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RESOURCE USE EFFICIENCY OF TEMPERATE SILK COCOONS IN NORTH-WESTERN HIMALAYAN REGION OF KASHMIR VALLEY, JAMMU AND KASHMIR, INDIA

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Abstract

Sericulture's resource efficiency are critical for long-term growth and contributes greatly to Kashmir's rural and urban economies for sustainable livelihood and inclusive growth. Mulberry plantations, silkworm rearing, reeling, and silk textile manufacturing is all part of the silk farming process. The primary goal of this research was to determine the socioeconomic features of silk worm rearers, as well as to analyze and assess the resource use pattern of silk cocoon in Kashmir valley. The study is empirical in nature, and data was collected from 334 respondents in silk farming-rich zones such as Anantnag and Baramulla in 2021-22 utilising a pre-tested structured interview schedule and purposeful stratified random sampling. Descriptive statistics and Cobb Douglas production function analysis were used to conduct this study's analysis. The results showed that generally, silk worm rearers in Baramulla and Anantnag were inefficient in their use of resources avail-able to them. Silkworm seed, mulberry leaves, silkworm rearing sheds were underutilized, while labour, disinfectants were over utilized by the farmers. The results further showed that sericulture farmers in Anantnag and Baramulla exhibit increasing returns to scale, indicating that the famers can increase their output by increasing the use of some of the key resources. The finding revealed that silk rearers in Baramulla and Anantnag districts of Kashmir valley were experiencing increasing return to scale. As the total of calculated coefficients of significant variables was found to be more than unity, (1.32).MVP indicates that there is still scope to invest in the study's elements in order to attain the best resource combination and profit maximisation. Incentives and techniques targeted at encouraging farmers to enhance silk cocoon production, such as better government administration of the current subsidy programme and efficient input delivery through sericulture-based centres to ensure silk worm farmers have easy access. This research proved that an intense integrated approach to balanced regional development can help the Kashmir valley's silk industry survive.

Key words: *silk cocoons, silk worm rearers, Cobb Douglas production function, marginal value product, Kashmir valley, India*

INTRODUCTION

Using local resources for agricultural sustainability has received a lot of attention in recent years. Proper exploitation and management of local resources, as well as the development of varied agro-based firms, have the ability to create a regional balance between the rural and urban sectors, as well as provide a sustainable source of income [7]. The expansion of the Kashmir sericulture is dependent on the natural environment. The mulberry crop, which is directly responsible for the generation of silk cocoons, is the foundation of sericulture. The cultivation of silk-producing organisms is known as silk farming. The phrase is derived from the Greek words sericos, which means silk, and culture, which means upbringing. Mulberry plant cultivation, silkworm rearing to generate silk cocoons, cocoon reeling to untwist silk filament, yarn manufacture, weaving, and silk fabric processing are all included [26, 31, 23]. It generates income for farm households in Kashmir throughout the year, primarily during the spring and autumn seasons [22, 43, 28].

Sericulture is a low-capital-intensive agro-based activity that generates a steady stream of revenue throughout the year in rural India. It provides a solid livelihood to more than 7.5 million people in 79 thousand villages across India, as well as other activities [25, 13].

In the midst of escalating poverty and inequality, sericulture has emerged as one of the most promising and perfect rural income-generating sectors, thanks to its short rearing period and high employment potential with quick turnover. It unmistakably offers a stable income for a huge number of marginal farmers and craftspeople [14]. Mulberry silk is a well-known variety of silk in the textile industry [3, 6]. It is a substantial economic subsidised income-generating activity for rural people in mountainous locations [53, 4] and provides employment in industries that are important in the metropolitan economy. China, India, Uzbekistan, Thailand, and Brazil are the world's top silk producers [14, 36, 37, 39].

In 2019, the International Sericultural Commission (ISC) released a study on sericulture producers and consumers. The United States of America (USA), Switzerland, the United Kingdom, and Germany are the top silk consumers and importers in Europe. Brazil produces 610 metric tonnes of silk yarn every year on an average of 2.6 hectares, boosting the livelihoods of rural families [2]. In 2017, China produced 145,000 metric tonnes of silk, whereas India produced 31,900 metric tonnes. In compared to India's 5.60% growth rate, Japan (7.31%), Brazil (3.82%), Thailand (%), and Korea (1.17%) all give 16.10% [9]. Sericulture has been promoted extensively in various parts of Africa, South Asia, and Latin America in order to improve women's empowerment and gender equality, as well as contribute to sustainable development goals [21]. It is thought to be a lucrative business with a lot of job opportunities [24, 17, 52, 35, 38].

Silkworms are responsible for the production of mulberry silk (*Bombyx mori*). Silkworms consume mulberry leaves and produce silk cocoons in 28 to 30 days, after which they spin the cocoons. Finally, the silk cocoons are purchased and spun into silk yarn by the reelers. J&K bivoltine silk is of high quality due to its agro-climatic conditions, which improves the economic status of sericulture producers and ensures long-term sustainability in the pre-cocoon and post-cocoon sectors.

Sericultural development strategy for underdeveloped countries should be oriented toward enhancing the productivity of land under cultivation while lowering costs and boosting input efficiency while causing little or no harm to humans and the environment. To decrease land degradation and input misuse, the primary requirement is to promote a healthy soil-plant-environment system. Modification of current farming systems in the field of soil nutrient restoration to encourage the adoption of Sericultural farming is a novel strategy for promoting eco-friendly farming. Reducing environmental consequences also contributes to well-being that is not derived from the market economy, such as the quality of life that comes with living in a healthy, appealing environment. Furthermore, boosting resource efficiency can raise industry's competitiveness, create opportunities, promote innovation, boost sectors like recycling and resource recovery, and assist assure the secure supply of critical resources. With the shortage of available agricultural land growing, improving crop output faces a new challenge: ensuring that land becomes more productive. This is where resource efficiency in our agricultural and food systems becomes important [45].

Literature review

Sericulture is an economic activity that comprises the cultivation of mulberry bushes and the raising of silkworms to generate silk threads utilising agricultural labour [16]. Sericulture is split into two categories: farm and industry. Growing silkworm feeding plants and rearing silkworm to generate silk cocoons are both part of the farm industry. The industry sector includes reeling, twisting, dyeing, printing, finishing, and knitting [44, 49, 10].

Silk has a bright future ahead of it and could be revolutionary in the next decades. Silk is now used in a variety of fields, including nutrition, cosmetics, biomaterials, pharmaceuticals, bioengineering, biomedicine, vehicle manufacture, home building, crafts, and the arts, despite its historic use in textiles. Increased stakeholder awareness, entrepreneurial experience sharing, and consumer accessibility are all required as global demand grows [37, 39, 6]. Sericulture, as a cottage, agro, and forestry-based industry, has been shown to improve sustainable livelihood. With all of the aforementioned characteristics of the silk industry, sericulture is an ideal industry for a long-term future [18, 19].

Mulberry silk, Tasar silk, Eri silk, and Muga silk are all produced in India's silk industry, which is world-renowned. India is the world's second largest producer of silk, with 31,906 metric tonnes [1, 9] and 15% of global raw silk output, ensuring the region's long-term prosperity [30]. Geographically, Asia produces the vast bulk of the world's silk, accounting for over 95% of total output. With an annual production of 142,005 metric tonnes, China is the world's biggest silk producer [21]. Mysore, Andhra Pradesh, Tamil Nadu, West Bengal, and Jammu & Kashmir are the major mulberry sericulture producing states of India, accounting for 98.5% of the country's silk production [1, 9]. India needed 27,005 metric tonnes of raw silk, but only produced 19,696 metric tonnes and imported 8,000-9,000 metric tonnes from China [5]. Currently, the consumption of silk products in industrialised nations is increasing, resulting in strong demand on the worldwide market and playing an important rolein foreign exchange earnings for developing countries around the world, resulting in the transition from sericulture to manufacturing [37]. On a commercial basis, Brazil is the fifth largest silk cocoon production [31]. Brazil shipped around 109 million tonnes of textiles and clothing and nearly 686 million tonnes of other goods in the first half of 2019 [11]. The silk industry's economic viability has a considerable impact on its long-term viability [23, 40].

Sericulture is a viable rural industry that provides remunerative work and significant opportunities for increasing human resource employability [27, 51, 50]. Silkworm seed, mulberry leaf, and labour have favourable and substantial associations with cocoon formation, according to [29, 41, 42]. [32] investigated the factors influencing cocoon production indrought prone region of Andhra Pradesh. [48] investigated resource efficiency in the Himachal Pradesh district of Bilasapur and the resource productivity of silk cocoon production. To the best of our knowledge, no such comprehensive study on the resource efficiency of silk cocoons has been undertaken in the Kashmir valley.

This research examines the resource efficiency of silkworm rearers in the viable regions of Anantnag and Baramulla, which is critical for policymakers to consider when developing policies to improve silk cocoon growth and productivity in the Kashmir valley. The major goal of this study was to look at the socioeconomic factors and resources that influence silkworm rearers'/farmers' ability to produce silk cocoons in Kashmir.

MATERIALS AND METHODS

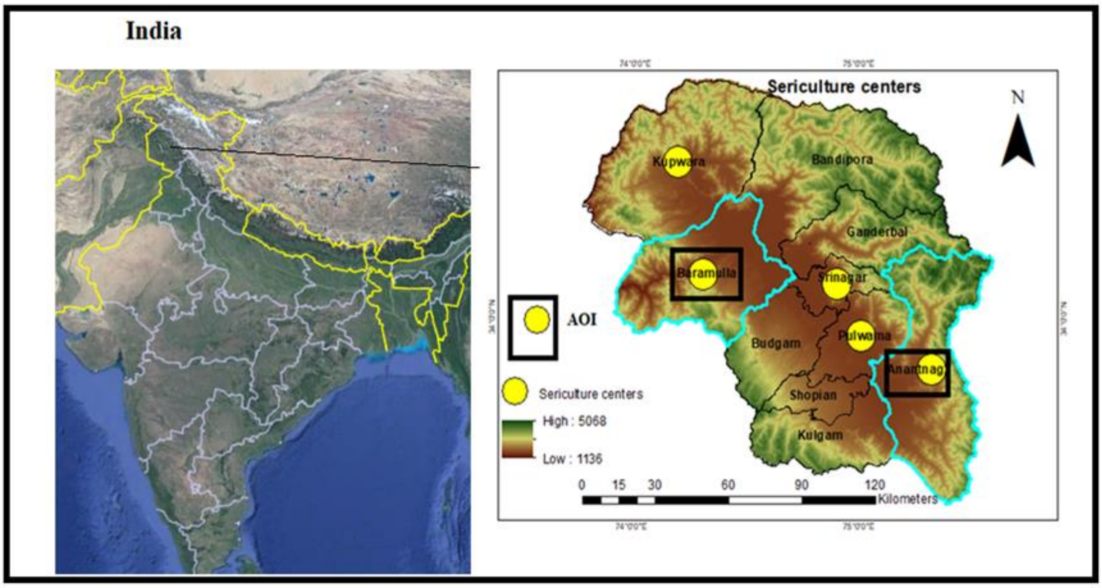
Study area

The Kashmir valley, which spans 15,220 square kilometres and located between the Pir Panjal and the western extremity of the Great Himalayan peaks, is a deep asymmetrical basin and mesogeographical region. The Pir Panjal Range to the Southwest and the main Himalayan range to the Northeast define the Kashmir valley, which stretches from 35° 22' to 34°43' N and 73° 52' to 75°42'E. It's about 135 kilometres long and 32 kilometres wide, and it's drained by the Jhelum River.

Kashmir valley is also known for its agricultural products such as fruit, vegetables, saffron, herbs, and minerals, as well as rare handicrafts such as silk carpets, shawls, and the finest embroidery. Mulberry trees, which are abundant in the Valley and form the backbone of the silk industry, have a diverse range of flora and fauna. Over 70% of the population is employed in agriculture and allied sectors like as sericulture, animal husbandry, and apiculture. The Twelfth Five-Year Plan (2012-2017) in J&K implemented an Industrial Policy that focuses on silk textile industries, silk carpet weaving, handloom and handicraft sectors, Khadi and village industries, and promotes green economy and eco-friendly firms.

Kashmir valley has a temperate environment with seasonal weather. The temperature ranges from 10°C in the winter to 39°C in the summer, with an average annual precipitation of 75cm [47, 15]. Weather has an impact on both mulberry cultivation and silkworm rearing. Mulberry cultivation and silkworm rearing are both affected by the weather. According to the World Bank's 2021 income classification, sericulture plays a crucial role in the Kashmir valley's subsistence options, which are typically landless and marginal. The Kashmir Valley's Himalayan topography is ideal for sericulture growth and development, allowing rearers to achieve silk farming sustainability [20].

The research area's most important sericulture centres are Anantnag and Baramulla in Kashmir Valley, which contribute the most silk cocoon production in Kashmir Valley [33, 34]. Sericulture helps to the development of a well-balanced economic sector in Kashmir's rural economy. Due to the geo-economic feasibility of sericulture, the union territory of Jammu and Kashmir has been able to increase its output of silk cocoons and yarn. According to the evaluation index, the future growth plan should concentrate on regional expansion of sericulture in economically viable locations, particularly in the districts / sericulture centres of Baramulla and Anantnag [34] (Map 1).



Map 1**.** Location map of study area
Source: Prepared by authors Arc GIS 10.4.

The information for this proposed study was gathered from both primary and secondary sources. Observation, personal interviews, targeted groups, debates, and other participatory community-based approaches were employed to collect primary data. Fieldwork was to be carried out in the Kashmir valley's Anantnag and Baramulla districts (2021). Aside from primary statistics, secondary data from the District Sericulture Offices in Anantnag and Baramulla (2021) revealed that silk growing employs 1,210 and 1,340 rearers, respectively. Anantnag and Baramulla represent the southern and northern parts of Kashmir, respectively, where the most silk cocoons are produced (Srinagar, DSO, 2021) [12]. In the Kashmir valley, Anantnag and Baramulla are considered prospective areas for sericulture development. The sampling strategy utilised in this study was purposive stratified random sampling, in which two sericulture-rich districts were chosen to represent the northern and southern halves of the valley, respectively, with an acceptable number of villages. A systematic questionnaire was used to collect primary data on silk cocoon output from 334 silkworm rearers.

The sample size determination formula developed by Barlett et al (2001) [8] was utilised in this investigation to determine the suitable sample size. The following equations were used to select the sample size consisting of 334 silkworm rearers for the current investigation.

n $= t^2(p)(q)/d^2$ .... (1)

where:
n = sample size,
t = value for selected alpha level of 0.025 in each tail = 1.96,
p = proportion of population engaged in silk cocoon production activities,
q = proportion ofpopulation who do not engage in silk cocoon production activities, and
d = acceptable margin of error for proportion being estimated = 0.05
n =1.962 $\times 0.5 \times 0.5/0.05^2$ = 334 rearers.

Cobb Douglas production function: Cobb Douglas production function was used to measure resource use efficiency of silk cocoons in potential sericulture centres of Kashmir valley, namely Baramulla and Anantnag, where sampling survey was conducted using a pre-structured questionnaire, to determine the effect of various independent variables on the output of silk cocoons.

The Cobb Douglas production is fitted in silk cocoons
Y = Production of Silk cocoons (Kgs)
X1 = Mulberry leaf production (Kgs),
X2 = silkworm seed (ounces)
X3 = Labours (mandays/yr.),
X4 = Disinfectants (Kgs/yr.)
X5 = Training/Experience of silkworm rearers
X6= Silkworm Rearing sheds,
X7= Family farming

Y= $b_0 X_1^{b1} X_2^{b2} X_3^{b3} X_4^{b4} X_5^{b5} X_6^{b6} X_7^{b7} e^{\mu}$ .... (2)

Apply Log from both sides:

$Log\ Y = Log\ b^0 + b_1 LogX_1 + b_2 LogX_2 + b_3 LogX_3 + b_4 LogX_4 + b_5 LogX_5 + b_6 LogX_6 + b_7 LogX_7 + \mu$ .... (3)

Marginal value product

The estimated coefficients were used to compute MVP. We can assess the relative importance of factors of production by studying marginal value product. Marginal value product of $X_{i,}$

I.e. for the i input, it is estimated by the following formula (equation 4)

MVP = bi $\times \frac{GM(Y)}{GM(XI)} \times Py$ ……………………………………………….(4)

where:
GM (Y) and GM (Xi) represents the geometric means of output and input, respectively,
b_i is the regression coefficient of ith input and
P_Y is the price of output.

The efficiency of input use was estimated using the following equation (5)

r = MVP/MFC …………………………… (5)

where:
r is the efficiency ratio,
MVP is the marginal value product of variable input and
MFC is the marginal factor cost (price per unit input).

Based on economic theory, a firm maximises profit with regard to resource use when the ratio of marginal return to the opportunity cost is one. The value of r less than unity indicates excess use of resources (there exist scope for reduction). If r is greater than one, it indicates underutilisation of resource (there is scope to increase. If r is equal to unity, it indicates optimum utilisation of resource [46].

r = 1, It denotes that the input was effectively utilised

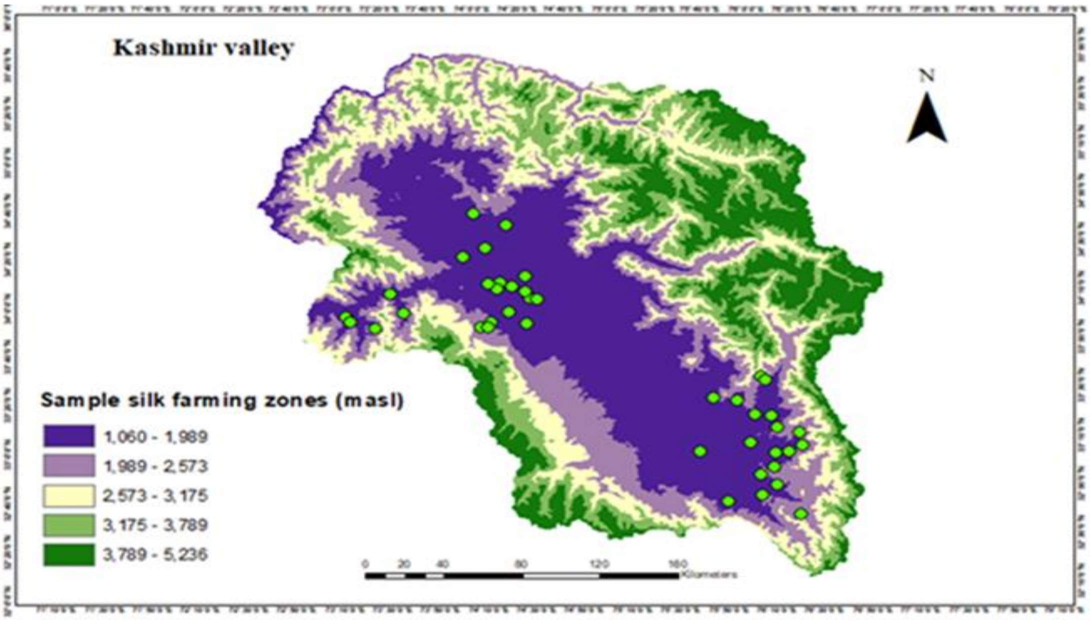
r > 1, It means that the input was underutilised, and that increasing the use of that resource would enhance both output and profit.

r < 1, It means that the input is overused, and that if less of it is used, both output and profit would be maximised.

RESULTS AND DISCUSSIONS

Socio- economic characteristics of silkworm rearers

The socioeconomic characteristics of silkworm rearers interviewed in the study are shown in Table 1. Table 1 also includes descriptive statistics on the characteristics of silk cocoon farmers. Males account for 25.15% of silk cocoon farmers in the sample, while females account for 74.85%. Because silk cultivation is more popular in indoors, it obviously means that more women are involved in it. According to the table, 37.43% of the silk rearers are between the ages of 40-50. This data clearly shows that the bulk of silkworm rearers engaged in sericulture activities belonged to old adults. The age factor is thought to be crucial in the farming experience of silkworm rearers.In terms of occupation, 86.50% of farmers were involved in both sericulture and agricultural operations, whereas 13.50% were only involved in sericulture. Agricultural crops are cultivated for food, while sericulture is grown for profit. In terms of literacy, 37% of farmers had completed secondary school, indicating that silk worm farmers have a high degree of literacy. This factor will give technology adoption and spread an additional boost. As we all know, experience makes a man perfect, thus we chose farm experience as one of the indicators to learn about the farmers' experience in the research area's sericulture activity. The vast majority of farmers (29%) have 11 to 15 years of experience on the farm.



Map 2. Sample silk farming surveyed villages of study area
Source: Field survey (2021-22).

When it comes to the sort of silkworm rearers family, the greater the family, the more family labour will be available for sericulture and agriculture operations, which are both labour intensive. Land is a crucial factor for understanding sericulture operations and the extent of farmers' land holdings in the research area.

The data shows that marginal rearers account for 85.32% of the 334 respondents with land holdings of less than 1 hectare and 14.67% of progressive rearers with land holdings of more than 3 hectares. Sericulture centres provided 1 ounce of silkworm seed to marginal rearers and 2 ounces of silkworm seed to progressive rearers. It appears that the majority of silk farmers fall into the marginal category, with the remaining belonging to progressive farmers. This clearly demonstrated that marginal farmers in Kashmir valley are primarily involved in silk farming.

Table 1. Socioeconomic characteristics of silkworm rearers in the study area (Anantnag and Baramulla)

Variable	Frequency	%	Mean	Standard deviation
Gender				
Male Female Total	84 250 334	25.15 74.85 100.00	-	-
Age group (years)				
< 30	90	26.95	24.75	5.10
30-40	125	16.46	35.20	4.15
40-50	55	37.43	46.10	4.90
50-60	40	11.97	54.40	5.15
>60	24	7.19	63.60	3.80
Total	334	100.00		
Occupation				
Sericulture	44	13.50		
Sericulture and Agriculture	290	86.50		
Total	334	100.00		
Education				
Illiterates	80	23.95		
Primary	100	29.94		
Secondary	125	37.42		
Higher secondary	20	5.98		
Above Higher secondary	9	2.69		
Farm experience (yrs.)				
5-10	90	26.94	7.25	2.0
11-15	100	29.94	13.30	2.10
16-20	95	28.44	17.20	2.65
20-25	40	11.97	23.40	1.90
26-30	9	2.69	27.30	2.50
Type of Family				
Joint family	38	11.37		
Nuclear family	296	88.62		
Land holding size of rearers (ha)				
Marginal (<1)	285	85.32		
Progressive (>3)	49	14.67		
Silk worm seed taken by rearers (ounces)				
Marginal 1	285	1 ounces		
Progressive 2	49	2 ounces		

Source: Field survey, 2021.

Silk Cocoon production was treated as a dependent variable, with factors such as mulberry leaf, silkworm seed, disinfectants, labour, farmer experience/training, silkworm rearing sheds, and family farming utilised to produce cocoons regressed. With a value of 0.83, the coefficient of multiple determinations (R^2) was significant, indicating that the factors included in the function could explain 83% of variation in cocoon production. The regression constant was positive. The regression coefficient of variable such as mulberry leaf was positive and significant at one per cent level with the value of 0.345 per cent implying that one per cent increase in the above said variable from the existing mean level would increase the production of cocoon by 34.5%. The regression coefficient of the variables such as labour, silkworm rearing sheds, family farming, training/experience of silkworm rearers, disinfectants were found to be non-significant.

Mulberry cocoons were the principal crop produced by silk worm rearers in the research area, which was influenced by a number of factors. Quantifying the degree of correlation and cause-and-effect link between cocoon production on the one hand and multiple factors impacting cocoon formation on the other is critical from a policy standpoint. This type of exercise could aid policymakers and sericulturists in focusing on the strategic variables. The purpose of this study is to look at the input-output relationship for cocoon production in the study area. Cobb-Douglas production function with seven explanatory variables was used. The results for full model and stepwise function are given in Table 2 and 3. The results of production function with all variables (Table 2) showed that only silk worms seed (X2) and numbers of mulberry feedings per day (X1) were the significant variables in affecting the cocoon production. The regression coefficients of Cobb-Douglas production function are the direct measures of elasticities of production for the inputs.

The results of the stepwise production function shown in Table 2 demonstrated that the most important variable determining cocoon generation was silk worm seed. This variable's coefficient revealed that a 1% increase would result in a 0.558 percent increase in cocoon production. The amount of mulberry feedings delivered to the silk worms per day. This variable reveals that a 1% increase in silk worm feeding frequency can result in a 0.345 percent increase in cocoon output. This variable shows that 1% increase in the frequency of silk worms feeding may bring 0.345 per cent increase in the cocoon production. During the survey period, it was found that feeding silk worms fresh mulberry leaves a number of times considerably aided their growth and maturity. The returns to scale for these variables were found to be more than unity, indicating that there is scope to improve the usage of these variables in silk cocoon manufacturing. Only two variables, silk worm seed and daily frequency of mulberry feeding to worms, were shown to have a significant impact on cocoon production, implying that increasing the use of these inputs might increase the amount of cocoon in the research area.

Table 2. Factor inputs impact on silk cocoon production in the studied area

Variables	Regression coefficient	Standard error
Intercept	2.143	
Mulberry leaf	0.345	0.024
Labour	0.176	0.038
Silkworm seed	0.558	0.143
Disinfectants	0.018	0.021
Training/Exp	0.067	0.042
Family farming	0.025	0.013
Silkworm rearing sheds	0.241	0.037
Coefficient of determination	0.83	
Observations	334	
F-Test	4.59	
P-value	0.007	

Source: Field survey (2021-22).

Table 3. Allocative efficiency of factor inputs in silk cocoon production using MVP/MFC ratio in the study area

Variables	MVP/MFC	Decision rule
Mulberry leaf	1.472	under- utilised
Labour	0.853	over-utilized
Silkworm seed	1.19	under- utilised
Disinfectants	0.678	over-utilized
Silkworm rearing sheds	1.13	under- utilised
Return to scale	1.32	under -utilised

Source: Field survey (2021-22).

It is clear from Table 3 that the MVP to MFC ratio was more than 1 for mulberry leaf (1.472), silkworm seed (1.194), and silkworm rearing sheds (1.19) which indicates underutilisation of resources. Thus results indicated that scope for reallocation of expenditure among these resource and optimize silk cocoon production. There exists scope for higher use of these resources from their existing level to reach optimum production of silk cocoon. The results of the present study show that the MVP to MFC was less than 1 for labour (0.853) disinfectants (0.946) were overused in silk cocoon production as the ratio of MVP to MFC was less than unity. There is a need to reduce the use of these resources to attain optimum silk cocoon production. The returns to scale calculated for silk cocoon rearers in the study area reveal increasing returns to scale. The results suggest that silk cocoon farmers could enlarge their productivity, given their disposable resources. That is, silkworm farmers can increase their silk cocoon output by employing more of the resources (silkworm seed, mulberry leaves and silkworm rearing sheds) employed in silk farming. Return to scale analysis in the present study showed value of 1.32 which indicates increasing return to scale in the study area and this finding was in line with the findings of [48 and 26].

Photo 1. Mulberry nurseries, Farmer pruning mulberry branches, Silkworms feed on chopped mulberry leaves, Silk cocoons in living room, silk cocoon trays, family farming, rearing sheds, Reeled mulberry silk. Cocoon marketing at sericulture centres.
Source: Field photographs of surveyed villages, 2021-2022.

CONCLUSIONS

In general, quantities of silkworm seed, mulberry leaves, and silkworm rearing sheds should be raised for maximum resource usage in silk cocoon production while labour and disinfectants should be minimised in the districts of Anantnag and Baramulla. For silkworm rearers to attain resource usage efficiency, incentives and tactics aimed at encouraging them to use hybrid silkworm breeds, experience/training of silkworm rearers, family farming, and rearing sheds are recommended. Extension officers should encourage silk rearers to join farmer-based organisations in areas where they already exist by explaining the benefits of such groups to the farmers. They should support silk rearers in forming such groups in regions where none exist, since this maintains the region's sustainability and plays a critical role in boosting resource use efficiency and silk cocoon productivity in the Kashmir valley.

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