JOURNAL OF CULTURAL ANALYSIS AND SOCIAL CHANGE

Journal of Cultural Analysis and Social Change,
2025, 10(4), 3819-3833
ISSN: 2589-1316

Economic Prospects for Silk Production of (Bombxy mori) Through Agricultural Cooperatives

Abdel-Hamed E. ElShazly[1], Mohamed F. Abouelenein[2*], Noura Roshdy[2], Alaa F. Helal[3], Issam Khelfaoui[4], Samy S. EL-Mezain[5], Ahmed, H, El-saffany[5]

[1] *Agricultural Economics Department, Faculty of Agriculture, Al-Azhar University, Cairo 11651, Egypt.*
[2] *Department of Insurance and Risk Management, College of Business, Imam Mohammad Ibn Saud Islamic University (IMSIU), Riyadh 11432, Riyadh, Saudi Arabia, Email: mabouelenein@imamu.edu.sa, (Corresponding Author)*
[3] *Economic and Social Agricultural Sciences Department, Faculty of Agriculture, Damietta University, Egypt*
[4] *School of Public Health, Shantou University/Institute of Local Government Development, Shantou Univer-sity, Shan-Tou 515063, China*
[5] *Plant Protection Departments, Faculty of Agriculture, Al-Azhar University, Egypt*

***Corresponding Author:** mabouelenein@imamu.edu.sa

Citation: ElShazly, A. E. E., Abouelenein, M. F., Roshdy, N., Helal, A. F., Khelfaoui, I., EL-Mezain, S. S., & El-saffany, A. H. (2025). Economic Prospects for Silk Production of (Bombxy mori) Through Agricultural Cooperatives, *Journal of Cultural Analysis and Social Change*, 10(4), 3819-3833. https://doi.org/10.64753/jcasc.v10i4.3665

Published: December 25, 2025

ABSTRACT

Natural silk production in Egypt encounters several challenges that hinder its growth and sustainability, despite its inherent natural and historical advantages that could yield substantial economic returns. This re-search aims to examine the economic trends for the potential of silk production through agricultural coopera-tives. Results indicate that the net present value (NPV) is approximately 3,291.6 thousand EGP per year during the investment period. The benefit-cost ratio (B/C ratio) for the mulberry-based silkworm project is around 1.3 over its lifespan. The profitability per invested pound stands at about 0.3 EGP. The internal rate of return (IRR) is approximately 47.1%, indicating a return of 47.1 piasters per invested pound, higher than the current bank interest rate of 21%. This suggests that investing in natural silk production is more economically and finan-cially viable than traditional savings. The capital turnover period is estimated at 2.12 years. Recommendations include establishing an agricultural information bank, integrating modern informational technology within cooperatives, and training staff. Enhancing coordination between cooperatives and research centers at various levels is crucial to stay updated with advancements in agricultural technology. Accurate data should be made available to assist researchers in universities and research centers. Broadcasting guiding prices through mod-ern communication tools and emphasizing cooperative education and training are vital.

Keywords: Economic Feasibility, Silk Cooperatives, Natural Silk Projects, Silkworm.

INTRODUCTION

Natural silk production is a high-value economic, agricultural, and industrial activity that plays a critical role in supporting the agricultural economy and artisan industries.. It generates national revenue and creates employment opportunities for youth of both genders. Rearing silkworms and production of silk is basically an agro-industry. It is divided into two sectors namely farm and industry. The farm sector involves growing silkworm's food plants, rearing silkworm to produce cocoons and producing eggs.(Siddiq, et al., 2015).Domestic production in Egypt does not meet local consumption. As one of the finest natural fibers, silk is highly sought after by consumers worldwide due to its high quality and diverse applications in textiles and luxury garments. (Abo Mousa& Taha,2021; Elsharkasy, et al., 2025).Egypt, with its favorable climatic conditions, holds great potential in this field, but the sector's growth fluctuated due to factors like limited governmental support, decreased focus on traditional agriculture, and global competition from countries such as China and India. Most of Egypt's silk production relies on traditional methods throughout all phases. The natural silk production involves agricultural activities starting from mulberry cultivation and culminating in raw silk production. The industrial activities include yarn preparation and textile manufacturing. During the period (2019 to 2022), Egypt's average raw silk production was approximately 693.68 kilograms. Agricultural cooperatives play a crucial role in enhancing the economics of natural silk production. There are specialized cooperatives for beekeeping and silk, totaling around ten with an average capital of approximately 896.3 thousand EGP. (CAPMAS)

Research Problem

The research problem involves the limited contribution of agricultural cooperatives in supporting and improving the economics of natural silk production. This limitation has led to decreased productivity, increased production costs, and weakened competitiveness both locally and globally. Additionally, natural silk production in Egypt faces numerous challenges to its growth and sustainability, despite its natural and historical potential for high economic returns. Therefore, this industry depends largely on the development of the silk industry by using improved strains of silkworms, and producing high-quality paper through better mulberry varieties and breeding methods (Tayade, 1984).

RESEARCH OBJECTIVE

This study aims to explore the economic potential for silk production through agricultural cooperatives, focusing on:

1. Examining modern methods of silkworm breeding and raw silk production, and their implementation in Egypt through specialized cooperatives.
2. Investigating the efficiency of silk production management to attract new groups, particularly young graduates, productive families, and rural women, to establish small projects (Taha, et al., 2008).

LITERATURE REVIEW

1- Silkworm Bombyx Mori—Sustainability And Economic Opportunity, Particularly For Romania

The economic potential and sustainability of Bombyx mori sericulture were examined by (Hăbeanu, et al.,2023), with a focus on Romania. This study showed that sericulture is economically important for a variety of valuable by-products, including mulberry leaves, excreta, pupae, sericin, and fibroin, which can be used in food, medicine, animal feed, the production of biodiesel, and organic fertilizers. The study stressed that small- and medium-sized farmers can make a lot more money if they diversify their by-products, especially if the government gives them money and makes policies that are good for them. Additionally, sericulture was demonstrated to enhance rural employment creation, income diversification, and the mitigation of rural-to-urban migration. The study found that to keep sericulture going for a long time, it is important to protect the genetic diversity of silkworms, improve the management of mulberry trees, and encourage new ways to add value to products. These results provide robust evidence that well-organized and supported sericulture cooperatives can generate significant economic and social value.

2- Opportunities For Improving The Environmental Profile Of Silk Cocoon Production Under Brazilian Conditions

(Barcelos, et al.,2020) performed an innovative life cycle assessment (LCA) of mulberry and silk cocoon production in Brazil. The research utilized the ReCiPe methodology across nine environmental impact categories, illustrating that mulberry cultivation exerted more significant environmental burdens than cocoon production, particularly regarding freshwater ecotoxicity, eutrophication, and human toxicity associated with fertilizer and pesticide usage. Cocoon production, on the other hand, took up a lot of land, changed the climate, and used up a lot of water, mostly because of the way mulberries were transported, electricity was used, and sanitation was done in silkworm farming. This study suggested useful ways to lessen the effects, such as switching out incandescent bulbs for LEDs, using reusable materials instead of Kraft paper, using organic fertilizers, and creating reverse logistics for packaging waste.

3- Lens On Tropical Sericulture Development in Indonesia: Recent Status and Future Directions for Industry and Social Forestry

(Andadari, et al.,2022) provided a comprehensive review of tropical sericulture development in Indonesia, analyzing both its current status and future directions. The study stressed that sericulture, which is based on the rearing of silkworms and the cultivation of mulberries, is an important non-timber forest product (NTFP) with substantial ecological, social, and economic potential. The sericulture can increase household incomes, create jobs in rural areas, and decrease migration to cities. However, its sustainability depends on improving institutional frameworks, creating better mulberry hybrids and silkworm strains, and making sure that credit and technical training are available. This study also pointed out that there is still a significant discrepancy between the supply and demand for silk in Indonesia, which presents a chance for cooperative-based production systems to close the gap in the market. The study showed that multi-stakeholder cooperation and integrated upstream and downstream policies are necessary to restore sericulture as a viable agro-industry.

4- Economic Analysis of Silkworm Rearing and Cocoon Production in Bilaspur District of Himachal Pradesh

(Abate, et al.,2014) used household survey data from 1,638 farm households in four major regions to examine how agricultural cooperatives affected the technical efficiency of smallholder farmers in Ethiopia. To account for selection bias between cooperative members and non-members, the study used a Stochastic Production Frontier (SPF) model in conjunction with Propensity Score Matching (PSM). The average efficiency of members was 71%, while that of non-members was 62%. The results consistently showed that cooperative membership increased technical efficiency by roughly 5 percentage points.

This study came to the conclusion that increasing farmer involvement in cooperatives is a practical way to boost agricultural transformation and technical efficiency in Sub-Saharan Africa. These observations highlight the efficiency and productivity increases that can be achieved when cooperatives are supported by supportive laws and strong institutional frameworks, which make them extremely pertinent to your research.

5- Transitioning The Silk Industry Towards Circularity: A Thematic Analysis of Sustainable Value Chain Practices

Using a thematic analysis of literature and ten expert interviews, (Hassan, et al., 2025) investigated how the global silk industry can shift from a conventional linear value chain to a circular economy model. Six key themes for integrating sustainability were found in the study:

(1) Waste utilization; (2) Product longevity and circular design ;(3) Education of consumers; (4) The development of technology;(5) Transparency and traceability;(6) Government control.

According to the findings, by-products of the silk industry, including mulberry branches, silkworm litter, pupae, low-quality cocoons, and sericin, can be recycled into textiles, fertilizers, animal feed, cosmetics, and biodiesel, which benefits the environment and the economy. The study emphasized how blockchain, IoT, and AI can enhance traceability, efficiency, and quality control throughout the silk value chain. It also emphasized that while policy support—such as training initiatives, subsidies, and circularity incentives—can hasten adoption, consumer education is essential for advancing sustainable practices.

6- Impact of Agricultural Cooperatives on Smallholders' Technical Efficiency: Evidence from Ethiopia

(Abate, et al. ,2014) used household survey data from 1,638 farm households in four major regions to assess how agricultural cooperatives affected the technical efficiency of smallholders in Ethiopia. In order to account for selection bias, the study compared cooperative members and non-members under comparable agro-ecological conditions using a Stochastic Production Frontier (SPF) model in conjunction with Propensity Score Matching (PSM). Cooperative membership improved technical efficiency by about 5 percentage points, according to the results, with members averaging 71% efficiency compared to 62% for non-members. According to the analysis, the main ways that cooperatives increased efficiency were by improving access to market connections, extension services, and essential inputs (better seeds and fertilizer). The results were not influenced by unobserved household characteristics or hidden biases, ac-cording to robustness checks, which included Rosenbaum bounds sensitivity analysis. Even non-members of cooperative villages tended to use more inputs, which suggest that cooperatives disseminate information and innovation at the community level, and then Sub-Saharan Africa's agricultural transformation can be facilitated by increasing cooperative membership and fortifying institutional support, both of which can result in notable efficiency gains.

Comparative Matrix of Key Sericulture and Cooperative Studies

Study	Country / Context	Primary Focus	Methods / Data	Key Economic Findings	Environmental / LCA Points	Cooperative / Policy Implications	Direct Relevance to my Study
Hăbeanu, et al., 2023	Romania (EU); sericulture as rural development lever	Sustainability & economic opportunities of Bombyx mori; valorization of by-products	Narrative synthesis; sector evidence; sustainability framing	Profitability improves via diversification (pupae, sericin/fibroin extracts, feed, fertilizers); supports SMEs' income & jobs	Mulberry sequestration; biodegradable fiber; ecosystem services of plantations	Public support & cooperative organization catalyze adoption; product diversification reduces risk	Supports expanding revenue streams in NPV/IRR; aligns with cooperative-led value addition in Egypt
Barcelos et al., 2020	Brazil; top-5 global producer; farm-level operations	Life Cycle Assessment (LCA) of mulberry & cocoon production	ReCiPe LCA across 9 categories; process inventory	Operational improvements (LEDs, packaging reuse, organic fertilizers) cut costs & impacts; strengthens competitiveness	Higher impacts from mulberry (toxicity/eutrophication); cocoons: land, climate, water depletion drivers	Coops & policy support enable tech upgrades and reverse logistics	Quantifies sustainability levers to integrate into NPV/IRR sensitivity for Egyptian cooperatives
Andadari et al., 2022	Indonesia (tropical developing country)	Status & prospects of sericulture; constraints & enablers	Systematic review of sectoral evidence	Rural jobs & income potential; supply–demand gap offers market opportunity	Mulberry aids soil conservation & carbon; silk is renewable/biodegradable	Need for stronger institutions, credit, extension; coops can close market gaps	Evidence for institutional pillars (finance, training) in cooperative feasibility models
Sharma, et al., 2019	India (Himachal Pradesh)	Farm economics of cocoon production; seasonality	2-stage random sample (n=60); Cobb–Douglas; break-even analysis	Spring crops viable; autumn often loss-making; economies of scale; seed & feeding frequency drive yields	— (not LCA-focused)	Coop marketing & tech support needed; large female labor share → inclusive policies	Parameters for cost–return blocks and seasonal risk scenarios in NPV/IRR

Abate et al., 2014	Ethiopia; mixed rainfed smallholders	Impact of coops on technical efficiency	Household survey (n=1,638); SPF + PSM; sensitivity (Rosenbaum)	Membership ↑ technical efficiency by ~5 p.p. (71% vs 62%); spillovers in input use	— (productivity/efficiency focus)	Coops ease access to inputs/extension; scaling membership boosts transformation	Strong empirical basis for efficiency gains in Egyptian sericulture coops
Hassan, et al., 2025	Global silk value chain (thematic + expert interviews)	Circular economy transition in silk industry	Thematic analysis; 10 expert interviews; framework building	By-product valorization & circular design improve margins; tech (AI/IoT/blockchain) boosts quality/traceability	Waste utilization; reverse logistics; SDG 12 alignment	Incentives, training, traceability standards; consumer education crucial	Blueprint for coop-led circular practices to enhance project NPV and resilience

Commentary on Literature Review

1. Economic Feasibility and Sustainability of Sericulture.

Numerous studies have consistently shown that sericulture can be a profitable and sustainable rural business when it is run with the right technologies and a variety of strategies. Evidence from Romania, Brazil, Indonesia, and India (Hăbeanu, et al., 2023; Barcelos, et al., 2020; Andadari et al., 2022; Sharma, et al., 2019) indicates that the valorization of by-products, the implementation of contemporary production methods, and environmental stewardship substantially enhance financial returns while mitigating seasonal and ecological risks. These results support the idea that silk production is a multifaceted value chain that can support both environmental sustainability and the creation of rural income, rather than just producing raw fiber.

2. Institutional And Cooperative Dimensions

The Cooperative membership enhances access to inputs, extension services, markets, and knowledge while lowering transaction costs and empowering marginalized groups like women and smallholders, according to empirical data from Sub-Saharan Africa and international discussions (Abate, et al., 2014; Wanyama, et al., 2009; Birchall and Simmons, 2009). Recent studies (Hassan, et al., 2025) expand on this perspective by tying cooperatives to the framework of the circular economy and highlighting the importance of waste management, technology, and traceability in developing competitive and sustainable silk value chains.

SUMMARY

These insights underscore a significant research deficiency: the necessity to amalgamate stringent financial assessment instruments (NPV, IRR) with the cooperative and institutional facets of sericulture. This study fills this gap by looking into the economic viability of cooperative-based silk production in Egypt, while also taking into account sustainability and innovation.

Research Gap and Contribution of the Present Study

Most current research primarily concentrates on either the financial and technical facets of sericulture or the institutional and social dimensions of cooperatives, lacking a systematic integration of both perspectives into a cohesive framework. Furthermore, most empirical evidence originates from Asian or Sub-Saharan contexts, with a scarcity of studies examining the Egyptian context, which is defined by distinct agricultural, social, and economic frameworks. By offering an integrated model that blends an institutional analysis of cooperative organization with rigorous financial evaluation tools (NPV, IRR, and B/C ratio), this study fills that gap. By doing this, it shows that sericulture projects under cooperative frameworks are not only economically feasible but also have the potential to support rural development, sustainability, and circular economy principles. Therefore, by placing sericulture within Egypt's cooperative sector, connecting it to the larger goals of Egypt Vision 2030, and offering useful insights for investors, policymakers.

METHODOLOGY AND DATA SOURCES

The research employs economic reasoning supported by descriptive and econometric statistical methods. This research includes calculating indicators (NPV) Net present value and internal rate of return (IPR) methods, thes methods are two financial techniques used to evaluate the investment value of technology (Anggraini, 2025), NPV refers to discounting future estimated cash flows at different times to the same time and calculating an amount, which can help investors determine whether a project is worth investing in. It can be expressed as an equation:

$$NPV = \sum_{t=0}^{T} \frac{CFt}{(1+r)^t}$$

(CFt= cashflow in year t, T= the last year in which cash flow must be calculated, r= discount rate) NPV does not represent the profits that investors will earn after T years but the choice of discount rate is a very important part of the calculation of NPV, and for the future NPV calculation, the discount rate usually is considered as the cost of capital or the expected return on this project (Zhang, 2024). It relies on two data sources:

1. Primary data collected through personal interviews with farm owners in Al-Salhia and Wadi El-Natrun using Rapid Appraisal techniques due to difficulty accessing these farms.
2. Secondary data obtained from publications of the Central Agency for Public Mobilization and Statistics (CAPMAS), and bulletins from the Ministry of Agriculture and Land Reclamation.

RESULTS

1-The role of cooperatives in silk production focuses on encouraging the cultivation of mulberry trees, particularly in new lands, and supporting farmers by providing them with the best and most productive mulberry varieties. This includes enhancing production quality, training farmers in silkworm rearing, supplying adequate quality and quantity of egg boxes, and improving silk extraction techniques to raise production quality and reduce waste. Cooperatives also aim to gather production from members, add value through processing, or sell to local and international factories and markets, ensuring the greatest possible benefit and fair prices that provide economic returns to cooperative members, thereby enhancing producer profitability. Additionally, they benefit from using production waste as natural fertilizers to increase soil fertility and productivity. The quantity and quality of mulberry leaves affect the rate of larval growth, development, weight, and survival rate, in addition to their impact on their fertility, longevity, movement, and competitive ability (Parra, 1991).

The average number of beekeeping and silk cooperatives reached about 10 during the period from 2012 to 2024, with a minimum of 7 cooperatives in 2012, representing about 70% of the average, and a maximum of 11 cooperatives. According to the general time trend equation for the number of beekeeping and silk cooperatives from 2010 to 2022, as indicated in Table 2, it is statistically insignificant at conventional significance levels, with an F-value of 3.58, which is less than the tabular value, and an R^2 of approximately 0.23, indicating that about 23% of the changes are time-related.

The average total number of specialized cooperatives reached about 101 during the period from 2012 to 2024, with a minimum of 79 cooperatives in 2012, representing about 78% of the average and a maximum of 121 cooperatives in 2021, representing approximately 119.8% of the average. According to the general time trend equation for the total number of specialized cooperatives during this period the model is statistically significant at the 0.05 probability level, where the data indicates an annual increase rate of approximately 1.7 cooperatives per year, with an F-value of 7.84, which is greater than the tabular value, and an R^2 of roughly 0.42, suggesting that about 42% of the changes are time-related- (table 2).

Table (1): Development of the Number of Specialized Agricultural Cooperative Societies in Egypt during the Period (2012 –2024)

Category	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Average
Beekeeping & Silk	**7**	**10**	**9**	**11**	**10**	**10**	**11**	**10**	**11**	**10**	**11**	**10**	**10**	**10**
Total	**79**	**92**	**91**	**100**	**103**	**109**	**105**	**99**	**106**	**121**	**103**	**103**	**102**	**101**

Source: Collected and calculated from the Central Agency for Public Mobilization and Statistics (CAPMAS), Annual Bulletin of Cooperative Activity in the Agricultural Sector, various issues.

Table (2): Time Trend Equations for the Number of Specialized Cooperative Associations in Egypt during (2012 – 2024)

Statement	General Time Trend Equations	R^2	Calculated F	Rate of Change%
1. Number of Beekeeping and Silk Associations	Y^=9.04+0.14X (1.89)	0.25	3.58	1.4
2. Total Number of Specialized Associations	Y^=89.46+1.65X (2.8)	0.42	7.84	1.63

Source: Compiled and calculated from Table 1 data •Significant at the 0.05 level.

The average Number of Members and Capital in Beekeeping and Silk Agricultural Cooperative Associations during the Period (2022 - 2024) reached about 2,620 members. This represents about 25.5% of the total number of members (associations) of all specialized agricultural cooperative associations in Egypt, totaling about 10.27 thousand members during the same period-(table 3). While the average number of members in beekeeping and silk cooperative associations (per individual) in Egypt reached about 3,230 members, represents about 25% of the total number of members (individuals) of all types of specialized agricultural cooperative associations in Egypt, which amounted to about 12.95 thousand members. While the average capital of beekeeping and silk cooperative associations in Egypt reached about 896.33 thousand pounds, represents about 5.24% of the total capital of all types of specialized agricultural cooperative associations in Egypt, which reached about 17.2 million pounds during the same period-(table 3).

Table (3): Average Number of Members and Capital in Beekeeping and Silk Agricultural Cooperative Associations and Their per Number of Members centage of the Total National Average (2022 - 2024)

	Number of Members				Capital (in thousand pounds)	%
	Associations	%	Individuals	%		
Beekeeping and Silk	2620	25,52	3230,33	24,95	896,33	5,24
Total	10265,33	100	12946,67	100	17109,33	100

Source: Compiled and calculated from the Central Agency for Public Mobilization and Statistics, (CAPMAS)

The (table 4) indicates that the average number of specialized agricultural cooperatives in Egypt was approximately 810 during the period (2022–2024), where Faiyum Governorate ranked first, with an average of about 316 cooperatives, accounting for about 39% of the total for specialized agricultural cooperatives. While the New Valley Governorate ranked last, with an average of only one cooperative, representing about 0.12% of the average during the period. While the average number of shareholding members in specialized agricultural cooperatives in Egypt reached approximately 61,700 during the period (2022–2024), where the Asyut Governorate ranked first, with an average about 15,830 members, presented about 25.7% of the total shareholding members in Egypt's specialized agricultural cooperatives, while the Sohag Governorate ranked last, with an average about 102 members, representing about 0.16% of the average during the period.

The average number of board members in specialized cooperatives in Egypt reached about 4,280 during the period (2022–2024), while the Faiyum Governorate ranked first, with an average about 1,580 board members, representing about 36.89% of the total, but the New Valley Governorate ranked last, with an average of only five board members, accounting for about 0.12% of the average during the period. While the average capital value of specialized agricultural cooperatives in Egypt reached about 151.55 million pound during the (2022–2024) ,where the Sharqia Governorate ranked first, with an average capital of about 81.12 million pound, presented about 53.53% of the total capital for these cooperatives in Egypt, while the New Valley Governorate ranked last, with an average capital of only 1,000, representing a negligible percentage of the total during the period.

Table (4): Average Number of Cooperatives, Members, and Capital in Specialized Agricultural Cooperatives by Governorate (Average for 2022–2024).

Governorate	No. of Specialized Cooperatives	%	No. of Shareholding Members	%	No. of Board Members	%	Capital (Thousand EGP)	%
Cairo	3	0.37	272.33	0.44	17	0.4	74.67	0.05
Alexandria	7.33	0.905	718	1.16	35.33	0.83	228.33	0.15
Port Said	4	0.494	1,684.67	2.73	24	0.56	587	0.39
Suez	1.67	0.206	539.33	0.87	8	0.19	15	0.01
Damietta	2.67	0.329	1,325.00	2.15	24	0.56	2,869.67	1.89

Dakahlia	11.67	1.44	2,497.33	4.05	100.33	2.35	4,430.00	2.92
Sharqia	239	29.495	4,136.00	6.71	1,273.00	29.75	81,122.33	53.53
Qalyubia	5.67	0.699	531	0.86	53	1.24	172.67	0.11
Kafr El-Sheikh	5.33	0.658	2,670.33	4.33	50	1.17	184.33	0.12
Gharbia	63	7.775	9,566.33	15.51	297	6.94	486.67	0.32
Monufia	19.33	2.386	1,880.67	3.05	100.33	2.35	156	0.1
Beheira	21	2.592	1,619.00	2.63	76	1.78	458.33	0.3
Ismailia	24	2.962	3,074.67	4.99	114	2.66	221	0.15
Giza	24.67	3.044	549	0.89	110	2.57	63.67	0.04
Beni Suef	8.67	1.07	279.67	0.45	44	1.03	2,295.67	1.51
Faiyum	316	38.998	7,891.67	12.8	1,578.33	36.89	236.67	0.16
Minya	10.33	1.275	1,517.33	2.46	156	3.65	57,581.33	38
Asyut	11	1.358	15,826.00	25.67	78	1.82	157.33	0.1
Sohag	2	0.247	101.67	0.16	22	0.51	6	0
Qena	14	1.728	3,160.67	5.13	41.33	0.97	68.67	0.05
Aswan	3	0.37	201	0.33	7	0.16	5	0
Luxor	2	0.247	184.67	0.3	20.67	0.48	86	0.06
Red Sea	5	0.617	207	0.34	29	0.68	3	--
New Valley	1	0.123	280	0.45	5	0.12	1	--
North Sinai	5	0.617	949	1.54	15	0.35	39.33	0.03
Total	810.33	100	61,662.33	100	4,278.33	100	151,549.67	100

Source: Compiled and calculated from the Central Agency for Public Mobilization and Statistics (CAPMAS).

While the average total number of silkworm egg boxes in Egypt reached about 266.83 during the period (2022–2024), where the Qena Governorate ranked first, with an average total of 39.83 egg boxes, presented about 14.93% of the average, while the Aswan Governorate ranked last, with an average of 0.33 egg boxes, representing about 0.12% of the average during the period-(table 5).

Table (5): Average Number of Silkworm Egg Boxes, Silkworm Cocoons, and Raw Silk Quantity in Egypt by Governorate (2022–2024)

Governorate	**Number of Egg Boxes**			**% of National Total**	**Silkworm Cocoons (kg)**	**% of National Total**	**Raw Silk (kg)**	**% of National Total**
	Domestic	**Imported**	**Total**					
Alexandria	0,17	3,17	3,33	1,25	29,43	1,43	9,47	1,37
Beheira	1,33	34,33	35,67	13,37	309,10	15,05	102,53	14,78
Gharbia	0,00	8,83	8,83	3,31	64,00	3,12	21,23	3,06
Kafr El	3,67	36,00	39,67	14,87	335,67	16,34	111,57	16,08
Dakahlia	0,33	38,33	38,67	14,49	303,93	14,80	95,30	13,74
Sharqia	3,17	1,00	4,17	1,56	31,50	1,53	10,67	1,54
Ismailia	0,00	1,33	1,33	0,50	10,33	0,50	3,43	0,49
Port Said	0,00	1,00	1,00	0,37	8,00	0,39	2,50	0,36
Monufia	1,00	4,67	5,67	2,12	41,80	2,03	13,53	1,95
Qalyubia	1,33	2,00	3,33	1,25	26,50	1,29	8,73	1,26
Cairo	8,33	6,67	15,00	5,62	120,90	5,89	39,90	5,75
Giza	1,17	8,83	10,00	3,75	66,53	3,24	21,83	3,15
Beni Suef	2,00	2,83	4,83	1,81	32,00	1,56	10,57	1,52
Fayoum	0,33	6,33	6,67	2,50	44,47	2,16	14,63	2,11
Minya	2,00	3,67	5,67	2,12	46,83	2,28	15,93	2,30
Assiut	5,00	0,50	5,50	2,06	38,17	1,86	12,43	1,79
Sohag	3,67	13,67	17,33	6,49	114,97	5,60	37,87	5,46
Qena	3,83	36,00	39,83	14,93	334,67	16,29	110,73	15,96

Aswan	0,33	0,00	0,33	0,12	2,33	0,11	1,00	0,14
New Valley	0,67	19,67	20,33	7,6	93,00	4,53	49,83	7,18
Total	38,33	228,50	266,83	100	2054,13		693,68	

Source: Ministry of Agriculture and Land Reclamation, Economic Affairs Sector, Bulletin of Fishery, Sericulture, and Food Processing Statistics, various issues.

The average production of silkworm cocoons in Egypt reached about 2.1 thousand kg during the period (2022–2024), where the Kafr El-Sheikh Governorate ranked first, with an average about 335.67 kg, represented about 16.34% of the total, while the Aswan Governorate ranked last, with an average about 2.33 kg, represented about 0.11% of Egypt's total production during the period-(table 5). While the average quantity of raw silk produced in Egypt reached about 693.7 kg during the period (2022–2024), where the Kafr El-Sheikh Governorate also led in this category, with an average output of 111.57 kg, represented about 16.08% of the total, while the Aswan Governorate ranked last, producing an average of only one kilogram, represented about 0.14% of the total raw silk production in Egypt during the period-(table 5).

Investment Performance Assessment for a Sericulture Project based on the cultivation of seven feddans of mulberry plants.

The project is assumed to have a twenty-year lifespan and is based on cultivating seven feddans of mulberry plants; also the model assumes the selection of suitable desert land in governorates with arable desert regions. The process includes land preparation, conditioning, and application of appropriate fertilizers, followed by planting mulberry seedlings at a rate of 7,000 seedlings per feddan. The seedlings are planted at regular intervals and consist of two varieties: 4,000 Indian seedlings and 3,000 Japanese seedlings. Each million silkworm larvae require 22 tons of mulberry leaves, if harvested more than four times, a single feddan can produce over 5 tons of leaves, sufficient to feed 2 million larvae annually across several rearing cycles (Choudhary, et al., 1991).Where the total investment cost for establishing a sericulture project on seven feddans of mulberry plants is about EGP 1,668,100. The cost of mulberry seedlings ranked first, accounting for 51.5%, this was followed by the cost of rearing house equipment which constituted 22.4%. The third-largest cost was the construction of a 400 m² rearing house equipped with cooling pads, exhaust fans, and plastic sheeting, representing 7.68% of the total-(table 6).

Table (6): Investment Costs in the First Year for the Sericulture Project

Item	Value (EGP)	Relative Importance (%)
Mulberry Seedlings (7,000 seedlings/feddan)	805,000	51.5
Land Preparation for Cultivation	75,600	4.84
Solar Power System	112,000	7.17
Irrigation Network	98,000	6.27
Rearing House (400 m²) with Cooling Pads, Fans, and Sheeting	120,000	7.68
Rearing Stands, Trays, Cleaning & Cocooning Nets, and Wire	350,000	22.39
Annualized Cost of Solar Station (for cooling and lighting)	2,500	0.16
Total	1,668,100	100

Source: Compiled and calculated from data collected from a research sample of silkworm farmers in 2024.

The Operating Cost Items for Modern Sericulture:

Variable Costs during the First Six Years: The variable costs in the first year of the project were approximately EGP 73,600. For years two through six, these costs were EGP 262,000, EGP 328,800, EGP 509,000, EGP 853,400, and EGP 1,021,400, respectively. A breakdown of these variable costs for each year is as follows:

a. Operating Costs in the First Year: The main cost items were permanent labor, 28 boxes of silkworm eggs (at a rate of 4 boxes per feddan for trial production), and land rent.

b. Operating Costs in the Second Year: Key items included permanent labor, a farm supervisor, land rent, the annualized cost of the solar station, and 56 boxes of eggs (8 boxes per feddan)

c. Operating Costs in the Third Year: The primary costs were permanent labor, a farm supervisor, land rent, the annualized cost of the solar station, and 112 boxes of eggs (16 boxes per feddan, marking the start of full-scale production)

d. Operating Costs in Years Four, Five, and Six: included the permanent labor, a farm supervisor, land rent, and the annualized cost of the solar station. The variable component was the number of egg boxes, which increased to approximately 245, 532, and 672 boxes (at rates of 35, 76, and 86 boxes/feddan) for the fourth, fifth, and sixth years, respectively.

Table (7): Annual Operating Costs for the Sericulture Project (Values in Thousand

Items	Value	Items	Value	Items	Value
First Year		**Second Year**		**Third Year**	
Labor	40	Permanent agricultural labor + supervisor	Permanent agricultural labor + supervisor	Permanent agricultural labor + supervisor	87.3
28 Egg Cartons	33.6	Land Rent	Land Rent	Land Rent	105
		Annual Share for a Solar Power Plant for Cooling and Lighting	2.5	Annual Share for a Solar Power Plant for Cooling and Lighting	2.5
		56 Egg Cartons	67.2	112 Egg Cartons	134
Total	**73.6**		**262**		**328.8**
Fourth Year		**Fives Year**		**Sixth Year**	
Items	**Value**	**Items**	**Value**	**Items**	**Value**
Permanent Farm Labor + Supervisor	107.5	Permanent Farm Labor + Supervisor	107.5	Permanent Farm Labor + Supervisor	107.5
Land Rent	105	Land Rent	105	Land Rent	105
Annual Share for a Solar	2.5	Annual Share for a Solar Power Plant for Cooling and Lighting	2.5	Annual Share for a Solar Power Plant for Cooling and Lighting	2.5
245 Egg Cartons	294	532 Egg Cartons	638.4	672 Egg Cartons	806.4
Total	**509**		**853.4**		**1021.4**

Source: Compiled and calculated from data collected from a research sample of silkworm farmers in 2024.

The Total Revenues

The (table 8) showed the detail the project's total revenue stream. In the first year, total revenue reached about 168,000 EGP from the sale of 280 safeehas[1] of cocoons. In the second year, revenue increased about 336,000 EGP, generated from the sale of 560 safeehas. The project operates on a trial basis during these first two years. Full-scale commercial operation commences in the third year, during which total revenue about 672,000 EGP from the sale of 1,120 safeehas. By the fourth year, revenue grew to about 1,639,900 EGP , derived from selling about 2,450 safeehas of standard cocoons, 367 safeehas of defective cocoons, and about 1,750 kg of waste utilized as organic fertilizer.

In the fifth year, the total revenue reached about 3,491,600 EGP , resulting from the sale of about 5,320 safeehas of standard cocoons, 798 safeehas of defective cocoons, and 2.8 tons of waste. Finally, in the sixth year, the total revenue amounted to about 3,967,600 EGP , generated from selling about 6,020 safeehas of standard cocoons, 903 safeehas of defective cocoons, and 3.5 tons of waste used as organic fertilizer.

The Additional Revenue from Intercropping

•The project incorporates an intercropping system, where vegetable crops such as onions, garlic, beans, and tomatoes are grown alongside the mulberry plants. This practice generates additional annual revenue estimated at 120,000 EGP per feddan, resulting in an estimated 840,000 EGP per year for the seven-feddan area.

Table (8): Revenues of the Sericulture Project

Years	Count	Item	Value in thousand pounds	Years	Count	Item	Value in thousand pounds
First Year	280		168	Fifth Years	5320	Standard Cocoons (safeeha)	3192

		Standard			798	Defective	159,6
Second Year	560	Standard Cocoons	336		2800	Waste (kg)	140
Third Year	1120	Standard Cocoons	672	Total			3491,6
Fourth Year	2450	Standard Cocoons	1479	Sixth Year	6020	Standard Cocoons	3612
	367	Defective Cocoons (safeeha)	73,4		903	Defective Cocoons (safeeha)	180,6
	1750	Waste (kg)	87,5		3500	Waste (kg)	175
Total			1639,9	Total			3967,6

Source: Compiled and calculated from data collected from a research sample of silkworm farmers in 2024.

Economic Feasibility Assessment of Natural Silk Production Projects:

Financial Analysis Results

The investment performance of the mulberry-based sericulture project was evaluated using discounted cash flow (DCF) metrics, which account for the time value of money and the project's economic lifespan by using utilized several key performance indicators:

A-Net Present Value (NPV): The current value of an investment's future net cash flows.

B-Internal Rate of Return (IRR): A metric used to estimate the profitability of potential long-term investments.

C-Payback Period (PBP): The time required for a project to recover the invested capital.

Analysis Assumptions: A discount rate of 21% was assumed, the project's productive lifespan assumed to be 25 years.

KEY FINDINGS

1. Net Present Value (NPV): estimated to about 3,291,600 EGP over its investment period.
2. Benefit-Cost Ratio (B/C Ratio): The B/C ratio for the project was calculated to be 1.3, this indicates that for every EGP pound invested, generate 1.3 EGP pound benefits, where the net profitability per invested pound is therefore about 0.3 EGP pound.
3. Internal Rate of Return (IRR): estimated at 47.1%, this rate is significantly higher than the prevailing 21% bank interest rate.
4. Payback Period: The capital recovery period estimated to about 2.12 years-(table 9).

Table (9): Financial Feasibility Indicators for the Sericulture Project at a 21% Discount Rate

Indicator	**Nominal Value**	**Present Value (PV)**	**% Change**
Revenue	13995.2	10703.7	%23.5-
Total Costs	10703.7	13995.2	%30.8
Net Present Value (NPV)	3291.6		
Benefit-Cost Ratio (B/C Ratio)	**1.30**		
Internal Rate of Return (IRR)	%47.1		
Payback Period (years)	2.12		

Source: Compiled and calculated from the analysis results of the Cost-Ben software program.

Investment Performance Indicators Under Conditions of Uncertainty:

The results of the sensitivity analysis, indicates the project's baseline Net Present Value (NPV) reached about 3,291,600 EGP with a several scenarios:

•Scenario 1: Cost Increases with 10% (with constant revenue): will lead to a NPV of 4,691,100 EGP; a 20% increase results in a NPV of 6,090,600 EGP; and a 50% increase will lead to a NPV of 10,289,600 EGP.

•Scenario 2: When both revenues and costs increase by 10%, the NPV decreases to 2,221,600 EGP, while when both revenues and costs increase by 50%, the NPV rises to 4,937,400 EGP.

•Scenario 3: when the Cost Increases by 50% increase while holding revenues constant causes the NPV to a negative value of about 2,060,200 EGP. This result indicates that the project is more sensitive to increases in costs than to increases in revenues (table 10).

Analysis Based on Revenue Delay:

- A one-year delay in revenues (with costs held constant) causes the NPV to plummet from 3,291,600 EGP to 862,700 EGP.
- If this one-year revenue delay combined with a 10% increases in costs, the project becomes financially unviable, with the NPV turning negative at about 207,700 EGP. This finding underscores the project's significant sensitivity to revenue delays.

Table (10): Sensitivity Analysis of Net Present Value (NPV) at a 21% Discount Rate

Change in Costs	Baseline Revenue	+10% Revenue	+20% Revenue	+50% Revenue	-10% Revenue	-20% Revenue	-50% Revenue
Baseline Costs	3291.6	4691.1	6090.6	10289.2	1892.1	492.5	-3706.0
+10% Costs	2221.2	3620.7	5020.3	9218.8	821.7	-577.8	-4776.4
+20% Costs	1150.9	2550.4	3949.9	8148.5	-248.7	-1648.2	-5846.8
+50% Costs	-2060.2	-660.7	738.8	4937.4	-3459.8	-4859.3	-9057.9
-10% Costs	4362.0	5761.5	7161.0	11359.6	2962.4	1562.9	-2635.7
-20% Costs	5432.3	6831.8	8231.4	12429.9	4032.8	2633.3	-1565.3
-50% Costs	8643.4	10042.9	11442.5	15641.0	7243.9	5844.4	1645.8

Source: Compiled and calculated from the analysis results of the Cost-Ben software program.

Table (11): Sensitivity of Net Present Value (NPV) to Revenue Delays and Cost Variations

Change in Costs	Baseline (No Delay)	1-Year Delay	2-Year Delay	3-Year Delay
Baseline Costs	3291.6	862.7	-1144.7	-2803.7
+10% Costs	2221.2	-207.7	-2215.1	-3874.1
+20% Costs	1150.9	-1278.1	-3285.4	-4944.4
+50% Costs	-2060.2	-4489.2	-6496.5	-8155.5
-10% Costs	4362.0	1933.0	-74.3	-1733.3
-20% Costs	5432.3	3003.4	996.0	-663.0
-50% Costs	8643.4	6214.5	4267.1	2548.1

Source: Compiled and calculated from the analysis results of the Cost-Ben software program.

Sensitivity Analysis Based on the Internal Rate of Return (IRR)

•A 10% increase in costs, while holding revenues constant, causes the IRR to drop from about 47.1% to about 36.56%.

•A 10% increase in cost with a 20% revenue decrease, the IRR plummets to 16.49%. This rate falls below the 21% opportunity cost (the prevailing market interest rate), rendering the project financially unattractive under these conditions.

•A 10% increase in costs combined with a one-year delay in project revenues reduces the IRR to 20.13%.

•A 10% decrease in costs, a three-year delay in revenues is severe enough to push the IRR down to 15.75%, again making it an unviable investment compared to the benchmark rate-(table 12).

Table (12): Sensitivity Analysis of the Internal Rate of Return (IRR)

Change in Costs	Baseline Revenue	+10% Revenue	+20% Revenue	+50% Revenue	-10% Revenue	-20% Revenue	-50% Revenue
Baseline Costs	47.12	60.13	75.48	161.79	35.55	24.75	N/A
+10% Costs	36.56	47.12	58.87	110.21	26.69	16.94	N/A
+20% Costs	28.30	37.4	47.12	84.47	19.41	9.96	N/A
+50% Costs	9.96	17.67	24.75	47.12	-0.05	N/A	N/A
-10% Costs	61.70	79.34	102.4	444.81	47.12	34.32	N/A
-20% Costs	84.47	113.37	161.79	N/A	63.71	47.12	4.29
-50% Costs	N/A	N/A	N/A	N/A	N/A	248.08	47.12

Source: Compiled and calculated from the analysis results of the Cost-Ben software program.

Table (13): Sensitivity of Internal Rate of Return (IRR) to Revenue Delays and Cost Variations

Change in Costs	Baseline (No Delay)	1-Year Delay	2-Year Delay	3-Year Delay
Baseline Costs	47.12	24.85	17.13	13.03
+10% Costs	36.56	20.13	13.94	10.6
+20% Costs	28.30	15.98	11.06	8.4
+50% Costs	9.96	5.41	3.63	2.72
-10% Costs	61.70	30.35	20.73	15.75
-20% Costs	84.47	36.96	24.89	18.84
-50% Costs	N/A	70.76	43.57	32.07

Source: Compiled and calculated from the analysis results of the Cost-Ben software program.

The Challenges Facing Natural Silk Production

A. Economic, Administrative, and Cooperative Challenges:

1. Insufficient Funding: A lack of capital to procure essential production inputs, such as silkworm eggs, mulberry trees, and rearing equipment, directly affects silk production (Bongale, et al. 1997).
2. Lack of Technical Expertise: Many farmers have limited knowledge of modern silkworm rearing and silk production techniques, which adversely affects both quality and yield.
3. lack of consistent, supportive government policies, such as tax exemptions or producer subsidies.
4. Marketing and Supply Chain Difficulties and marketing channels for natural silk are inadequate.
5. Inefficient Cooperative Management and a lack of coordination among members limit their effectiveness in improving silk production.
6. Competition from the Synthetics.
7. Price Volatility: Fluctuations in global silk prices expose local producers to the risk of financial losses.

B. Challenges Related to Silkworm Rearing and Stock Management

1. Improper Feeding: where the Feeding larvae with unwashed or contaminated leaves (e.g., those with droppings from diseased birds) is a common issue.
2. Environmental Exposure: Exposing the stock to direct sunlight or harsh air currents (both hot and cold) leads to disease and high mortality rates.
3. Diseases: There is a shortage of effective medications to combat diseases that affect silkworms during the rearing process.(Adly, et al. 2022).
4. Poor Husbandry Practices: Starvation, irregular feeding, poor hygiene, and overcrowding can cause multiple larvae to spin a single, tangled cocoon, which cannot be reeled.
5. Lack of Preventive Measures: Failure to protect the stock from pests, rodents, mosquitoes, ants, and birds.
6. Improper Molting Management: Failure to observe the pre-molting (fasting) period and apply necessary molting powders.
7. Incorrect Stifling: Improperly stifling (roasting) the cocoons after harvesting fails to kill the pupae inside, where the pupa then matures into a moth.

C. Investor-Specific Challenges

1. Suboptimal Location: Establishing projects in hot, arid regions negatively impacts production.
2. Lack of Expertise: Investors often lack experience in the sericulture system.
3. Improper Reeling and Degumming: Haphazard reeling of cocoons without proper degumming (sericin removal) reduces the quality and value of the final product.
4. Poor Sourcing of Eggs: Purchasing silkworm eggs of unknown origin can introduce viruses to the stock. (Souad and Ghazi, 2005)
5. There is difficulty in obtaining high-yield silkworm eggs, as locally available strains have lower productivity compared to imported varieties (Rehab, et al., 2017).

CONCLUSION

The results of this study confirmed that the economic viability of investing in natural silk production in Egypt through agricultural cooperatives, with a net present value of about 3.29 million pound, an internal rate of return of 47.1%, a benefit–cost ratio of about 1.3, and a payback period of roughly 2.12 years. These robust financial indicators illustrate that cooperative-based silk production can be highly profitable and competitive, yet the sensitivity analysis reveals that this viability is fragile under less favorable conditions. The study also emphasizes how important agricultural cooperatives are to the success of the silk industry because they boost productivity (by using better mulberry and silkworm rearing techniques), enable more effective marketing, and give producers crucial technical assistance

RECOMMENDATIONS

1-Establish a Cooperative Bank to finance all activities undertaken by agricultural cooperatives, including those in the sericulture sector.

2-Provide Modern Rearing Equipment and Training.

3-Develop Cooperative Marketing and establish a cooperative marketing system for cocoons and silk.

4-Invest in Advanced Technology and provide advanced equipment and tools for cocoon reeling and silk spinning, and train technicians in associated industries such as carpet weaving.

5-Implement Continuous Training and Innovation and conduct ongoing workshops to introduce the latest operational and manufacturing technologies

6-Enhance Government and Educational Support to promote the sector through awareness seminars and farmer outreach and integrated the sericulture into the curricula of agricultural and industrial vocational schools.

7-Develop an Information Infrastructure and establish an agricultural information bank and equip cooperatives with modern information technology, including training for staff.

Declarations

Ethical Approval and Consent to Participate
Not applicable

Competing Interests

The authors declare that they have no competing interests.

FUNDING

This work was supported and funded by the Deanship of Scientific Research at Imam Mohammad Ibn Saud Islamic University (IMSIU) (grant number IMSIU-DDRSP2504).

REFERENCES

Abou-Mousa, T. M., & Taha, R. H.(2021).An Economic Study of Silkworm Rearing and Natural Silk pro-duction in the Arab Republic of Egypt, Journal of Agricultural Economics and Social Sciences, 12(3). https://doi.org/10.21608/jaess.2021.160946

Abate, et al. (2014). Impact of agricultural cooperatives on smallholders' technical efficiency: evidence from Ethiopia, Annals of Public and Cooperative Economics 85:2. https://cgspace.cgiar.org/server/api/core/bitstreams/da627d9c-3628-43a8-bebe-41397179f93f/content

Andadari, et al.(2022). Lens on tropical sericulture development in Indonesia: Recent status and future direc-tions for industry and social forestry. Insects, 13(10), 913. https://doi.org/10.3390/insects13100913

Anggraini, A. (2025). Analisis Perbandingan Npv Dan Irr Penggunaan Hidroponik Smart System Dan Manual System Terhadap Tanaman Selada (Studi Kasus Di Cv Malaka Farm Soppeng), Journal Pertanian erke-lanjutan, 13(2): 206 -216. https://doi.org/10.30605/perbal.v13i2.6376

Barcelos, et al.(2020). Opportunities for improving the environmental profile of silk cocoon production under Brazilian conditions. Sustainability, 12(8), 3214. https://doi.org/10.3390/su12083214

Birchall J, Simmons, R.(2009).Co-operatives and poverty reduction: evidence from Sri Lanka and Tanzania. Co-op College, Manchester, https://coopseurope.coop/development/sites/default/files/co-operatives-and-poverty-reduction.pdf

Bongale, et al.(1997).Leaf nutritive quality associated with maturity levels in fourteen important varieties of mulberry (Moru sspp.). Sericologia, 37(1): 71-81. https://pascal-francis.inist.fr/vibad/index.php?action=getRecordDetail&idt=2783420

Choudhury, et al. (1991): Effect of spacing, crown height and method of pruning on mulberry leaf yield, quality of cocoon yield. Ind. J. of Seric. 30(1): 46-53. https://eurekamag.com/research/007/260/007260523.php

Central Agency for Public Mobilization and Statistics www.capmas.gov.eg (CAPMAS)

Diab, Y. A., et al.(2009),: Economic Feasibility Study for silk production under Egyptian conditions, Assiut J. of Agric. Sci., 40 (4)(136-159). https://ajas.journals.ekb.eg/article_268810_f5edceed3b220f31784736d1d4db70d5.pdf

El-Adly, et al.(2022): Evaluation of chitosan and silver nanoparticles Against isolated pathogens from Mul-berry Silkworm, Bomby x mori l. (Lepidoptera: Bombycidae) under laboratory condition Brazilian Journal of Biology, vol. 82ns e264903. https://doi.org/10.1590/1519-6984.264903

Elsharkasy, et al.(2025). Economic Feasibility Study of A Sericulture Project to Produce Natural Silk, Journal of the Advances in Agricultural Researches Volume: 30 (1). https://doi.org/10.21608/jalexu.2025.348120.1250

Kipriotis, E., & Grekov, D.(2000).Some nutritional studies on some Bulgarian silkworm (Bombyx mori L.) hybrids reared in northern Greece. International Journal of Industrial Entomology, 1(2), 155-159. https://koreascience.kr/article/JAKO200011920930771

Hăbeanu, et al.(2023). Silkworm Bombyx mori—sustainability and economic opportunity, particularly for Romania. Agriculture, 13(6), 1209. https://doi.org/10.3390/agriculture13061209

Hassan, et al.(2025).Transitioning the silk industry towards circularity: A thematic analysis of sustainable value chain practices. Sustainable Production and Consumption, 56, 94-111. https://doi.org/10.1016/j.spc.2025.03.009

Mahmoud, M. M (2013): Effect of Various Kinds of Dietary Proteins In Semi – Artificial Diets on the Mulberry Silkworm Bom y xmori, L. Egypt. Acad. J. Biolog. Sci., 6(1): 21-26. https://journals.ekb.eg/article_13815_3a7dfe5122d88cecbbea0efdb5f4682c.pdf

Parra, J.R.P.(1991). Food consumption and utilization by insects in: Panizzi AR & Parra JRP (eds) Nutrition-al ecology of insects and its implications for pest management. 359 p. Manole, Sào Paulo. https://www.taylorfrancis.com/chapters/edit/10.1201/b11713-9/

Raman, et al.(1995). Effect of seasons and mulberry varieties on the feed conversion efficiencies of different silkworm hybrids of Bombyx mori L. Uttar Pradesh J. of Zoology.15 (3): 157-161. https://www.mbimph.com/index.php/UPJOZ/article/download/1308/1267/2478

Rehab, H. Taha.; Eman M. Hassan and Marwa N. Moustafa (2017): Assessment of Different Imported Hybrids of Mulberry Silkworm, Bomby xmori, L. in Egypt. Egypt. Acad. J. Biolog. Sci., 10(7): 99–105. https://doi.org/10.21608/eajb.2017.12097

Siddiq, et al.(2015). Economics of silk production as an alernative source of income in the rural areas of bogra district, J. Sylhet Agril. Univ. 2(2):289-300. https://jsau.sau.ac.bd/wp-content/uploads/2017/11/019-Siddiq-et-al.-2015-48_Econ.pdf

Souad, M. Mahmoud and Ghazy, M. M. U (2005): Performance of two hybrids of silkworm, Bomby xmori, L. in different locations. Egypt. J. Agric. Res., 83(3): 1039-1041. https://journals.ekb.eg/article_102626_0.html

Sharma, et al.(2019).Economic analysis of silkworm rearing and cocoon production in Bilaspur district of Himachal Pradesh, Economic Affairs, 64(3), 589-597. https://doi.org/10.30954/0424-2513.3.2019.15

Taha, et al.(2017).Assessment of Different Imported Hybrids of Mulberry Silkworm, Bombyx mori L. in Egypt ,Egyptian Academic Journal of Biological Sciences ,Egypt. Acad. J. Biolog. Sci., 10(7): 99–105 . https://journals.ekb.eg/article_12097_83a00f38c9e2d7388696506dcca9256e.pdf

Tayade, D.S. and Jawale, M.D. (1984): Studies on the comparative performance of silkworm races against different varieties of mulberry under Marathwada conditions. Sericologia, 24(3): 361-364. https://www.scirp.org/reference/referencespapers?referenceid=3142125

Wanyama , et al.(2009). 'Reinventing the wheel, African cooperatives in a liberalized economic environ-ment', Annals of Public and Cooperative Economics, 80 (3), 361–392. https://doi.org/10.1111/j.1467-8292.2009.00390.x

Zhang, C. (2024); A Comparative Study of The Application of NPV And IRR To Real Estate Investment De-cision- Making, Highlights in Business, Economics and Management, Volume 41,p 377. https://doi.org/10.54097/rsmybq28.