture-based agroforestry systems represent an integrated land-use strategy that combines silk production with sustainable agro based forestry, offering ecological and economic benefits across diverse Indian landscapes. This review explores the potential of combining sericulture with agroforestry models involving mulberry, tasar, eri, and muga silkworms. These systems enable the integration of host trees with food crops, fruit trees, and fodder grasses, enhancing soil fertility, biodiversity, and carbon sequestration while diversifying farm incomes. This paper highlights successful cases in the Indian context to review the models' broader replicability. With appropriate policy support, research-based innovations, and participatory adoption strategies, sericulture-based agroforestry can significantly contribute to rural resilience, environmental sustainability, and climate-adaptive agriculture.

Keywords: Sericulture, agroforestry systems, climate resilience, carbon sequestration and livelihood

Introduction

The sustainable management of natural resources has become increasingly critical in addressing livelihood and nutritional security challenges, particularly in developing nations like India, which hosts approximately 17.78% of the global population (Worldometer, 2024) [46]. Climate change presents significant challenges to agricultural systems worldwide, affecting food security, livelihoods and ecosystem stability (Mirzabaev *et al.*, 2022; Prajapati *et al.*, 2024; Yuan *et al.*, 2024) [27, 35, 47]. This urgent situation calls for the development of sustainable and resilient agricultural practices to address these challenges effectively (Nawaz *et al.*, 2024, Saleem *et al.*, 2020) [32, 41]. Agroforestry is an alternative land-use system that intentionally integrates trees with field and horticultural crops on the same land. This synergistic approach promotes ecological balance by improving the soil's physical and biological characteristics, ultimately contributing to sustainable carbon storage (Jose, 2019; Nair *et al.*, 2010; Sheppard *et al.*, 2020) [19, 30, 43]. This integrated approach becomes particularly relevant as India faces socioeconomic impacts of overpopulation, coupled with challenges of limited arable land, deteriorating soil health and declining agricultural productivity (Pandey, 2007) [33].

Sericulture, the practice of cultivating silkworms for silk production is a vital economic activity in many rural areas

(Kiruba *et al.*, 2024). India produces four main varieties of silk - mulberry, tasar, eri and muga. Each of these types is grown in specific region and has unique characteristics (Jaiswal *et al.*, 2020, Kar *et al.*, 2013) [17, 20]. Sericulture, with its historical and cultural significance, requires host trees such as *Terminalia arjuna*, *T. tomentosa*, *Shorea robusta* and *Persea bombycina*, which naturally complement agroforestry landscapes (Choudhary *et al.*, 2023) [6]. These trees serve multiple purposes, including acting as windbreaks to protect crops from damage while supporting silk production. Sericulture has been traditionally practiced in several areas as an additional occupation particularly among marginal populations (Datta, 2000) [28], though its full potential remains unrealized due to challenges such as lack of systematic mulberry plantation and farmers' priority for subsistence crop production (Mir *et al.*, 2022) [26]. By combining sericulture with agroforestry, a farming system that integrates trees, crops and livestock present a unique opportunity for enhancing climate resilience while providing economic benefits and risk minimization for sericulture farmers (Lu *et al.*, 2004; Wang *et al.*, 2010, Majumdar *et al.*, 1967a) [23, 13, 25]. This paper critically reviews the potential integrations and present approaches of sericulture-based agroforestry systems within the Indian context, emphasizing their socio-economic benefits and environmental sustainability.

Possible integration of Mulberry sericulture and agroforestry

Mulberry silk, which forms the majority of India's silk production, is derived from the *Bombyx mori* silkworm (International Sericultural Commission, 2013) ^[45]. These silkworms feed exclusively on mulberry leaves and the cultivation of mulberry trees is widespread in regions such as Karnataka, Andhra Pradesh and West Bengal (Datta, 2000) ^[28]. Mulberry trees are highly versatile and can be intercropped with various food crops, including pulses, legumes, vegetables and cereals such as sesame, maize, rice etc (Chanotra *et al.*, 2024) ^[5]. Low temperature and deciduous habit of mulberry would not allow rearing during winter, although intercrops could be grown easily between mulberry rows. Vegetables such as cabbage, knol khol, and cauliflower can be cultivated instead of mustard, as they require a shorter growing period (Dhyani *et al.*, 1996; Gargi *et al.*, 1994) ^[10, 1]. Additionally, fruit crops like banana, guava, litchi, and mango along with timber trees like the pipal (*Ficus religiosa*) and sal (*Shorea robusta*), can be planted as border or fence crops (Rafiqui *et al.*, 2023) ^[37]. However, when planning crop combinations with mulberry, it is essential to ensure that no chemical pesticides are used. Only organic methods, bio-pesticides and integrated pest management (IPM) techniques should be employed for pest control, as the use of pesticides can harm the silkworms (Baciu *et al.*, 2023; Reddy *et al.*, 2024) ^[2, 38].

Possible integration of Tasar sericulture and Agroforestry

Tasar silk is derived from the silkworm *Antheraea mylitta*, which feeds on various wild host trees, including sal (*Shorea robusta*), asan (*Terminalia tomentosa*), and arjun (*Terminalia arjuna*) (Bindu *et al.*, 2006). Tasar silk cultivation is mainly practiced across central and eastern parts of India, with significant activity in states such as Jharkhand, Chhattisgarh, and Odisha (Sahay, 2018) ^[40]. The cultivation of these host trees for Tasar silkworms is often integrated into forest management or agroforestry systems, allowing for the incorporation of fruit trees, cereal crops and vegetables. This agroforestry approach provides significant economic benefits by diversifying income sources and reducing dependency on a single crop. In dryland areas, pastureland between trees can serve as an alternative land-use strategy (Dutta *et al.*, 2024) ^[11].

Possible integration of Eri sericulture and Agroforestry

Eri silk is produced by the *Samia ricini* silkworm, which feeds primarily on castor (*Ricinus communis*) and occasionally other plants such as cassava (Kumar *et al.*, 2010). This unique type of silk is predominantly cultivated in Assam and other north-eastern states of India, where the favourable climate supports its growth (Hows, 2024). The cultivation of castor plants, a key host for eri silkworms, is often integrated into diverse agricultural systems (Jigyasu *et al.*, 2025) ^[18]. Castor is commonly intercropped with a variety of food crops, including vegetables, pulses and oilseeds like groundnut and soybean, enhancing the overall land productivity (Desai *et al.*, 2024; Perumal *et al.*, 2025) ^[9, 34]. Furthermore, eri silk production aligns well with agroforestry systems, where castor and other host plants can be cultivated alongside fruit trees, timber species, and other

crops not only boosts crop yields but also provides supplementary income for farmers, making it an attractive option for smallholder farms (Kumara, 2023) ^[22].

Possible integration of Muga sericulture and Agroforestry

Exclusive to Assam, muga silk is produced by the *Antheraea assamensis* silkworm, which feeds on som (*Machilus bombycina*) and soalu (*Litsea polyantha*) trees (Baruah, 2020; Das, 2021) ^[3, 8]. Muga silk is highly valued for its golden hue and remarkable durability (Iiad, 2025) ^[16]. The trees used in muga cultivation thrive in subtropical agroforestry systems, where they often provide shade (R, 2024). To accommodate the growth of other crops like rice, linseed, sesame etc. and fruits like pineapple, guava, ber etc. combination with the muga trees, periodic pruning and proper management are necessary to ensure optimal conditions for both the trees and the intercropped plants (Source: "How You Can Grow Muga Food Plantation" CMERTI, 2016) ^[15].

Benefits of seri based agroforestry system

From an environmental standpoint, incorporating silk-producing plants into agroforestry systems helps to enrich soil health, boost biodiversity and improve carbon storage (Jose, 2019) ^[19]. These advantages support the long-term sustainability and resilience of agricultural landscapes, playing a key role in reducing the effects of climate change (Rolo *et al.*, 2023) ^[39].

Improvement of soil health: Host plants of mulberry, tasar, eri and muga sericulture play a significant role in improving soil fertility by contributing organic matter through fallen leaves, these plants help to increase the soil nitrogen levels and prevent erosion (Kaushal *et al.*, 2024) ^[21]. Furthermore, deep root systems of the trees in agroforestry system improve soil structure, enabling better water retention and drainage (Fahad *et al.*, 2022) ^[12].

Carbon Sequestration: Carbon sequestration is a process where carbon dioxide is absorbed and stored within trees (Kumar *et al.*, 2023). In Seri-based agroforestry system the mulberry and other silk host trees especially tasar and muga culture trees can store enough carbon dioxide so it helps towards mitigating climate change by reducing the level of greenhouse gas emission (Nath *et al.*, 2024) ^[31].

Biodiversity Conservation: Tasar and muga silk cultivation encourages the protection and regeneration of natural forests, where wild trees serve as hosts for silkworms (Chowdary, 2024) ^[7]. These forested areas contribute to maintaining biodiversity by providing habitats for various species and promoting natural pest control (Mwaniki *et al.*, 2021) ^[29].

Income diversification: Agroforestry allows the integration of cash crops, fruits, medicinal plants, or shade-tolerant crops, ensuring farmers are not overly dependent on a single source of income (Baruah, 2024) ^[3]. Farmers can earn from both silk production (selling cocoons or raw silk) and other intercropped agricultural products such as vegetables, pulses or medicinal plants, providing

financial stability.

Income from Eco-Tourism and Agro-Tourism:

Sericulture farms can attract visitors interested in silk production, offering opportunities for eco-tourism or educational tours, diversifying income sources further.

Shortcomings/limitations/challenges of seri-based agroforestry

Despite all these benefits, poor maintenance and management can create limitations in adopting this system.

Restricted Use of Pesticides: Sericulture systems discourage the use of chemical pesticides to protect silkworms, as they are highly sensitive to toxins. This restriction increases the risk of pest infestations on crop as well as host plants of sericulture and can reduce the productivity of overall system (Bora *et al.*, 2012)^[4]. Limited use of chemical interventions may require alternative pest control methods, which can be more costly or less effective. Integrated Pest Management (IPM) and biopesticides can be employed in this system for effective pest and disease management (Singh & Saratchandra, 2002)^[44].

Shading Problems by Host Plants (Tasar and Muga):

Host plants like Arjun, Asan (for Tasar), and Som, Soalu (for Muga) are often large trees, which can cause excessive shading. This reduces the growth and productivity of understorey crops in an agroforestry setup. Dense canopies may also hinder proper sunlight penetration lower photosynthetic activity and stunted growth of intercropped species (Handiso *et al.*, 2024)^[14].

Resource Competition: Host plants for silkworms (e.g., mulberry, Arjun, Asan, Som) compete with other crops in the agroforestry system for essential resources such as water, nutrients, and sunlight (Luedeling *et al.*, 2015)^[24]. Host trees require regular irrigation, particularly in dry seasons, which can be challenging in water-scarce regions. Water shortages may lead to stunted growth of plants, directly impacting leaf quality and quantity for silkworm feeding ultimately the desired yield of cocoon production (Sarkar, 2020b)^[42].

Present Works

Several effective agroforestry models have been identified for promoting sericulture, along with recommended cultivation practices in Indian context. These systems combine ecological and economic benefits, supporting sustainable livelihoods for rural farmers. Here are a few suggested models are discussed below.

1. Mulberry based Silvipasture System

The mulberry-based silvipasture system, ideal for Jammu & Kashmir, Himachal Pradesh and Uttarakhand, integrates *Morus alba* trees with grasses like Napier hybrid and *Setaria* to produce quality fodder year-round. Trees are planted on slopes with bunding or terraces at a spacing of 3x3 meters, and managed with fertilization and pruning techniques. The system yields up to 8,000 kg/ha of tree fodder and 24,000 kg/ha of grass fodder annually, supporting the livestock economy with initial incomes of Rs. 12,000-14,000/ha,

increasing to Rs. 50,000-60,000/ha as it matures (Source: Natural Resource Management Division- MAFW, 2021).

2. ICAR-CSB collaborative project on promotion of seri-based agro forestry system

In May 1993, a collaborative project by the Indian Council of Agricultural Research (ICAR) for the North-Eastern Hill Region and the Central Silk Board was launched at the ICAR Research Farm in Barapani, Meghalaya. Conducted on acid Alfisol across 3 hectares (2 ha on foothills with 30-48% slope, 1 ha in valley), the project focuses on developing sericulture-based land-use technologies for the region's agroforestry systems.

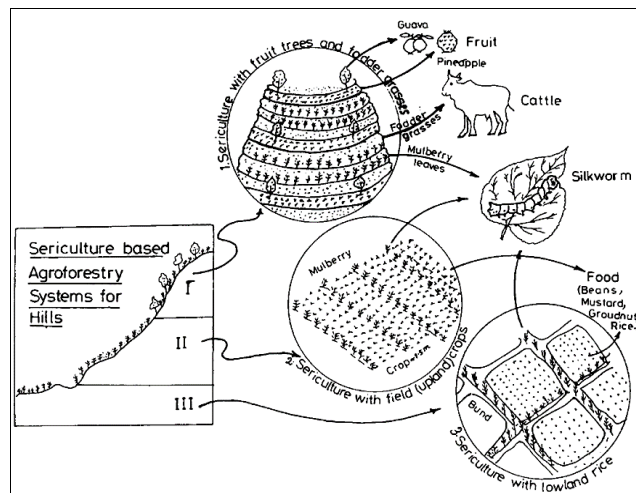


Fig 1: Schematic Diagram of Seri based AFS for North-Eastern Hilly Region of India (Dhyani *et al.*, 1996)^[10].

The trials highlighted mulberry varieties like TR-4 and S-1635, yielding up to 19 tons of leaves/ha and supporting bivoltine races such as NB-18 with cocoon yields of 19.8 kg per 10,000 larvae. Intercropping with field crops like French bean and mustard enhanced net returns (Rs. 41,380/ha), while rice-mulberry integration in lowlands allowed multiple harvests annually with favorable land equivalent ratios. By year three, the fruit tree-fodder model yielded 24,000 kg/ha of green fodder, reinforcing the system's ecological and economic sustainability. These systems offer year-round fodder, enhance soil conservation, and serve as a sustainable alternative to shifting cultivation in North eastern hilly areas (Dhyani *et al.*, 1996)^[10].

Conclusion

Sericulture-based agroforestry systems represent a promising sustainable agricultural model that effectively addresses multiple challenges facing Indian agriculture. The integration of silk production with traditional agroforestry practices demonstrates remarkable potential for enhancing both environmental sustainability and economic viability of farming operations. The successful implementation of various models including incorporating mulberry, tasar, eri, and muga silk production—shows that these systems can be adapted to diverse geographical and climatic conditions across India. The evidence from implemented projects, particularly the ICAR-CSB collaborative initiative in Northeast India, demonstrates that these integrated systems can significantly improve agricultural productivity and

farmer income. The achievement of doubled cocoon yields through improved mulberry varieties and the generation of substantial net returns validates the economic viability of these systems (Dhyani *et al.*, 1996) ^[10]. The environmental benefits of these integrated systems are equally significant. This system also improved soil health through organic matter contribution (Sheppard *et al.*, 2020) ^[43] and enhanced biodiversity conservation demonstrate the systems' potential for climate change mitigation and ecosystem restoration (Mwaniki *et al.*, 2021) ^[29]. The multiple revenue streams generated through silk production, crop cultivation, and potential eco-tourism opportunities provide farmers with resilient income sources throughout the year (Kalita & Thakuria, 2015; R T *et al.*, 2022). However, the successful implementation of these systems requires careful consideration of identified challenges, including pest management constraints, shading issues, resource competition etc. These limitations necessitate the development of targeted solutions and management practices, particularly in the areas of integrated pest management and spatial arrangement of components (Reddy *et al.*, 2024) ^[38]. Future research should focus on optimizing these systems for different agro-ecological zones and developing innovative solutions to address the identified challenges, thereby enhancing their adoptability and impact across diverse farming communities.

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