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Strategies and Approaches for Promotion of Sustainable Bivoltine Sericulture in India

NATIONAL ACADEMY OF AGRICULTURAL SCIENCES, NEW DELHI
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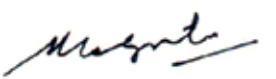
Preface

The silk industry in India is an age-old agro-based industry. It has considerable potential for generating employment and income for farmers and other players in the silk value chain. The diverse climatic conditions of the country confer it an advantage of producing all types of naturally available silks. India is the second-largest producer of silk and also its most significant consumer. Nevertheless, most domestically produced raw silk is of low quality, compelling the country to import quality raw silk to meet the growing demand for quality silk fabrics.

Considering these facts, late Padma Bhushan Prof M. Mahadevappa had proposed to NAAS to organize a brainstorming session on “Strategies and Approaches for Promotion of Sustainable Bivoltine Sericulture”, which was organized on September 22, 2021, under the convenorship of Dr S.B. Dandin and Dr Shailaja Hittalmani, along with Dr S. Rajendra Prasad, as co-convener. I place my gratitude to late Prof M. Mahadevappa for proposing discussion on this important topic, and my sincere thanks to Dr S.B. Dandin, Dr Shailaja Hittalmani and Dr S. Rajendra Prasad for shouldering the responsibility of organizing the brainstorming session. I am grateful to all the participants and panellists for their active participation and valuable suggestions. I also thank the reviewers for their critical inputs and Dr Pratap Singh Birthal and Dr Malavika Dadlani for their editorial support.

I hope that the recommendations of this brainstorming session will be helpful to all the stakeholders involved in the silk value chain.



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(Trilochan Mohapatra)
President

Strategies and Approaches for Promotion of Sustainable Bivoltine Sericulture in India

1. INTRODUCTION

Sericulture is a labour-intensive, agro-based rural industry. It has considerable potential to generate employment and income for the marginalized sections of the society, including the landless, marginal and small farm households and women. Agriculture engages 42% of the workforce in India but on millions of tiny landholdings. Close to 70% of the 150 million landholdings are of a size not exceeding one hectare. For households cultivating such small pieces of land, agriculture alone cannot be the sole source of livelihood. They look for income and employment opportunities outside primary agriculture. Silk industry offers an excellent opportunity to several of them in five sequentially interrelated activities: (i) growing of food plants as a source of feed for silkworms, (ii) production of silkworm eggs as primary input, (iii) rearing of silkworms to produce cocoons, (iv) reeling of cocoons to produce raw silk, and (v) weaving, printing and dyeing of fabric.

India is the second-largest producer of silk after China accounting for about one-third of the global raw silk output. China and India together share 91% of the total raw silk production. Uzbekistan, Thailand, Brazil, Vietnam, North Korea and Iran are other silk-producing countries. The global silk production is on a declining trend — between 2016 and 2020. it fell by more than half, mainly due to a drastic decline in its production in China (Figure 1). Note, sericulture is a labour-intensive activity, and China confronts an acute shortage of labour and higher wages, rendering silk production uneconomical. On the other hand, India's silk production has increased considerably. Between 2016 and 2020, India's share in global silk production almost doubled.

Given these trends, India's prospects for promoting sericulture are pretty vivid. India's diverse climatic conditions confer an advantage of producing all types of commercially exploited natural silks, viz., Mulberry, Eri, Muga, Oak Tasar and Tropical Tasar. Mulberry silk, however, dominates — it accounts for about 70% of the total raw silk production. It has the potential to emerge as a leading supplier of silk and silk-based products to the international market.

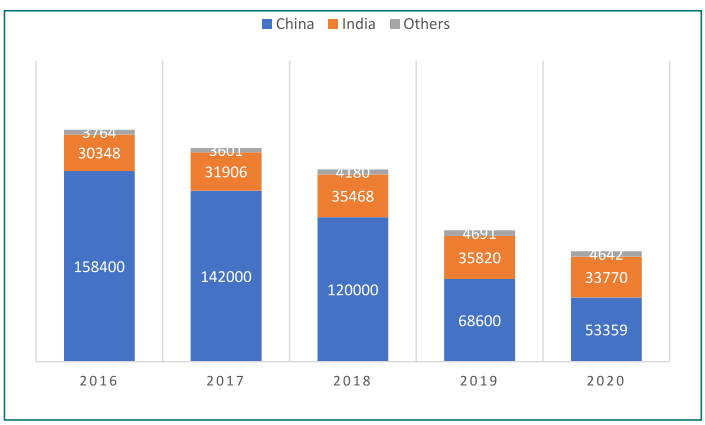

Fig. 1. Trends in global raw silk production (MT)

Source: www.Isc @ inserco.in

2. INDIA'S SERICULTURE INDUSTRY

In 2018-19, India produced 35468 tons of raw silk, of which the mulberry silk contributed 25345 tons (Table 1). Over time, India's silk production has increased considerably. Bivoltine silk has shown tremendous growth within the mulberry silk segment, raising its share to 31% in 2018-19 from a little over 5% at the beginning of the twenty-first century. The production of multivoltine silk also increased but not as fast. During this period, the output of Vanya silks, viz., the Tasar, Eri and Muga, too proliferated, consolidating their share in the total raw silk production from 8.6% to 28.9%. Of the total output of Vanya silks, the Eri accounts for about two-thirds. Except for the Muga silk, the production of all other Vanya silks increased considerably. Note that India is also the largest consumer of silk, and demand for silk clothes has grown.

Table 1. Trend in raw silk production in India

Particulars	Unit	IX Plan 1997-02	X Plan 2002-07	XI Plan 2007-12	XII Plan 2012-17	2017-18	2018-19	2019-20 (Target)
Mulberry plantation	Ha	232076	191893	181089	216810	223926	235001	257000
Mulberry silk production								
Bivoltine	MT	840	1100	1685	5266	5874	6987	8500
Multivoltine	MT	15002	15425	16587	16007	16192	18358	18865
Subtotal	MT	*15842*	*16525*	*18272*	*21273*	*22066*	*25345*	*27365*
Raw silk yield	Kg/ha	68.26	86.12	92.90	98.12	98.54	107.85	111
Vanya silk production								
Tasar	MT	249	350	1590	3268	2988	2981	3515
Eri	MT	1160	1485	3072	5637	6661	6910	7370
Muga	MT	100	115	126	170	192	233	280
Subtotal	MT	*1509*	*1950*	*4788*	*9075*	*9840*	*10124*	*11165*
Total	MT	**17351**	**18475**	**23060**	**30348**	**31906**	**35468**	**38530**

Source: www.csb.gov.in

Sericulture is an age-old agro-based industry in India, being in vogue for more than 500 years. The country produces all commercially known silk varieties - Mulberry, Tasar, Muga and Eri. However, the silk industry is highly fragmented and unorganized and is dominated by micro and small scale enterprises. The industry engages 8.51 million persons, mostly belonging to the tribal and disadvantaged communities. More than half of the workforce comprises women (54%). Currently, the sericulture industry is valued at Rs 15000 crores.

Sericulture has several distinct features that makes it preferable over other land-based activities.

- It is suitable for diverse agro-climates and farming conditions.

Fig. 2. Sericulture map of India 2020-21

Source: www.csb.gov.in

- It is eco-friendly and offers several ecosystem services.
- It is labour-intensive and generates regular cash flow (8-10 times a year) with significant value addition matching with the resource endowments and cash flow requirements of the economically weaker sections of the society, including the landless, marginal and small farm households.

3. MULBERRY SERICULTURE

The production of mulberry silk in India is concentrated in the states of Karnataka, Andhra Pradesh, Tamil Nadu, West Bengal and Jammu & Kashmir. Together, they account for 95% of the mulberry silk production. Nevertheless, the mulberry-based sericulture is also gradually spreading to the non-traditional states like Madhya Pradesh, Maharashtra, Uttarakhand, Assam, Manipur and Uttar Pradesh. Although the mulberry-based sericulture can be taken up in all types of climate, it is more prominent in the subtropical climates of Southern India. In West Bengal, sericulture has been in vogue for more than three centuries, but owing to climatic fluctuations, it produces mainly multivoltine mulberry. Nistari pure race and Nistari crossed with hardy bivoltine races are also cultivated in the state.

3.1 Employment Potential

In India, sericulture is practiced by about 1.2 million farm households, engaging approximately 8.51 million persons in different segments of the silk value chain. The majority of the workers are

from the economically weaker sections of society. Given the increasing demand for silk, there is considerable scope for employment generation along the silk value chain. At the upstream, the Mulberry cultivation, including the rearing of the silkworm, generates 3505 man-days/ha/annum, and the other associated non-farm activities (processing and value addition to cocoons) at the downstream generate 2897 man-days per annum. On the whole, the cultivation of Mulberry in one hectare generates 6402 man-days/annum (Shetty 2014). Activity-wise employment in the silk industry is shown in Table 2.

Table 2. Activity-wise employment generation in mulberry sericulture (per ha)

Sl. No.	Activity	Man-days
1	Mulberry cultivation and silkworm rearing	1255
2	Reeling of silk cocoons	2250
3	Twisting	432
4	Weaving : Handloom Weaving: Power loom	438 122
5	Printing & dyeing	95
6	Finishing	1784
7	Silk waste processing	26
	Total	**6402**

Source: Shetty (2014)

3.2 Women Empowerment

The silk industry is labour-intensive, and an important characteristic of the workforce in the industry is the involvement of women comprising 54% of the workers engaged in different activities such as plantation, silkworm rearing, silk reeling weaving etc. (Table 3). Many of these activities, such as the rearing of silkworms, spinning or reeling of yarn and weaving, require less physical energy and can gainfully engage older women and young girls staying indoors (Dandin and Vaijayakumari, 2015). A few women-friendly attributes of the sericulture industry are:

- It involves primarily indoor activities with a low requirement of physical energy.
- It requires a low level of technical skills.
- Silkworm rearing demands delicacy and infant care, which are inherent qualities among women.
- Landless families can get employment on several non-farm activities such as silkworm rearing, silk reeling, twisting, printing and dyeing.
- It provides continuous cash flow.

Table 3. Involvement of women in different sericultural activities

	Activity	Involvement of women (%)
1	Mulberry cultivation	49.55
2	Silkworm rearing	49.67
3	Silkworm seed production	20.46
4	Silk reeling	48.81
5	Silk throwing	56.34
6	Silk weaving	49.02
7	Dyeing and printing	41.00
8	Silk spinning	80.00
9	By-products utilization	65.00
	Mean	**53.45**

Source: Dandin (2004); Shetty (2014)

3.3 Integrated with Farming System

Agriculture has started facing several threats, including the quantitative and qualitative degradation of land and water resources, and climate change, leading to the slowing down productivity growth and farm income. An integrated farming system, including all the land-based activities such as horticulture, animal husbandry, fisheries, poultry and sericulture, is considered a pathway for efficient and sustainable development of agriculture and agriculture-based livelihoods because of optimum use of land, water and labour, and utilization of by-products of one enterprise in other enterprises. Given these advantages, there is a need to alter the Mulberry cultivation system with wider spacing and training Mulberry as a high bush or dwarf tree to facilitate intercoalition of short-duration vegetables, pulses and green manure crops. In this context, the time-tested crop combinations, namely 'silk and milk in India' and 'sericulture and fisheries', are well-recognized and need to be scaled up.

4. BIVOLTINE SERICULTURE

India's growing silk industry requires '3A and above grade' quality bivoltine raw silk in bigger lots (each lot weighing 75-100 kg) to meet the demand of power/advanced looms for both warp and weft and handlooms for warp. Silk yarn and cocoons are the main marketable products. The quality of cocoons determines the yarn quality for the fabrics produced. In 2019-20, India produced 7009 MT of bivoltine (BV) raw silk and 52567 MT of commercial BV cocoons worth Rs 2103 and Rs 1777 crores, respectively. Varanasi, Kanchipuram, and Dharmavaram are the silk weaving hubs and consume the bulk of the domestically produced and imported bivoltine silk. The indigenously produced cross breed (CB) silk, from the Shidlgatta in Karnataka, is used to manufacture Zari sarees.

The bulk of the Indian bivoltine silk of '2A and above grade' is used as weft in power looms. The imported Chinese silk of 'high-quality 3A and above grade' is used in large weaving units for producing high-quality clothes for the high-end domestic and export market because of its availability in larger lot size of uniform quality parameters for better weaving performance for preparation of high twisted crepe, chiffon and organzine yarn of more than few hundred meters.

The domestically produced bivoltine silk, although comparable to Chinese silk, is available only in smaller lots of 25-50 kilograms. Both cocoon producers and silk reelers are small entrepreneurs; hence there is enormous variation in the quality within and among the raw silk lots that make it challenging to use in large modern weaving units. According to the studies on cocoon quality conducted by the Central Silk Technological Research Institute (CSTRI), Bengaluru, only about half of the total quantity of raw silk produced in India conforms to the Chinese yarn in quality. Therefore, there is a need to address the issues confronting the production of '3A and above grade' quality silk in bulk.

4.1 Factors Contributing to the Production of Bivoltine Quality Silk

The quality of the bivoltine raw silk is a cumulative effect of the technological inputs of several interdependent activities starting from the production environment, including the quality of soils on which sericulture is practiced. Dr Yasuhisa Mano, a Japanese silkworm breeding expert and Dr Michio Mizuide, a reeling specialist, visited India in 1974 and compared the Indian bivoltine sericulture to the "chicken-or-egg story". Similarly, Dr Takabayashi and Mr Kinoshita, experts from JICA, Japan, assessed the "BV Raw Silk Production Program" during 1992-97 and opined that bivoltine cocoons and improved cocoon processing with automatic reeling machines should not be looked at in isolation and adopted partially. Hence, they suggested a comprehensive interlinking of all the factors (Yamada, 2020). A compromise in the application of technology at any of the stages will have a profound impact on the upstream production. All the stakeholders, namely, silkworm breeders, egg producers, CRCs, farmers, reelers, extension agencies and policymakers, have specific roles in ensuring the quality of bivoltine raw silk (>3A grade). Hence, it is essential for all the stakeholders to be aware of the critical technologies, processes parameters and minimum required facilities, and they must follow all the recommended practices meticulously to achieve quality silk yarn production. Significant factors contributing to the production of quality cocoons and their conversion into yarn suggested by Dandin et al.(2003) are illustrated in Figure 3.

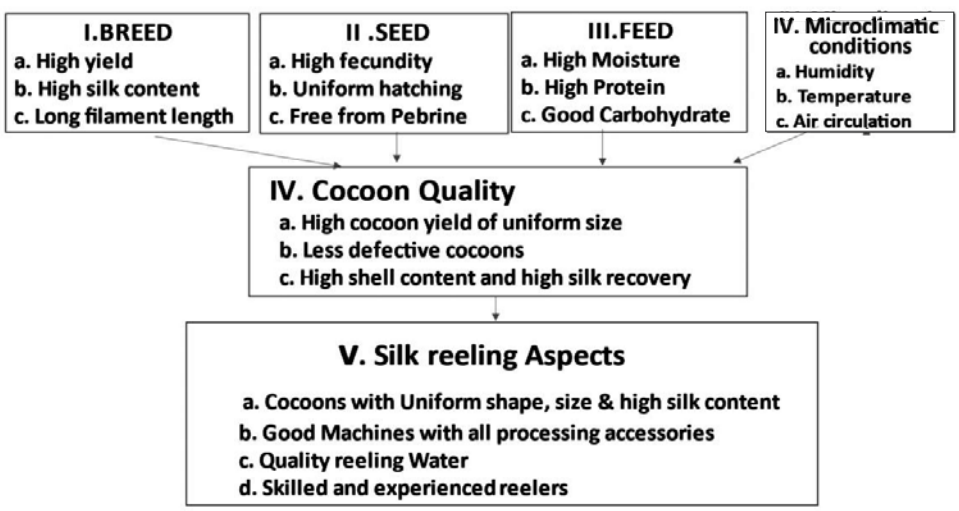

Fig. 3. Factors responsible for achieving the graded BV raw silk

Source: Dandin et al.(2003)

5. TECHNOLOGY-LED PRODUCTION, PRODUCTIVITY AND INCOME IMPROVEMENT

India has emerged as a world leader in tropical sericulture research because of the diversity in climatic conditions for rearing silkworms. It is important to note that most of the improved technologies have been fully adopted by most sericulture farmers, which is reflected in an increase in productivity and quality of raw silk and farmers' income (Dandin and Giridhar, 2010).

5.1 Technologies and Practices

High yielding varieties: Mulberry varieties developed in India have the highest leaf yield globally. The leaf yield increased from 30000 tons/ha in the 1970s to 65000 tons/ha in the 1990s (Table 4).

Table 4. Popular high yielding Mulberry varieties in India

	Variety	Region	Developed at	Leaf yield MT/ha
1	S-36	South -irrigated	CSRTI, Mysore, Karnataka	25-30
2	Victory-1	South - irrigated	CSRTI, Mysore, Karnataka	55-60
3	S-1635	Eastern and Northeast-irrigated	CSRTI, Berhampore, West Bengal	35-40
4	G2 (young age worms)	South - irrigated	CSRTI, Mysore, Karnataka	55-60
5	G4	South - irrigated	CSRTI, Mysore, Karnataka	55-60

Source: www.csb.gov.in

Recommended cultivation practices: Besides the improved varieties, the following practices have helped increase leaf yield and quality, enabling farmers to rear more eggs and get more cocoon yield.

- Wider spacing with pit system of planting, 90 cm x 90 cm. Paired row system of planting (90cm x60 cm) x 150 cm
- Use of nursery raised rooted plants of 4-5 months to establish new gardens
- Use of higher doses of Farm Yard Manure @20 MT/ha twice a year
- Application of chemical fertilizers, 300:120:120 of NPK/ha, five times a year after one year of crop establishment
- Integrated Pest Management (IPM) for controlling pests and diseases
- Five times shoot harvest, followed by inter-culture operations
- Basal pruning of plant in June and middle pruning in October

Improved silkworm breeds: Research has made a significant contribution to developing high yielding varieties of silkworms by exploiting the hybrid vigour. The high yielding varieties of silkworm races with disease resistance and better yarn quality have been developed in the cross breed and bivoltine hybrids (Table 5). The cocoon yield has been reported to be 65-70 kg/ 100 disease-free layings (dfl) with reduced renditta of 6-7(CSRTI, 2017).

Table 5. Improved silkworm breeds in India

Hybrids	Region	Season
PM X CSR 2	South and Central India	All seasons
CSR2 x CSR4	South India Temperate/Sub-Tropical Zones	All seasons in South & favourable seasons in other regions
FC1 x FC2	South, North, Northwest East and Northeast	All seasons in South & favourable seasons in other parts
SK6 x SK7	East and Northeast	Spring & autumn
Nisthari X NB4D2	East and Northeast	Summer & autumn

Source: www.csb.gov.in

Recommended silkworm rearing practices

- Construction of exclusive rearing houses of recommended size with good ventilation
- Disinfection of rearing houses twice, i.e., before and after every crop
- Self-system of rearing with a recommended spacing of 600 sq ft for every 100dfls
- Supply of young-age worms separately in chowki rearing centres
- Two times shoot feeding every day during morning and evening
- Use of recommended bed disinfectants for worms after resuming every instar
- Use of activated lime powder during every moulting to keep the bed dry
- Mounting of mature worms for cocooning after full growth giving sufficient spacing
- Harvesting of cocoons on the sixth or seventh day of spinning
- Transport of cocoon for marketing in a plastic box after sorting, cleaning and de-flossing

Silk reeling: Silk reeling is an industrial activity wherein cocoons are used to produce raw silk as raw material for fabric manufacturing. Several technologies have been developed to improve silk quality and recovery:

- Multi-end reeling machinery/technology package for multi-bivoltine cocoons, consisting of cocoon drying, cocoon cooking, reeling, vacuum permeation and re-reeling
- Bivoltine silk reeling technology package
- Indigenous automatic reeling machinery/technology package consisting of conveyor cocoon drying, vacuum permeation pre-treatment, conveyor cocoon cooking, automatic silk reeling, vacuum permeation and re-reeling

- Web-silk reeling machine
- Pupae by-product: handling & processing machinery package
- Energy management in reeling
- Split buttons for producing quality raw silk
- Conveyor cocoon drying machine

5.2 Extension Programs

Technologies have been successfully demonstrated and transferred to the fields through a few extension programs (CSRTI,2017):

- Japan International Cooperation Agency Funded Project Japan International Cooperation Agency (JICA) Project for Promotion of Practical Bivoltine Sericulture Technologies (PPPBST), (1996-2002)
- PEBS- (2002-2007) exclusively for bivoltine
- Institute-Village Linkage Program (IVLP) was implemented during 2002-2007
- Catalytic Development program (CDP), 2008 - 2012 for productivity improvement
- Bivoltine Cluster Promotional Program (BCPP), 2013-2017
- 'Silk Samagra' (2017-2020) for improving silk quality and productivity

CSB has implemented these programs in collaboration with the Department of Sericulture of the state, NGOs and Farmers Producers Organizations (FPOs). The JICA team recommended the basic ideas and modalities, and the same was followed subsequently with required modifications. Overall progress achieved is given in Tables 6 and 7.

Table 6. Bivoltine crop performance in different extension programs

Particulars	PPPBST	PEBS	IVLP	CPP-I	CPP-II
	1979-2002	2002-2007	2003-2007	2008-2012	2013 -2020
No. of TSCs	10	18	16	22	106
No. of Farmers	142	3998	1510	5682	81162
No. of DFLs used (Lakhs)	2.84	52.7	107.89	110.99	2143.9
Cocoon yield/ 100 DFLs (Kg)	69.46	65.70	65.83	64.98	68.92
Cocoon price (Rs.)	201.29	161.49	195.00	216.38	346.00

Source: www.csrtimys.res.in

The adoption of improved technologies supported by the extension programs has led to a tremendous increase in production, productivity and quality of silk (Table 7).

Table 7. Indicators of performance

	Indicators	1970	2020	% change
1	Mulberry area in hectares	98248	237578	139
2	Mulberry leaf yield (MT/ha)	10 -12	50-60	400
3	Leaf quality (Leaf: Cocoon Ratio. in Kg)	30-35	23-35	30
4	Races used	All multivoltine	CB AND Bivoltine	-
5	DFLs brushed/ha (No.)	1200-1500	2000-2500	66
6	Proportion of CRC brushed DFLs (%)	-	75-80	-
7	Cocoon yield/100 DFLs (Kg)	15-20	60-65	225
8	Cocoon crop stability (%)	60	90	50
9	Defective cocoons (%)	>15	<8	100
10	Shell percentage	12-13	20-21	61
11	Renditta	12-15	6-7	54
12	Raw silk quality (Grade)	Gradeless	A and above	-
13	Total raw silk production	2319	23896	930

Source: CSB (2020)

The industry's growth rate over the last five plan periods, as given in CSB(2919), is shown in Table 8.

Table 8. Trend in productivity, conversion and employment in sericulture industry

Plan period	Renditta	Raw silk productivity (kg/ha)	Cocoon productivity (kg/ha)	Cocoon yield (kg/100 dfls)	Employment (lakh persons)
VIII plan (1992-97)	8.9	46.16	412.10	36.15	59.67
CAGR (%)	*-2.2*	*4.0*	*1.7*	*-1.1*	*0.1*
IX Plan (1997-02)	8.8	68.26	601.60	41.84	55.00
CAGR (%)	*-0.6*	*6.5*	*5.9*	*1.9*	*0.9*
X Plan (2002-07)	8.2	86.12	705.92	47.70	60.30
CAGR (%)	*-1.3*	*2.8*	*1.4*	*1.7*	*1.5*
XI Plan (2007-12)	7.7	100.90	772.39	58.21	75.60
CAGR (%)	*-1.2*	*2.8*	*1.6*	*3.1*	*4.3*
XII Plan (2012-17)					
2012-13	7.7	94	724.40	52.69	76.53

Plan period	Renditta	Raw silk productivity (kg/ha)	Cocoon productivity (kg/ha)	Cocoon yield (kg/100 dfls)	Employment (lakh persons)
2013-14	7.3	95.93	704.04	57.35	78.50
2014-15	7.4	97.31	726.60	58.84	80.30
2015-16	7.4	98.01	718.09	59.01	82.50
2016-17	7.3	98.12	726.44	60.24	85.10
CAGR (%)	*-1.1*	*0.9*	*-0.2*	2.7	*2.1*
2017-18	7.33	98.54	722.04	59.83	86.04
2018-19	7.32	107.85	789.62	61.39	91.78
CAGR (%)	*-0.1*	*4.6*	*4.6*	*1.3*	*3.3*
CAGR % (2012-13 to 2018-19)	*-0.7*	*2.0*	*1.2*	*2.2*	*2.6*

Source: CSB, Bengaluru

5.3 Economics of Sericulture

In southern India, because of the congenial climate for the continuous growth of Mulberry, the leaf is available throughout the year. Farmers in Karnataka, Andhra Pradesh and Tamil Nadu rear silkworms 5-6 times a year. With the new two-plot system and availability of chowki worms, farmers can harvest 8-10 crops a year. Accordingly, sericulture economics has been calculated based on the silkworm rearing calendar.

The following aspects play a significant role in harnessing higher income

- Number of leaf/shot crops harvested per year
- Quantum of leaf yield per year or per crop
- Leaf-Cocoon ratio (reflects leaf quality)
- Number of DFLs/ larvae brushed per crop
- Effective rate of rearing (ERR) (survival rate till cocooning)
- Single cocoon weight
- Percentage of good cocoons and silk content

Sericulture economics has been studied both under-irrigated and rainfed conditions and for bivoltine and cross breed races. Table 9 shows the economics of sericulture using improved cross breed 'Kolar Gold' under irrigated conditions. Besides the higher income, sericulture has a distinct advantage of providing a regular flow of income every six weeks from the two-plot system after 8-9 months of planting. Mulberry, being a perennial crop, produces leaves continuously for 15-20 years at a regular interval of 60-70 days (Trivedi and Sarkar, 2017; Puroshotam,2014; Jayaram et al., 2011)

Table 9. Summary of annual income from sericulture on small farms (2 acres) under two plot/10 crop systems with V1 variety of Mulberry

	Details	Cross breed Kolar Gold (PM x CSR2)	Bivoltine Hybrid FC1 x FC2
1	Leaf yield @ of 60,000 mt/ha/y	48,000 mt	48,000 mt
2	No. of crops	10	10
3	Leaf yield per crop	4,800 kg	4,800 kg
4	DFLs to be brushed per crop	250	200
5	DFLs to be brushed per year	2500	2000
6	Cocoon yield per crop	60 kg	65 g
7	Cocoon yield per year @ 60 kg/100 DFLs CB and 65 kg/100 DFLs BV	1,500	1,300
8	Gross income from DFL @ Rs. 300/kg of CB and Rs. 350/kg of BV	4,50,000.00	4,55,000.00
9	Cost of cocoon production 55% of total income of CB and 60% for BV*	2,47,500.00	2,50250.00
10	**Net income**	**2,02,500.00**	**2,04,750.00**

*includes family labour cost also.

Source: *www.csrtimys.org*

Several studies (e.g., Dandin et al., 2005; Jayaram, 2010; Purushotham, 2014; Trivedi and Sarkar, 2015; Jayaram, 2011; Mattigatti et al., 2000) have shown sericulture more profitable compared to other cash crops (Table 10).

Table 10. Comparative economics of crops, 2017-18

Crop	Rs/ha/annum				Cost of production (Rs/qtl)
	Total cost (Rs)	Gross returns (Rs)	Yield ('00 kg)	Net returns (Rs)	
Paddy (irrigated)	135705	152303	70	16598	1941
Turmeric	364045	553145	58	189100	6260
Tomato	375288	342445	372	-32843	1009
Banana	807725	1021983	725	214258	1114
Sugarcane	195000	260000	10000	169000	1950
Pomegranate	481260	631555	146	150295	3298
Sericulture	311930	516750	13	204820	23542

5.4 Sericulture Value Chain

The silk industry has a long tail production chain with six main marketable products, i.e., leaves, eggs, chwaki-reared worms, cocoons, raw silk and fabric. Besides, there are two intermediate

conversion points and three by-products: the cut cocoons, silk waste, and pupae. Profits gained from each activity are pretty large, making sericulture an economically viable enterprise (Mattigatti et al., 2000; Dandin and Kumaresan, 2003; Dandin, 2019; Jayaram, 2011). Table 11 shows key economic parameters of the sericulture value chain.

Table11. Price spread and market margin in the sericulture value chain

Entrepreneur	Value addition		Market margin		Price spread	
	(Rs.)	%	(Rs.)	%	(Rs.)	%
Rearers	1243.61	32.11	858.88	46.72	2410.90	40.07
Reelers	525.30	13.56	92.73	5.05	618.03	10.27
Twisters	211.87	5.50	126.80	6.91	338.67	5.63
Dyers	468.73	12.10	31.87	1.74	500.60	8.32
Weavers	1020.94	26.36	347.67	18.94	1368.61	22.75
Traders	402.24	10.37	377.47	20.57	779.70	12.96
Total	3872.69	100.00	1835.42	100.00	6016.52	100.00

Source: CSB

6. SILK VISION 2030

India has tremendous scope to increase its silk production and emerge as a leading supplier of raw silk and silk products in the domestic and international markets. India imports a sizable amount of quality raw silk from China. This is mainly because of the slow growth of bivoltine silk production due to the decline in area under Mulberry cultivation in its traditional belt, the low output of bivoltine eggs and an inadequate number of Automatic Reeling Machines. In alignment with the Indian Silk

Fig. 4. Midterm and long-term production targets

Source: CSB

Vision 2030, and keeping in view the present status, potentials and future scope, the following mid-term and long-term plans are suggested for the industry. The target of CB/ICB and bivoltine raw silk production *vis-à-vis* the requirement of commercial seed for 2020-21 to 2024-25 (mid-term) and 2025-26 to 2029-30 (long-term) are shown in Figure 4 and Table 12 (CSB 2018).

Table12. Target for bivoltine silk production by 2030

	Year	Mulberry (MT)	
		Bivoltine	Total Mulberry
Short-term	2016-17	5260	22660
	2017-18	6100	23900
	2018-19	7200	25300
	2019-20	8500	27000
Medium-term	2020-21	10000	28900
	2021-22	12000	31500
	2022-23	12850	32850
	2023-24	13800	34300
	2024-25	14800	35800
Long-term	2025-26	15800	37350
	2026-27	17000	38800
	2027-28	18000	39950
	2028-29	19000	41100
	2029-30	20000	42200

Source. *www.csb.gov.in*

7. RESEARCH, DEVELOPMENT, MONITORING AND POLICY NEEDS

Research and development activities have contributed immensely to the growth of the sericulture industry in India. This could happen because of the support provided under the three external aided projects, namely, KSP-1, NSP and JICA, for nearly three and a half decades (Kojima, 2000). Under these projects, an excellent research infrastructure has been created. However, presently, these institutions face a scarcity of financial and human resources. On the other hand, climate change is emerging as a new challenge.

7.1 Research Gaps

Research and development gaps in pre-cocoon and post-cocoon activities

Activities
▪ Use of microbial consortia for conversion of mulberry waste into organic manure
▪ Effective control of leaf roller and root rot, aphids and thrips
▪ Explore the use of Agro-textiles (Agro-Tech) such as shade net, leaf harvesting net, Uzi net etc., in sericulture activities which are already used in horticulture and other crops
▪ Efforts for exchange of silkworm genetic resources
▪ Maintenance of parental breeds confirming to their parental characteristics
▪ Explore the possibility of using alternate male component (FC2) cross breed production and development of more double hybrid combinations
▪ More research emphasis on mounting, mountages and climate management during cocooning and also labour saving
▪ Specific research programs for using defective cocoons, pupa, defective cocoon, cut cocoon, silk waste, etc.
▪ Alternate uses of silk and by-products in the bio-medical and cosmetics industry
▪ An easy and quick method for pupa level sex separation, Pebrine detection & Flacherie management
▪ Training of scientists in advanced sericulture countries
▪ Strategize to produce a substantial quantum of high-grade silk to reduce the import of raw silk and ultimately become an exporter of raw silk
▪ Design and development of silk products to cater to the international markets

To address these gaps, there is an immediate need to augment research resources and network projects involving specialized institutes of ICAR, CSIR, MoF & E and SAUs. In the post-cocoon areas, research products need to be upscaled at the industry level.

Sericulture education to meet the specialized manpower requirements for the R&D level also needs to be addressed. This is more important in biotechnology, nanotechnology, and biomedical applications. Short-duration certificate and diploma courses are important for the rural youth to aquire required skills. Skill Development Council of India's programs may be effectively utilized.

7.2 Corporatization of Sericulture and Seri-enterprises

To ensure large scale quality bivoltine production to meet the demand of export-oriented units and power looms, large farmers/ corporates interested to set up large Automatic Reeling units can enter into a contract with farmers capable of absorbing modern technology for the production of superior quality bivoltine cocoons. Policy interventions to support farmers on the lines of the horticulture sector are required.

While the corporate houses can identify farmers with the support of Departments of Sericulture (DOSs) and Central Silk Board (CSB), they should be able to develop a model of buy-back good quality cocoons based on quality-linked price formula. The farmers identified by the corporate

houses can be provided with financial assistance and technical support by the Central Silk Board. A Model Linkage Program for the production of 100 MT of bivoltine raw silk is presented in Table 13, which can be customized as per the requirements.

Table 13 : Model linkage program for production of 100 MT of bivoltine raw silk (from seed to yarn per year)

1	Raw silk production target	100 MT
2	Automatic reeling machines	3 (400 ends each)
3	Cocoons required	710 MT
4	Chawki rearing centres	3 @ 4 lakh DFLs/year
5	Eggs required	12.00 lakh
6	Mulberry area	675 ha
7	No. of farmers	1125 (0.6 ha)

7.3 Accelerating the Use of ICT

Information and communication technology offers enormous scope in reaching the unreached. ICT enabled tools and methodologies can be applied by developing tailor-made apps for training and extension programs.

7.4 IPR Issues

Intellectual property and patenting are becoming important. Hence, there is a need for establishing a separate Intellectual Property & Business Management (IP & BM) Cell to address the increasing needs of commercialisation of technologies and products.

7.5 Policy Implementation Desk

For the orderly growth of any industry, a long-term policy is a must. As a supportive unit, a Policy Implementation Desk is imperative to monitor and report progress against the set targets. Therefore, it is proposed to have a Policy Implementation Desk at CSB with a competent officer directly reporting to the Member Secretary of CSB on the various developments from time to time, plan promotion of sericulture through continuous engagement/ partnership with agencies like NRLM, MoRD, MOA&FW and KVIC. The first task of the Policy Implementation Desk shall be to break the policy into implementable short-term targets and provide inputs to the implementing officers. Breaking the long-term goals into short-term implementable interventions will make it easy to reach the targets in the stipulated time.

7.6 Trade Desk

One of the primary objectives of the medium and long-term policy should be to establish the country's position in international trade. A major reason for the depressed trade is that the private sector handles the entire silk trade, and the government has minimal intervention. The trade is not monitored continuously, and the state machinery has little control or understanding of the happenings in international trade. It is, therefore, necessary to incentivize and monitor trade to achieve a quantum jump in silk export. Hence, it is essential to establish a Trade Desk at the CSB. The Trade Desk will also work out the competitive advantage of various silk products and provide

inputs for diversification of the products and new destinations for export. The trade statistics should be collected and prominently displayed to provide inputs to policymakers and traders. The trade desk should also address investment, tariffs, and subsidies issues. The trade desk should also organize interface meetings of traders and policymakers to understand major problems and seek solutions.

7.7 Action Plan, Milestones and Progress Indicators

To achieve the set targets, there is a need to develop a time-bound actionable plan, monitor performance indicators. This should be a joint effort involving all agencies and stakeholders. Clear-cut guidelines, annual targets for all the major components, and division of work need to be well defined and regularly monitored, as suggested by Kawahami (2011) and Kojima (2020). The model developed and implemented can be adapted with modification rather than reinventing the wheel. The CSB has already set the targets and production/ quality indicators, are shown in Tables14 and 15.

Table 14. Milestones and productivity indicators

	2017	2023	2030
Expansion of mulberry area(Lakh Hectares)	2.3	3-00	3.86
Mulberry leaf productivity (MT/ha/year)	45-50	48-52	55-60
Seed (Egg) production (Lakh DFLs)	2210	3212	3840
Cocoon yield improvement (Kg/ha)	55-60	58-62	65-70
Renditta	7.32	7-00	6-5
Raw silk productivity(Kg/ha/year)	98-1	102	110
Employment (Lakh persons)	85.1	100	150
Reduction in silk import (MT/annum)	2022	1050	-
Export earnings (Rs crores)	2093	2250	4000

Source: Central Silk Board

Table 15. Summary of suggested policy measures

	Stakeholders	Requirements	Policy prescriptions
1	**Silkworm seed producers**	Supply of quality seed in required quantity at reasonable price	▪ Support private sectors for infrastructure and seed cocoon support to private grainers ▪ Produce quality seed to bridge the gap ▪ Regulate price of seed cocoons and quality standards through system and product certification

2	**Chawki rearing**	Supply of quality chawki worms at reasonable price	▪ Regulate quality standards of chawki worms and chawki silkworm price ▪ Quality assurance: Chawki rearers to be compensated for crop loss due to diseased chawki worms
3	**Farmers**	▪ Good rearing house with mounting space ▪ Access to improved technology ▪ Area expansion ▪ Improved host plant and silkworm breed ▪ Price fluctuation for cocoons resulting in a distress sale ▪ Knowledge gap on soil health, water management, disease control. * Need for mechanization and skilled labour	▪ Assistance for construction of scientifically designed rearing house with mounting space ▪ Strengthening extension system at the central, state and private level and also collective action for service delivery and extension ▪ Make available improved host plant varieties, silkworm breeds (season and region-specific for 5 seri zones) with based seed stock readily available to farmers ▪ Specific policy to expand sericulture in the potential area in traditional and non-traditional states. ▪ Integration of sericulture with other farming activities ▪ Cocoon gradation, quality-based pricing system, cocoon storage facility at cocoon markets ▪ SVK on sericulture, Seri resource centers, seri- polyclinic, seri-input supply centres, door to door disinfection centers attached to the Chawki rearing center ▪ Promote machinery manufacturers and hire service units involving rural youth; promote skill up-gradation in machinery handling and repair ▪ Sericulture to be treated on par with agriculture to get the benefits of power subsidy, agriculture subsidy, support under national calamity disaster fund, etc.

4	**Reelers**	▪ Upgrade from charka, cottage basin to MEM and ARM ▪ Limited resource for upgradation	▪ Improved machines for reelers ▪ Product diversification, by-product utilisation ▪ Indigenous and imported reeling machinery for Mulberry, ▪ Enhance credit flow to silk sector; specially reeling ▪ Skill upgradation
5	**Weavers**	Need for better market and price for handloom products	▪ Promote traditional design banks, GI and handloom tags; improve dye and weaving quality, design intervention, surface ornamentation ▪ Improved technology for drudgery reduction and productivity improvement and skill upgradation ▪ Fancy, knitwear and value-added products
6	**Consumers**	▪ Need quality silk ▪ Consumer protection against unscrupulous sale of art silk	▪ Popularisation of silk mark and awareness on pure silk, varieties of silk ▪ Generic and brand promotion of Indian silk ▪ Quality testing facilities across the silk value chain to maintain quality standards ▪ SMOI need to have a strong legally framed surveillance mechanism to check unscrupulous sale of art silk in the name of pure silk
7	**Exporters**	Need to boost the stagnated growth in silk export	▪ Generic and brand promotion of Indian silk in global markets ▪ Quality testing facilities to maintain quality standards, BIS standards ▪ Product mix, new designs, organic silk as per the demands of the global market ▪ Export market research and branding ▪ Trade desk to promote a quantum jump in the silk export

8	**Seri business enterprise**	More investment in sericulture, measures to overcome drought, depleting water table, climate change	▪ Institutional credit for climate-resilient sericulture to make it more productive, sustainable and economically viable ▪ FDI, venture capital, incubation centre, start-up, corporate sericulture to promote seri business enterprises
9	**All Stakeholders**	▪ More resources from central and state governments to implement sericulture development programmes ▪ Stability in price volatility silk yarn ▪ More trained manpower and knowledge upgradation	▪ Tap resources from industry and corporates to support silk clusters under CSR; increase fund flow through MGNREGS, RKVY, and MUDRA ▪ Enhance credit flow to sericulture ▪ Introduce sericulture as a subject at the high school level (both theory and practical) to bridge the knowledge ▪ Price stabilisation, price insurance, cocoon and yarn bank ▪ Corrective measures to stabilize silk price ▪ Capacity building and training, service delivery through CBO, cluster approach, paraprofessionals, technical consultants for skill ▪ Evolving into a new generation ICSRE (Indian Council for Sericulture Research and Education) ▪ Policy implementation desk to promote sustainable sericulture business enterprises

Source: Draft document of National Sericulture Policy of CSB (2020)

8. CHALLENGES, STRATEGIES AND ROADMAP

8.1 Challenges

- Depleting groundwater resources and shortage of irrigation water
- Global warming and climate change/uncertainty effects
- Urbanization and shrinking cultivated land in traditional/rural areas
- Non-availability of skilled workforce

- Declining organic carbon level and adverse effects of excessive use of chemical fertilizers and pesticides on soil health
- Inadequate supply of quality eggs and shortage of cold storages
- The emergence of new pests and pathogens
- Improper rearing conditions including mounting space, especially for big farmers
- Inconsistency in cocoon quality due to use of defective mountages
- Non-availability of sufficient automatic reeling units
- Underutilization of by-products
- Acute shortage of trained field and extension staff
- Lack of quality-based and uniform pricing policy for seed cocoons, seed and commercial cocoons
- Inadequate supply of improved reeling machines (ARMs)

8.2 Strategies and Roadmap

Required developmental approaches and policy reforms: Strong technology and policy support is imperative for the orderly growth of any industry. However, no single technology/ approach can remain valid for long under the dynamic system. Hence, the technological adjustments and implementation practices need readjustments. Similarly, the Acts and policies need to be reformed. Following are a few suggestions:

Technical and developmental aspects

- Expansion of Mulberry only in potential areas following a cluster approach
- Soil fertility and soil health management especially organic carbon
- Water conservation and increase in water-use efficiency
- Development of double hybrid race combinations
- Educating farmers in cocoon quality aspects, especially the use of rotary mountages
- Enhancing egg production capacity both in the public and private sectors
- Establishment of one more P1 Grinage and additional cold storage facilities
- Standardization of chawki rearing centers (CRCs) and their activities
- Development and promotion of semiautomatic/automatic systems for sorting cocoons at the time of reeling.
- Enhancement of improved reeling capacity, especially ARMs
- Strengthening extension system and develop skilled manpower through training of youths
- Corporate sector involvement and end-to-end operations with built-in organic linkage similar to contract farming

- Strengthening marketing system for cocoon and raw silk in non-traditional areas
- Effective use of by-products such as pupae, silk waste and sericin for value addition and income generation
- Involvement of community-based organizations such as FPOs and SHGs for transfer of technologies

Policy reforms

- GST on silk machinery may be exempted
- Extending the period of anti-dumping duty on raw silk
- Revoking Most Favored Nation (MFN) status and also removal of sensitive items like silk/silk products from the list of items agreed under FTA
- Uniform policy for both seed cocoons and seed produced by all the agencies to provide a level playing ground
- Reforms in existing cocoon marketing system/ provision for contract farming

Detailed recommendations are given in appendix I.

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Appendix I: Detailed Recommendations

a. Mulberry cultivation

- Expansion of mulberry area in a cluster mode in potential regions of non-traditional states like Maharashtra, Madhya Pradesh and Odisha and non-traditional areas in traditional states
- Development of seri-based Integrated Farming System Models (Agroforestry & Sericulture; Horticulture & Sericulture) and Agri-Seri combined farming to utilise forest lands and fallow lands with tree Mulberry plantation with wider spacing in rainfed areas
- Emphasis on improving soil health, organic matter content, and organic crop protection approaches, including the use of bio-fertilizers and crop protectants to reduce chemical use and footprints

b. Egg production

- Seed multiplication system should be strengthened in association with DoS & CSB and maintain parental traits and vigour following set procedures meticulously
- Encourage private grainuers for quality seed production by creating level playing grounds and providing financial support, including common cold storage facilities
- Seed/seed cocoon prices should be uniformly adopted based on actual production costs and acceptable profit margins, and the same should be revised from time to time
- Development of indigenous sex separation and Pebrine detection machines

c. Silkworm rearing

- New bivoltine double hybrids & high yielding Mulberry varieties developed by different institutions under field trials should be released at the earliest
- Season and location-specific technological interventions focusing on cocooning management and development of new mountages
- Disease resistant/thermo-tolerant silkworm hybrids should be popularized
- More research efforts are needed to develop cheap appliances and machinery
- Infrastructure and mechanization for drudgery free sericulture

d. Post-cocoon activities

- Development of consumer-oriented value-added products (e.g., pharmaceuticals, nutraceuticals, cosmetics and animal feed) from the by-products of the silk industry
- Repeated training and skill development of reelers, twisters and weavers to achieve desired recovery and quality of raw silk/fabric
- Study to be conducted on demand-supply for export quality raw silk
- Study on availability of quality cocoons for production of silk of > 4A grade is necessary to educate farmers for improvement of cocoon quality

- For efficient use of huge quantity of silk waste/inferior cocoons, it is high time to establish spun silk mills
- Bigger lots of uniform quality yarn is the need of the hour and private industry should be invited to establish large scale reeling units
- Study on functioning of existing ARMs is imperative to understand the constraints and mid-term corrections and assessment of future requirements of ARMs for import substitution and export

e. Extension

- Weightage for vertical growth of sericulture production along with simultaneous exploration of ways for horizontal expansion of sericulture utilizing wastelands
- Organize repeated up-skilling programs & ECPs/ICT based awareness in collaboration with DoSs/CSB/SAUs/ICAR-KVKs to transfer the recent/need-based technologies at grassroots levels
- Need to utilize lead farmers and community-based organizations to support the extension programs
- Extension systems should cover all the industry activities (e.g., egg production and weaving) rather than confining only to cocoon production
- Extension approach must be holistic and address the quality, drudgery, health and social issues while increasing production and productivity
- Extension must be demand-driven, and the extension staff must be well trained
- Farmers' innovations must be analyzed for efficacy
- Encouragement of women in sericulture through appropriate financial assistance.
- Clustering of stakeholders and product aggregation could be the best approach for farmers, reelers, twisters, weavers, etc

f. Marketing

- Proper production linked/value-chain management should be established for addressing existing sericulture problems/obstacles
- Cost-effective and consumer-preferred sericulture product diversification
- Efficient marketing system for controlling price fluctuations
- Cocoon insurance should be the best approach to safeguard the interests of cocoon producers in the event of price collapse/distress sale
- Artificial intelligence-based market calendar and price forecasting
- Government agencies like KSMB in Karnataka must be made financially stronger for participation in marketing for price stabilization

g. Policy interventions and other issues

- Price stabilization fund to safeguard the interests of stakeholders
- Rationalization of duty structure and duty exemption on silk machinery
- Continue anti-dumping duty on raw silk for some more years
- Revoking Most Favored Nation (MFN) status
- Establish 'Sericulture Complexes' to work as single window system to provide solutions to stakeholders along the value chain
- Encourage seri-startups/entrepreneurs/incubation centers
- Brand promotion for different varieties of silks and sericulture products
- Sericulture stakeholders should be interlinked in the production chain to establish organic linkages and coordinated functioning
- Focus on Vanya sericulture as India is unique in the production of Tasar, Eri and Muga
- Controlling illegal silk/cocoons trade

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