

TOWARDS SUSTAINABLE SERICULTURE: DEVELOPMENT AND VALIDATION OF A SUSTAINABILITY ASSESSMENT SCALE

Pooja, V¹., Nagaraj, K, H²., Shivlingaiah, Y. N³., Manjunath Gowda⁴, Amrutha Basavaraju¹ Varsha, S. C.¹

¹Ph.D. Scholar, Department of Agricultural Extension, University of Agricultural Sciences, GKVK, Bengaluru

²Professor and Editor, Communication Centre, University of Agricultural Sciences, GKVK, Bengaluru

³Director of Extension, University of Agricultural Sciences, GKVK, Bengaluru

⁴Professor, Department of Sericulture, University of Agricultural Sciences, GKVK, Bengaluru

ABSTRACT

Sustainability in sericulture has become increasingly important for ensuring long-term productivity, profitability and environmental conservation. The present study assessed the sustainability status of sericulture farmers in the traditional and non-traditional sericultural districts of Karnataka. A total of 240 farmers, comprising 120 each from traditional and non-traditional districts, were selected for the study. Sustainability was assessed using seven dimensions viz., ecological, economic, social, technological & innovative, policies & institutional, health & physical sustainability. The findings revealed a significant difference in the overall sustainability levels of farmers between the two categories of districts. In the traditional district, less than half (46.67 %) of the farmers belonged to the medium sustainability category whereas in the non-traditional district, less than half (45.83 %) belonged to the high sustainability category. The association between district type and overall sustainability was moderate (Cramer's $V = 0.331$). Dimension-wise analysis showed that traditional district farmers performed better in ecological and economic sustainability, while non-traditional district farmers exhibited higher technological and innovative, policies and institutional, health and physical sustainability. Social sustainability did not differ significantly between the two districts, indicating comparable levels of community participation, family support and social well-being. Statement-wise analysis further revealed significant differences in several sustainable practices between the two districts. However, the overall Cohen's d values indicated negligible effect sizes across most dimensions, suggesting that although statistical differences existed, the magnitude of these differences was generally small. The study concludes that traditional districts showed better ecological and economic sustainability due to their long experience in sericulture, while non-traditional districts performed better in technological, institutional, health and physical sustainability because of improved infrastructure, scientific practices and stronger extension support. Enhancing extension services, institutional support and the adoption of sustainable technologies can further improve the sustainability of sericulture farming in Karnataka.

KEYWORDS: Sustainability, participation, sericulture, ecological, health

INTRODUCTION

Sericulture is one of the oldest agro-based rural enterprises, integrating mulberry cultivation, silkworm rearing and silk production into a sustainable farming system. Besides producing the valuable natural fibre silk, the sector provides regular employment and income opportunities to rural households, particularly small and marginal farmers and women. Due to its low investment requirement, quick economic returns and labour-intensive nature, sericulture plays a significant role in livelihood security and rural development (Central Silk Board, 2023; Reddy et al., 2017).

India is the second-largest producer of silk in the world and the only country that commercially produces all five major varieties of silk. The sector supports the livelihoods of nearly 9.2 million people through mulberry cultivation, silkworm rearing, reeling and weaving activities (Central Silk Board, 2023). Karnataka is the leading producer of mulberry silk in India, with districts such as Ramanagara and Kolar serving as traditional sericulture hubs. In recent years, sericulture has expanded to non-traditional districts due to favourable government initiatives, improved technologies and increasing farmer interest in crop diversification.

Despite its economic importance, sericulture faces several challenges, including climate variability, rising input costs, labour scarcity, natural resource degradation and market fluctuations, which threaten its long-term sustainability (Birthal et al., 2021; IPCC, 2022). Sustainable sericulture therefore requires the adoption of scientific mulberry cultivation, hygienic silkworm rearing, integrated pest and disease management, efficient resource use and environmentally sound production practices (Dandin and Giridhar, 2014).

Traditional sericultural districts have benefited from decades of farming experience, better infrastructure and well-established extension support. In contrast, non-traditional districts are relatively recent entrants where farmers have increasingly adopted scientific practices with the support of government programmes and extension services. However, differences in resource availability, technology adoption and institutional support may influence the sustainability of sericulture production across these regions.

Previous studies have emphasized the importance of improved management practices for enhancing sericulture productivity and sustainability. Sakthivel et al. (2012) reported that integrated pest management and improved rearing practices contribute to healthier silkworm crops, although the adoption of biological control measures remains limited. Likewise, Reddy et al. (2019) highlighted that resource constraints and inadequate institutional support continue to affect sustainable sericulture development. Strengthening extension services and improving farmers' access to information and innovations can promote the adoption of sustainable practices (Anderson and Feder, 2004; Aker, 2011).

Although several studies have examined technology adoption, constraints and management practices in sericulture, comprehensive assessments of sustainability across ecological, economic, social, technological and innovative, policies and institutional, health and physical dimensions are limited. Therefore, the present study was undertaken to assess and compare the sustainability status of sericulture farmers in the traditional and non-traditional sericultural districts of Karnataka, with the aim of generating evidence to support sustainable sericulture development.

METHODOLOGY

Research Design and Study Area

An ex-post facto research design was adopted, and the study was conducted in Bengaluru South (Traditional) and Chitradurga (Non-traditional) districts of Karnataka to assess the sustainability status of sericulture farmers.

Sampling Framework and Sample Size

A multistage random sampling technique was followed to ensure adequate representation of sericulture farmers from both traditional and non-traditional production systems.

1. **Selection of Taluks:** Two taluks were selected from each district based on the extent of sericulture cultivation and production.

- **Ramanagara district (Traditional):** Kanakapura (productive) and Channarayana (less productive).
- **Chitradurga district (Non-traditional):** Molakalmuru (productive) and Chitradurga (less productive).

Selection of Villages: From each selected taluk, six villages (three productive and three non-productive) were selected, resulting in 12 villages per district.

Selection of Respondents: From each selected village, 10 sericulture farmers were selected using simple random sampling.

Accordingly, the final sample comprised 120 sericulture farmers from the traditional district and 120 from the non-traditional district, resulting in a total sample size of 240 respondents. The multistage sampling procedure ensured adequate representation of diverse sericulture production systems while minimizing sampling bias (Cochran, 1977; Kothari, 2004).

Scale construction procedure: Likert scale consisting of 132 statements were collected, using Edwards and Chave criteria, editing of statements, relevancy analysis, item analysis it was reduced to 113, 102, 89 and 69 statements respectively. Finally, 69 statements were used for final data collection with Sericulture. During relevancy test with 34 respondents in non-sampling area the t-value more than 1.761 was considered for retention of statement. The relevancy percentage considered was more than 85 per cent. The validity of the instrument was found to be 0.983 and reliability coefficient (r) was 0.967. The reliability was tested using split-half method.

RESULTS AND DISCUSSION

The data presented in Table 1 revealed that in the traditional Sericulture district, less than half (46.67 %) of the Sericulture farmers belonged to medium level of overall sustainability, followed by low (38.33 %) and high (15.00 %) level. In contrast, in the non-traditional Sericulture district, less than half (45.83 %) of the Sericulture farmers belonged to high level of overall sustainability followed by medium (34.17 %) and low (20.00 %) level. The Chi-square (χ^2) value of 26.30 was significant at one per cent level, indicating a significant difference in the distribution of Sericulture farmers across the sustainability categories between the traditional and non-traditional district. Further, the Cramer's V value of 0.331 indicated a moderate association between the type of Sericulture district and the overall sustainability level of the Sericulture farmers.

The predominance of medium sustainability among farmers in the traditional district may be attributed to the long-standing practice of Sericulture, which has enabled farmers to acquire substantial experience and adopt many of the recommended production practices. However, challenges such as declining soil fertility, labour scarcity, fluctuations in cocoon prices, recurring pest and disease incidence and the limited adoption of advanced sustainable technologies may have constrained their ability to achieve a higher level of sustainability.

Conversely, the higher proportion of highly sustainable farmers in non traditional districts can be attributed to the recent expansion of Sericulture in these regions. Because these enterprises were established more recently, farmers were able to adopt modern infrastructure and scientific practices for mulberry cultivation and silkworm rearing right from inception. Furthermore, they benefited from targeted institutional support, robust extension services, and dedicated government programmes, factors that collectively enhanced farm productivity while fostering environmentally and economically sound sustainable production systems.

Statistically, the moderate Cramer's V value (0.331) confirms a moderate association between the type of Sericulture district and the overall sustainability level of farmers. This underscores that variations in production conditions, infrastructure availability, and institutional support between traditional and non-traditional districts

significantly influence regional sustainability outcomes. These findings are strongly supported by previous observations of Kankanawadi et al., (2025).

Table 1: Overall sustainability of Sericulture farmers

n=240

Sl. No.	Category	Traditional district (n ₁ =120)		Non-traditional district (n ₂ =120)		χ^2	Cramer's v
		f	%	f	%		
1	Low (<243.50)	46	38.33	24	20.00	26.30**	0.331
2	Medium (243.50 – 271.10)	56	46.67	41	34.17		
3	High (>271.10)	18	15.00	55	45.83		

**One per cent level of significance, * Five per cent level of significance, NS-Non significance, f-Frequency, % Percentage, χ^2 - Chi square

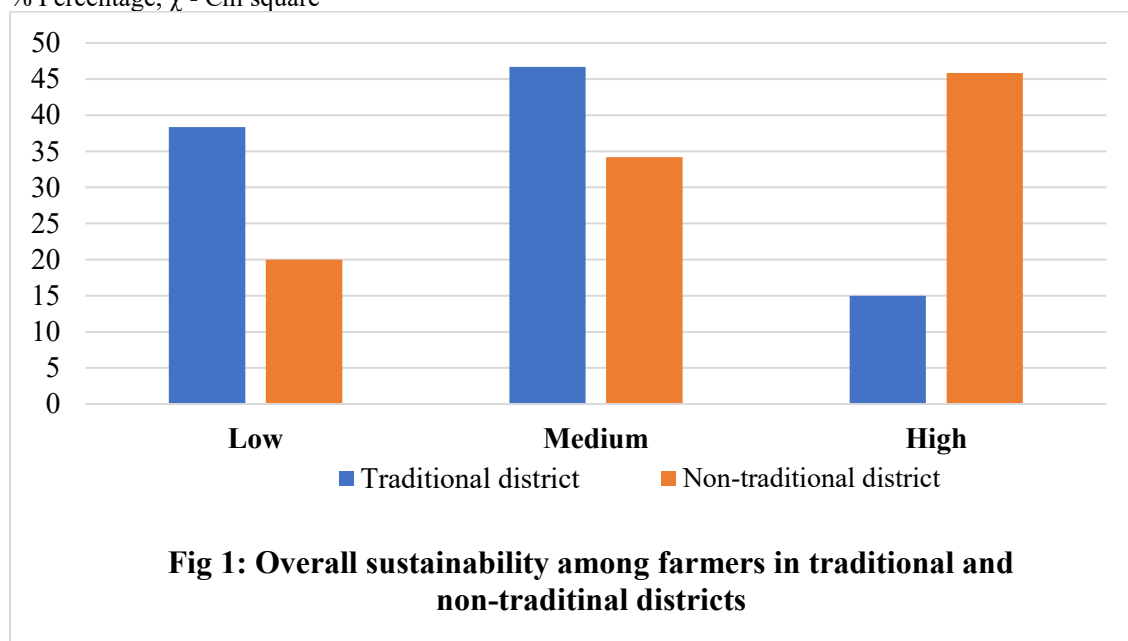


Fig 1: Overall sustainability among farmers in traditional and non-traditional districts

Data in Table 2 highlights that with respect to ecological sustainability, in the traditional Sericulture district, less than half (47.50 %) of the Sericulture farmers belonged to the high category, followed by medium (39.17 %) and low (13.33 %). In the non-traditional Sericulture district, less than half (47.50 %) of the Sericulture farmers belonged to the low category, followed by medium (33.33 %) and high (19.17 %). The Chi-square (χ^2) value of 38.00 was significant at one per cent level, indicating a significant difference between the two groups. The Cramer's V value (0.398) indicated a moderate association between the type of Sericulture district and the ecological sustainability level of the farmers

Traditional Sericulture district may be attributed to the long-standing practice of Sericulture, which has enabled farmers to gain substantial experience in conserving soil fertility, utilizing farm resources efficiently, and adopting environmentally sustainable cultivation practices. Over the years, continuous engagement in Sericulture may have encouraged farmers to integrate practices such as the use of organic inputs, efficient water management and recycling of farm residues, thereby improving the ecological health of their farming systems. On the other hand, farmers in the non-traditional district, having comparatively less experience in Sericulture, may still be in the process of adopting and effectively implementing these sustainable ecological practices, resulting in lower levels of ecological sustainability.

With regard to economic sustainability, less than half (46.67 %) of the Sericulture farmers in the traditional district belonged to high category, followed by medium (44.17 %) and low (9.16 %). Conversely, in the non-traditional district, nearly half (46.67 %) of the Sericulture farmers belonged to low category, followed by medium (34.17 %) and high (19.16 %). The Chi-square (χ^2) value of 44.70 was significant at the one per cent level. The Cramer's V value (0.432) indicated a moderate association between the type of Sericulture district and the economic sustainability level of the farmers.

The better economic sustainability observed in the traditional district may be attributed to well-established market linkages, extensive farming experience, stable cocoon production, and better access to Sericulture-related infrastructure and support services. In addition, the long-standing presence of Sericulture in these areas may have enabled farmers to achieve higher productivity, generate more consistent income, and manage production costs more effectively. On the other hand, farmers in the non-traditional district might have faced challenges such as

limited market access, lower production efficiency, and inadequate infrastructure, which could have constrained their economic sustainability.

Regarding social sustainability, less than half (45.00 %) of the Sericulture farmers in the traditional district belonged to medium category, followed by low (33.33 %) and high (21.67 %). In the non-traditional districts, more than one-third (35.83 %) of the Sericulture farmers belonged to medium category, followed by high (35.00 %) and low (29.17 %). The Chi-square (χ^2) value of 4.71 was found to be non-significant, indicating that there was no significant difference between the traditional and non-traditional district with respect to social sustainability. The Cramer's V value (0.140) indicated a weak association between the type of Sericulture district and the social sustainability level of the farmers, which was consistent with the non-significant Chi-square result. The non-significant difference in social sustainability between the traditional and non-traditional districts suggests that farmers in both regions experienced comparable levels of social support, community participation and overall social well-being. This similarity may be attributed to the presence of active farmer networks, regular interaction with fellow Sericulture farmers, and access to extension activities that promote knowledge sharing and collective participation. As a result, the social dimension of sustainability appears to be relatively consistent across both the categories of districts.

In the context of technological and innovative sustainability, less than half (44.17 %) of the Sericulture farmers in the traditional district belonged to medium category, followed by low (40.83 %) and high (15.00 %). While, less than half (47.50 %) of the Sericulture farmers in the non-traditional district belonged to high category, followed by medium (36.67 %) and low (15.83 %). The Chi-square (χ^2) value of 32.90 was significant at one per cent level. The Cramer's V value (0.370) indicated a moderate association between the type of Sericulture district and the technological and innovative sustainability level of the farmers.

The higher technological and innovative sustainability observed in the non-traditional district may be attributed to the greater adoption of improved technologies, better exposure to extension programmes and the establishment of Sericulture enterprises based on recent scientific recommendations. Farmers in these districts may also be more receptive to adopting modern cultivation and silkworm rearing practices, as many have initiated Sericulture with a stronger emphasis on scientific management.

In the context of policies and institutional sustainability, slightly more than half (57.50 %) of the Sericulture farmers in the traditional district belonged to low category, followed by medium (31.67 %) and high (10.83 %). In the non-traditional districts, more than half (62.50 %) of the Sericulture farmers belonged to the high category, followed by medium (20.00 %) and low (17.50 %). The Chi-square (χ^2) values of 69.40 were significant at one per cent level. The Cramer's V value (0.538) indicated a strong association between the type of Sericulture district and the policies and institutional sustainability level of the farmers.

The elevated policies and institutional sustainability recorded in the non-traditional district stems primarily from robust institutional support, superior access to government schemes, regular extension services and increased awareness among farmers about various developmental programmes launched during Sericulture expansion. Such targeted interventions incentivized farmers to leverage institutional resources more effectively, ultimately strengthening the sustainability of their Sericulture enterprise.

Pertaining to health sustainability, nearly two-third (63.34 %) of the Sericulture farmers in the traditional district belonged to the low category, followed by medium (20.83 %) and high (15.83 %). whereas, more than half (56.67 %) of the Sericulture farmers in the non-traditional district belonged to the high category, followed by medium (32.50 %) and low (10.83 %). The Chi-square (χ^2) value of 76.90 was significant at one per cent level. The Cramer's V value (0.566) indicated a strong association between the type of Sericulture district and the health sustainability level of the farmers.

The higher level of health sustainability observed in the non-traditional district may be attributed to greater awareness among farmers about occupational health and safety, better adoption of protective measures during Sericulture activities, and improved access to health-related information and support services. These factors may have encouraged safer farming practices, thereby contributing to better health sustainability.

In terms of physical sustainability, slightly more than half (51.67 %) of the Sericulture farmers in the traditional district belonged to the low category, followed by medium (33.33 %) and high (15.00 %). In the non-traditional district, more than half (55.84 %) of the Sericulture farmers belonged to the high category, followed by medium (25.83 %) and low (18.33 %). The Chi-square (χ^2) value of 47.50 was significant at the one per cent level, indicating a significant difference between the two groups. The Cramer's V value (0.445) indicated a moderate association between the type of Sericulture district and the physical sustainability level of the farmers.

The higher level of physical sustainability observed in the non-traditional district may be attributed to better rearing infrastructure, improved housing and farm facilities, greater access to basic amenities, and recent investments in Sericulture-related assets. These improvements may have provided farmers with a more supportive production environment, enabling them to manage Sericulture activities more efficiently and sustainably.

The Cramer's V values further indicated that the relationship between the type of Sericulture district and the different dimensions of sustainability varied from weak to strong. Among the dimensions, health sustainability (0.566) and policies and institutional sustainability (0.538) showed the strongest associations, suggesting that these aspects differed considerably between the traditional and non-traditional districts. In contrast, social sustainability showed only a weak association (0.140), indicating that the social sustainability status of the

farmers was fairly similar across both districts. The obtained results are in line with the findings of Kankanawadi et al. (2025).

Table 2: Distribution of farmers based on their sustainability dimension

n=240

Sl. No.	Dimensions	Category	Traditional district (n ₁ =120)		Non-traditional district (n ₂ =120)		χ^2	Cramer's v
			f	%	f	%		
1	Ecological Sustainability	Low (<23.50)	16	13.33	57	47.50	38.00**	0.398
		Medium (23.50 – 27.52)	47	39.17	40	33.33		
		High (>27.52)	57	47.50	23	19.17		
2	Economic Sustainability	Low (<44.56)	11	9.16	56	46.67	44.70**	0.432
		Medium (44.56 – 51.89)	53	44.17	41	34.17		
		High (>51.89)	56	46.67	23	19.16		
3	Social Sustainability	Low (<40.29)	40	33.33	35	29.17	4.71 ^{NS}	0.140
		Medium (40.29 – 46.03)	54	45.00	43	35.83		
		High (>46.03)	26	21.67	42	35.00		
4	Technological and Innovative Sustainability	Low (<36.71)	49	40.83	19	15.83	32.90**	0.370
		Medium (36.71 – 42.44)	53	44.17	44	36.67		
		High (>42.44)	18	15.00	57	47.50		
5	Policies and Institutional Sustainability	Low (<27.25)	69	57.50	21	17.50	69.40**	0.538
		Medium (27.25 – 36.91)	38	31.67	24	20.00		
		High (>36.91)	13	10.83	75	62.50		
6	Health Sustainability	Low (<40.19)	76	63.34	13	10.83	76.90**	0.566
		Medium (40.19 to 45.37)	25	20.83	39	32.50		
		High (>45.37)	19	15.83	68	56.67		
7	Physical Sustainability	Low (<24.31)	62	51.67	22	18.33	47.50**	0.445
		Medium (24.31 – 27.47)	40	33.33	31	25.83		
		High (>27.47)	18	15.00	67	55.84		

**One per cent level of significance, * Five per cent level of significance, NS-Non significance, f-Frequency, % Percentage, χ^2 - Chi square

Details presented in Table 3 indicates the statement-wise ecological sustainability which was significantly higher among Sericulture farmers in the traditional district (Mean= 3.38) than in the non-traditional (Mean= 2.99) with a significant t-value of 6.60 (p<0.01). In the traditional district, practicing drip irrigation and rainwater harvesting to save water and conserve groundwater ranked first (Mean= 4.98), followed by preferring locally adopted mulberry varieties that are better suited to local conditions (Mean= 4.97; Rank-II) and buying chawki worms from approved centres for better silkworm health and yield (Mean= 4.89; Rank-III). In the non-traditional district, buying chawki worms from approved centres for better silkworm health and yield, ranked first (Mean= 4.87), followed by preferring locally adapted mulberry varieties that are better suited to local conditions (Mean= 4.63; Rank- II) and using green manure, farmyard manure or other organic supplements to enhance soil fertility

(Mean=3.24; Rank-III). The practice of protecting nearby water bodies through safe management of mulberry and silkworm waste ranked fifth in the traditional district (Mean= 3.40) and fourth in the non-traditional district (Mean= 2.78). Regular soil testing and following nutrient recommendations ranked seventh in the traditional district (Mean= 1.93) and fifth in the non-traditional district (Mean= 2.62), with a significant difference between the two groups ($t=4.00$; $p<0.01$). The use of biological control methods to manage pests and diseases ranked sixth in both traditional (Mean= 1.85) and non-traditional district (Mean= 2.11) with a non-significant difference. The practice of using nitrogen-fixing and phosphorous-solubilizing biofertilizers for mulberry cultivation was the least adopted in both traditional (Mean= 1.64) and non-traditional district (Mean= 1.58), with no significant difference between the district. The Cohen's d value (0.066) indicated a negligible effect size, suggesting that the magnitude of the overall difference in ecological sustainability between the traditional and non-traditional districts was very small.

The significantly higher ecological sustainability observed in the traditional district may be attributed to farmers' long-standing experience in Sericulture, better access to extension services and greater adoption of environmentally sustainable practices (Central Silk Board, 2023; Department of sericulture, Government of Karnataka, 2024). The higher use of drip irrigation, rainwater harvesting and locally adapted mulberry varieties reflects efficient resource management and adaptation to local conditions. The widespread procurement of chawki worms from approved centres indicates the importance given to quality silkworm seed (Basavaiah and Kallimani, 2020). However, the low adoption of nitrogen-fixing and phosphorus-solubilizing biofertilizers in both districts points to limited awareness and availability, highlighting the need for stronger extension efforts to promote eco-friendly nutrient management. Earlier studies have also emphasized that biofertilizers improve soil fertility and mulberry productivity but their adoption remains limited because of inadequate awareness and technical guidance (Central Silk Board, 2022). The negligible Cohen's d value (0.066) further indicates that although the overall mean difference between the two districts was statistically significant, the magnitude of the difference was small.

Table 3: Ecological sustainability of Sericulture farmers
n=240

Statements		Traditional district (n ₁ =120)		Non-traditional district (n ₂ =120)		t-value	Cohen's d value
		Mean score	Rank	Mean score	Rank		
1	Adopting regular soil testing and adapting nutrient recommendations	1.93	VII	2.62	V	4.00**	-0.041
2	Using green manure, farmyard manure, or any other organic supplements to enhance soil fertility	3.43	IV	3.24	III	-1.01 ^{NS}	0.009
3	Using nitrogen fixing and phosphorous solubilizing biofertilizer for mulberry	1.64	VIII	1.58	VIII	-0.55 ^{NS}	0.005
4	Using biological control methods to manage pests and diseases in mulberry and silkworms	1.85	VI	2.11	VI	1.79 ^{NS}	-0.017
5	Growing local mulberry varieties that are better suited to local conditions	4.97	II	4.63	II	-4.99**	0.127
6	Practicing drip irrigation and rainwater harvesting to save water and conserve groundwater	4.98	I	2.10	VII	-24.31**	1.147
7	Protect nearby water bodies by safely managing mulberry and silkworm waste	3.40	V	2.78	IV	-2.79 ^{NS}	0.024
8	Buying chawki worms from approved centres for better silkworm health and yield	4.89	III	4.87	I	-0.529 ^{NS}	0.004
Overall ecological sustainability		3.38		2.99		6.60**	0.066

**One per cent level of significance, * Five per cent level of significance, NS-Non significance

The findings presented in Table 4 shows the economic sustainability scores which were significantly higher among Sericulture farmers in the traditional district (Mean= 3.96) than in the non-traditional district (Mean= 3.46), with a significant t-value of 7.51 ($p<0.01$). In the traditional district, having access to reliable markets for selling cocoons ranked first (Mean= 4.95), followed by producing good quality cocoons and cleaning them to obtain better market prices (Mean= 4.89; Rank- II) and managing risks by combining Sericulture with other allied activities (Mean= 4.47; Rank- III). In the non-traditional district, producing good quality cocoons and cleaning them to obtain better market prices ranked first (Mean= 4.88), followed by providing a steady and growing income (Mean= 4.49; Rank-II) and managing microclimate in different seasons using local/advanced techniques (Mean= 4.12; Rank- III). The practice of using online platforms and digital marketing to monitor cocoon process and increase market opportunities ranked fifth in the traditional district (Mean= 3.74) but eleventh in the non-traditional district (Mean= 2.40), with a significant difference ($t=-7.98$; $p<0.01$). Similarly, maintaining proper financial records and budgeting the Sericulture activities ranked twelfth in the traditional district (Mean= 2.74) and sixth in the non-traditional district (Mean= 3.83), while obtaining credit or loans needed to maintain Sericulture enterprise ranked thirteenth (Mean= 2.15) and eight (Mean= 3.46) in the traditional and non-traditional districts respectively, with both practices showing significant differences between the groups ($t=7.63$; $p<0.01$). The least adopted practice in the traditional districts was obtaining credit or loans as needed to maintain and grow the Sericulture enterprise (Mean= 2.15), whereas in the non-traditional district it was having access to reliable markets for selling cocoons (Mean= 1.80). Further, the Cohen's d value (0.066) indicated a negligible effect size, suggesting that the magnitude of the difference in overall ecological sustainability between the traditional and non-traditional districts was very small.

The significantly higher economic sustainability observed in the traditional district may be attributed to better market linkages, greater farming experience, established marketing channels and wider adoption of income-enhancing practices (Central Silk board, 2022; FAO, 2014). The high importance given to reliable market access and quality cocoon production reflects the strong market orientation of farmers in these areas. In contrast, farmers in the non-traditional district focused more on maintaining a suitable rearing environment and ensuring a stable household income, indicating their efforts to improve production efficiency. Their comparatively higher use of financial record keeping and formal credit may be due to increased institutional support. However, limited market access and lower adoption of digital marketing highlight the need to strengthen market infrastructure, digital literacy and value chain linkages in the non-traditional district (FAO, 2014). The negligible Cohen's d value (0.066) further indicates that, despite the statistically significant difference in economic sustainability between the two districts, the magnitude of the difference was small.

Table 4: Economic sustainability of Sericulture farmers
n=240

Statements		Traditional district (n ₁ =120)		Non-traditional district (n ₂ =120)		t-value	Cohen's d value
		Mean score	Rank	Mean score	Rank		
1	Analyzing the cost-benefit ratio of each crop cycle and plan cocoon production schedule based on market trends to increase income	2.78	XI	3.30	IX	2.86*	-0.026
2	Keeping a portion of earnings for reinvestment in sericulture enterprise and also for improving farm infrastructure and inputs	3.95	X	3.93	V	-0.29 ^{NS}	0.002
3	Manage risks by combining sericulture with other allied activities	4.47	III	3.20	X	-7.89**	0.107
4	Make study profit by growing mulberries and raising silkworms	4.26	VIII	3.99	IV	-1.98*	0.019
5	Producing good quality cocoons and cleaning them to get better market prices	4.89	II	4.88	I	-0.17 ^{NS}	0.001
6	Sericulture gives a steady and growing income	4.42	VI	4.49	II	0.59 ^{NS}	-0.005
7	Maintaining proper financial records and budgeting for sericulture activities	2.74	XII	3.83	VI	4.92**	-0.042
8	Obtaining credit or loans as needed to maintain and grow sericulture enterprise	2.15	XIII	3.46	VIII	7.62**	-0.069
9	Having access to reliable markets for selling cocoons	4.95	I	1.80	XIII	-34.91**	1.329

10	Converting rearing waste into compost and other products to generate additional income	4.42	VII	2.18	XII	-17.20**	0.193
11	Believing that sericulture increases competitiveness and create more export opportunities for silk products	4.13	IX	3.69	VII	-3.26*	0.030
12	Managing rearing in micro climate during different seasons using local/advanced techniques	4.46	IV	4.12	III	-2.87*	0.031
13	Using online platforms and digital marketing to monitor cocoon prices and increase market opportunities	3.74	V	2.40	XI	-7.98**	0.074
Overall economic sustainability		3.96		3.46		7.51**	0.080

**One per cent level of significance, * Five per cent level of significance, NS-Non significance

The social sustainability scores in Table 5 did not differ significantly between the traditional districts (Mean= 3.88) and the non-traditional districts (Mean= 3.97), as indicated by the non-significant t-value of 1.59. In the traditional districts, maintaining positive relations with family and neighbours and seeking their support for Sericulture activities ranked first (Mean= 4.78), followed by family support for continuing Sericulture as a livelihood (Mean= 4.65; Rank- II) and providing fair wages and maintaining good working environment for farm labourers (4.56; Rank- III). In the non-traditional district also, maintaining positive relations with family and neighbours ranked first (Mean= 4.67), followed by family support for continuing Sericulture (Mean= 4.61; Rank- II) and providing fair wages and maintaining a good working environment for farm labourers (Mean= 4.49; Rank- III). Participation in farmer interest groups, self-help groups, community groups and cooperatives ranked eleventh in the traditional district (Mean= 2.71) and eight in the non-traditional district (Mean= 3.72), showing a significant difference ($t= 5.67$; $p<0.01$). Similarly, using Sericulture-related services without experiencing prejudice or discrimination ranked tenth in the traditional district (Mean= 2.88) and sixth in the non-traditional district (Mean= 3.79), with a significant difference ($t= 5.45$; $p<0.01$). The least adopted practice in the traditional district was participated in farmer groups and cooperatives (Mean= 2.71), whereas in the non-traditional district it was the perception that Sericulture keeps rural people employed, reduces migration to cities and provides well-paying jobs (Mean= 3.23). Further, the Cohen's d value (-0.018) indicated a negligible effect size, suggesting that the magnitude of the difference in overall social sustainability between the traditional and non-traditional districts was trivial.

The statistically non-significant difference in social sustainability between traditional and non-traditional districts corroborated by a negligible Cohen's d value (-0.018) indicates that Sericulture farmers in both regions maintain comparable overall levels of social sustainability. This common baseline is primarily anchored in strong family support and cohesive community relationships, highlighting the vital role of informal social capital in sustaining Sericulture enterprises across geographical boundaries. However, distinct regional mechanisms were also observed: farmers in traditional district placed greater emphasis on preserving and sharing indigenous knowledge, whereas those in non-traditional districts demonstrated higher participation in farmer organizations and superior access to institutional services, likely catalysed by recent agricultural extension efforts. Despite these positive indicators, specific structural vulnerabilities exist. The lower participation in collective groups in traditional district, alongside the muted recognition of Sericulture as a primary livelihood option in non-traditional district, underscores the need for tailored interventions. Policy framework should prioritize revitalizing the collective action in traditional hubs while enhancing community awareness regarding the long-term economic potential of sericulture in expanding regions.

Table 5: Social sustainability of Sericulture farmers
n=240

Statements		Traditional district (n ₁ =120)		Non-traditional district (n ₂ =120)		t-value	Cohen's d value
		Mean score	Rank	Mean score	Rank		
1	Maintaining positive relations with family and neighbours and taking their help in sericulture activities whenever needed	4.78	I	4.67	I	-1.49 ^{NS}	0.016
2	Actively participating in farmer interest groups, self-help groups, community groups and cooperatives related to sericulture	2.71	XI	3.72	VIII	5.67**	-0.048

3	Encouraging family or village to share traditional knowledge about sericulture practices	4.47	IV	3.95	V	-3.89**	0.042
4	Imparting the knowledge and helping other farmers, particularly those who are new or younger to embrace new technologies and best practices in sericulture	3.82	VI	3.68	X	-0.87 _{NS}	0.008
5	Support of family members in decisions regarding continuing, sericulture since it is a livelihood for the family	4.65	II	4.61	II	-0.32 _{NS}	0.002
6	No prejudice or discrimination while taking sericulture-related services from line departments and other associated organizations	2.88	X	3.79	VI	5.45**	-0.049
7	Family's social status can be improved from the earnings of sericulture activities	3.54	VIII	4.38	IV	5.71**	-0.046
8	Respecting and accepting traditional ecological knowledge while also adopting innovations in sericulture	3.21	IX	3.74	VII	3.09*	-0.029
9	Providing fair wages and maintaining good working environment for farm labourers	4.56	III	4.49	III	-0.70 _{NS}	0.007
10	Feeling that sericulture keeps the rural people employed by reducing migration to cities, and provide well-paying jobs	3.68	VII	3.225	XI	-3.12*	0.027
11	Feeling that youth should be encouraged to take part in sericulture to reduce migration to cities	4.39	V	3.5	IX	-6.84**	0.0738
Overall social sustainability		3.88		3.97		1.59_{NS}	-0.018

**One per cent level of significance, * Five per cent level of significance, NS-Non significance

It is evident from Table 6 that technological and innovative sustainability scores were significantly higher among Sericulture farmers in the non-traditional districts (Mean= 3.73) than in the traditional districts (Mean= 3.48), with a significant t-value of 3.97 ($p < 0.01$). In the traditional district, awareness that successful cocoon production depends on proper disinfection of rearing house ranked first (Mean= 4.95), followed by awareness of pest and disease management in silkworm rearing (Mean= 4.92) and awareness of pest and disease management in mulberry cultivation (Mean= 4.89). In the non-traditional districts, awareness of the recommended fertilizer requirement for mulberry and adopting it accordingly ranked first (Mean= 4.76), followed by awareness that successful cocoon production depends on proper disinfection of rearing house (Mean= 4.75) and awareness of pest and disease management in mulberry cultivation (Mean= 4.63). Consulting experts, attending Farmers Field Schools and seeking technical advice ranked tenth in the traditional district (Mean= 2.10) but fifth in the non-traditional district (Mean= 3.99), while looking for government or NGO-supported initiatives promoting innovative practices ranked eleventh in the traditional district (Mean= 2.09) and sixth in the non-traditional district (Mean= 3.89), with both practices showing significant differences between the groups. The least adopted practice in the traditional district was looking for initiatives that support creative practices funded by government or non-governmental organizations (Mean= 2.09), whereas in the non-traditional district it was regularly using digital resources such as Facebook, Instagram, YouTube, mobile applications and SMS alerts for Sericulture updates (Mean= 1.98). Further, the Cohen's d value (-0.038) indicated a negligible effect size, suggesting that the magnitude of the difference in overall technological and innovative sustainability between the traditional and non-traditional districts was very small.

The significantly higher technological and innovative sustainability observed among farmers in the non-traditional district may be attributed to greater participation in training programmes, frequent interaction with extension personnel and increased dependence on institutional support for adopting improved technologies. Farmers in traditional district demonstrated stronger awareness of essential scientific practices such as rearing house disinfection and pest and disease management, reflecting their long experience in Sericulture. In contrast, farmers in non-traditional district exhibited greater inclination towards seeking expert guidance, participating in innovation-oriented programmes and adopting recommended fertilizer practices, indicating active learning and technology acquisition. The comparatively low use of digital resources in the non-traditional districts and limited participation in innovation support programmes among traditional district farmers suggest the need to strengthen digital extension services and promote innovation-oriented interventions to further enhance technological sustainability across both categories of Sericulture farmers. The negligible Cohen's d value (-0.038) indicates

that, although a statistically significant difference was observed between the two districts, the magnitude of the difference in technological and innovative sustainability was negligible.

Table 6: Technological and innovative sustainability of Sericulture farmers

n=240

Statements		Traditional district (n ₁ =120)		Non-traditional district (n ₂ =120)		t-value	Cohen's d value
		Mean score	Rank	Mean score	Rank		
1	Regular usage of digital resources like Facebook, Instagram, YouTube Mobile Apps, and SMS alerts for sericulture updates to keep up with the latest developments in the field	3.12	VI	1.98	XI	-7.07**	0.056
2	Implementing low-cost innovations like ant wells, bamboo/plastic montages, solar lighting/heating, solar-powered leaf cutting machines, etc. to increase productivity	4.69	V	3.01	X	-11.00**	0.150
3	Comparing and evaluating the performance of traditional vs. modern rearing methods for higher economic returns	2.14	IX	3.02	IX	5.18**	-0.050
4	Consultation with experts, attending Farmer Field Schools, and seeking technical advice	2.10	X	3.99	V	12.22**	-0.102
5	Look for initiatives that support creative practices and are funded by the government or non-governmental organizations	2.09	XI	3.89	VI	11.44**	-0.095
6	Attending training programmes to learn new technologies	2.34	VII	3.57	VII	7.14**	-0.062
7	Experimenting with new practices to improve productivity and quality even though the risk is involved	2.30	VIII	3.14	VII	4.50**	-0.046
8	Being aware of pest and disease management in mulberry cultivation	4.89	III	4.63	III	-3.18*	0.054
9	Awareness about pest and disease management in silkworm rearing	4.92	II	4.55	IV	-4.57**	0.081
10	Successful cocoon or crop production process depends on the mulberry house being disinfected	4.95	I	4.75	II	-3.19*	0.044
11	Being aware of recommended fertilizer requirement for mulberry and adopt accordingly	4.72	IV	4.76	I	-2.31*	0.030
Overall technological and innovative sustainability		3.48		3.73		3.97**	-0.038

**One per cent level of significance, * Five per cent level of significance, NS-Non significance

The analysis presented in Table 7 on policies and institutional sustainability indicated that scores were significantly higher among Sericulture farmers in the non-traditional district (Mean= 3.69) than in the traditional district (Mean= 2.72), with a significant t-value of 8.96 ($p < 0.01$). In the traditional district, receiving timely market information through official channels and/or farmer networks ranked first (Mean= 3.99), followed by being knowledgeable about different government programmes such as insurance and subsidies offered by the Sericulture department (Mean= 3.44; Rank- II) and awareness of government schemes and subsidies available for Sericulture (Mean= 3.38; Rank- III). In the non-traditional district, benefiting from programmes such as Rashtriya Krishi Vikas Yojana (RKVY), Silk Samagra and MGNREGA ranked first (Mean= 4.44), followed by the perception that institutional support and government policies have aided silk farming (Mean= 4.28) and knowledge of different government programmes related to Sericulture (Mean= 4.16). Regular interaction with extension officers for technical and administrative support ranked eighth in the traditional district (Mean= 2.16) but fourth in the non-traditional district (Mean= 3.91), while participation in government-sponsored training

programmes related to Sericulture ranked ninth in the traditional district (Mean= 2.05) and sixth in the non-traditional district (Mean= 3.71), with both practices showing significant differences between the groups. The least adopted practice in the traditional district was membership in a silk cooperative society or federation (Mean= 1.97), whereas in the non-traditional district it was receiving timely market information through official channels and/or farmer networks (Mean= 2.36). Further, the Cohen's d value (-0.085) indicated a negligible effect size, suggesting that the magnitude of the difference in overall policies and institutional sustainability between the traditional and non-traditional districts was very small.

The significantly higher policies and institutional sustainability observed in the non-traditional district may be attributed to stronger institutional support, greater participation in government development programmes and closer interaction with extension agencies. Farmers in these areas appeared to benefit more from schemes such as Silk Samagra and Rashtriya Krishi Vikas Yojana (RKVY), along with regular extension services that promoted improved Sericulture practices. Unlike, farmers in the traditional district relied more on established market information networks and their existing knowledge of government programmes than on formal institutional support. However, the low level of membership in cooperative societies among farmers in the traditional district and the limited access to timely market information in the non-traditional district highlight the need to strengthen farmer organizations, enhance extension services, and improve market information systems across both districts. The negligible Cohen's d value (-0.085) further indicates that, although a statistically significant difference was observed between the traditional and non-traditional districts, the magnitude of the difference in policies and institutional sustainability was very small.

Table 7: Policies and institutional sustainability of Sericulture farmers

n=240

Statements		Traditional district (n ₁ =120)		Non-traditional district (n ₂ =120)		t-value	Cohen's d value
		Mean score	Rank	Mean score	Rank		
1	Knowledge about the different government programmes (such as insurance and subsidies) offered in the line departments	3.44	II	4.16	III	4.52**	-0.039
2	Interacting with extension officers for technical and administrative support	2.16	VIII	3.91	IV	9.97**	-0.092
3	Participating and obtaining benefit from government-sponsored training programmes related to sericulture	2.05	IX	3.71	VI	10.03**	-0.089
4	Member of a silk cooperative society or federation	1.97	X	3.08	IX	6.54**	-0.0062
5	Obtaining benefits from programmes like the Rashtriya Krishi Vikas Yojan / Silk Samagra / MGNREGA	2.20	VII	4.44	I	14.14**	-0.115
6	Timely market information through official channels and or farmer networks	3.99	I	2.36	X	-9.24**	0.097
7	Government schemes being transparent and beneficial	2.42	V	3.62	VII	6.89**	-0.061
8	Department of Sericulture providing the timely information and assistance	3.33	IV	3.48	VIII	0.38 ^{NS}	-0.002
9	Awareness about government schemes and subsidies available for sericulture	3.38	III	3.89	V	2.82 ^{NS}	-0.025
10	Institutional support and government policies aiding silk farming	2.29	VI	4.28	II	11.68**	-0.099

Overall policies and institutional sustainability	2.723	3.69	8.96**	-0.085
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**One per cent level of significance, * Five per cent level of significance, NS-Non significance

Examination of Table 8 shows that the health sustainability scores were significantly higher among Sericulture farmers in the non-traditional district (Mean= 4.57) than in the traditional district (Mean= 3.99), with a significant t-value of 10.70 ($p<0.01$). In the traditional district, maintaining the Sericulture environment (rearing house and farm) clean and hygienic to prevent health issues ranked first (Mean= 4.90), followed by having access to nearby healthcare services in case of any illness or injury (Mean= 4.82; Rank- II) and not allowing children and elderly family members to participate in disinfection or other activities which expose them to harmful chemicals (Mean= 4.62; Rank- III). Unlike the traditional district separating living areas from Sericulture rearing units to reduce health hazards ranked first (Mean= 4.99), followed by maintaining the Sericulture environment clean and hygienic to prevent health issues (Mean= 4.94; Rank- II) and having access to nearby healthcare services in case of any illness or injury (Mean= 4.78; Rank- III). Building a rearing shed with good ventilation to avoid respiratory problems ranked eighth in the traditional district (Mean= 3.24) and fourth in the non-traditional district (Mean= 4.76), while preferring organic or less harmful alternatives in Sericulture whenever possible to reduce health risks ranked tenth in the traditional district (Mean= 2.95) and seventh in the non-traditional district (Mean= 4.42), with both practices showing significant differences between the two districts. The least adopted practice in the traditional district was preferring organic or less harmful alternatives in Sericulture whenever possible to reduce health risks (Mean= 2.95), whereas in the non-traditional district it was avoiding excessive use of chemicals in order to reduce the hazards to human and environmental health (Mean= 4.14). Further, the Cohen's d value (-0.089) indicated a negligible effect size, suggesting that the magnitude of the difference in overall health sustainability between the traditional and non-traditional districts was very small.

The higher health sustainability observed among farmers in the non-traditional district may be due to better awareness of occupational health, improved rearing facilities and greater adoption of safe farming practices encouraged through extension programmes. Farmers in both districts placed high importance on maintaining clean rearing environments ensuring access to healthcare services, reflecting their awareness of the role of health in sustainable Sericulture. The higher adoption of practices such as separating living areas from rearing units, providing well-ventilated rearing sheds and using safer alternatives in the non-traditional district indicates greater emphasis on preventive health measures. In the traditional district, farmers were also aware of these practices; however, as Sericulture is a long-established livelihood, rearing is often carried out within or close to residential houses for convenience and economic reasons. Promoting affordable improvements in rearing infrastructure and safer production practices could further enhance health sustainability in these areas. The small Cohen's d value (-0.089) indicates that, despite a statistically significant difference between the traditional and non-traditional districts, the practical magnitude of the difference in health sustainability.

Table 8: Health sustainability factors of Sericulture farmers

n=240

Statements		Traditional district (n ₁ =120)		Non-traditional district (n ₂ =120)		t-value	Cohen's d value
		Mean score	Rank	Mean score	Rank		
1	Taking necessary safety measures to prevent coming into contact with dangerous chemicals (such as pesticides or disinfectants)	4.09	VI	4.52	V	3.11*	-0.025
2	Avoiding excessive use of chemicals in order to reduce the hazards to human and environmental health	3.33	VII	4.14	X	4.72**	-0.037
3	Maintaining sericulture environment (rearing house, farm) clean and hygienic to prevent health issues	4.90	I	4.94	II	1.03 ^{NS}	-0.007
4	Awareness about occupational health hazards in sericulture	4.54	IV	4.33	IX	-1.76 ^{NS}	0.017
5	Access to nearby healthcare services in case of any illness or injury	4.82	II	4.78	III	-0.69 ^{NS}	0.005

6	Awareness about the symptoms of occurrence when exposed to pesticide	4.17	V	4.41	VIII	1.94 ^{NS}	-0.015
7	Building a rearing shed with good ventilation to avoid respiratory problems	3.24	VIII	4.76	IV	9.89**	-0.069
8	Separating living areas from sericulture rearing units to reduce health hazards	3.23	IX	4.99	I	11.99**	-0.077
9	I prefer organic or less harmful alternatives in sericulture whenever possible to reduce health risks	2.95	X	4.42	VII	8.96**	-0.069
10	I do not allow children and elderly family members in disinfection or other activities which expose them to harmful chemicals	4.62	III	4.44	VI	-1.73 ^{NS}	0.016
Overall health sustainability		3.99		4.57		10.70**	-0.089

**One per cent level of significance, * Five per cent level of significance, NS-Non significance

Table 9 illustrates that the physical sustainability scores which were significantly higher among Sericulture farmers in the non-traditional district (Mean= 4.57) than in the traditional district (Mean= 4.07), with a significant t-value of 8.85 ($p < 0.01$). In the traditional district, feeling physically safe while working alone or with family members in the field or rearing house ranked first (Mean= 4.92), followed by owning a mulberry farm and silkworm rearing shed (Mean= 4.85; Rank- II) and ensuring the farm and rearing house are safe from theft and damage through fencing, lighting and other security measures (Mean= 4.49; Rank- III). In the non-traditional district also, feeling physically safe while working alone or with family members ranked first (Mean= 4.96), followed by ensuring the farm and rearing house are protected from theft and damage through fencing, lighting and other security measures (Mean= 4.87; Rank= II) and having weather-resistant Sericulture infrastructure (Mean= 4.84; Rank- III). Owning a mulberry farm and silkworm rearing shed showed high adoption in both districts with no significant difference. The least adopted practice in both the traditional (Mean= 1.95) and non-traditional district (Mean = 3.56) was insuring Sericulture assets such as equipment, crops and rearing houses against risks, although the difference between the districts was significant ($t = 8.69$; $p < 0.01$). Further, the Cohen's d value (-0.074) indicated a negligible effect size, suggesting that the magnitude of the difference in overall physical sustainability between the traditional and non-traditional districts was very small.

The higher physical sustainability observed among farmers in the non-traditional district may be attributed to better investment in farm infrastructure and greater adoption of safety measures to protect Sericulture assets. Farmers in both districts reported feeling physically safe while working in their fields and rearing houses and most owned their own mulberry farms and rearing sheds, reflecting a strong sense of security in Sericulture farming. The higher adoption of weather-resistant infrastructure and security measures such as fencing and lighting in the non-traditional district indicates greater emphasis on protecting farms from environmental and external risks. In the traditional district, although farmers had established Sericulture units, comparatively lower investment in improved infrastructure and asset protection measures may be due to long-standing farming practices and cost considerations. Encouraging affordable infrastructure upgrades and wider adoption of asset insurance could further strengthen physical sustainability in both districts. The negligible Cohen's d value (-0.074) further indicates that, although a statistically significant difference was observed between the traditional and non-traditional districts, the magnitude of the difference in physical sustainability was very small.

Table 9: Physical sustainability factors of Sericulture farmers

n=240

Statements		Traditional district (n ₁ =120)		Non-traditional district (n ₂ =120)		t-value	Cohen's d value
		Mean score	Rank	Mean score	Rank		
1	Possessing own mulberry rearing farm and silkworm rearing shed	4.85	II	4.82	IV	-0.39 ^{NS}	0.003

2	Ensuring farm and rearing house are safe from theft and damage by installing fencing, lighting, and other security measures	4.49	III	4.87	II	3.99**	-0.027
3	Not encountered any serious threats from animals or intruders to my sericulture assets (such as silkworms, mulberry plantations, or equipment)	4.26	IV	4.40	V	0.89 ^{NS}	-0.009
4	Feeling physically safe while working alone or with family members in the field or rearing house	4.92	I	4.96	I	0.88 ^{NS}	-0.006
5	Sericulture infrastructure (e.g., rearing house, cocoon storage) is resistant to weather-related damage (rain, wind, heat)	3.83	V	4.84	III	7.49**	-0.052
6	Ensuring Sericulture assets (equipment, crops, rearing house, etc.) against risks	1.95	VI	3.56	VI	8.69**	-0.091
Overall physical sustainability		4.07		4.57		8.85**	-0.074

**One per cent level of significance, * Five per cent level of significance, NS-Non significance