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Economic feasibility studies for Chawki rearing in sericulture

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Abstract
Chawki rearing, the initial stage of silkworm rearing in sericulture plays a crucial role in determining the success and productivity of the silk industry. This study explores the economic feasibility of chawki rearing as a specialized practice thereby examining its financial viability for sericulture farmers. Through cost-benefit analysis, the research evaluates the profitability of chawki rearing by comparing the inputs such as labour, infrastructure and feed costs with the outputs, primarily high-quality silkworm eggs (chawki worms) ready for further rearing stages. The study also considers external factors influencing profitability thereby including market fluctuations in silk prices, government subsidies and technological innovations that can enhance productivity. A key focus is on the economies of scale achievable in chawki rearing particularly how large-scale operations can reduce per-unit costs thus making the practice more financially sustainable. Additionally, the research examines the environmental conditions essential for optimal chawki rearing as well as the potential challenges such as disease management and high mortality rates that can affect economic outcomes. The findings suggest that while chawki rearing requires significant initial investment in terms of infrastructure and expertise, it presents an economically feasible opportunity for the chawki growers when managed efficiently. The study concludes with recommendations for improving economic returns through training programs, better disease control measures and more robust financial support systems. This research contributes to the broader understanding of the sericulture value chain and highlights chawki rearing as a critical but often underexplored area to achieve profitability.

Keywords: Benefit-cost ratio, Chawki rearing, economic viability, profitability, sericulture.

Introduction
Sericulture, the cultivation of silkworms for the production of silk has been an important economic activity in many countries for centuries (Bharathi *et al.*, 2024). It is a labour-intensive agro-based industry that holds significant potential for rural development and employment generation particularly in regions where agricultural opportunities are limited (Kallimani *et al.*, 2021) [6]. As a multifaceted process, sericulture involves several critical stages from cultivating mulberry plants to rearing silkworms and harvesting silk (Bharathi *et al.*, 2024). One of the most vital yet often under-explored phases in this process is *chawki rearing*, the initial stage of silkworm rearing cycle. This stage, which involves nurturing young silkworms (from the first to the second instar) is fundamental to ensuring the health and quality of the silkworms that will eventually produce silk cocoons. Understanding the economic feasibility of chawki rearing particularly as a specialized practice within the broader sericulture industry, is essential for farmers, policymakers and stakeholders who seek to optimize silk production and enhance profitability (Kumari and Rajan, 2013) [14].

Chawki rearing represents a specialized phase in the silkworm lifecycle where silkworms are reared under controlled environmental conditions to ensure their optimal growth (Bharathi *et al.*, 2024). Silkworms in this early stage are highly susceptible to disease, temperature fluctuations and nutritional deficiencies thereby making proper chawki rearing critical for the later stages of cocoon production (Kallimani *et al.*, 2021) [6]. The success of this stage directly impacts the quality of cocoons and ultimately the yield of silk.

Due to its sensitive nature, many sericulture farmers prefer to outsource chawki rearing to specialized chawki rearing centers (CRC's) which have the expertise, equipment and controlled environments necessary for successful silkworm development (Reddy, 2011) [15]. The benefits of outsourcing chawki rearing are manifold. Farmers who receive healthy, well-reared silkworms from chawki centers can reduce the risks associated with poor rearing practices and focus on later-stage silkworm rearing where the worms are less vulnerable. Furthermore, by dividing the sericulture process into specialized tasks, chawki rearing offers the potential for enhanced efficiency and higher-quality silk production, benefiting both farmers and the broader silk industry. However despite its importance, chawki rearing remains an under-researched area particularly in terms of its economic viability (Savithri and Sujathamma, 2013) [19].

Evaluating the economic feasibility of chawki rearing involves analysing the costs associated with this stage of sericulture in relation to the potential financial returns (Bharathi *et al.*, 2024). Like any agricultural practice, chawki rearing requires investments in infrastructure, labour, feed and disease management. In regions where environmental conditions are not ideal, additional investments may be needed to create controlled environments that support healthy silkworm development. The potential for disease outbreaks further adds to the complexity as disease management and prevention strategies are critical to minimizing losses (Sakthivel *et al.*, 2016) [17].

On the revenue side, the economic benefits of chawki rearing derive from the sale of high-quality silkworms to farmers as well as potential government subsidies aimed at supporting sericulture. In countries like India and China where sericulture is a major economic activity, government initiatives often include financial incentives for farmers engaged in chawki rearing (Bharathi *et al.*, 2024). These can include subsidies for infrastructure development, disease prevention programs and technical training. Thus, a comprehensive economic feasibility study must take into account not only the direct costs and revenues of chawki rearing but also the broader institutional and market contexts in which it operates (Dasari *et al.*, 2018) [5].

Materials and Methods

The study on economic feasibility for chawki rearing in sericulture was conducted through a detailed analysis of costs and returns associated with a chawki rearing center (CRC). The data was collected from 5 CRC's located in sericulture-intensive regions. The sample CRC's were selected based on operational scale, production capacity and experience in chawki rearing (Sivaprasad *et al.*, 2015) [20]. The materials used included financial records, operational cost data and farmer interaction for understanding revenue streams. The materials included in the study were

1. **Chawki rearing units**: These included rearing trays, temperature control systems, mulberry leaves, disinfectants and rearing space.
2. **Labour**: Human resources involved in mulberry cultivation, leaf harvesting and care of silkworm larvae.
3. **Financial data**: Comprehensive cost records for fixed and variable costs such as labour, mulberry plantation, inputs (disinfectants, trays & electricity) and market prices of chawki worms (Dasari *et al.*, 2018) [5].

The methodology involved in the study were

1. **Data Collection**: A questionnaire was used to gather primary data from CRC owners on revenue and costs. Secondary data was obtained from published sericulture research reports.
2. **Cost Analysis**:
   - **Fixed Costs**: Infrastructure, equipment and land lease.
   - **Variable Costs**: Labour, mulberry garden maintenance, disinfectants and electricity.
   - **Apportioned Costs**: Apportioned costs are allocated to each production cycle based on the lifespan of fixed assets and the frequency of rearing cycles (Sakthivel *et al.*, 2016) [17].
3. **Revenue Analysis**: Revenue was calculated based on the market price of chawki worms sold per batch.
4. **Profitability Metrics**:
   - **Gross Profit**: Calculated as total revenue minus total variable costs.
   - **Net Profit**: Deducted all fixed and apportioned costs from the gross profit.
   - **Benefit-Cost Ratio (BCR)**: The BCR was derived by dividing total revenue by total costs (fixed + variable) (Kallimani *et al.*, 2021) [6].
5. **Feasibility Assessment**: The profitability indices including net profit, gross profit and BCR were used to assess economic feasibility. A BCR greater than 1 indicated that chawki rearing was economically viable (Jayaram and Bindroo, 2013) [4].

Economics of chawki rearing

Area under mulberry - 1 hectare
Mulberry variety - S36
Plot system type - Single plot system
Spacing - (150 + 90) cm × 60 cm (paired row system)
Leaf yield - 30,000 kg/ha/year
No. of batches for rearing - 2 batches per month
No. of batches for rearing - 24 batches/annum
No. of Dfls reared per batch - 5000 Dfl's per batch
Leaf requirement per batch - 1000 kg
S36 (NPK Requirement) - 225:150:150 kg/ha/yr
FYM - 40MT/ha/yr

Table 1: Establishment Cost of Chawki Mulberry Garden (1 year)

Sl. No.	Particulars	Cost (Rs.)
1.	Tractor Rotavator (10 hrs) @ Rs.500/hour	5,000
2.	Harrowing (6 hrs) @ Rs.500/hour	3,000
3.	Farm Yard Manure (20 MT) @ Rs.1000/MT	20,000
4.	Farm Yard Manure application (10 mandays) @ Rs.500/manday (broadcasting)	5,000
5.	Final Land Levelling(6hrs) @ Rs.500/hr	3,000
6.	Bund former (6hrs) @ Rs.500/hr	3,000
7.	Planting preparation: Ridge-furrow adjustments (10 mandays) @ Rs.500/manday	5,000
8.	Planting material (12,500 plants/ha) @ Rs.0.5/plant (adopting paired row system)	6,250
9.	Transportation of Planting material	500
10.	Planting (20 mandays) @ Rs.500/manday	10,000
11.	Hoeing/weeding (50 mandays) @ Rs.500/manday	25,000
	Establishment cost (A)	85,750

Table 2: Every Year Maintenance Cost of Chawki Mulberry Garden (per ha/year)

Sl.no	Particulars	Cost (Rs)
1.	Farm Yard Manure (40 MT) @ Rs.1000/MT	40,000
2.	Fertilizer (NPK-225:150:150 kg/ha/year) @ (N:P:K- 6.4:8.4:19.6 Rs/Kg)	5,280
3.	Manure and fertilizer application (20 mandays) @ Rs.500/mandays	10,000
4.	Irrigation (100 mandays)	50,000
5.	Power tiller weeding 4 times/yr (40hrs) @ Rs.500/hr	20,000
6.	Pruning and leaf harvesting using Pruner (100hrs) @ 100 Rs/hr	10,000
7.	Leaf harvest (50 mandays) @ Rs.500/mandays	25,000
8.	Rent on land @ 20,000 Rs/ acre	50,000
9.	Maintenance cost every year (B)	2,10,280
10.	Establishment cost (A)	85,750
11.	Apportioned cost (C)	5,717
12.	Total cost for leaf production every year (D=B+C)	2,15,997
13.	Total Leaf Harvested(Kg/Ha)	30,000
14.	Production cost for 1 kg mulberry leaves	7.19
15.	Total cost for leaf production (per batch) for 1000 kg (E)	7190

Table 3: Investment on Rearing Building and Equipments (for 5000 Dfls/Batch)

SI. No	Rearing building/equipment	Number/quantity required	Rate (Rs.)	Cost (Rs.)	Life span (years)
1.	Rearing house for chawki worms (1800 sq.ft.)	1	300/sq.ft	5,40,000	25
2.	Plastic rearing tray (3'x 4')	300	500/unit	1,50,000	10
3.	Wooden chawki stand	20	600/unit	12,000	10
4.	Feeding stand	5	250/unit	1250	5
5.	Leaf chopping board	5	250	1250	5
6.	Knife	5	100	500	2
7.	Generator	1	30,000	30,000	10
8.	Power sprayer with mask	1	15,000	15,000	10
9.	Room heater	2	10,000	20,000	5
10.	Humidifier	2	8,000	16,000	5
11.	Microscope	2	1500	3,000	5
12.	Wet & dry thermometer	2	1000	2000	5
	Total fixed cost (C)			7,91,000	

Table 4: Cost -Benefit Ratio Calculation

Average annual production costs and returns	Cost (Rs.)
Disinfectants for rearing	20,000
Cost of dfl's (Rs.18/dfl) for 5000 dfl's per batch for 24 batches in a year	21,60,000
Labour for silkworm rearing (2 womens/day) for 300 days/yr @ Rs.300 per women	1,80,000
Miscellaneous cost	10,000
Total cost for chawi rearing (for 24 batches) @ 5000dfl's/batch (F)	23,70,000
Total cost for leaf production (per batch) for 1000 kg (E)	7190
Total cost for leaf production (for 24 batches) @ 1000 kg/batch (G)	7190×24 = 1,72,560
Total Expenses for chawki production per year (H=F+G)	25,42,560
Total returns (by selling chawki worms @ (Rs.40/dfl) for 5000 dfl's per batch for 24 batches in a year (I)	48,00,000
Annual net returns (H-I)	22,57,440
Net returns (per batch)	94,060
Benefit Cost ratio = 1.89 > 1 (So, the project is feasible)	

Results and Discussion

From an economic viewpoint, the cost structure outlined in the table 1 reflects establishment expenses necessary for establishing a sericulture-related agricultural operation, such as mulberry cultivation. The mechanization costs including tractor rotavator and harrowing have incurred around Rs. 5,000 and Rs. 3,000 respectively which highlights a shift towards capital-intensive farming which can improve efficiency and yield by reducing reliance on manual labour. These capital inputs are upfront investments that may reduce long-term costs through improved productivity (Kumaresan *et al.*, 2011) [13]. FYM incurred around Rs. 20,000 and its broadcasting in the field has incurred an expense of Rs. 5,000 which represents essential investments made to enrich soil fertility thereby contributing to sustainable farming practices and long-term productivity. These organic inputs while requiring higher initial outlays can potentially reduce the dependency on chemical fertilizers thus offering long-term cost savings. Additionally, labour-intensive activities such as planting (Rs. 10,000) and weeding/hoeing (Rs. 25,000) emphasize the significant role of human capital in sericulture. High labour costs reflect the persistent challenge of labour dependence in farming which could be a constraint for smaller farmers (Sanappa and Govindan, 2004) [18]. The total establishment cost of Rs. 85,750 can be seen as a necessary investment for establishment thereby aimed at creating an optimal environment for crop growth and managing risks such as soil erosion or inadequate irrigation through bund forming and land levelling. For larger-scale farmers, these investments can lead to economies of scale thus improving overall profitability. However for smallholders, these upfront costs may present financial barriers, necessitating external support or credit access for successful implementation (Diab and Rateb, 2009) [2].

Table 2 illustrates the recurring costs involved in mulberry leaf production, essential for sericulture. The use of FYM

(@40 MT @ Rs. 1,000/MT) and fertilizer (NPK), totalling Rs. 45,280 highlights significant variable inputs to sustain soil fertility and ensure healthy mulberry growth. This reflects an ongoing investment in natural capital to maximize yields crucial for maintaining profitability in leaf production. The application of manure and fertilizers (Rs. 10,000 for 20 mandays) and irrigation costs (Rs. 50,000 for 100 mandays) emphasize the labour-intensive nature of sericulture particularly for activities that cannot be easily mechanized thus driving up operational costs (Sakthivel *et al.*, 2012) [16]. The costs for power tiller weeding (Rs. 20,000), pruning and leaf harvesting have incurred around Rs. 10,000 and Rs. 25,000 respectively reflect both mechanized and manual processes thereby balancing capital investment with labour. Land rent estimated around Rs. 50,000 per acre adds a fixed cost element, critical in determining overall land-use efficiency. The maintenance cost totals Rs. 2,10,280 annually with an additional apportioned establishment cost of Rs. 5,717 thus leading to a total cost of Rs. 2,15,997 for leaf production. With an annual yield of 30,000 kg of leaves, the production cost per kilogram is Rs. 7.19. This cost efficiency directly impacts the profitability of the sericulture operation, as lower production costs per unit can enhance competitive advantage in the chawki rearing business especially when scaled up (Kumaresan *et al.*, 2008) [12].

Table 3 represents the capital investment required to establish a chawki rearing facility, crucial for early-stage silkworm development. Highest expenses goes for the rearing house (Rs. 5,40,000), accounting for over two-thirds of the total fixed cost that reflects the significant infrastructure investment needed for a controlled environment essential for healthy silkworm growth. The 25-year lifespan of the building suggests that while the upfront cost is high, it can be amortized over time thereby reducing the per-year burden. The purchase of plastic rearing trays (Rs. 1,50,000), chawki stands and other equipment like feeding stands, leaf chopping boards and knives indicates the capital requirements for proper silkworm handling and feeding (Anonymous, 2023) [1]. These tools have a relatively long lifespan (5-10 years) thus making them durable investments. The inclusion of critical equipment like a generator (Rs. 30,000), power sprayer, humidifier and room heater (totalling Rs. 81,000) reflects the importance of maintaining optimal temperature and humidity conditions to ensure high-quality silkworm rearing. Investments in devices like microscopes and thermometers (Rs. 5,000 combined) for monitoring silkworm health and environmental conditions further highlight the attention to detail required in this specialized farming stage. The total fixed cost of Rs. 7,91,000 demonstrates the substantial upfront investment necessary for modern chawki rearing. However, when distributed over the lifespan of these assets, these costs can enhance productivity, improve cocoon yield and increase profitability thus making it a worthwhile investment for sericulture entrepreneurs (Halder, 1998) [3].

The table 4 outlines the annual production costs and returns for chawki silkworm rearing thus providing a comprehensive breakdown of various expenses and the financial outcome. The rearing process involves 24 batches per year each with 5000 disease-free layings (DFLs). The total cost for DFLs is ₹21,60,000 with each DFL priced at ₹18. Disinfectants were crucial for maintaining a healthy rearing environment which add another ₹20,000 annually (Kallimani *et al.*, 2021) [6]. Labour costs calculated based on employing two women for 300 days at ₹300 per day per woman cost around ₹1,80,000. Miscellaneous costs including unforeseen expenses are estimated at ₹10,000. In addition to these, leaf production costs for feeding the silkworms are calculated at ₹7,190 per batch thus totalling ₹1,72,560 annually for 24 batches. Combining all these expenses results in a total annual cost of ₹25,42,560 for chawki rearing and leaf production. The revenue is generated by selling chawki worms which priced at ₹40 per DFL. With 5000 DFL's per batch across 24 batches, the total returns from sales reach ₹48,00,000. Subtracting the total expenses from the returns yields a net annual profit of ₹22,57,440 which translates to a net return of ₹94,060 per batch. The benefit-cost ratio was found to be 1.89 as it indicates that the project is financially viable with returns significantly outweighing the costs thereby making the enterprise a profitable venture in sericulture related business (Dasari *et al.*, 2018) [5].

Conclusion

Chawki rearing is a critical stage in the sericulture process with significant implications for the quality and yield of silk production. This study on the economic feasibility of chawki rearing reveals that while the practice requires substantial initial investment in infrastructure, labour and disease management as it offers considerable benefits in terms of efficiency, improved silkworm health and enhanced cocoon productivity. The success of chawki rearing largely depends on factors such as access to modern technology, effective disease control measures and economies of scale which can reduce per-unit costs and increase profitability. Government policies, subsidies and technical support play a pivotal role in making chawki rearing financially viable particularly for small-scale farmers. Cooperative models and centralized chawki rearing centers (CRC's) have shown promise in spreading costs and providing high-quality silkworms to farmers thereby improving overall silk production efficiency. Despite its challenges, chawki rearing represents an economically feasible practice when approached with careful planning, investment in technology and adherence to best practices. The integration of chawki rearing as a specialized component within the sericulture industry can significantly contribute to improving both the quality of silk and the financial sustainability of sericulture farmers. Future research and policy initiatives should focus on further optimizing chawki rearing practices and expanding support systems to enhance the profitability of this crucial stage in the silk value chain.

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