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Original Article

Understanding Constraints in Muga Sericulture: A Comparative Analysis of Producer Perceptions in Assam, India

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Abstract: *Muga silk, a unique non-mulberry silk produced in Assam, plays an important role in rural livelihoods but faces several production and market-related challenges. This study examines the key constraints faced by Muga producers and how these vary across different groups. Using primary data from 798 producers in Dhemaji and Lakhimpur districts, the study applies the Garrett ranking technique and independent samples t-tests as analytical tools. The findings show that pest and disease attacks and seasonal risks are the most serious constraints, followed by issues related to input quality and technical knowledge, as perceived by the respondents. Financial and infrastructural challenges are perceived to be of moderate concern, while labour shortage and low price are perceived to be relatively less severe. The results also reveal clear differences across producer groups: integrated producers, who are involved in both cocoon and fabric production, face greater challenges related to inputs, pest and disease attack, storage, and finance due to higher capital and quality requirements, while non-integrated producers, who are involved only in cocoon production, are more affected by labour shortages, low prices, inadequate market access and limited technical knowledge. Training is found to reduce the severity of technical constraints, although access remains uneven. Overall, the study highlights that constraints are not uniform but vary with production roles and resource access, pointing to the need for more targeted and context-specific policy support.*

Keywords: *Muga Sericulture, Production Constraints, Value Chain Integration.*

I. INTRODUCTION

Muga silk, a distinctive non-mulberry silk produced exclusively in Assam, India, occupies a unique position within the global sericulture sector due to its ecological specificity, durability, and cultural value. It is derived from the semi-domesticated silkworm Antheraea assamensis, which is endemic to the region and reared under open, outdoor conditions on host plants such as Som (Persea bombycina) and Soalu (Litsea monopetala). Recognizing its natural golden sheen, exceptional strength, traditional heritage, and territorial uniqueness, Muga silk of Assam has also been accorded Geographical Indication (GI) status, reflecting that its quality is dictated by a specific physical environment. Muga cultivation is traditionally linked to indigenous practices and regional identity, and it helps people in rural areas make a living. The sector is mostly made up of small farmers, and the way they produce goods is closely linked to the conditions in their area and the resources they have at home.

Even though Muga sericulture is important, it is still open to a lot of different kinds of uncertainty. The process of making silk is naturally affected by the weather, the availability of host plants, and biological factors that affect the health of silkworms. Also, producers have to deal with bigger social and economic problems, like getting inputs, infrastructure, credit, and connections to markets. These factors together determine the results of production and affect how stable the income from sericulture is.

In recent years, policymakers have put more focus on making sericulture a more stable way to make a living (Mushtaq et al., 2022), especially in areas where there aren't many other ways to make money. People have been working to boost productivity, add value, and encourage producers to learn new skills. But for these kinds of interventions to work, it's very important to have a clear picture of the problems that people at the grassroots level are dealing with. Policy interventions are likely to be misaligned if the most important constraints are not found.

The way Muga is made is also changing at the same time. A lot of producers are still working on making cocoons, but more and more are getting involved in integrated activities that include processing and making fabric. This change is an effort to get more value out of the production system, but it also makes things more complicated in terms of resource needs, risk exposure, and operational demands.

In this situation, it is important to do a systematic evaluation of the limitations that Muga producers face. Consequently, this study endeavours to deliver a systematic and comparative evaluation of the challenges encountered by Muga producers in Assam. Specifically, it aims to identify and rank the key constraints faced by the Muga producers. By focusing on producers' own assessments and comparing experiences across different categories of operations, the study seeks to generate evidence that can encourage more targeted and context-specific policy interventions. Against this objective, the study seeks to provide an answer to the research question: whether the perceived severity of constraints faced by the Muga producers differs across producer categories defined by integration status and training exposure. Such an assessment not only helps in identifying priority areas for intervention but also provides insights into how production challenges are distributed across different segments of producers. Understanding these dynamics is particularly relevant for designing policies that enhance both productivity and resilience in the sector.

II. REVIEW OF RELATED LITERATURE AND RATIONALE

Most of the research that has been done on sericulture has looked at its potential as a way to make a living and find work, as well as how different biological and environmental factors affect production. The sector is widely viewed as a dependable source of income, especially for small and marginal farmers, due to its modest investment needs, brief gestation period, and appealing returns (Vani et al., 2023). But not all farmers will see the same benefits. Some studies indicate that larger farmers typically achieve greater profits, suggesting that the benefits of sericulture may be more effectively realised at larger operational scales (Govindasamy et al., 2023).

At the same time, a number of social, economic, and environmental factors affect how well sericulture works as a way to make a living. Even though it has a lot of potential, production often falls short of expectations because of ongoing problems like limited access to technology, poor training, pest and disease outbreaks, and unpredictable weather. Empirical research offers additional understanding of these challenges. Roy and Mukherjee (2015) utilised primary data from a significant silk-producing district in West Bengal, revealing that employment generation in sericulture is affected by household size and the employment of male hired labour, whereas education exhibits a negative correlation. This means that the sector is still mostly made up of people who are poor and socially disadvantaged, and there hasn't been much progress toward a more modern and appealing way to make a living. The study also shows that farmers face major problems, such as small plots of land, poor financial situations, and being taken advantage of by moneylenders and traders. This shows that problems go beyond production to marketing as well.

In a study of cocoon production in Karnataka, Yadav (2008) found that pest and disease attacks, high labour costs, lack of proper technical guidance, and poor rearing practices were all major reasons why productivity was low. Other studies have also pointed to bigger problems with the structure and the market. Hoque (2023) noted a downward trend in sericulture and raw silk production after 2001, which he attributed to price changes, a lack of storage space, limited market access, and insufficient financial support. Govindasamy et al. (2023) further underscored the significance of environmental factors, including unpredictable weather patterns and the consequential impacts of pesticide application by adjacent farmers.

The literature identifies technological adoption as a significant dimension. Research on Assam reveals that farmers possess a fundamental understanding of basic practices, yet their knowledge of advanced rearing and management techniques is insufficient (Vijay, Yarazari, and Mech, 2020). Hatibaruah (2022) reports similar findings, indicating that the majority of sericulture farmers are small landholders with moderate educational attainment. The study also finds that education, landholding size, and income have a big impact on whether or not people use better practices. This shows how important it is to give people targeted training and extension support to help them be more productive.

Environmental and ecological factors also have a big effect on the results of sericulture. Borah (2025) uses secondary data to show that the availability of host plants and the state of the environment are two important factors that affect production growth in Assam. Das and Saikia (2023) show that higher temperatures and less regular rain have hurt cocoon production and jobs. This shows how vulnerable the sector is to climate change. Because many rural families depend on sericulture income, these kinds of environmental risks have a big effect on their livelihoods.

Recent studies from Assam further underscore the multifaceted constraints encountered by sericulture farmers. Bhuyan et al. (2025) identified high input costs, limited access to credit, silkworm diseases, inadequate storage, and low market prices as major challenges, with economic and technical constraints being particularly significant. Nunisa et al. (2023), employing Garrett ranking, indicated that farmers encounter challenges at every stage of production, including shortages of feed plants, inadequate equipment, substandard seeds, insufficient technical expertise, financial limitations, and fragile market structures characterised by intermediaries. Sarma et al. (2023) highlighted the significant entrepreneurial potential of sericulture in Assam, particularly in Muga cultivation, while underscoring the necessity for institutional support through training, financing, and technology to facilitate the success of young entrepreneurs.

There is still not much empirical research that looks at the Muga sector in a nuanced way, even though the existing literature gives us useful information about the problems of sericulture. The diversity within the sector has not been sufficiently examined. Muga producers work at different points in the value chain, from making cocoons to more complex systems that include reeling and weaving. These differences have important effects on the economy. Producers who add value often need more money and have to meet stricter quality standards. On the other hand, producers who only do primary production are more directly affected by production risks and changes in the market. Despite these differences, systematic comparisons across such groups remain largely underexplored. A similar gap exists with respect to training and technical knowledge. Although training is widely recognised as an important tool for improving productivity and resilience, there is limited empirical evidence on how access to training shapes the way producers experience and perceive production constraints, particularly in the context of Muga sericulture.

Addressing these gaps requires going beyond purely technical assessments and paying closer attention to producers' own experiences. Although the present study relies on producers' subjective assessments of constraints, such perceptions are not arbitrary. Indigenous knowledge systems are very important to Muga farming in Assam, and many producer households have been doing it for generations. Their long-term involvement gives them firsthand knowledge of the state of the environment, production risks, and operational problems. Their perceptions are based on practical knowledge and insights that are specific to their situation and may not be fully captured by technical or outside evaluations alone. The study uses producers' evaluations as a reliable and useful way to find and rank constraints because it understands how valuable this kind of indigenous knowledge is.

The study adds to the literature in two ways: it combines perception-based ranking with group-wise statistical comparison. First, it gives real-world proof of how important different constraints are in Muga production, based on the producers' own evaluations. Second, it shows how structural factors like where you are in the value chain and how easy it is to get training affect how strong and what kind of constraints you have.

The results are likely to have big effects on policy. Finding the most serious problems and figuring out how they affect different groups of producers can help people come up with targeted solutions. These kinds of targeted approaches are necessary to make the Muga sericulture sector more efficient, resilient, and long-lasting.

III. MATERIAL AND METHODS

A) Data and Sampling Design

This study employs a combination of survey-based structured interviews and focus group discussions for data collection. The survey involved no physical intervention, clinical procedures, or engagement with vulnerable populations. Informed and voluntary consent was obtained from all participants after explaining the study's purpose and ensuring strict confidentiality of the raw information provided. A purposive selection of Dhemaji and Lakhimpur districts has been undertaken for the study due to their high concentration of Muga producers, including both cultivators and weavers. Within these districts, respondents were identified using a snowball sampling technique, ensuring adequate representation across different categories of producers. The sample size was determined using Cochran's formula for unknown populations (Cochran, 1977):

$$n_0 = \frac{Z^2 p(1-p)}{E^2}$$

Where, n_0 is the unadjusted sample size for the unknown population, Z is the Z value at a specific confidence level, p is the estimated population proportion, and E is the margin of error. Using a 95% confidence level, a 5% margin of error, and an estimated population proportion of 50%, the sample size for each district is calculated at 384 respondents, making the total sample size 768. The final sample comprises 798 respondents, with 398 from Dhemaji district and 400 from Lakhimpur district. This exceeds the minimum sample size requirement suggested by Cochran's formula, thereby enhancing the precision and reliability of the estimates.

B) Identification and Measurement of Constraints

A set of ten major constraints associated with Muga production was identified based on preliminary field interactions, literature review, and expert consultation. These include: pest/disease attack, seasonal risk, unavailability of quality input, lack of technical knowledge, poor storage, lack of financial support, inadequate market access, lack of own finance, labour shortage, and low price. Respondents were asked to rank these constraints according to their perceived severity. Since direct ranking produces ordinal data that cannot be meaningfully averaged, the Garrett Ranking Technique was employed to convert ranks into quantitative scores.

C) Grouping Variables

To examine heterogeneity in perceptions, producers were classified based on:

- Integration status: A binary variable distinguishing integrated producers (engaged in both Muga cocoon and fabric production) from non-integrated producers (engaged only in Muga cocoon production).
- Training status: A binary variable indicating whether the producer had received any formal training related to Muga

cultivation or processing.

D) Research Techniques

Since direct ranking of constraints as stated by the participants produces ordinal data that cannot be meaningfully averaged, the Garrett Ranking Technique has been employed to convert ranks into quantitative scores. The Garrett ranking method transforms ordinal rankings into cardinal scores, enabling comparison across respondents and aggregation at the sample level. For each respondent, the ranks assigned to constraints were converted into percent positions using the formula (Garrett, 1969):

$$Percent\ Position = \frac{100(R_{ij} - 0.5)}{N_j}$$

Where R_{ij} is the rank given for the i^{th} constraint by the j^{th} respondent, and N_j is the total number of constraints ranked.

These percent positions were then converted into Garrett scores using standard conversion tables. The mean Garrett score for each constraint was computed by averaging across all respondents. Higher mean scores indicate greater perceived severity. Based on these scores, constraints were ranked to identify the most critical challenges faced by producers.

To assess whether differences in perceived severity of the constraints between groups are statistically significant, independent samples t-tests were conducted for each constraint. Given the possibility of unequal variances across groups, Levene's test for equality of variances (Levene, 1960) was first performed. When the null hypothesis of equal variances was rejected, the Welch t-test (Welch, 1947) was used; otherwise, the standard t-test assuming equal variances was applied.

IV. RESULTS AND DISCUSSIONS

This section analyses the constraints faced by Muga producers by combining perception-based ranking with statistical comparison across producer groups.

A) Ranking of Production Constraints Using Garrett Scores

This subsection analyses the relative severity of production constraints using mean Garrett scores, thereby identifying the most critical challenges faced by Muga producers.

Table 1: Ranking of Constraints Faced by Muga Producers Based on Mean Garrett Scores

Constraint	Mean Garrett Score Across All Producer Categories	Rank
Pest/disease attack	73.93	1
Seasonal risk	70.50	2
Unavailability of quality input	64.08	3
Lack of technical knowledge	51.16	4
Poor storage	44.52	5
Lack of financial support	40.41	6
Inadequate market access	39.68	7
Lack of own finance	36.78	8
Labor shortage	27.45	9
Low price	24.50	10

Source: *Authors' computation from Field survey*

Table 1 presents the mean Garrett Scores of ten production constraints across all producer categories and their corresponding ranks.

The results indicate that biological and climatic risks are perceived as the most critical constraints. *Pest/Disease Attack* (Mean = 73.93) and *Seasonal Risk* (Mean = 70.50) occupy the first and second ranks, respectively. This suggests that producers perceive pest infestations, disease incidence, and seasonal fluctuations as the most significant challenges affecting Muga cultivation.

Constraints related to input quality and technical knowledge are also perceived as significant. In particular, the mean scores of *Unavailability of Quality Input* (64.08) and *Lack of Technical Knowledge* (51.16) indicate that producers view limited access to high-quality inputs and inadequate technical knowledge as major barriers to operational efficiency and productivity.

Financial and infrastructural limitations, including *Poor Storage* (44.52), *Lack of Financial Support* (40.41), *Inadequate Market Access* (39.68), and *Lack of Own Finance* (36.78), are perceived as moderately severe constraints. These reflect producers' perceptions of challenges related to capital availability, storage infrastructure, and logistical support, which can influence long-term sustainability.

Finally, *Labour Shortage* (27.45) and *Low Price* (24.50) are perceived as the least severe constraints, indicating that producers regard labour availability and prevailing market prices as relatively minor concerns in the current production context.

The mean Garrett Scores presented in Table 1 have been illustrated graphically in Figure 1.

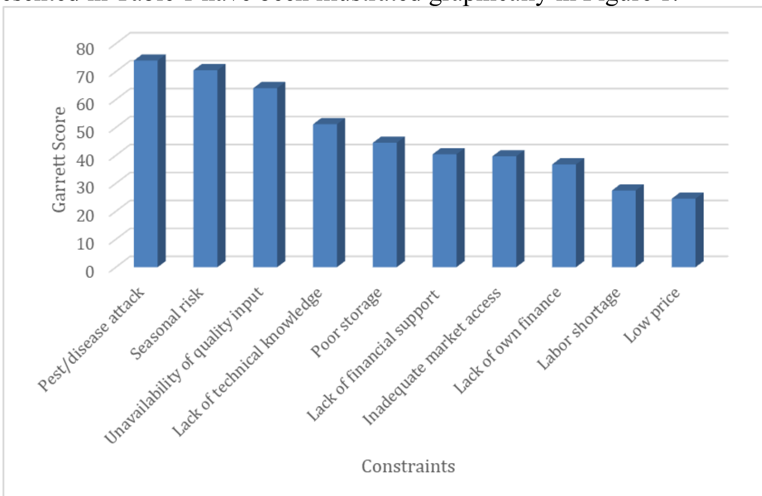

Figure 1. Bar diagram Representing Severity of Constraints Faced by Muga Producers Based on Mean Garrett Scores
Source: *Authors' computation from Field survey*

B) Differential Perception of Constraints by Integration Status

This section examines the research question of whether the perceived severity of individual constraints differs significantly between integrated and non-integrated producers. Each constraint is analysed separately using descriptive statistics and independent samples t-tests.

a. Pest/Disease Attack

Muga silkworm rearing is highly susceptible to pest infestations and disease outbreaks, which can significantly affect cocoon yield and quality. This subsection examines the perceived severity of pest and disease attack and evaluates whether it differs significantly between integrated and non-integrated producers.

Table 2: Descriptive Statistics of Garrett Scores for the Constraint "Pest/disease attack" by Integration Status

	Integration dummy	N	Mean	Std. Deviation
Pest/disease attack	0 (non-integrated)	131	71.24	10.65
	1 (integrated)	667	74.45	7.54

Source: *Authors' computation from Field survey*

The descriptive statistics in Table 2 indicate that the mean Garrett Score for integrated producers (Mean = 74.45) is higher than that of non-integrated producers (Mean = 71.24), suggesting that integrated producers perceive this constraint to be more severe. With respect to variability, the standard deviation is higher among non-integrated producers (SD = 10.65), indicating greater heterogeneity in their perception of pest and disease-related constraints. In contrast, the lower variability among integrated producers (SD = 7.54) suggests a more consistent perception of this constraint within that group.

An independent samples t-test was conducted to examine whether there exists a statistically significant difference in the perceived severity of the constraint "pest/disease attack" (measured through Garrett Scores) between integrated and non-integrated producers, and the results are presented in Table 3.

Table 3: Results of Independent Samples t-test for the Constraint "Pest/disease attack" by Integration status

Measure	Value
Levene's Test (F)	12.800***
t-value (Welch)	-3.289
Degrees of Freedom	156.545
p-value (2-tailed)	0.001***
Mean Difference	-3.21
95% Confidence Interval	[-5.135, -1.282]

Source: *Authors' computation from Field survey*

Levene's test for equality of variances was found to be statistically significant (F = 12.800***), indicating that the assumption of equal variances is violated. Therefore, the Welch t-test (unequal variances assumed) is considered appropriate. The results of the Welch test show that the difference in mean scores is statistically significant at the 1 per cent level (t = -3.289, p = 0.001). The negative t-value and mean difference (-3.21) indicate that integrated producers report significantly higher Garrett Scores for this constraint compared to non-integrated producers. The 95 per cent confidence interval (-5.135 to -1.282) does not include zero, reinforcing the statistical significance and robustness of the estimated difference.

From an economic point of view, integrated producers may think that pest and disease attacks are worse because they are more sensitive to changes in quality and have stricter output requirements because they make value-added products. Integrated producers are involved in reeling and weaving, which means they sell cocoons at an intermediate stage. The quality of the final fabric depends a lot on how the cocoons are doing. Even small amounts of pest or disease damage can make the yarn less strong, less uniform, and less reelable. This directly affects the quality and marketability of the finished product.

Also, integrated producers usually have higher costs and are more focused on the market, which makes them more likely to respond to losses related to quality. Because of this, integrated producers may think that pest or disease outbreaks are worse even when they are at the same level, because the economic effects are worse than those of people who sell cocoons at the primary stage.

b. Seasonal Risk

Muga cultivation is highly dependent on seasonal and climatic conditions, with variations in temperature, rainfall, and humidity significantly influencing silkworm survival and cocoon production. This subsection examines the perceived severity of seasonal risk and evaluates whether it differs significantly between integrated and non-integrated producers.

Table 4: Descriptive Statistics of Garrett Scores for the Constraint "Seasonal risk" by Integration Status

	Integration_dummy	N	Mean	Std. Deviation
Seasonal risk	0 (non-integrated)	131	71.10	8.35
	1 (integrated)	667	70.38	8.68

Source: *Authors' computation from Field survey*

The descriptive statistics of Table 4 indicate the perceived severity of the constraint *"seasonal risk"* among integrated and non-integrated producers. The mean Garrett Score for non-integrated producers (Mean = 71.10) is slightly higher than that of integrated producers (Mean = 70.38), suggesting that non-integrated producers perceive seasonal risk as marginally more severe. In terms of variability, the standard deviation is slightly higher among integrated producers (SD = 8.68) compared to non-integrated producers (SD = 8.35), indicating greater heterogeneity in the perception of seasonal risk among integrated producers. This may reflect differences in how integrated producers manage risks across both cocoon rearing and value-added fabric production activities. Non-integrated producers, focused primarily on cocoon production, have a more uniform experience of seasonal impacts.

It is evident from Table 5 that Levene's test for equality of variances was not statistically significant (F = 0.292), indicating that the assumption of equal variances is satisfied. Therefore, the standard t-test assuming equal variances is appropriate. The t-test results show a t-value of 0.868 with a p-value of 0.386, indicating that the difference in mean Garrett Scores between integrated and non-integrated producers is not statistically significant. The mean difference is 0.72, with a 95 per cent confidence interval ranging from -0.903 to 2.334. Since the confidence interval includes zero, this confirms that there is no statistically meaningful difference between the two groups in terms of perceived seasonal risk.

Table 5: Results of Independent Samples t-test for the Constraint "Seasonal risk" by Integration status

Measure	Value
Levene's Test (F)	0.292
t-value (equal variances)	0.868
Degrees of Freedom	796
p-value (2-tailed)	0.386
Mean Difference	0.72
95% Confidence Interval	[-0.903, 2.334]

Source: *Authors' computation from Field survey*

Economically, this indicates that both integrated and non-integrated producers face similar exposure to seasonal fluctuations, such as rainfall, temperature changes, or other climatic factors that affect Muga cultivation. Although integrated producers engage in value-added activities, the dependency on cocoon rearing for their production still exposes them to seasonal risk, making this constraint relevant for both groups.

c. Unavailability of Quality Input

The availability of quality inputs, particularly healthy silkworm seed and suitable host plant resources, is essential for ensuring productivity and maintaining cocoon quality in Muga sericulture. This subsection examines the perceived severity of the unavailability of quality input and evaluates whether it differs significantly between integrated and non-integrated producers.

Table 6: Descriptive Statistics of Garrett Scores for the Constraint "Unavailability of quality input" by Integration Status

	Integration_dummy	N	Mean	Std. Deviation
Unavailability of quality input	0 (non-integrated)	131	60.37	11.32
	1 (integrated)	667	64.80	7.65

Source: *Authors' computation from Field survey*

The descriptive statistics of Table 6 reveal differences in the perceived severity of the constraint *"unavailability of quality input"* between integrated and non-integrated producers. The mean Garrett Score for integrated producers (Mean = 64.80) is higher than that of non-integrated producers (Mean = 60.37). This indicates that integrated producers perceive the unavailability of quality inputs as a more severe constraint compared to non-integrated producers. With respect to variability, the standard deviation is higher among non-integrated producers (SD = 11.32), suggesting greater heterogeneity in their experiences and perceptions of input-related constraints. In contrast, the relatively lower standard deviation (SD = 7.65) among integrated producers indicates a more consistent and uniform perception of this constraint within that group.

Table 7: Results of the Independent Samples t-test for the Constraint "Unavailability of quality input" by Integration Status

Measure	Value
Levene's Test (F)	23.085***
t-value (Welch)	-4.299
Degrees of Freedom	154.144
p-value (2-tailed)	0.000***
Mean Difference	-4.43
95% Confidence Interval	[-6.476, -2.398]

Source: *Authors' computation from Field survey*

Table 7 shows that Levene's test for equality of variances was found to be statistically significant (F = 23.085***), indicating that the assumption of equal variances is violated. Therefore, the Welch t-test is used. The results show that the difference in mean scores is statistically significant at the 1 per cent level ($t = -4.299$, $p < 0.01$). The negative t-value and mean difference (-4.43) indicate that integrated producers report significantly higher Garrett Scores for this constraint compared to non-integrated producers. The 95 per cent confidence interval (-6.476 to -2.398) does not include zero, reinforcing the robustness of the result.

The types of activities that the two groups did can explain this finding. Integrated producers who make fabric work at a stage that is more advanced in the value chain, where having consistent access to high-quality inputs is important for keeping product quality and market standards. Because they rely on high-quality raw materials like cocoons and yarn, they are more sensitive to problems with inputs. Because of this, any inputs that are not available or are not of good quality are seen as a major problem.

d. Lack of Technical Knowledge

Muga sericulture involves a range of technical practices related to silkworm rearing, host plant management, and post-cocoon handling, requiring adequate knowledge and skills for efficient production. This subsection examines the perceived severity of the lack of technical knowledge and evaluates whether it differs significantly between integrated and non-integrated producers.

Table 8: Descriptive Statistics of Garrett Scores for the Constraint "Lack of Technical Knowledge" by Integration Status

	Integration_dummy	N	Mean	Std. Deviation
Lack of Technical Knowledge	0 (non-integrated)	131	55.11	15.87
	1 (integrated)	667	50.38	11.83

Source: *Authors' computation from Field survey*

The descriptive statistics in Table 8 reveal differences in the perceived severity of the constraint *"Lack of Technical Knowledge"* between integrated and non-integrated producers. The mean Garrett Score for non-integrated producers (Mean = 55.11) is higher than that of integrated producers (Mean = 50.38), indicating that non-integrated producers perceive the lack of technical knowledge as a more severe constraint compared to integrated producers. The standard deviation is higher among non-integrated producers (SD = 15.87), suggesting greater heterogeneity in their experiences and perceptions of technical knowledge-related constraints. In contrast, the relatively lower standard deviation (SD = 11.83) among integrated producers indicates a more consistent and uniform perception of this constraint within that group.

Table 9: Results of the Independent Samples t-test for the Constraint "Lack of Technical Knowledge" by Integration Status

Measure	Value
Levene's Test (F)	16.905***
t-value (Welch)	3.234
Degrees of Freedom	159.551
p-value (2-tailed)	0.001***
Mean Difference	4.73
95% Confidence Interval	[1.839, 7.607]

Source: *Authors' computation from Field survey*

Table 9 reveals that Levene's test for equality of variances was again found to be statistically significant (F = 16.905***), suggesting heterogeneity in variances across the two groups. Therefore, the Welch t-test is used. The results confirm that the difference in mean scores is statistically significant at the 1 per cent level (t = 3.234, p = 0.001). The estimated mean difference of 4.73 further indicates that non-integrated producers face, on average, higher technical constraints compared to their integrated counterparts. The 95 per cent confidence interval (1.839 to 7.607) does not include zero, reinforcing the robustness of this difference.

The variation in perceived technical constraints can be elucidated by the distinct positions of producers within the value chain, alongside their unequal access to opportunities for skill enhancement. Integrated producers, who make fabric, work at a higher level that requires specialised skills like weaving and reeling. Focus group discussions indicate that some of these producers have been trained in both Muga rearing and weaving, which improves their technical skills and makes them feel less limited. On the other hand, non-integrated producers who mainly sell cocoons said they only had access to training related to rearing, which limited their exposure to more advanced techniques.

But it's important to remember that not all training benefits are the same. Only a relatively small proportion of producers in both groups reported receiving formal training, indicating that access to technical knowledge remains uneven. Even so, it seems that integrated producers have an advantage when it comes to handling technical problems if they have even partial or selective access to skill development and value addition. So, the fact that integrated producers feel less technical constraints may be due to their place in the value chain and the fact that they have better, though limited, access to training, institutional support, and learning opportunities. This shows how integration can help improve skills and also shows how important it is for both groups to get more technical training that is more widely available.

e. Poor Storage

Storage constraints can affect both the quality and handling of cocoons and finished products in Muga sericulture. This subsection examines how the severity of poor storage is perceived across different producer groups.

Table 10: Descriptive Statistics of Garrett Scores for the Constraint "Poor storage" by Integration Status

	Integration_dummy	N	Mean	Std. Deviation
Poor storage	0 (non-integrated)	131	41.57	10.99
	1 (integrated)	667	45.10	9.58

Source: *Authors' computation from Field survey*

Table 10 presents the descriptive statistics that indicate differences in the perceived severity of the constraint *"poor storage"* between integrated and non-integrated producers. The mean Garrett Score for integrated producers (Mean = 45.10) is higher than that of non-integrated producers (Mean = 41.57), suggesting that integrated producers perceive poor storage as a more severe constraint compared to non-integrated producers. In terms of variability, the standard deviation is only slightly higher among non-integrated producers (SD = 10.99) than among integrated producers (SD = 9.58), indicating greater heterogeneity in how non-integrated producers experience storage-related challenges. In contrast, integrated producers show more consistent perceptions of this constraint.

Table 11: Results of the Independent Samples t-test for the Constraint "Poor storage" by Integration status

Measure	Value
Levene's Test (F)	0.381
t-value (equal variances)	-3.759
Degrees of Freedom	796
p-value (2-tailed)	0.000***
Mean Difference	-3.53
95% Confidence Interval	[-5.375, -1.687]

Source: *Authors' computation from Field survey*

It is evident in Table 11 that Levene's test for equality of variances was not statistically significant (F = 0.381). Therefore, the standard t-test assuming equal variances is appropriate. The t-test results show a t-value of -3.759 with a p-value of 0.000, indicating that the difference in mean Garrett Scores between the two groups is statistically significant at the 1 per cent level. The mean difference is -3.53, with a 95 per cent confidence interval ranging from -5.375 to -1.687. The negative sign of the t-value and mean difference indicates that integrated producers report significantly higher Garrett Scores for poor storage compared to non-integrated producers, and the confidence interval does not include zero, confirming the robustness of this result.

From an economic perspective, this finding may be explained by the higher stakes faced by integrated producers. Integrated producers, who are engaged in value-added activities such as reeling and weaving, require storage for both raw cocoons and finished fabric. If you don't store things properly, they can lose quality, go bad, or get damaged, which hurts both production efficiency and sales. Non-integrated producers who only sell cocoons may not have to follow as strict storage rules because their products are often sold faster and don't need as complicated storage. As a result, integrated producers see bad storage as a bigger problem.

f. Lack of Financial Support

Limited access to institutional finance and outside financial help can make it hard for producers to buy inputs, build infrastructure, and do activities that add value. This part looks at how serious people think the lack of financial help is and whether it is different for integrated and non-integrated producers.

Table 12: Descriptive Statistics of Garrett Scores for the Constraint "Lack of financial support" by Integration Status

	Integration_dummy	N	Mean	Std. Deviation
Lack of financial support	0 (non-integrated)	131	34.04	11.64
	1 (integrated)	667	41.66	9.16

Source: *Authors' computation from Field survey*

The descriptive statistics presented in Table 12 indicate differences in the perceived severity of the constraint *"lack of financial support"* between integrated and non-integrated producers. The mean Garrett Score for integrated producers (Mean = 41.66) is higher than that of non-integrated producers (Mean = 34.04), suggesting that integrated producers perceive a lack of financial support as a more severe constraint compared to non-integrated producers. In terms of variability, the standard deviation is higher among non-integrated producers (SD = 11.64), indicating greater heterogeneity in their perception of financial constraints. In contrast, integrated producers show more uniform perceptions (SD = 9.16), reflecting a relatively consistent experience of financial challenges across this group.

Table 13: Results of the Independent Samples t-test for the Constraint "Lack of financial support" by Integration Status

Measure	Value
Levene's Test (F)	22.146***
t-value (Welch)	-7.08
Degrees of Freedom	163.052
p-value (2-tailed)	0.000***
Mean Difference	-7.62
95% Confidence Interval	[-9.749, -5.497]

Source: *Authors' computation from Field survey*

Table 13 shows that Levene's test for equality of variances was statistically significant (F = 22.146***). Therefore, the Welch t-test has been used. The results show a t-value of -7.08 with a p-value of 0.000, indicating that the difference in mean Garrett Scores between integrated and non-integrated producers is statistically significant at the 1 per cent level. The mean difference is -7.62, and the 95 per cent confidence interval ranges from -9.749 to -5.497. The negative sign of the t-value and mean difference indicates that integrated producers report significantly higher Garrett Scores for lack of financial support compared to non-integrated producers, and the confidence interval does not include zero, confirming the robustness of the result.

Economically, the higher perceived severity of financial support constraints among integrated producers can be explained by the larger capital requirements associated with their production activities. Integrated producers engage in both cocoon rearing and value-added fabric production, which requires substantial investments in inputs, equipment, and processing facilities. Specifically, reeling and weaving demand expensive resources such as handlooms, power looms, reeling machines, and other supporting tools, as well as recurrent operational expenses. Consequently, integrated producers are more sensitive to limitations in credit access, institutional loans, subsidies, or other forms of financial support. In contrast, non-integrated producers, who primarily sell cocoons, face lower capital intensity and simpler operational needs, making financial constraints less binding. Therefore, integrated producers perceive a lack of financial support as a more severe and impactful constraint.

g. Inadequate Market Access

Market access influences producers' ability to sell output at remunerative prices. This subsection analyses how the severity of market-related constraints is perceived across different producer groups.

Table 14: Descriptive Statistics of Garrett Scores for the Constraint "Inadequate market access" by Integration Status

	Integration_dummy	N	Mean	Std. Deviation
Inadequate Market access	0 (non-integrated)	131	41.27	9.86
	1 (integrated)	667	39.37	11.14

Source: *Authors' computation from Field survey*

The descriptive statistics in Table 14 indicate differences in the perceived severity of the constraint *"Inadequate market access"* between integrated and non-integrated producers. The mean Garrett Score for non-integrated producers (Mean = 41.27) is slightly higher than that of integrated producers (Mean = 39.37), suggesting that non-integrated producers perceive market access as a marginally more severe constraint. In terms of variability, the standard deviation is higher among integrated producers (SD = 11.14), indicating greater heterogeneity in their perception of market access constraints. Non-integrated producers show slightly lower variability (SD = 9.86), reflecting more uniform experiences of market access issues.

Table 15: Results of Independent Samples t-test for the Constraint "Market access" by Integration Status

Measure	Value
Levene's Test (F)	15.482***
t-value (Welch)	1.968
Degrees of Freedom	200.861
p-value (2-tailed)	0.05
Mean Difference	1.9
95% Confidence Interval	[-0.003, 3.797]

Source: *Authors' computation from Field survey*

Levene's test for equality of variances was statistically significant (F = 15.482***) as presented in Table 15, so the Welch t-test is used again. The result shows a t-value of 1.968 with a p-value of 0.050. This indicates that the difference in mean Garrett Scores between the two groups is borderline significant at the 5 per cent level. The mean difference is 1.9, with the 95 per cent confidence interval ranging from -0.003 to 3.797. Since the confidence interval just includes zero, this suggests that while non-integrated producers perceive market access as slightly more severe than integrated producers, the difference is not strongly statistically robust.

This result may reflect that both groups face challenges in accessing markets, but the slightly higher mean score for non-integrated producers suggests that selling raw cocoons exposes them to more consistent market limitations. In many cases, non-integrated producers depend on a relatively small number of weavers as their primary buyers, which restricts their market options. In contrast, integrated producers sell finished products such as fabric, allowing them to access a wider and more diverse set of market channels. The borderline significance indicates that while market access is a concern for both groups, the difference in perception remains relatively modest.

h. Lack of Own Finance

Muga sericulture often requires producers to rely on their own financial resources to meet routine production expenses, particularly in situations where access to external finance is limited or delayed. This subsection examines the perceived severity of the lack of own finance and evaluates whether it differs between integrated and non-integrated producers.

Table 16: Descriptive Statistics of Garrett Scores for the Constraint "Lack of own finance" by Integration Status

	Integration_dummy	N	Mean	Std. Deviation
Lack of own finance	0 (non-integrated)	131	31.28	12.05
	1 (integrated)	667	37.86	9.98

Source: *Authors' computation from Field survey*

Table 16 presents the descriptive statistics that indicate differences in the perceived severity of the constraint *"lack of own finance"* between integrated and non-integrated producers. The mean Garrett Score for integrated producers (Mean = 37.86) is higher than that of non-integrated producers (Mean = 31.28), suggesting that integrated producers perceive a lack of their own financial resources as a more severe constraint compared to non-integrated producers. In terms of variability, the standard deviation is higher among non-integrated producers (SD = 12.05), indicating greater heterogeneity in their perception of personal financial constraints. Integrated producers, with a slightly lower SD (9.98), exhibit more uniform perceptions of this constraint.

Table 17: Results of Independent Samples t-test for the Constraint "Lack of own finance" by Integration Status

Measure	Value
Levene's Test (F)	10.977***
t-value (Welch)	-5.862
Degrees of Freedom	166.817
p-value (2-tailed)	0.000***
Mean Difference	-6.58
95% Confidence Interval	[-8.788, -4.360]

Source: *Authors' computation from Field survey*

Following the significance of Levene's test for equality of variances (F = 10.977***) as presented in Table 17, the Welch t-test is considered appropriate. The results show a t-value of -5.862 with a p-value of 0.000, indicating that the difference in mean Garrett Scores between integrated and non-integrated producers is statistically significant at the 1 per cent level. The mean difference is -6.58, and the 95 per cent confidence interval ranges from -8.788 to -4.360. The negative sign of the t-value and mean difference indicates that integrated producers report significantly higher Garrett Scores for lack of own finance compared to non-integrated producers, and the confidence interval does not include zero, confirming the robustness of the result.

This result can be explained by the higher capital intensity of integrated production activities. Integrated producers, who engage in both cocoon rearing and value-added fabric production, require substantial personal financial resources to invest in raw materials, handlooms, power looms, reeling machines, and other supporting equipment. Consequently, limitations in personal finances can significantly constrain their operations and expansion. Non-integrated producers, focused mainly on cocoon production, face lower capital requirements, making this constraint less severe for them.

i. Labour Shortage

Muga sericulture is a labour-intensive activity, requiring timely and skilled labour not only during silkworm rearing and host plant maintenance but also in post-cocoon operations such as reeling and weaving. This subsection examines the perceived severity of labour shortage and evaluates whether it differs between integrated and non-integrated producers.

Table 18: Descriptive Statistics of Garrett Scores for the Constraint "Labour shortage" by Integration Status

	Integration_dummy	N	Mean	Std. Deviation
Labour Shortage	0 (non-integrated)	131	35.78	16.18
	1 (integrated)	667	25.81	10.09

Source: *Authors' computation from Field survey*

The descriptive statistics in Table 18 indicate differences in the perceived severity of the constraint *"labour shortage"* between integrated and non-integrated producers. The mean Garrett Score for non-integrated producers (Mean = 35.78) is higher than that of integrated producers (Mean = 25.81), suggesting that non-integrated producers perceive labour shortage as a more severe constraint compared to integrated producers. In terms of variability, the standard deviation is considerably higher among non-integrated producers (SD = 16.18), indicating greater heterogeneity in their perception of labour shortage. This suggests that the extent of labour scarcity varies widely across non-integrated producers. In contrast, the lower variability among integrated producers (SD = 10.09) reflects a more uniform perception of this constraint within that group.

As per the results presented in Table 19, the Welch t-test is considered appropriate since Levene's test for equality of variances was found to be statistically significant (F = 148.323***). The results of the Welch test show that the difference in mean scores is statistically significant at the 1 per cent level (t = 6.797, p < 0.01). The positive t-value and mean difference (9.97) indicate that non-integrated producers report significantly higher Garrett Scores for this constraint compared to integrated producers. The 95 per cent confidence interval (7.069 to 12.863) does not include zero, reinforcing the statistical significance and robustness of the estimated difference.

Table 19: Results of Independent Samples t-test for the Constraint "Labour shortage" by Integration status

Measure	Value
Levene's Test (F)	148.323***
t-value (Welch)	6.797
Degrees of Freedom	150.472
p-value (2-tailed)	0.000***
Mean Difference	9.97
95% Confidence Interval	[7.069, 12.863]

Source: *Authors' computation from Field survey*

From an economic perspective, the lower perceived severity of labour shortage among integrated producers may be attributed to differences in the nature and flexibility of labour requirements across production stages. Although integrated producers are also engaged in cocoon production, they combine this with value-added activities such as reeling and weaving. Insights from focus group discussions suggest that cocoon rearing is highly specialized and context-specific, requiring detailed knowledge of host plant management and silkworm care, making it difficult to substitute labour easily during shortages. However, integrated producers are not solely dependent on this stage. The additional activities of reeling and weaving involve skills that are relatively more transferable and less location-specific compared to rearing. This allows integrated producers to draw upon a broader pool of semi-skilled or adaptable labour for at least part of their production process. As a result, even if labour shortages affect rearing, their overall production system retains some flexibility.

In contrast, non-integrated producers rely entirely on cocoon production, where labour requirements are highly specific and less substitutable. Consequently, labour shortages become more binding and are perceived as more severe. Thus, diversification of activities and partial flexibility in labour use enable integrated producers to better absorb labour constraints, leading to a lower perceived severity of labour shortage.

j. Low Price

Constraints related to price realization reflect underlying market structures and differences in bargaining power across producers. This subsection assesses whether the perceived severity of low price varies between integrated and non-integrated producers.

Table 20: Descriptive Statistics of Garrett Scores for the Constraint "Low price" by Integration Status

	Integration_dummy	N	Mean	Std. Deviation
Low price	0 (non-integrated)	131	31.24	10.77
	1 (integrated)	667	23.17	6.55

Source: *Authors' computation from Field survey*

The descriptive statistics in Table 20 reveal differences in the perceived severity of the constraint *"Low price"* between integrated and non-integrated producers. The mean Garrett Score for non-integrated producers (Mean = 31.24) is higher than that of integrated producers (Mean = 23.17), suggesting that non-integrated producers perceive low prices as a more severe constraint compared to integrated producers. In terms of variability, the standard deviation is higher among non-integrated producers (SD = 10.77), indicating greater heterogeneity in their perception of low price issues. This suggests that the impact of market prices on profitability varies widely among non-integrated producers. In contrast, the lower variability among integrated producers (SD = 6.55) reflects a more uniform perception, possibly due to more consistent sales channels or pricing strategies associated with value-added fabric production.

Table 21 shows that Levene's test for equality of variances was found to be statistically significant (F = 133.682***), indicating that the assumption of equal variances is violated. Therefore, the Welch t-test (unequal variances assumed) is considered appropriate. The results of the Welch test show that the difference in mean scores is statistically significant at the 1 per cent level (t = 8.280, p < 0.01). The positive t-value and mean difference (8.07) indicate that non-integrated producers report significantly higher Garrett Scores for this constraint compared to integrated producers. The 95 per cent confidence interval (6.146 to 9.998) does not include zero, confirming the robustness of the result.

Table 21: Results of the Independent Samples t-test for the Constraint "Low price" by Integration Status

Measure	Value
Levene's Test (F)	133.682***
t-value (Welch)	8.280
Degrees of Freedom	149.395
p-value (2-tailed)	0.000***
Mean Difference	8.07
95% Confidence Interval	[6.146, 9.998]

Source: *Authors' computation from Field survey*

The difference can be explained by the stage of the value chain at which each group operates. Non-integrated producers, who sell cocoons at the primary production stage, are more exposed to price fluctuations and have limited ability to influence the final price. Their market is often restricted to a small set of buyers, such as local weavers, which further weakens their bargaining position. In contrast, integrated producers sell value-added products such as finished Muga fabric, which commands a higher price in the market due to the value added through reeling and weaving. As a result, they are better able to capture the premium associated with the final product and are relatively less affected by low prices as a constraint.

Overall, the findings indicate that the severity of constraints varies across producer categories, reflecting differences in resource access and value chain participation.

C) Role of Training in Shaping Perception of Technical Constraints

In addition to differences across producer categories, the role of training in shaping the perception of technical constraints is examined in this section, particularly the extent to which training reduces the perceived severity of a lack of technical knowledge.

Table 22: Descriptive Statistics of Garrett Scores for the Constraint "Lack of Technical Knowledge" by Training Status

	Training_dummy	N	Mean	Std. Deviation
Lack of Technical knowledge	0 (no training)	499	52.77	11.60
	1 (received training)	299	48.47	13.94

Source: *Authors' computation from Field survey*

Table 22 shows the descriptive statistics, which indicate the perceived severity of the constraint *"lack of technical knowledge"* among producers with and without prior training. Producers without training have a higher mean Garrett Score (Mean = 52.77) compared to producers with training (Mean = 48.47). This suggests that training reduces the perceived severity of technical knowledge constraints, as trained producers are better equipped with skills and information to manage rearing and value-added activities. In terms of variability, the standard deviation is higher among trained producers (SD = 13.94), indicating greater heterogeneity in their perception of technical knowledge constraints. This may reflect differences in the quality, intensity, or type of training received, as not all trained producers acquire the same level of skill or experience. Non-trained producers show slightly lower variability (SD = 11.60), reflecting a more uniform perception of technical constraints due to limited exposure.

As presented in Table 23, Levene's test for equality of variances was statistically significant (F = 22.359***), hence the Welch t-test is used. The results show a t-value of 4.481 with a p-value of 0.000, indicating that the difference in mean Garrett Scores between trained and non-trained producers is statistically significant at the 1 per cent level. The mean difference is 4.30, with a 95 per cent confidence interval ranging from 2.414 to 6.182. The positive mean difference indicates that producers without training perceive technical knowledge constraints as significantly more severe than producers with training, and the confidence interval does not include zero, confirming the robustness of this result.

Table 23: Results of Independent Samples t-test for the Constraint "Lack of Technical knowledge" by Training Status

Measure	Value
Levene's Test (F)	22.359***
t-value (Welch)	4.481
Degrees of Freedom	540.775
p-value (2-tailed)	0.000***
Mean Difference	4.30
95% Confidence Interval	[2.414, 6.182]

Source: *Authors' computation from Field survey*

Economically, the finding highlights the role of training in reducing operational and technical barriers. Training equips producers with knowledge and skills for cocoon rearing, reeling, and weaving, enabling them to manage production more efficiently and adopt improved practices. Producers without training, lacking these skills, experience greater technical difficulties, which is reflected in their higher Garrett Scores.

V. CONCLUSION

This study examined the constraints faced by Muga producers in Assam by combining perception-based ranking with statistical comparison across producer groups. Using the Garrett ranking technique, the analysis identified pest/disease attack and seasonal risk as the most severe constraints, followed by limitations related to input quality and technical knowledge. Financial constraints were found to be of moderate importance, while labour shortage and low price were perceived as relatively less severe. The comparative analysis reveals important heterogeneity in how these constraints are experienced. Integrated producers, involved in value-added activities, generally regard limitations concerning quality inputs, storage, and financial resources as more significant, indicative of their increased reliance on stable inputs and elevated capital demands. Non-integrated producers, on the other hand, say that they have more serious problems with labour shortages, low prices, and gaps in technical knowledge. This is because they depend on primary production and don't have as much access to value addition. The results also show that training can help people feel less limited by technical problems, but not everyone has equal access to that training. The results indicate that constraints in Muga sericulture differ among producer groups and are significantly associated with variations in production roles and resource accessibility, underscoring the necessity for more tailored strategies.

From a policy point of view, the overall ranking shows that the most important issues to address first are pest and disease management, seasonal risks, and access to quality inputs and technical knowledge. These are the problems that seem to be having the biggest impact on producer performance. So, strengthening pest and disease control, making it easier to get quality inputs, and expanding training, especially for producers who don't have much technical experience, could all make a big difference. Even though problems with money and infrastructure don't seem as urgent, better access to money, storage, and market connections can still help with long-term sustainability.

These suggestions come from the empirical analysis, but you should be careful when you read them. The research utilises perception-based data from specific districts and employs non-probability sampling, potentially constraining the generalisability of the findings. Still, it gives us useful information about the kinds of constraints that producers face and how important they are in relation to each other. The results underscore the significance of context-specific and tailored interventions in promoting the sustainability of Muga sericulture.

Conflict of Interest

The authors declare that there is no conflict of interest concerning the publication of this paper.

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