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Sericulture: An Alternative Source of Income to Enhance the Livelihoods of Small-scale Farmers and Tribal Communities

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ABSTRACT

This paper provides a summary review of the development and implementation of BAIF's sericulture programme in the Indian state of Maharashtra. BAIF Development Research Foundation (BAIF), a national NGO based in Pune, Maharashtra, has been active in developing and promoting better livelihood options for the rural poor in the country. Recognising the potential of sericulture to provide self-employment and remunerative returns, BAIF initiated on-station experiments in 1989 to obtain first-hand experience with various aspects of the technology of silkworm rearing and to test potential refinements to suit local conditions. In a second step, sericulture practices were taken to farmers in the field on a pilot basis in Maharashtra, Gujarat, and U.P. (present Uttranchal). BAIF adopted a multi-pronged strategic approach by introducing a technology-based integrated farming model, empowering and capacitating communities to take the lead in implementation and marketing of the produce, but providing strong backup support with an effective monitoring system. This paper provides an overview of the technological innovations that resulted from BAIF's on-station and on-farm experimentation, the economics of sericulture along the entire value chain from cocoon to raw silk to silk fabric, and the environmental impact of two forms of sericulture – smallholder farmers using planted mulberry trees and tribal communities, relying on Arjuna / Asan trees in natural forests to feed the silkworms.

1 Sericulture in India and Maharashtra

Since ages, silk and silk fabrics have attracted mankind and have found their place among the most valued and elegant human fabrics. India is the world's second largest producer of raw silk (18,500 MT/yr)[7]. However, because of high domestic demand (25,000 MT/yr)[7], the country imports more than 8,500 MT/yr. By the year 2025 domestic demand is expected to increase to 45,000 MT/yr[7]. Therefore, silk production has tremendous growth potential in India, which could provide additional employment opportunities for up to 4 million rural families.

At present, approximately 8 million families (of these 80% are rural poor) are involved in silk production as part of their livelihood, engaging in sericulture as an agro-based cottage industry. Due to favorable agro-climatic conditions (suitable temperature and humidity), traditional skills and market potential, silk production is mostly confined to states like Karnataka, Andhra Pradesh, West Bengal and Jammu and Kashmir. The predicted demand growth for silk could generate self-employment and remunerative livelihood opportunities for the most disadvantaged sections of society, especially for small and marginal farmers and the landless poor through silk worm raring, reeling of yarn, weaving of fabric, and value-addition as non-farm activities.

Maharashtra, a state without a tradition of silk production, has a large gap between demand and supply of raw silk and more than 4,000[3] silk weavers in Yeola, Paithan, and Mohadi areas source their raw silk from neighbouring states, amounting to a total value of 'imports' of Rs2,500 to 3,000 million (USD 50 to 60 million) per year. This demand for raw silk could become a source of rural employment within Maharashtra.

Introduction of sericulture was tried out in Maharashtra way back in the year 1959 by Maharashtra Khadi and Village Industries Board, and later by a separate Directorate, established by Maharashtra Government. However, these initial attempts to introduce sericulture were not successful and the industry did not expand to any significant extent in the state.

The main constraints to sericulture in Maharashtra state were: lack of mulberry tree varieties adapted to local agro-climatic conditions, lack of suitable silkworm races, and lack of knowledge and skills among the farmers. Moreover management practices were poor, leading to diseases and low productivity (30kg/100DFL[1]).

In 2005 there were 3,000 families maintaining 4,200 acres of mulberry plantations spread over 1,004 villages of 20 districts[3] in Maharashtra. In 2008, the number of families adopting sericulture had increased to 8,000 with over 10,000 acres of mulberry plantations, however with low

[1] DFL: Disease free laying, i.e. a bunch of approximately 500 disease-free silkworm eggs

productivity (30kg/100DFL)[3]. Among the mulberry silk producing states in India, Maharashtra occupies the seventh position.

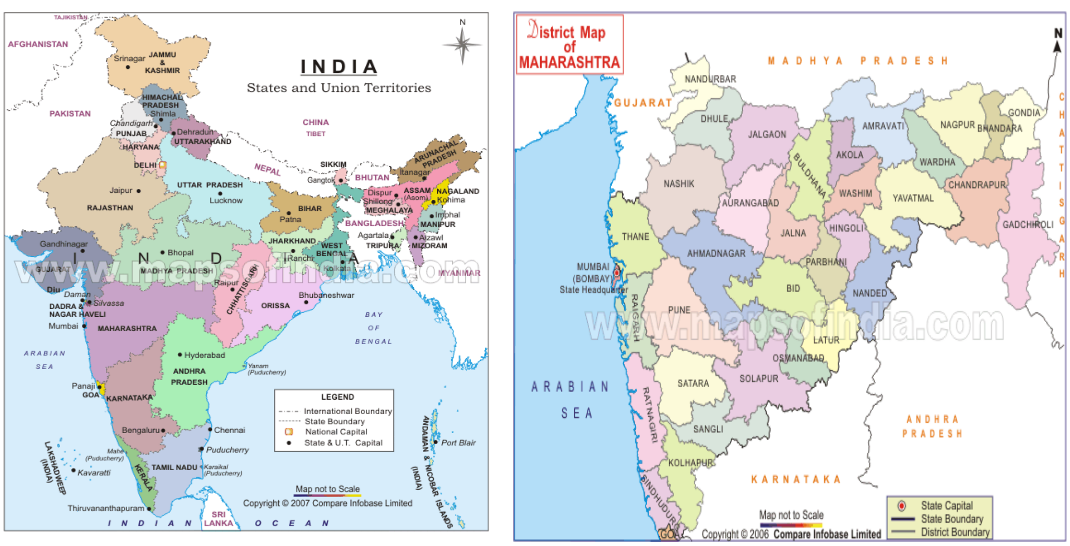
2 The State of Maharashtra

Maharashtra is India's third largest state in terms of area of about 308,000 square kilometers and the second largest state in terms of population, Figure 1. As per 2001 census[2], the population of Maharashtra state is approximately 96,752,000 resulting in a population density of 322.5 people per km^2. Over 64% of the population is employed in agriculture or agriculture-related activities[1]. The area under irrigation is 33,500 km^2 (11%)[1]. Rice, jowar (sorghum), bajara (millet), wheat, oranges, grapes, bananas, mangoes and pulses are the important food crops. Cash crops include groundnut, cotton, sugarcane, turmeric and tobacco.

2.1 Agro-climatic conditions

Geographically, Maharashtra can be divided into five main regions: Vidarbha, Marathwada, North Maharashtra, Western Maharashtra, and Konkan regions. Climatic conditions of Maharashtra are semi-dry. The temperature ranges from 10^{o}C to 47^{o}C and annual rainfall from 700 to 1,000 mm. Seven agro-climatic zones extend from Western Ghats (Sahyadri Mountain range) to the Deccan plateau on the East.

Figure 1: Location of Maharashtra in India and districts of Maharashtra



2.2 Pune district, the cradle of sericulture development in Maharashtra

Pune district is situated in the western part of the state of Maharashtra, the western Ghat region extending to the Deccan plateau. The total population of the district is 7.2 million (census 2001), with a population density of 460 persons per km^2. The district has a high literacy rate of 81%[1], higher than the state and national average. Pune is the second most industrialized district of the state.

The district has a pleasant climate, with temperature ranging between 12 and 37^{o}C. The average rainfall for the district varies between 600 to 700 mm. per annum. Maximum precipitation is observed during June to September. The district extends across four of the seven agro-climatic zones, namely the Ghat, sub-mountain, plain and the scarcity zone[1]. As a whole, Pune district shows more variation in agriculture practices compared to other districts in Maharashtra.

The total geographical area of the Pune district is 1.5 million ha, of which around 64% is cultivable land and 24% is under irrigation. The district is blessed with five important irrigation projects, which provide for a higher irrigation percentage than in the state as a whole. Sugarcane is the major cash crop, followed by vegetable cultivation. This fact is reflected in the large number of sugar factories in the district (10). Other food crops are jowar (sorghum), millet, wheat, and pulses.

Farmers from the Pune district were facing the typical problems of volatility of agricultural markets affecting the returns from their agriculture produce, such as sugar cane and vegetables, diminishing farm productivity due to soil degradation from over-irrigation and poor water quality, and labour shortages. This situation triggered the search for alternative, agriculture-based, sources of rural incomes to assure better livelihood options for marginal and small-scale farmers in Pune district.

3 Experimenting with Sericulture; an Alternative Livelihood Option

Since four decades, BAIF Development Research Foundation (BAIF), a national NGO based in Pune, Maharashtra, has been active in developing and promoting better livelihood options for the rural poor in the country. BAIFs' research and development (R&D) efforts are oriented towards innovative activities that have the potential to benefit the poor.

Sericulture is an activity to produce raw silk based on rearing silkworms fed on leaves from mulberry plants or from Asan and Arjuna trees (Tasar) occurring in natural forests (Box 1).

Box 1: Major silk types in India

Mulberry silk: Fine quality silk from silkworms reared on mulberry tree leaves; has the major share in total silk (89%).

Tasar silk: Coarse quality silk from silkworms raised on Arjuna / Asan trees in natural forests; constitutes a minor share (2%) in total silk.

Eri silk: Fine quality silk from silkworms reared on Castor (*Ricinni communis*) leaves; has about 8% share in total silk. Household activity in the northeast states of India.

Muga silk: Coarse spun silk from northeast India, from silkworms reared on Som (*Persea bombycina king*), Soalu (*Litsaea polyantha*) leaves collected from forests; constitutes a negligible share (<1%) of total silk.

Agro-climatic conditions of Pune district are conducive for silkworm rearing, however some extra care is required during the summer and winter seasons to prevent heavy losses due to high (>35^{o}C) and low (<15^{o}C) temperatures. Recognising the potential of sericulture to provide self-employment and remunerative returns, BAIF initiated on-station experiments in 1989 at the Central Research Station (CRS) in Uruli Kanchan, a village close to Pune, to obtain first-hand experience with various aspects of the technology of silkworm rearing and to test potential refinements to suit local conditions. In a second step, sericulture practices were taken to farmers in the field on a pilot basis in Maharashtra, Gujarat, and U.P. (present Uttranchal). However, the initial programme failed due to various remaining knowledge gaps and due to the lack of an assured market. Major technical constraints identified during this first pilot phase were the lack of:

- suitable mulberry varieties which perform in Maharashtra and help mitigate against soil degradation,
- a suitable package of agronomic practices for local soil and agro-climatic conditions;
- required skills and practices in silk worm rearing;
- disease-free layings (DFL) of suitable silkworm races and other rearing inputs.

The above technical shortcomings were compounded by poor market access and volatile prices. As silk was a relatively new commodity in the area, there was no marketing infrastructure and producers were at the mercy of traders from outside. Hence prices were fluctuating largely and not remunerative.

Despite these setbacks, BAIF continued its efforts to develop suitable technologies, refining them to suit to local conditions and conceptualizing their delivery as well as exploring marketing options. After having acquired sufficient confidence in the technologies at the Central Research Station, BAIF embarked on testing these in the field, which gave birth to a second field programme in 1998. Initially, this programme was undertaken by BAIF on an experimental basis with financial support from the Commission of European Communities (CEC). Five families were selected for the purpose of testing the technologies, technology refinement and value-addition, leading to the end product of silk fabrics.

3.1 Objectives and elements of BAIF's (second) sericulture programme

BAIF's sericulture programme aimed at the development of appropriate technologies and silkworm races to improve the quality and yield of silk in order to provide an alternative cropping system leading to better livelihood opportunities for marginal and small-scale farmers, under irrigated as well as rain-fed conditions, in traditional and non-traditional silk producing areas. To this end, BAIF had to conduct research and develop appropriate technologies in the following areas:

- evaluation and introduction of suitable mulberry varieties,
- development of techniques and products to improve mulberry production,
- evaluation and introduction of suitable silkworm races,
- development of products to control silkworm diseases and input materials necessary for silkworm rearing,
- the establishment of an institute for the production of eggs of improved silkworm races to supply disease free laying's (DFL), i.e. bunches of around 500 disease free silk worms eggs.

The programme also aimed to stimulate the interest of poor tribal and other marginalized communities for value-addition activities and empower them to engage in 'market realities'.

3.2 BAIF's strategic approach

BAIF adopted a multi-pronged strategic approach by introducing a technology-based integrated farming model, empowering and capacitating communities to take the lead in implementation and marketing of the produce, but providing strong backup support with an effective monitoring system. The cornerstones of BAIF's strategy were:

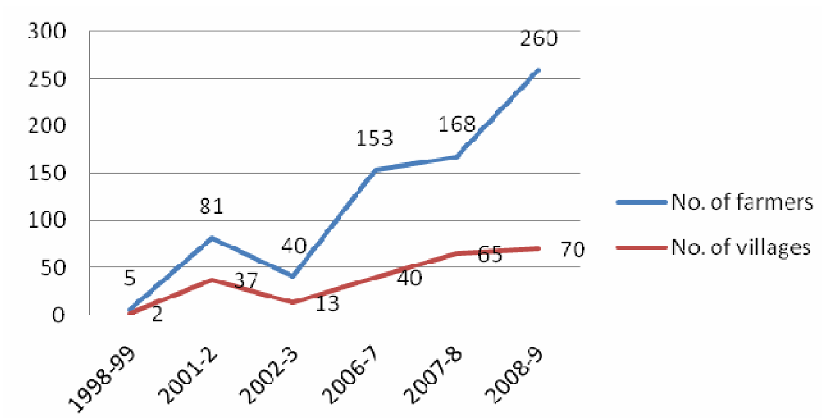
a) Promotion of a **low-risk, integrated farming model** determined by the availability of land, water and family labour. As sericulture is a multi-cycle 'crop' (5 to 8 'crops' in a year), production risk is low as loss of one cycle can be compensated by gains in other cycles, i.e. farmers do not loose the whole annual crop as in case of other crops. This was complemented by enhancing the production of other crops through nutrient recycling using sericulture manure.
b) Promotion of a **cooperative society** to ensure ownership of all primary producers in the final product - silk fabric - , i.e. promotion of broad-based distribution of benefits from value-addition and partial protection of farmers from market risks.

c) Development and introduction of a system to continuously **monitor and evaluate** technology, assess the technology gaps and provide required support, inputs and services.

4 BAIF-led Development of Sericulture in Pune District

The number of farming households engaged in sericulture in Pune district under BAIF's sericulture programme have increased from five in 1998 to 260 in the current year (2009) (Fig 2).

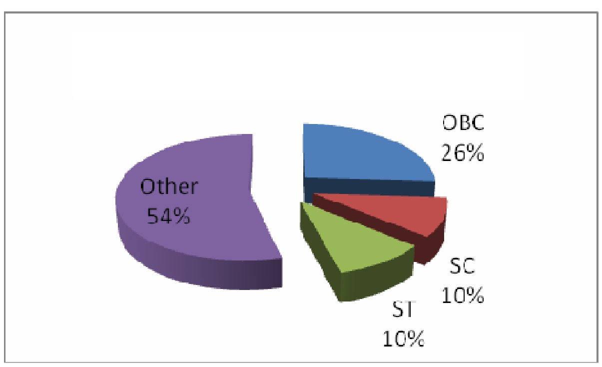
Figure 2: Villages and households engaged in sericulture in Pune district, 1998-2009



Drop in 2003 was due to market fluctuation and diseases.

Social heterogeneity is common in most villages in Pune district, with the majority of households classified as belonging to 'other backward communities' (OBC). The majority (54%) of participating farmers belong to the 'progressive' farming community, 26% to 'other backward communities', and around 20% are 'scheduled caste and scheduled tribes' (SC and ST, who are regarded as suppressed communities) (Figure 3).

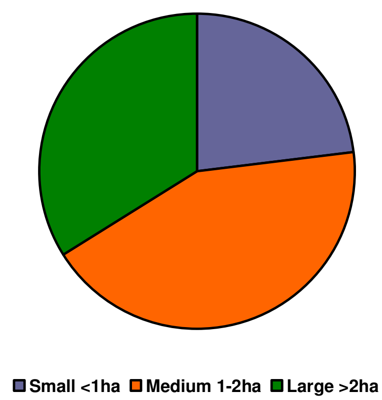
Figure 3: Social composition of farmers participating in BAIF's sericulture programme



BAIF motivates farmers to, initially, start with half or maximum one acre of mulberry plantation as in case of a loss of production on account of 'beginner's skills', the latter should be minimal and as it takes one to two years for farmers to fully understand the technical aspects of silkworm rearing.

Focus is on small-scale farmers having land holdings of less than three acres. Once a farmer adopts sericulture as an agricultural practice, s/he is put under the care of a so-called ‘area lead farmer’ or *Rasham Doot*, from which s/he sources her/his input materials and obtains technical support in the first year. In case of major problems, these farmers, also referred to as sericulturist / silk worm ‘rearers’ can contact BAIF any time. When sufficiently experienced, ‘rearers’ can become area lead farmers, who are responsible for input supply, including silkworm eggs. ‘Rearers’ can book and procure input materials from lead farmers. Sixty-six percent of the farmers participating in the sericulture programme hold less than two hectares of cultivable land (Figure 4).

Figure 4: Farmers in BAIF’s sericulture programme by size of landholding, 2009.



1ha=2.5 acres of land

A *Resham Doot* supervises and advises 5 to 25 ‘rearers’. BAIF provides input materials at concessional rates to *Rasham Doots*, who can earn Rs2,500 to Rs5,000 (USD 50 to 100) per month from the concessions on the material supplied to farmers. This is a very cost effective method for nurturing and adopting new ‘rearers’.

It was decided to provide minimum market support to ‘rearers’ (in terms of input supply and output marketing) in order to, initially, create confidence and later on to establish links to government and private buyers of cocoons.

Average cocoon yields of BAIF-guided farmers were higher at 57kg/100DFL than the state average of <40kg/100DFL. The highest cocoon productivity recorded was 103kg/100DFL.

4.2 Technologies developed and refined

BAIF developed suitable cost-effective technologies, using its learning from the past experiences for mulberry cultivation, silk worm rearing and refined them to overcome the field difficulties. These technologies were tested on station as well in the field and were proven to be 'user-friendly' and thus suitable for adoption in the field. Similarly, preventive medicines and growth promoters were developed to enhance the yields of mulberry trees and silk worm cocoons (Annex V).

Mulberry cultivation:

- Variety and plantation: Improved varieties of Mulberry, V1 and S-1635 for irrigated conditions, were introduced in place of the traditional variety to provide better foliage production in terms of quality and quantity. A package of management practices was also developed, including direct planting of cuttings.
- Irrigation: Water-saving methods of irrigation were introduced, such as sprinklers and drips, for households who could afford them. For households who could not afford the former the technique of 'paired rows', which save water and labour for flooding, were developed and promoted.
- Nutrient management: Use of leaf waste and worm excreta to enrich the soil. Introduction of probiotics, vermicompost and micronutrients developed by BAIF helped the farmers to improve the productivity and soil health and reduce the use of chemical fertilizer.
- Leaf harvest: A pruning machine was developed with the help of a private engineering firm to reduce the labour and hardship involved in cutting the leaves of mulberry trees.

Silkworm rearing:

- Introduction of improved silkworm races: Crossbred; BAIF I and II; (a cross of multi-voltine and bi-voltine silkworm races) silkworms were developed to increase cocoon production (60 to 100kg cocoon/100DFL). The crossbred has the characters of hardiness from the multi-voltine and the better quality of silk from bi-voltine silkworms. BAIF I and II were introduced to replacing old silkworm varieties.
- Rearing practices: Simple, cost-effective dismountable sheds were developed and introduced for rearing the worms using local material and skills. Cost-cutting practices such as feeding of shoots with leaves instead of only leaves were also introduced as was feeding worms twice instead of four times a day. Bed cleaning was reduced to once at the beginning of cycle of 30 to 35 days in place of the earlier practice of cleaning every other day. While maintaining sanitation, these practices helped reduce costs and labour of silkworm rearing.

- Nr. of 'crops'/year: Prior to introduction of BAIF's sericulture programme, summer was a 'no crop' season resulting in 2 to 4 rearings in a year. Due to the availability of foliage and silkworm races suitable for rearing during the summer the number of 'crops' was increased to 5 to 8 per year.
- Management of silk worm diseases: Apart from good nutrition and management, preventive measures for disease control are important to optimize cocoon production. Silkworms are very sensitive and prone to bacterial, viral, and fungal diseases that can result in heavy mortality and losses to the extent of 10 to 40% of production. Proper hygiene and timely use of effective medicines can prevent and control disease outbreaks and reduce mortality and losses.

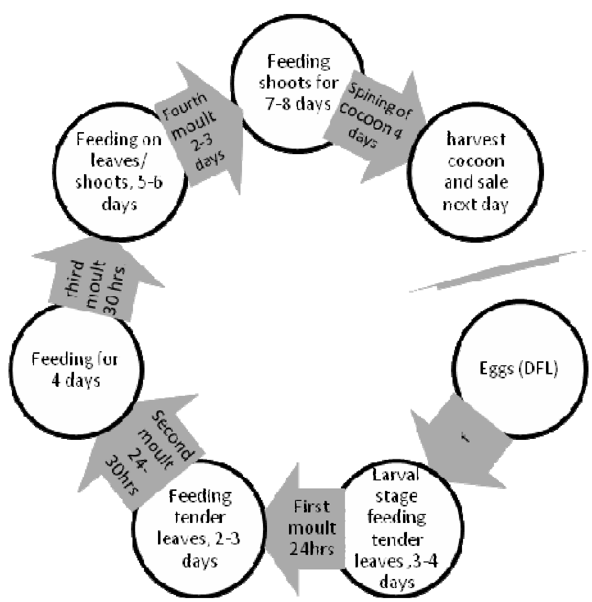
Box 2: Silkworm races

Bi-voltine: Only two generational cycles can be completed per year, the worms are sensitive to environment changes and 'crop' losses are high. Cocoon production is less than 50kg/100DFL.

Multi-voltine: Silkworms which can be reared many times in a year (8 to 12 cycles). The worms are hardy and have high survival rates and can produce more than 50 to 70 kg/100DFL. The quality of silk is slightly inferior to that of bi-voltine races.

Crossbred: A cross of multi-voltine female with bi-voltine male (BAIF I; YWG XCSR2, BAIF II; WBC1 X CSR2). These crosses perform better in Maharashtra than the previous two and are therefore being promoted. Average cocoon production ranges from 50 to 100kg/100DFL. It is the 'race' preferred by farmers due to its combination of hardiness and higher production.

Figure 5: Silkworm rearing cycle in farm sheds



Box 3: Silkworm diseases

Silkworms are prone to certain viral, bacterial and fungal diseases, which can drastically reduce production by 10 to 40%. The major diseases prevailing in the area are:

Grasserie; a viral disease can result in 30 to 40% cocoon loss,

Flacheire; a combined viral and bacterial disease affecting silkworms, which can wipe out the whole crop,

Rakshit is a probiotic culture developed by BAIF to protect from these two pathogens, effectively preventing and / or reducing losses.

Muscardine; a fungal disease that can cause heavy loss of up to 30%;

Vinashak is a fungicide developed by BAIF, which effectively controls this disease.

Pebrine; a disease caused by protozoan that is passed through eggs from infected moths.

Strict quality control measures, under supervision of BAIF as per the norms of **ISO 9000, 2001**, have prevented losses of the farmers.

Uzi fly (Tricolia bombisys), a disease caused by local fly that can result in 10 to 15% losses.

Proper **hygiene and management** can prevent some of the emerging problems of silkworm rearing.

Box 4: Piloting Tasar (*Antheraea mylitta*) silk production for livelihood support of tribal communities

Growing demand for organic and natural wild silk and abundance of of Asan (*Terminallia tomentosa*) and Arjuna (*Terminallia arjuna*) forest trees, a primary food plant of Tasar worms, in forests of Thane district led BAIF to explore the promotion of Tasar silk production as livelihood component for tribal communities in the area. Thane, a North West district of Maharashtra has a total forest area of 2,671 km^2. Tribal communities, which are socio-economically disadvantaged, poorly literate, live in and around forest areas and constitute up to 90% of the total population in the district. Minor (non-wood) forest produce is a major source of their livelihoods. Seasonal migration is a common livelihood strategy of tribal households.

Given the conducive agro-climatic conditions and abundance of *T. arjuna* in the area, BAIF, the Regional Tasar Research Station (RTRS), Bhandara, and the Directorate of Silk (DOS), Government of Maharashtra, decided to test a bi-voltine (Dhaba) silkworm race that has a larval duration from 40 to 45 days and can be reared in natural forest on trees in the months of September to November. Starting with only four households in 2001, the number of adopters has risen to 89 in 2006. On average 250 to 300 DFLs were reared by the households producing 15 to 40 cocoons per DFL.

4.3 Farmer selection, nurturing and 'handholding'

BAIF field officers organise group meetings with farmers in the villages, which is followed by a visit to demonstration plots of 'rearers'. Anyone, irrespective of caste or religion, who is motivated, willing to work on her/his own land, ready to invest in a rearing shed with local materials at minimal cost is accepted as beneficiary and trained for 5 to 16 days at the BAIF Campus at Uruli Kanchan. The training is free of cost and doesn't require payment for boarding and lodging. Thereafter, beneficiaries are provided with 'farmer-specific need-based' technical support and input materials except for the housing/shed required for silk worm rearing by the nearest *Resham Doot*. BAIF makes it conditional for each 'rearer' to adopt all technologies and input materials developed and this is monitored closely by the *Resham Doot*, so that any lacuna can be identified and addressed early on.

4.4 Selection of lead farmers (Resham Doots)

A *Resham Doot* is preferably a local youth, who has a Secondary or a Higher Secondary School Certificate, and is a progressive sericulturist with leadership qualities, being able to motivate and coordinate fellow farmers from the same cluster. The *Resham Doot*, who is regularly trained and oriented towards sericulture, is a critical link and important person in the delivery chain and monitoring of the programme in the field. S/he is involved in farmer selection, facilitation, provision of technical inputs and market support, risk cover, feedback, reporting, linking to the government and fundamental in ensuring the sustainability of the programme.

4.5 Community mobilization and value-addition: the Progressive Association of Sericulturists (PAS)

Community-felt needs to safeguard farmers against exploitation, counteract adverse market forces, and appropriate some of the benefits of value-addition triggered the process of forming a community-based organization, the Progressive Association of Sericulturists (PAS). Initially, BAIF motivated and organized 'lead farmers', 'rearers', weavers, and fashion designers to form an informal cooperative society to manage value-addition and marketing (of cocoons, raw silk, fabric and readymade) to the benefit all stakeholders involved in the silk chain from cocoon production to readymade. Value-addition from spinning cocoon to silk yarn was introduced as a household activity and a small cottage unit has recently been established near Uruli. Weaving yarn to silk fabric is presently being outsourced to gain experience. In 2007, after gaining sufficient confidence, members themselves registered as cooperative society in 2007 under the name of 'PAS Silk Producers Cooperative Society Ltd', commonly known as PAS. The society brings producers, processors and end-users together in groups, but the leadership remains with the producers.

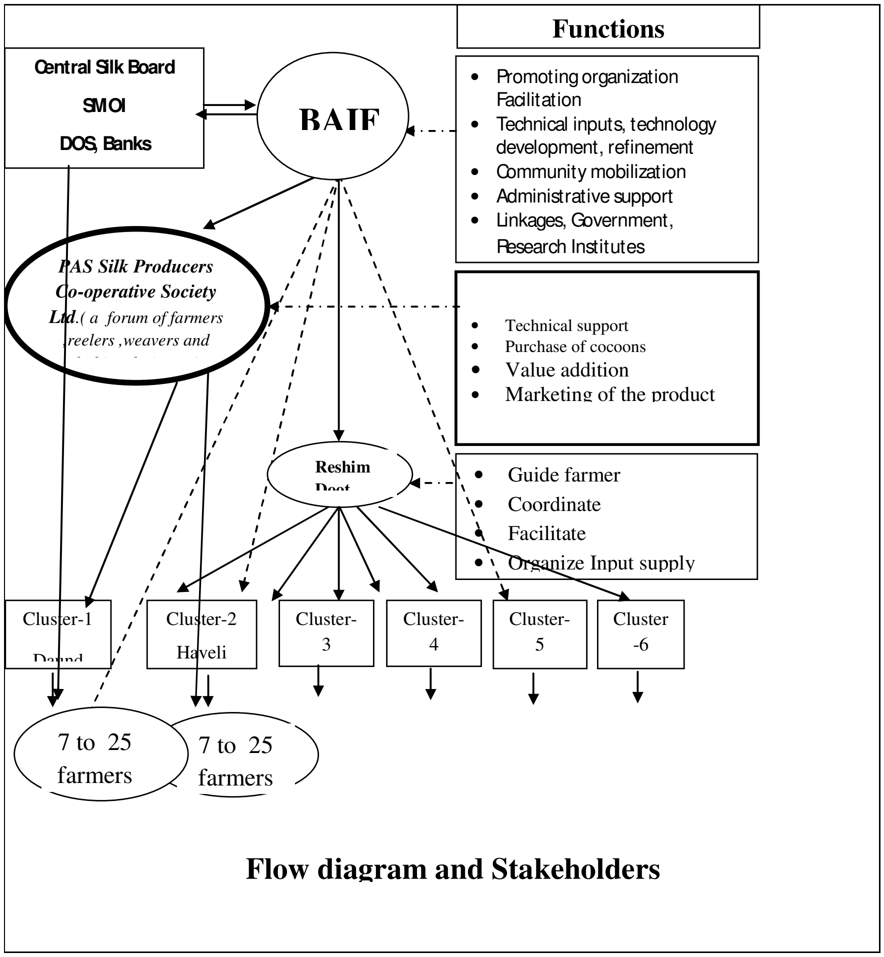
BAIF provided office space and a showroom cum sale centre free of cost at its Central Research Station, Uruli. This proved to be a unique win–win situation for producers, processors and manufacturers as product sales have gone up to Rs600,000 (USD 12,000) in 2008 from initial sales of Rs11,000 (USD 220) in 2003. However, as the PAS society is still relatively new, it does not have sufficient funds to withstand major market fluctuations. Hence, presently strategic efforts are made to sell the products at earliest profitable level and silk fabrics are considered the last option, unless orders are available.

4.5 Convergence and linkages with government agencies, banks, and professionals

Since BAIF's sericulture programme is recognized by Maharashtra's Directorate of Sericulture, Nagpur, benefits of existing schemes from the central and state silk board, government of India and Maharashtra, are being passed on to farmers. Disease free layings supplied by BAIF are subsidized by the government at the rate of 75%, while other products for disease protection, growth promoters and fungicides for silkworms are subsidized to be provided by BAIF at a cost of 15 to 20% below the existing market rate of other agencies. The main objective of these subsidies is to promote the use of eco-friendly products to improve cocoon production and to bring down the cost of production.

The government has opened a 'cocoon purchase center' at Uruli, to purchase cocoons at a market determined price. However, the market price for cocoons is around 15% lower than that received by 'rearers' in Karnataka and Andhra Pradesh. Between 2007 and 2009, over a period of 16 months, the cocoon purchase center has purchased 191 MT of cocoon. Credit support to farmers was provided by banks through the cooperative society (PAS). Linkages for marketing were established between processors, reelers, weavers and with the Central Silk Board (see Figure 6).

Figure 6: Stakeholders involved in sericulture



5 Economic Evaluation of Sericulture in Pune and Thane Districts

BAIFs' efforts in promoting sericulture after technology refinement have proved to be a success in non-traditional areas of Maharashtra. Sericulture not only provided a better livelihood opportunity but also resulted in gainful self-employment at the doorstep of the farmers. It has enhanced household income and, in the case of tribal families, reduced migration.

5.1 Mulberry silk production and value-addition

The number of farmers enrolled in BAIF's sericulture programme almost doubled in the last three years, which is indication of its economic viability and its importance to the farmers. Although half of these farmers were new entrants, during 2008-9 average cocoon production of the 260 families was 211kg/acre, resulting in a gross income of Rs34,615/acre/family (USD 692) (Table 1).

Table 1: Mean annual cocoon production per acre in kg and household (hh) income

Season	Av. cocoon production per acre (kg)	Av. income per acre (Rs)	Av. income per hh (Rs/hh)
2001-2	40.4	3,987	3,396
2002-3	70.9	7,661	7,469
2006-7	252.5	25,813	13,497
2007-8	213.0	30,430	45,645
2008-9	211.0	34,615	51,293

*In 2008-9 half of the farmers were new entrants, which affected average production and income.

*Average mulberry cultivation was 0.8 acres in 2002 and 1.5 acres in 2009, which has implications on average income per household.

At the outset, the first two years are needed to stabilize the mulberry cultivation and for the acquisition of sufficient skills by farming households. After stabilization in the third year, cocoon production reaches yields of 1,080kg/acre/year from 8 rearings, providing a total gross income of Rs156,600 (USD 3,132) (cocoon yield Rs151,200/acre/year plus income from manure, valued at Rs5,400/acre/year, from worm excreta and leaf waste). After deducting expenditures (at non-subsidized prices) of Rs117,524/acre/year (USD 2,350) (mulberry tree cultivation, silk worm rearing inclusive of labour cost, and depreciation of investments at 10% year, but exclusive of opportunity costs for land and subsidies) a farming household receives a net income from sericulture of Rs39,076/year/acre (USD 782), which is significantly higher (by 133 to 270%) than the net income obtained from the main cash crop, sugarcane (Rs14,500 to 29,450/acre) reported by Kshirsagar, 2006[3,8,11]. (Details in Annex 1).

Box 5: Return to labour from sericulture

Silkworm rearing and mulberry cultivation has high employment potential in the ‘backyard’ of farming households. It provides employment of 562 person-days per acre per year. After the first two years required to ‘stabilize’ the sericulture ‘enterprise’, and during which net income is marginal, income per acre, without accounting for the cost of family labour, is in the order of Rs96,000 (USD 1,920). Return to labour in sericulture therefore amounts to Rs171/person/day (USD 3.5), which is 70 percent above the local wage rate of unskilled rural labour (Rs100/day) and explains why sericulture is a preferred ‘employment’ opportunity for farming households. Even with a drop in yield of 12%, as occurred in the second year of the programme, income per acre, without accounting for the cost of labour, would be in the order of Rs79,276 (USD 1,586) with return to labour still being Rs167/person/day (USD 3.3).

At peak periods, mostly all family labour is used for the activity, as it is essential to be attentive during the last few days of the rearing cycle and hence farmers do not rely on hired labour to avert risk. However, overall women are the major (71%) contributors of labour for feeding, maintaining hygiene, harvesting cocoons, maintaining temperature and humidity in the rearing shed, and cutting mulberry leaves in addition to their house management and kitchen chores

Volatility of the price for cocoons stimulated BAIF to promote the organisation of value-addition through production of yarn, fabrics and establishment of market outlets. Table 2 displays the value addition of silk yarn production and fabric weaving: the first stage of cocoon to yarn provided 12% additional benefits over raw cocoon and weaving produced another 8% of value-added.[9] (See Annex II for details).

Table 2: Financial analysis of value-addition in silk production and processing per acre of mulberry trees (yield of 1,080 kg cocoon)

	Amount (kg or m)	Market price / cost (Rs.)	Total value / cost (Rs.)	Value-added (%)
Cocoon	1,080kg	140/kg	151,200	
Process: Reeling, twisting, degumming		21/kg[1]	22,680	
Silk yarn	125.28kg	1,551/kg	194,310	11.7
Process: Weaving, bleaching, colouring, overhead		935/kg[2]	117178	
Silk fabric	1,674m	200/m	334,800	7.5

[1] cocoon; [2] silk yarn

Third stage processing to readymade sold through outlets provided by BAIF, increased the profitability by 13% over fabric due to value addition and total profitability increased by 40% over raw cocoons to readymade when processed at farm level.

This silk value chain is new in Pune and still under development, but seems promising. It is however too early to draw conclusions at this stage, as it has to withstand various market forces and the interests of established traders and middlemen.

5.2 Tasar silk production and value addition

Tasar silk worm production was 'piloted' with four families in Thane district. It is a seasonal activity (September to November) which can provide 'family employment' for 50 days/year. The highest cocoon production of 40 cocoons/DFL was recorded in 2004, while it dropped to a low of 15 cocoons/DFL in 2006 due to high rainfall and management problems. About 80% of the cocoons produced were of good quality. Cocoons were sold at the rate of Rs0.50/cocoon and each family thereby earned a gross income of Rs4,800/300DFL (USD 96), excluding labour costs (Annex III). This activity provided employment and income for the families, which otherwise migrate to urban areas during this period of the year in search of sources of livelihood support. (After transplanting paddy in July/August families migrate in August/September and return for harvest in November/December, some families migrate again in the post-harvest period of December/January and come back in March/April for land preparation).

Introducing a new activity always brings challenges, in terms of production, productivity, and marketing of the produce, particularly in tribal communities. There was no market for the cocoons from this tribal area and thus promoting value-addition from cocoons to silk yarn in Thane district was necessary in order to obtain a marketable product. Promoting reeling of the same cocoons at village level provided additional gross income of Rs11,200/farming household (USD 224) and an additional 60 days of employment (Annex III). This value addition from cocoon to raw silk increased household income by four times.

Return to labour of cocoon production / collection, the first stage in the value chain was Rs44.8/day, which is slightly below the local wage rate for unskilled labour in the area (Rs50/day). The returns to labour in transformation of cocoons to silk thread, however, was Rs106.7/day, which is more than double the local wage (Annex III). The present experience advocates for promoting value-addition from cocoon to reeling silk yarn during times when families migrate from the area due to scarcity of opportunities to generate income.

Although, Tasar silk production has been adopted by 189 tribal families up to 2008, there are number of challenges to Tasar silk production in Thane district: climatic uncertainty leading to heavy silkworm losses, managerial difficulties, sourcing of adequate DFLs and market uncertainties.

5.3 Farmer perceptions of sericulture

Farmers that have engaged in sericulture are quite positive about sericulture as an alternative (or complement) to traditional cash crops. Based on interviews of 35 farmers, an assured market and the likelihood of a regular and remunerative income were by far the most important criteria for engaging in sericulture, irrespective of landholding size. ‘Handholding support’ was the fourth most important criterion mentioned for taking up sericulture.

Although sericulture carries the risk of losses due to silk worm diseases or crop failure, the majority of farmers from the medium (1-2 ha, 74%) and large (>2 ha, 66%) landholding size category perceived it as a low risk production system, while small farmers, being more vulnerable, generally perceived it as a medium risk activity.

6 Environmental Impacts

Apart from supporting livelihoods and providing employment, sericulture waste (mulberry waste and silkworm excreta) improves soil health through nutrient recycling and reduces the use of chemical fertilisers. Nutrient recycling along with changes in agronomic practices and water saving measures proved to be effective in controlling soil degradation and reducing the use of precious water. Tasar silk production as livelihood component of tribal communities motivates these to control deforestation and illegal cutting of trees and to regenerate forests.

6.1 Nutrient recycling, water management and soil health

A total of 58 tonnes of biomass is produced per acre per year, 33% and 66% being leaves and shoots respectively, used for worm feeding. The total waste from leaves (10%) and shoots (90%) amounts to 40 tons/acre/year. This waste is converted into 9.8 tonnes of rich compost used nutrient recycling the nutrients in to soil. Manure from leaves and manure is rich in potassium and phosphorus compared to cattle manure (Annex IV).

Apart from resulting in a marginal increase in crop productivity, excreta waste improves soil health by increasing soil nutrients, especially phosphorous and potassium. Soil content of micronutrients such as manganese, zinc and iron also increased substantially by applying waste from mulberry leaves and excreta.

The introduction of sprinklers and drips saved water use by 70 to 80% and thereby also reduced degradation of soils due to over-irrigation and poor water quality used for perennial crops such as sugarcane. Flood irrigation, planting in rows and applying the alternate furrow method reduced water use by 30%. Water-saving methods coupled with use of worm excreta and mulberry waste dramatically improved soil health (Table 3).

Table 3: Soil status before and after application of silkworm excreta / mulberry shoots and leaf manure and improved water management

Parameter	Before	After
ph	7.9	8.0
Electrical conductivity	0.2	0.3
Nitrogen (kg/ha)	200.7	401.4
Phosphorus (kg/ha)	75.7	349.4
Potassium (kg/ha)	672	1,176
Copper (ppm)	2.6	4.7
Iron (ppm)	5.3	9.8
Mangenese (ppm)	7.6	18.8
Zinc (ppm)	0.8	2.8
Boron (ppm)	1.2	1.3

6.2 Protection of common property forest resources

Tasar silk production, besides providing direct economic benefits to households engaged in sericulture, also motivates households to regenerate natural forest habitats and protect the trees as they provide a direct means of livelihood support, thereby sustaining and enriching the environment to the indirect benefit of society as a whole. So far 2,500 hectares of forest area with approximately 5,000 trimmed plants (trimmed for better foliage and silk worm rearing) per hectare are being protected by the 189 tribal families engaged in Tasar silk production.

7 Summary and Lessons Learned

The development and introduction of sericulture in Maharashtra illustrates that the learning approach of the development agency (BAIF) was successful in improving the livelihoods of the small-scale farmers and tribal communities in the state. Identification of a market opportunity, research and development, community empowerment and learning from failure were the key factors for the success. In short, BAIF's approach involved the following steps:

- Identification of a market opportunity - for smallholder households this should involve a high-value product that can be produced on a small piece of land and provides gainful employment for family labour;
- Consideration of the entire value chain - product markets and marketing are important, but so is input supply (e.g. if farmers don't get the DFLs the chain breaks down);
- Adaptive research, first on-station, then on-farm to address technology gaps in production, and if needed, in processing;
- Establishing socially-adapted, self-multiplying mechanisms for technology dissemination;
- Organization of the actors along the value chain.

Successful application of this approach requires a coordinating body / agency, and this is perhaps the most important, but probably least remunerative, contribution of BAIF in this case.

Sericulture clearly provides remunerative 'employment' for family members and economic benefit to farming households. Sericulture can be an alternative land-based production system, which improves land productivity, increases income of smallholder farmers and, concomitantly, improves soil health. However, sericulture was not a traditional activity in Maharashtra and its introduction required a substantial amount of adaptive research. Sericulture innovations developed and disseminated by BAIF include:

- Increased number of silkworm rearings (8 to 9 rearings/year) provided employment (562days/year/acre, mostly women) of family labour at the farm, which otherwise is 'underemployed'.
- Improved mulberry cultivation, water management and nutrient recycling through use of waste resulted in higher foliage production and feed for silkworms leading to higher cocoon production 1,080kg/acre and a net income of Rs39,706/acre/year after crop stabilization.

- Introduction of water saving devices and practices reduced use of precious water by 30 to 80% and saved on the costs of irrigation and labour.
- A package of agronomic practices and nutrient recycling which controlled soil degradation and improved soil health.
- Handholding support and timely provision of inputs with assured quality and effective extension enabled farmer to successfully add sericulture to their portfolio of farming activities.

A number of generic lessons about pro-poor technology development and its dissemination

1. Attempting to genuinely understand farmers' difficulties in adopting a new agricultural activity can provide useful feedback for refining various technological, economic, organizational, and social aspects of the new activity.
2. Lessons from failure are equally; or perhaps even more important for scientists and organizations/agencies to refine and develop the appropriate technology suitable to local conditions with minimum risk.
3. Well designed extension programmes are a necessary condition for the uptake of new farming activities that enhance the livelihood of rural households, especially if they are small-scale farmers.
4. Value-addition can increase the profitability of a new activity but needs to be competitive and in a position to withstand adverse market forces.
5. Adverse market forces can effectively be counteracted through people's organization, which can be in the interest of farmers and empowers the community. Collective insurance mechanisms can further protect farmers against production and market risks.
6. Good market governance and a transparent, well-structured, quality-based pricing policy, which provides farmers extra returns for quality, benefits and motivates farmers to enhance the quality of their product.
7. The pilot experience of promoting Tasar silk production, demonstrates that this activity can provide supplementary income to tribal households in remote forest areas and results in enrichment of the environment by community-based protection and regeneration of forests. This is a direct and local form of paying rural families for environmental services.

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9 Disclaimer & Contacts

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10 Annexes

Annex I: Economics of silkworm rearing on one acre mulberry cultivation for seasons 2005-6; 2006-7; 2007-8 (all values in IN Rs).

Parameter	1st year	2nd year	3rd year
Capital Expenses			
REARING SHED (50 X 20 X 13 FT)	80,000		
REARING STAND (44 FT X 5 FT X 4 NOS X 2 NOS)	20,000		
PLASTIC TRAYS (3 X 2 FT)*20no.@ Rs.450/tray	9,000		
PL.MOUNTAGES (15 FOLD) 80*@ Rs.70/Mountage	5,600		
PRUNING MACHINE 1 @ Rs. 20,000	20,000		
Total Capital Expenses	**134,600**		
Recurring Expenses			
a: Mulberry cultivation			
1. Input costs: Land preparation and mulberry plantation	10,900	600	600
Manure	7,700	2,800	2,800
Fertiliser and micronutrients	2,110	11,300	11,300
2. Labour costs: Land preparation, manure, fertiliser application, pruning	4,000	2,600	2,600
Weeding	4,000	1,600	1,600
Labour for agronomic practices @ Rs.100/day	8,400	1,600	1,600
Labour charges for irrigation/year	1,800	4,800	4,800
b: Silkworm rearing			
1. Input costs: DFL, @ Rs. 4 per 100DFL	1,600	6,400	7,200
Chemicals, fungicide, and disinfectants	1,869	13,564	13,564
2. Labour costs: Worm rearing, cleaning & disinfecting, and transport @ Rs. 100/day	10,800	36,800	45,600
c: Miscellaneous expenses			
Repairs and maintenance	2,000	5,000	5,000
Electricity	3,000	3,000	3,000
Depreciation	0	13,460	13,460
Transportation charges to procurement centre	1,200	4,400	4,400
Total Expenses	**59,379**	**107,924**	**117,524**
Input costs = a1+b1+c	30,379	60,524	61,324
Labour costs = a2+b2	29,000	47,400	56,200
Income			
Cocoon @ Rs. 140/kg	30,800 (220kg)	134,400 (960kg)	151,200 (1,080kg)
Other income worm excreta and mulberry waste	690	5,400	5,400
Gross Income	**31,490**	**139,800**	**156,600**
Net Income (per year)	**-27,889**	**31,876**	**39,076**

* In the third year, after mulberry has stabilised, a total 562 days labour (mostly family labour) are used every year per acre of silk production valued @ Rs100/day, more than 70% is contributed by women.

* Excludes opportunity cost for land

* 8 rearings/acre are taken by farmer in third year yielding 1,080 kg of cocoon/year

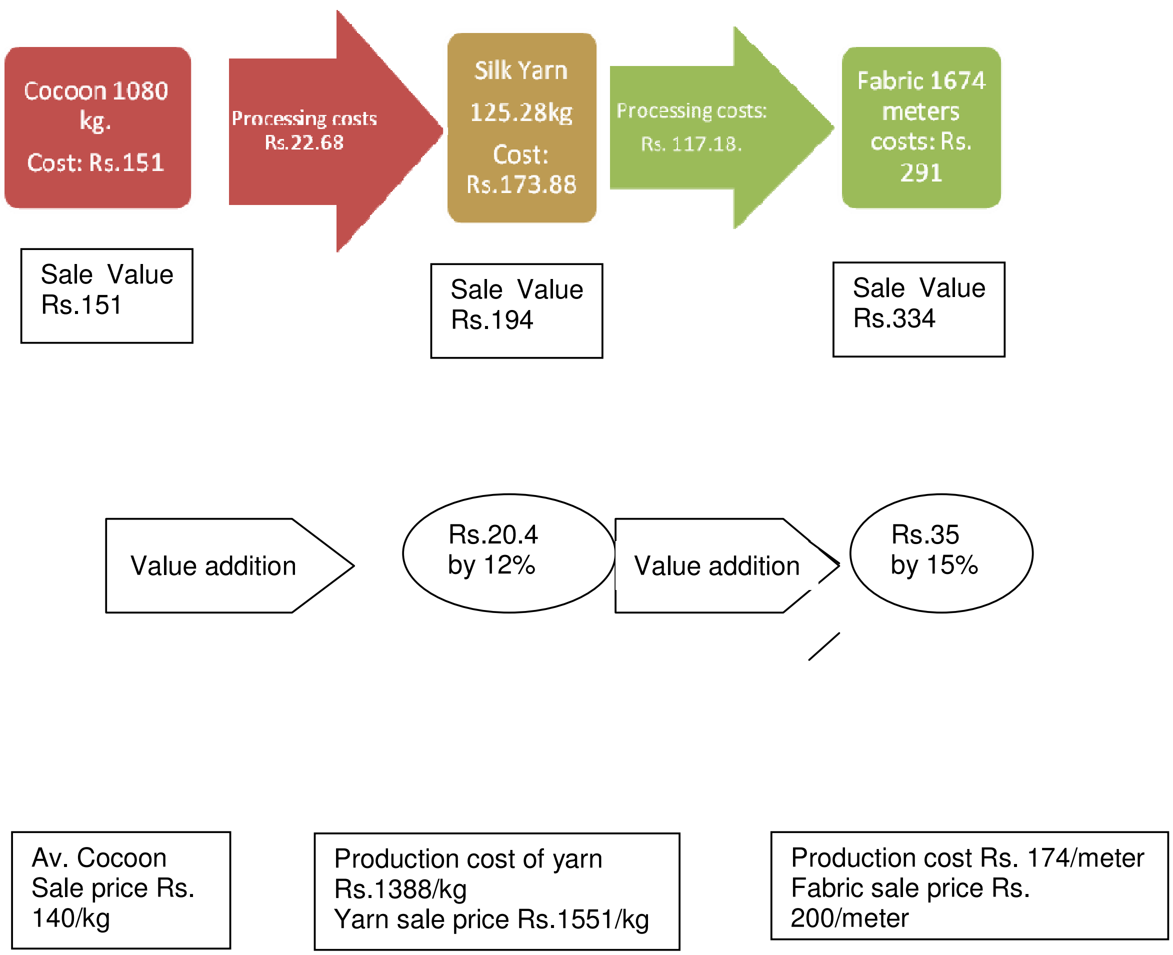
* First year two rearings are taken

* Depreciation is taken @ 10% of total capital investment

* Above calculations do not include subsidies, in the first year the subsidy on inputs is Rs1,480 (@ 75% for DFL and 15% for chemicals) and in the third year it is Rs7,434 plus an additional Rs4,000 which can be saved on depreciation of the shed.

Annex II Silk value chain and its economics: from cocoon to yarn and fabric

Value addition per acre of silk products at farm level in Rs. 000



Value addition from cocoon to yarn and fabric at farm level increases revenue by 12% at yarn level and by 15% at fabric level over the base cocoon product.

Processing costs and value addition in silk value chain

	Particular	Amount Rs.	Value added
Cocoon to silk yarn			
6 kg cocoon required to produce 1 kg silk yarn	Cocoon @ 140/kg*6	840	
	Labour	85	
	Fuel	10	
	Sub-Total	***935***	
Twisting	Labour	100	
	Fuel	10	
Losses @ 5%	Losses	46	
	Sub-Total	***156***	
Degumming	Labour	15	
	Fuel	10	
Losses @ 25%	Losses	272	
	Sub-Total	***297***	
	Total Cost (per kg)	**1,388**	
	Market Price (per kg)	**1,551**	**12%**
Yarn to Fabric*			
48 grams WARP+WEFT yarn required to produce 1 m of fabrik	Yarn *	115	
	Weaving charges	30	
	Colour cost	10	
	Bleaching Cost	5	
	Overheads, marketing	25	
	Total Cost (per m)	**185**	
	Market Price (per m)	**200**	**8%**

One kg cocoon produces 116 gm yarn (30% processing losses) that produces1.55 meter of fabric.

*Yarn considered at market price, Combination of very fine WARP (25% @ Rs.1,800/kg) and Weft (75% @ av. market price Rs.1,470/kg) yarn[9].

Fabric to cloth and its marketing is a specialised professional task that can yield value addition up to 40% but needs competitive professional marketing skills.

USD 1= Rs. 50.

Annex III Economics of bi-voltine Tasar cultivation cum reeling in Thane district (all values in IN Rs)

Particulars	Quantity	Total Value
Capital expenses		
Chawki net	1 @ 3,500	3,500
Trays	5 @ 100	500
Secateurs	2 @ 150	300
Total capital expenses		**4,300**
Recurring expenses		
Chemicals		500
DFL @ Rs4/DFL[1]	300	1,200
Depreciation @ 20%		860
Total recurring expenses (a)		**2,560**
Labour costs		
Labour for cocoon collection @ Rs50/day	50 days	2,500
Labour for reeling @ Rs50/day	60 days	3,000
Total labour cost (b)		**5,500**
Gross income		
From cocoons @ Rs0.50/cocoon (c)	9,600 cocoons[2]	4,800
From raw silk @ Rs1,400/kg (d)	8 kg	11,200
Net income excl. labour cost		
From cocoon collection	(c-a)	2,240
From silk production	(d-c)	6,400
Total net income excl. labour cost	(d-a)	8,640
Total net income incl. labour cost	(d-a-b)	**3,140**
Return to labour (Rs/day)		
From cocoon production / collection	2,240/50	44.8
From silk production	6,400/60	106.7
From entire chain	8,640/110	78.6

[1] Excludes subsidies

[2] 40 cocoons/DFL*300*80% good cocoons

Annex IV Chemical composition of mulberry waste and cow dung

Parameters	Leaf waste	Worm excreta	Leaf and excreta	Cow dung
pH	7.92	8.32	7.98	7.81
Electrical conductivity	5.83	4.94	4.94	8.30
Organic carbon	1.30	1.12	1.05	1.26
Nitrogen%	1.57	1.66	1.62	1.79
Phosphorus%	3.00	2.80	2.64	2.08
Potassium %	0.56	0.24	0.51	0.12

Annex V Technologies developed and refined for cost effective, user-friendly silkworm rearing

	Traditional practice	Introduced refined practice
	Mulberry Cultivation	
1	Plantation – plotting method (Old varieties)	Direct Plantation through cutting / sapling (New varieties V1, S- 1635, yield 2-3 times higher)
2	Intensive plantations involving more labour & fertilizer	Paired & row system less strenuous and irrigation and fertilizer
3	Irrigation by flood system	Gravity / drip, sprinkler systems at cost
4	Heavy doses of fertilizers	Introduced probiotic, vermicompost, organic cultivation, use of micronutrients; Use of leaf waste and excreta of worms
5	Pruning manually – 11 persons day / acre	Pruning machine – 1 person day / acre
	Silk worm rearing	
6	Old race with low yields	Improved race with higher yield. Biovoltine (Hybrid)
7	Converting (part) house for rearing	Simple / dismountable rearing shed
8	Leaf plucking method	Shoot feeding method
9	Feeding 4 times / day	Feeding 2 times / day
10	Bed cleaning recommended on alternate days	Bed cleaning once at the beginning of the cycle
11	Mounting – Hand picking method (3 days)	No Hand picking method (Shut & forget)
12	2 crops / year (Spring & Autumn)	4-5 crops / year (All season)
13	Recommended rearing temperature 25 to 30^{0}C	15 to 37^{0}C