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ARAŞTIRMA MAKALESİ **RESEARCH ARTICLE**

Clustering and employment opportunities in the development of sericulture and cocoon production in the northwestern region of Azerbaijan

Azerbaycan'ın kuzeybatı bölgesinde ipekçilik ve koza üretiminin geliştirilmesinde kümeleme ve istihdam fırsatları

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ABSTRACT

The article examines the development dynamics of sericulture and cocoon production sectors in the northwestern region of Azerbaijan (Sheki-Zagatala economic-geographical region) during the period 2018–2023, the application of a cluster-based production model, and the impact of these sectors on employment. The aim of the study is to evaluate the effectiveness of the cluster approach to enhance the economic potential of sericulture, one of the region's traditional economic activities, and to investigate changes in the labor market within this field. The research employs both qualitative and quantitative analyses based on official statistical data, regional development programs, and reports from local executive authorities, identifying the influence of the silk industry on the regional labor market. A SWOT analysis was conducted to assess the development opportunities and existing challenges of these sectors. Considering the sericulture potential of the region, clusters and subclusters were identified based on production, labor market, and other functional characteristics. For the first time, a monomorphic logistic model was developed and applied to organize clustering in sericulture and cocoon production, demonstrating its effectiveness as a tool for optimizing the regional production chain.

ÖZET

Makalede, Azerbaycan'ın kuzeybatı kesiminde yer alan Şeki-Zakatala ekonomik-coğrafi bölgesinde, 2018–2023 yılları arasında ipekçilik ve koza üretimi sektörlerinin gelişim dinamikleri, küme (klaster) temelli üretim modelinin uygulanması ve bu sektörlerin istihdama etkisi incelenmiştir. Araştırmanın amacı, bölgenin geleneksel ekonomik faaliyetlerinden biri olan ipekçiliğin ekonomik potansiyelini artırmak amacıyla küme yaklaşımının etkinliğini değerlendirmek ve bu alandaki iş gücü piyasasındaki değişimleri analiz etmektir. Çalışmada, resmi istatistik veriler, bölgesel kalkınma programları ve yerel yönetim raporları temel alınarak nitel ve nicel analizler yapılmış; ipek endüstrisinin bölgesel iş gücü piyasası üzerindeki etkisi ortaya konmuştur. Söz konusu alanların gelişim olanaklarını ve mevcut zorluklarını değerlendirmek amacıyla SWOT analizi gerçekleştirilmiştir. Bölgenin ipekçilik potansiyeli göz önünde bulundurularak, üretim, iş gücü piyasası ve diğer işlevsel özelliklere göre kümeler ve alt kümeler tanımlanmıştır. İpekçilik ve koza üretimi alanında kümeleşmenin sağlanmasına yönelik olarak ilk kez geliştirilen monomorf lojistik model uygulanmış ve bu modelin bölgesel üretim zincirinin optimize edilmesinde etkili bir araç olduğu gösterilmiştir.

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INTRODUCTION

Sericulture provides a steady source of income and job opportunities for rural populations, diversifying income streams beyond traditional agriculture. The industry supports employment across various stages, including mulberry cultivation, silkworm rearing, and silk processing, often offering more stable employment compared to seasonal agriculture (Mala et al., 2024). The sericulture industry requires relatively low initial investment, making it accessible to small-scale farmers and landless laborers. The simplicity of sericulture operations allows individuals with minimal education and training to participate effectively, promoting inclusive growth and providing livelihoods to marginalized sections of society (Bukhari et al., 2019).

As we mentioned today, sericulture provides continuous employment to millions of people worldwide. In countries like Azerbaijan, it has been instrumental in socio-economic transformation, offering a viable means of livelihood for many rural households. Particularly, the Shaki-Zagatala region is notable for its historical connection to silk production, and the resurgence of this industry provides vital employment opportunities and contributes to the area's socio-economic development.

The Sheki-Zagatala economic region is located in the northwestern part of Azerbaijan, on the southern slopes of the Greater Caucasus Mountains, encompassing the Balaken, Zagatala, Qakh, Sheki, Oghuz, and Gabala districts. The most developed district in the region is Sheki. This economic region, with significant potential for the agrarian sector, plays an important role in the country's economy and is crucial for ensuring employment for the population. In the modern era, the development of this sector is largely influenced by state programs and the implementation of innovative agricultural technologies.

The targeted development strategy and reform course implemented by the government is one of the key factors ensuring the sustainable development of every country and is a significant factor in enhancing competitiveness in the modern global economy. One of the main factors conditioning the development of Azerbaijan, which is among the leading countries in the agricultural sector, is the dynamic development of its regions. In this context, achieving superior development of the agricultural sector in the new economic conditions is of great importance. Among the measures taken for the overall development of the agrarian sector, revitalizing and developing high-export-potential fields plays a special role. In this regard, the sustainable measures implemented for the development of traditional sectors such as cocoon production and sericulture, along with strengthening state support, aim to increase interest in these areas, ensure employment for rural populations shortly, boost exports, and accelerate the influx of foreign currency into the country (İsmayilova, 2024).

The development of sericulture in Azerbaijan is primarily linked to the ancient history and rich traditions of the northwestern region, especially Sheki. The traditions of cocoon production have been preserved and developed over centuries, playing a significant role in the lives of the local population. Archaeological research in the area has proven the development and extensive use of sericulture in agriculture (Alizadeh et al., 2008). Historical sources indicate that silk produced from sericulture, which began to take shape in the 5th-6th centuries, was exported along the Great Silk Road to many countries starting from the 12th century. Scientific literature highlights that in the 18th and 19th centuries, cocoon production in the Sheki-Zagatala economic region reached its peak. During these years, Azerbaijan produced 9,000 to 10,000 tons of fresh cocoons annually, with silk products primarily exported to Russia and then to European countries. Notably, silk produced in Sheki was distinguished by its quality and was highly valued in foreign markets (Valiyev, 1977). In the late 20th century, following the collapse of the USSR and the disruption of traditional production and trade relations, cocoon production and other significant agro-industries sharply declined, with most enterprises collapsing and only a few operating on a limited scale. During that period, the two breeding and sericulture stations, seven cocoon seed factories, nearly thirty fresh cocoon drying plants, and about eighty cocoon collection and processing points ceased operations. This led to a serious decline in the silk industry, and cocoon production dropped from 3,587 tons in 1910 to 3,202 tons in 1993 (Alizadeh et al., 2008).

In the early years of independence, research conducted on the modern spatial organization of agriculture in the Sheki-Zagatala economic region shows that the reforms implemented during that period led to significant changes in the sector structure of agriculture. As a result of these changes, the roles of strategically important sectors with high export potential, such as tobacco cultivation, tea growing, animal husbandry, silkworm farming, and sericulture, sharply decreased. Consequently, productivity fell significantly, household incomes declined, and employment opportunities in agriculture weakened. Even though there was a rich raw material base for silk and cocoon production in the industrial structure of the economic region, these opportunities were underutilized (Agabalayev, 2015). To increase employment and improve social welfare, according to the decree dated September 15, 2016, on "State Support for the Development of Sericulture in the Republic of Azerbaijan," it is planned to provide subsidies for individuals engaged in cocoon production based on the type of raw cocoon accepted by the cocoon processing and cocoon production enterprises, at a rate per kilogram (Strategic Roadmap, 2016).

Azerbaijan's formation of its economic relations as an independent state, the application of market economy principles, and the granting of land to private ownership indicated the necessity for new approaches to developing sericulture and cocoon production. Based on this, a concept was developed in 2017 aimed at the development of sericulture using new innovative methods and modern technologies, and based on it, the 'State Program for the Development of Sericulture and Cocoon Production in the Republic of Azerbaijan for 2018–2025' was adopted. The main objective of this State Program is to ensure the sustainable development of sericulture, increase the raw material supply for the silk processing industry, enhance the quality and volume of produced goods, create new economic entities, strengthen the export potential of silk products, and increase employment. To achieve these goals, the program includes measures such as the restoration and reconstruction of existing orchards, increasing the productivity of mulberry trees, developing silkworm breeding, creating new productive breeds and hybrids of silkworms, organizing sericulture and cocoon production based on modern technologies, supporting and promoting silk product exports, and implementing clustering (State Program, 2017). The implementation of the State Program is anticipated to significantly contribute to strengthening the country's overall economic potential by improving the living conditions of the population living in sericulture districts and influencing the development of other sericulture-related areas. Additionally, a strategic goal has been set to increase raw cocoon production to 6,000 tons by 2025.

From the analysis and generalization of the research materials, it is clear that the 'State Program for the Socio-Economic Development of the Regions of the Republic of Azerbaijan for 2019–2023' highlights a new phase in the country's socio-economic life, particularly in accelerating economic development in the regions, ensuring decent employment for the population, increasing social welfare, and strengthening ecological security (State Program, 2017). In the document "Azerbaijan 2030: National Priorities for Socio-Economic Development," approved in 2021, the potential for ensuring macroeconomic stability is emphasized, aiming to elevate the national standard of living. The document prioritizes the engagement of labor and resources to increase economic activity in regions and raise their share of national income (National Priorities, 2021).

The article presents a detailed analysis of activities carried out in sericulture in the Sheki-Zagatala economic region from 2018 to 2023. During this period, the dynamic indicators of the produced cocoon products have been reviewed. The current state of sericulture and cocoon production has been assessed through SWOT analysis. Additionally, results related to the development and application of a logistic monomorphic model suitable for clustering based on the conducted analyses have been discussed. In this study, the identification of clusters for the development of sericulture and cocoon production, which is one of the main directions of the agricultural sector in the northwestern region of Azerbaijan, and the development of a logistics model based on these clusters, is presented for the first time as a scientific innovation. We propose that the application of this monomorphic logistics model, tailored to specific situations, will facilitate the formation of relevant activities, services, and production structures in the region's sericulture and silk industry, ensuring their integrated and sustainable operation. As a

result, expansion within the sericulture and cocoon production sector, an increase in employment levels across the region and the country as a whole, and the assurance of economic development are expected. In the research work, the following tasks were carried out by the research objectives:

1. Investigation, analysis, and evaluation of the current situation in the field of sericulture and cocoon production in the country and region.
2. Determination of the share of raw cocoon production from fresh cocoons in the overall production of the country for each district within the Sheki-Zagatala economic region from 2018 to 2023.
3. Identification of clusters and sub-clusters related to activities and services in the field of sericulture and cocoon production.
4. Evaluation and analysis of the employment level of the rural population in sericulture and cocoon production for each district within the economic region.
5. Development of a logistic strategy for organizing economic specialization and integrated activities by sericulture and cocoon production clusters in the region.
6. Preparation of proposals regarding the diversification of small and medium enterprises in the context of clusters related to sericulture and cocoon production in the northwestern region.

MATERIALS and METHODS

The review highlights key areas identified by numerous researchers and scholars that may aid in understanding the challenges pertinent to the current study and help pinpoint existing research gaps. The primary sources for the literature review in the research encompass published research papers, articles from reputable national and international journals, theses, and books.

Aslam et al. (2020) investigated the impact of cluster promotion programs on the silk industry in Uttarakhand. Their study highlights the role of clustering in enhancing productivity, improving employment opportunities, and fostering technological advancements in sericulture. Similarly, Naidu et al. (2019) explored the impact of bivoltine sericulture on the socioeconomic development of farmers in the Madakasira cluster, emphasizing that the implementation of Cluster Promotion Programs (CPP) significantly enhanced household incomes, improved employment stability, and promoted the adoption of scientific practices in sericulture.

Rahmatullah (2012) focused on the management of climatic factors for successful silkworm (Bombyx mori L.) crop production. He emphasized the importance of maintaining optimal environmental conditions for enhancing silk yield and ensuring sustainable production. The study underscores both natural factors—such as climate, temperature, soil composition, and topography—and socio-economic elements—including the availability of high-quality raw materials, affordable skilled labor, reliable power supply, and efficient transportation—as pivotal to the advancement and prosperity of sericulture.

Guler (2021) conducted a multi-dimensional scaling and clustering analysis of sericulture in Turkey, identifying key regional patterns in silk production. The study provides insights into how clustering mechanisms contribute to improving production efficiency and resource allocation. Similarly, Bayır (2024) utilized Local Indicators of Spatial Association (LISA) to discover sericulture clusters, emphasizing the significance of geographic concentration in optimizing productivity and employment generation in the sector.

Kherkatary and Daimari (2017) analyzed the growth pattern of raw silk production and employment generation in Assam. Their economic analysis highlights the role of sericulture in rural employment and livelihood security. Likewise, Lakshmanan et al. (2011) explored rural labor employment through mulberry sericulture, illustrating how sericulture serves as a source of sustainable employment in agrarian economies.

Hoque and Hasmi (2017) studied the growth and development of sericulture production and mulberry cultivation in West Bengal. Their findings reveal that expanding mulberry cultivation directly influences cocoon production and

employment opportunities. Karthick Mani Bharathi et al. (2024) investigated the impact of mechanization in the post-cocoon sector and non-mulberry sericulture, highlighting how technological advancements can enhance productivity, reduce labor intensity, and contribute to the sustainable development of the sericulture industry. Kumaresan et al. (2008) provided an economic analysis of large-scale sericulture farming, highlighting efficiency in production and cost-benefit analysis. Their study suggests that large-scale farming has the potential to enhance productivity while ensuring economic sustainability. Tuigong et al. (2015) examined mulberry and silk production in Kenya, illustrating how sericulture contributes to rural economic development in African nations. The research also identifies several challenges, including fluctuations in cocoon prices, inadequate storage facilities, and the lack of proper markets.

Yakişan and Yılmaz (2022) studied the influence of environmental factors on cocoon quality in Diyarbakır, Turkey, emphasizing the role of local conditions in determining silk yield and quality. Their study underscores the importance of regional adaptations in sericulture practices. Mushtaq et al. (2023) explored the role of sericulture in achieving Sustainable Development Goals (SDGs), asserting that sericulture contributes to poverty alleviation, employment generation, and environmental sustainability.

Based on the presented scientific sources, the dynamics of cocoon production in the Sheki-Zagatala economic region from 2018 to 2023 has been extensively and deeply analyzed. This analysis covers the trends of increase and decrease in production during different periods, as well as the impact of market demand and government support on this sector. The factors affecting cocoon production have been studied from various aspects, and the changes occurring during those periods have been assessed in detail. At the same time, thorough research has been conducted on the current state of the local silk industry and the variability of demand in this sector. Based on the results of these studies, a SWOT analysis was carried out, and clusters and sub-clusters in sericulture and silkworm production were identified.

The research used various methodological approaches, and in addition to field studies, existing statistical and analytical materials were analyzed. The following official requests have been made to state and private organizations for the purpose of conducting a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis, and relevant analyses have been conducted based on the responses received:

- Ministry of Agriculture of the Republic of Azerbaijan
- Regional Department of the Ministry of Economy of the Republic of Azerbaijan
- Sheki Regional Agrarian Science Center
- Sheki Regional Department of Agriculture
- Silk Breeding Station of the Ministry of Agriculture of the Republic of Azerbaijan in Qakh
- Executive authorities of the six districts involved in the research
- Sheki Silk JSC
- Farmers and entrepreneurs operating in each district
- Records of participation in the monitoring group of the Ministry of Agriculture of the Republic of Azerbaijan
- Artisans operating in each district
- Information published by mass media (communication outlets)
- Official annual reports of the State Statistical Committee of the Republic of Azerbaijan

The following data have been collected from various institutions involved in the cocoon production sector in the Northwestern region of Azerbaijan:

1. The area of mulberry orchards and the number of mulberry saplings planted in each district up to 2018.
2. The number of mulberry saplings planted and the total area of mulberry orchards from 2016 to 2022.
3. The quantity of silkworm eggs (measured in boxes) distributed to silkworm breeders by district from 2018 to 2023.
4. The volume of raw silk (fresh cocoon) produced by district from 2018 to 2023.

5. The annual quantity of fresh cocoon, defective cocoon, and pupa products delivered to Sheki Silk JSC.
6. The silk products processed from fresh cocoon at Sheki Silk JSC, the items manufactured from these products, and their sales volume.
7. Souvenirs and craft items created by local artisans using silk threads, fabrics, cocoon pupa, and other materials.

Based on this information, a SWOT analysis has been conducted to assess the current state of the silkworm farming sector. The analysis identified several following key aspects:

Sericulture is a labor-intensive industry due to its capacity to generate substantial employment, especially in rural and semi-urban areas. It encompasses various stages-from mulberry cultivation (the primary food source for silkworms) to silkworm rearing, cocoon harvesting, and silk processing-each providing distinct employment opportunities (Dasar et al., 2021). The industry offers both direct and indirect employment across these stages, including mulberry cultivation, silkworm rearing, reeling, twisting, and weaving. Notably, sericulture has been identified as a promising avenue for women's employment, with female workers predominantly involved in tasks such as cocoon-cutting, sexing, and egg incubation. For instance, in India, sericulture activities generate substantial employment opportunities, engaging numerous families in regions like West Bengal (Roy et al., 2012).

For this purpose, the study provides a detailed analysis of the development levels of sericulture, cocoon processing, production, and the populations engaged in these activities across six districts of the Sheki-Zagatala economic region from 2018 to 2023. The role of logistics in the supply chain of cocoon production involves the movement, storage, and processing of raw materials (such as silkworm eggs and mulberry leaves) and finished products (such as cocoons and silk fibers) (Christopher et al., 2011). Based on this analysis, we have proposed, a logistic monomorphic model to facilitate clustering in the fields of cocoon production and sericulture. The logistic monomorphic model focuses on optimizing a singular or unified supply chain system, which, in the case of sericulture, involves a single type of product (such as cocoon production) moving through various stages of the supply chain (production, processing, and distribution). We anticipate that the application of this novel approach will create favorable conditions for increasing employment opportunities within the clusters by ensuring the optimal distribution of production resources. Moreover, the model aims to balance the demand and supply within the sericulture sector, which is critical for implementing sericulture activities in the region in a more systematic and efficient manner. Another expected benefit of the model is the reduction of logistical inefficiencies and the successful execution of production processes by maximizing cluster integration. This approach is vital for enhancing the competitiveness of sericulture, cocoon processing, and production, addressing employment challenges, and ensuring sustainable economic growth.

Strengths:

- In the country, there is a rich tradition, knowledge, experience, and skills in sericulture and cocoon production.
- There are natural (climate, vegetation, hydrological conditions) and ecological factors that condition the dynamic development of this field in the country.
- The presence of higher silk-producing and more productive breeds and hybrids in the material and technical base fund of the "Silkworm Selection" laboratory of the Sheki Regional Scientific Centre of the Azerbaijan National Academy of Sciences (ANAS).
- Organization of specialized staff training in sericulture and cocoon production in vocational, technical, and higher education institutions, with improvements in the admission plan to match labor market needs.
- Availability of technical facilities, equipment, and technological processes for cocoon processing, silk thread, and other product production.
- The silk produced in Azerbaijan has superior biological and technological qualities.

- The demand for silk fabric and products made from it exists both in domestic and foreign markets.
- Sericulture is a currency-earning sector that contributes to increasing the social welfare of the rural population and enhancing employment.
- The presence of seed factories that provide industrial-grade silkworm seeds to the farms engaged in sericulture.
- The existence of cocoon drying stations for the initial processing of harvested cocoons, as well as cocoon reception and processing stations.

Weaknesses:

- The shortage of skilled labor and specialized training programs in sericulture and cocoon production.
- The physical deterioration of sericulture infrastructure, and the weak technical provision of silkworm farms, Az.ETII (Silk Research Institute), breeding stations, and silkworm seed factories. Lack of modern silkworm houses that meet technical requirements.
- The scarcity of feed resources, and the limited number of mulberry plantations with productive and high-quality biological and technological indicators. Existing mulberry plantations do not meet modern planting and care technology requirements.
- The lower profitability of sericulture compared to other sectors of the economy.
- The requirement for long-term capital investment in sericulture.
- The absence of small and medium enterprises in the silk industry in Azerbaijan.
- Inadequate measures for monitoring and combating diseases.
- Low level of promotional work and awareness training to stimulate farmers.
- Limited opportunities for farmers to export their products to foreign markets. The competition from low-cost producers poses a threat to the sustainability of cocoon production in the country.
- Problems with providing low-interest loans to farmers engaged in sericulture and cocoon production under favorable conditions.
- Customs duties and value-added tax on the import of machinery and equipment from abroad for farmers operating in this field.
- The mismatch of silk threads and other product types with foreign market conditions.
- The low purchasing power of the local population for valuable silk products, lead to a high market share of products made from artificial silk.
- The lack of modern technology and equipment in processes such as silkworm processing, spinning silk threads, weaving silk fabric, dyeing and finishing silk fabrics, and other related processes.
- The absence of a specific legislative framework directed towards the development of these sectors.
- The existence of monopolistic practices and unhealthy competition among farmers and entrepreneurs engaged in the production of cocoon and silk products.

Opportunities:

- Availability of sufficient natural-economic and agro-ecological conditions for increasing the feed base and expanding existing mulberry orchards.
- Presence of opportunities for training specialist personnel in sericulture and cocoon production.
- Availability of a raw material base for producing various products (fabric, silk scarves, head coverings, shawls, carpets, etc.) from the silk threads obtained in the cocoon processing process.
- The large number of workers in agriculture.
- Prioritization of state support for agriculture.
- Existence and potential expansion of an industrial structure that stimulates product production.

- Integration of sericulture into the tourism industry, providing visitors with the opportunity to familiarize themselves with cocoon production processes and purchase locally produced silk products.
- Utilization of silkworm waste as an ecologically clean alternative to chemical fertilizers for producing nutrient-rich organic fertilizers.
- Silk-based products serve as an alternative to synthetic components in accessories, souvenirs, textiles, furniture, and other products.
- Opportunities to increase employment by involving a broader segment of the population in sericulture and cocoon production, as well as expanding the area of mulberry orchards.

Threats:

- Presence of competitors with comparative advantage in the global market.
- Absence of small and medium-sized enterprises in the silk industry in the region.
- Standards applied in sericulture and cocoon production not meet international requirements.
- Destruction of the silkworm breeding seed fund during epidemic and pandemic periods.
- Destruction of the feed base due to wars, natural disasters, and other technological factors.
- The low market price of silk, the monopsonistic structure of the silk market.
- Loss of potential employment opportunities due to the spread of pests and diseases that could cause significant losses in cocoon production.
- Trade barriers, tariffs, and restrictions imposed by importing countries limit access to the international silk market.

In subsequent research, we conducted analyses regarding the solutions to existing problems to maximize the use and benefits of those opportunities.

RESULTS and DISCUSSIONS

The results of our SWOT analysis on the current status of sericulture and cocoon production in Azerbaijan confirm that, despite the adoption of numerous state programs over the years and the implementation of state-level measures, significant progress in this field has not yet been achieved. Therefore, in subsequent research and analyses, we will reference the indicators for fresh cocoon production in the country from 2018 to 2023 and calculate the share of the Sheki-Zagatala economic region in the total national production (Selimova & Selimova, 2022) (Table 1). To this end, data on fresh cocoon production nationwide from 2018 to 2023, along with information on production across six districts within the economic region for the specified years (Table 2), were utilized.

Between 2018 and 2023, the production of fresh silkworm cocoons in Azerbaijan exhibited considerable fluctuations. In 2018, production was recorded at 514 tons, with a notable increase in 2019, reaching 644 tons—the highest during this period. However, a decline occurred in 2020, when production decreased to 447 tons. The following year, 2021, saw a modest recovery, with production rising to 497 tons. In 2022, another decrease took place, resulting in a production of only 341 tons, marking the lowest point in the six-year span and representing a 47% decrease compared to 2019. A slight recovery was noted in 2023, with a total of 352 tons produced. Over the entire period, cumulative production reached 2,795 tons, with an average annual production of 465 tons.

Table 1. Quantity of fresh cocoon produced in Azerbaijan (2018-2023) (tons)
Çizelge 1. Azerbaycan'da üretilen taze koza miktarı (2018-2023) (ton)

No.	Year	Fresh Silkworm Cocoon (tons)
1.	2018	514
2.	2019	644
3.	2020	447
4.	2021	497
5.	2022	341
6.	2023	352
Total	-	2795
Average	-	465

Table 2. Quantity of fresh silkworm cocoons produced in Sheki-Zagatala economic region from 2018 to 2023 (tons)
Çizelge 2. 2018-2023 yıllarda Şeki-Zagatala ekonomik bölgesinde üretilen taze ipekböceği kozası miktarı (ton)

Admisntrative districts	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Sheki	48,196	47,900	32,899	32,035	20,758	14,138
Oghuz	5,187	8,891	8,04	6,595	2,549	2,899
Qakh	25,304	27,296	12,696	22,464	10,539	12,497
Zagatala	48,109	52,946	36,165	43,084	22,925	28,907
Balaken	29,818	44,144	31,197	43,068	31,495	28,172
Qabala	9,110	15,478	6,78	12,64	12,64	7,202
Total for Sheki-Zagatala economic region	165,724	196,655	127,777	159,886	100,906	93,815

As shown in Table 2, the share of fresh cocoon production in the six districts of the Sheki-Zagatala economic region has decreased over the specified years compared to previous years. The data for the Sheki district indicate a continuous decline from 2018 to 2023. Production, which was 48,196 in 2018, decreased to 14,138 in 2023, representing a reduction of approximately 70.7%. In the Oghuz district, production fluctuated from 2018 to 2023, decreasing from 5,187 in 2018 to 2,899 in 2023, which shows a decline of approximately 44.1%. For the Qakh district, fluctuations in production were recorded between 2018 and 2020. After 2020, production began to rise again, reaching 12,497 in 2023, an increase of approximately 45.9% compared to 2018. In the Zagatala district, production also fluctuated from 2018 to 2023. After 2019, an increase was observed, with production reaching 28,907 in 2023, an increase of approximately 16.5% compared to 2018. In the Balaken district, production increased from 2018 to 2021 but then decreased after 2021, dropping to 28,172 in 2023, which represents a decrease of approximately 11.2% compared to 2018. In the Gabala district, production decreased from 9,110 in 2018 to 7,202 in 2023, showing a decline of approximately 21%. Overall, there were fluctuations in production in the Sheki-Zagatala economic region from 2018 to 2023. Total production, which was 165,724 in 2018, decreased to 93,815 in 2023, representing a reduction of approximately 43.4%.

Based on the statistical data presented in Tables 1 and 2, the share of fresh cocoon production for individual districts in the Sheki-Zagatala economic region from 2018 to 2023 has been calculated as a percentage. The results are presented in Figure 1.

As shown in Figure 1, this indicator has not varied significantly across individual years. In 2018, it was 32%; in 2019, it was 30.3%; in 2020, it was 28.3%; in 2021, it was 31.9%; in 2022, it was 29.3%; and in 2023, it was 26.4%. The results indicate that this economic region plays a significant role in the country's production of fresh silkworm cocoons, accounting for 26% to 32% of the total production.

In the next study, the percentage share of each administrative unit in the fresh silkworm cocoon production of the Sheki-Zagatala economic region for the years 2018 to 2023 has been calculated based on statistical data and illustrated in Figure 2.

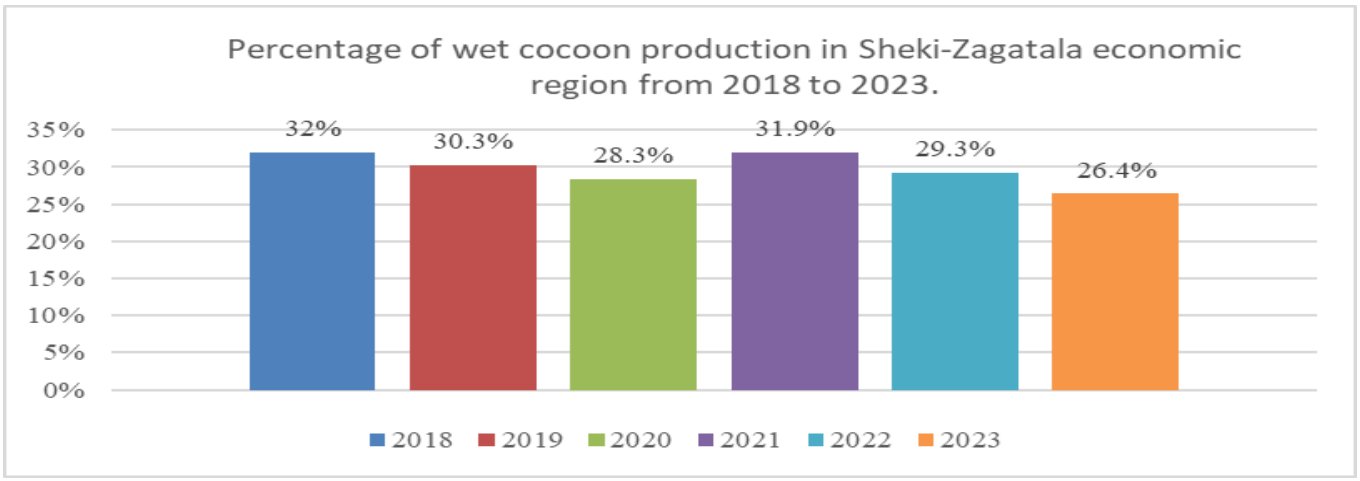

Figure 1. The share of fresh cocoon production in the total output (%) in the Sheki-Zagatala economic region for the years 2018-2023

Şekil 1. Şeki-Zagatala ekonomik bölgesinde 2018-2023 yılları arasında ıslak koza üretiminin toplam üretimdeki payı (%)

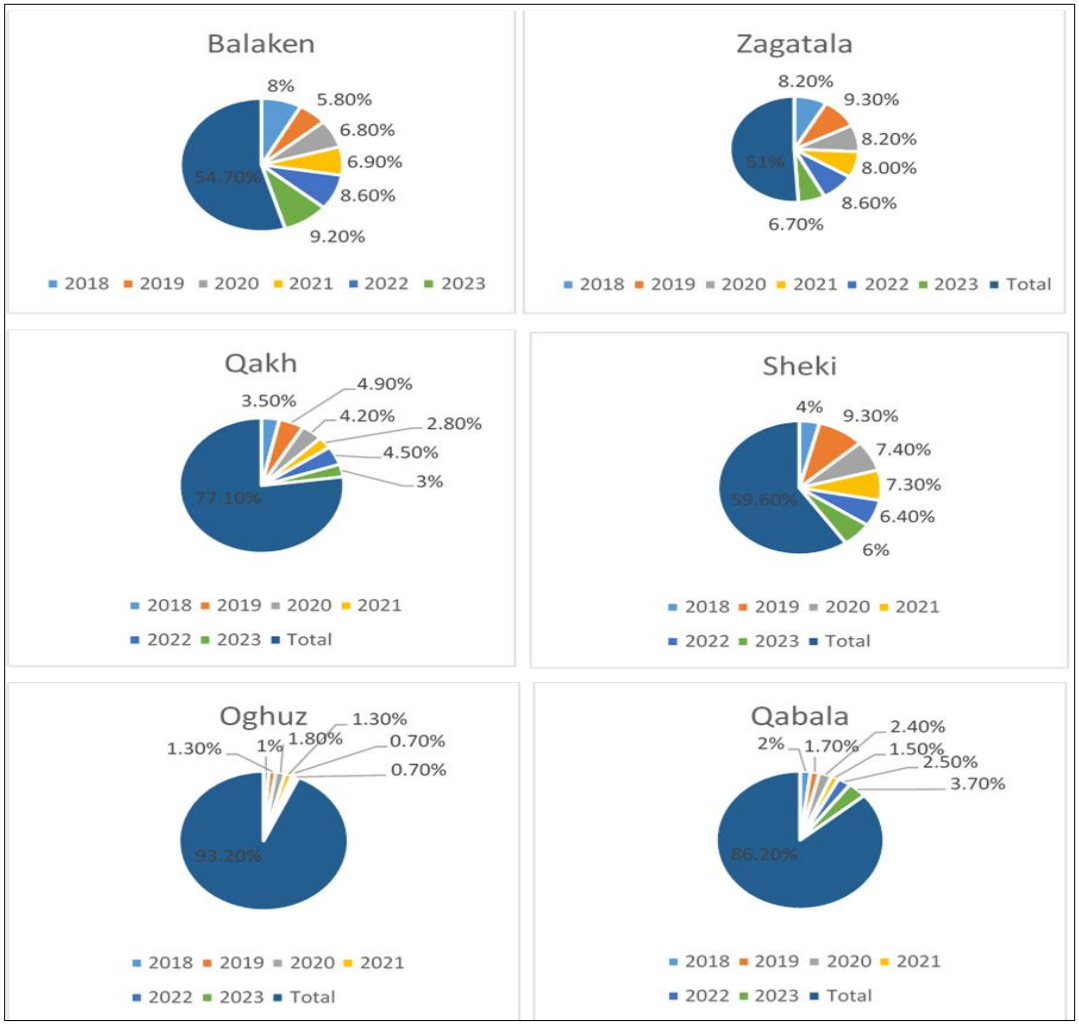

Figure 2. The percentage (%) of harvested fresh silk cocoons in total production by economic region for individual administrative districts within the Sheki-Zagatala economic region from 2018 to 2023

Şekil 2. 2018-2023 yılları arasında Şeki-Zagatala ekonomik bölgesindeki bireysel idari ilçelerde ekonomik bölgelere göre hasat edilen taze ipek kozasının toplam üretimdeki yüzdesi

The Sheki district has consistently maintained a prominent role in fresh cocoon production over the years, as illustrated in the figure. For instance, the district's production share was 9.3% in 2018, then decreased to 7.4% in 2019, 7.3% in 2020, 6.4% in 2021, 6% in 2022, and finally 4% in 2023. Thus, from 2018 to 2023, the share of fresh cocoon production in Sheki varied between 4% and 9.3%. In comparison, the Zagatala district recorded production shares of 9.3% in 2018, 8.2% in 2019, 8% in 2020, 8.6% in 2021, 6.7% in 2022, and 8.2% in 2023. The Balaken district's shares were 5.8% in 2018, increasing to 6.8% in 2019 and 6.9% in 2020, then rising to 8.6% in 2021, 9.2% in 2022, and settling at 8% in 2023. In the Qakh district, production shares began at 4.9% in 2018, then dropped to 4.2% in 2019, 2.8% in 2020, and 4.5% in 2021, before further declining to 3% in 2022 and 3.5% in 2023. The Oghuz district's production shares were quite low, with 1.0% in 2018, 1.3% in 2019, 1.8% in 2020, 1.3% in 2021, and a reduction to 0.7% in both 2022 and 2023. The Gabala district reported shares of 1.7% in 2018, 2.4% in 2019, 1.5% in 2020, 2.5% in 2021, 3.7% in 2022, and 2.1% in 2023.

The next phase of the study evaluated the engagement of the rural population in cocoon production across each administrative area. To achieve this, statistical data on the distribution of silkworm seed quantities among the populations of the Sheki, Balaken, Zagatala, Qakh, Oghuz, and Gabala districts from 2018 to 2023 were analyzed, as shown in Table 3.

Table 3. The quantities of silkworm industrial seeds in boxes distributed among the administrative districts of the Sheki-Zagatala economic region from 2018 to 2023, along with the corresponding population engaged in cocoon production

Çizelge 3. 2018-2023 yılları arasında Şeki-Zagatala ekonomik bölgesinin idari bölgelerine dağıtılan kutulardaki ipekböceği tohumu miktarı ve koza üretimiyle uğraşan nüfus

N.	Administrative districts	2018		2019		2020		2021		2022		2023	
		Seed (box)	Population	Seed (box)	Population	Seed (box)	Population	Seed (box)	Population	Seed (box)	Population	Seed (box)	Population
1.	Sheki	800[1]	2000[2]	1800	4500	1740	4165	1500	3750	1200	3000	1000	2500
2.	Balaken	450	1125	1075	2665	1300	3250	1000	2500	800	2000	600	1500
3.	Zagatala	650	1625	1500	3750	1450	3625	1200	3000	1000	2500	800	2000
4.	Qakh	500	1250	875	2190	860	2150	830	2075	820	2050	700	1750
5.	Oghuz	625	1565	875	2180	860	2150	550	1375	390	975	400	1000
6.	Gabala	260	650	500	1250	520	1300	300	750	280	700	300	750
7.	Total for the Sheki-Zagatala Econ. Reg.	3985	8215	6625	16465	5730	16640	4380	15520	4490	11225	3800	9500

[1]800 boxes represent the quantity of distributed silkworm seeds

[2]2000 people indicate the number of individuals who received silkworm seeds (assuming two boxes per family, with an average of 4-5 members per family).

Based on the information presented in the table, the share of employment calculated as a percentage for each district corresponds to the quantity of mulberry silk moth seeds distributed to the rural population during the specified years. The results by region are presented in Table 4.

Table 4. The percentage of the rural population engaged in cocoon production from 2018 to 2023
Çizelge 4. 2018-2023 yılları arasında koza üretimiyle uğraşan kırsal nüfusun yüzdesi

No.	Administrative districts	Rural population (thousands)	Percentage of population participating in cocoon production (%)					
			2018	2019	2020	2021	2022	2023
1.	**Sheki**	115.9	1.7	3.8	3.5	2.8	2.6	2.1
2.	**Balaken**	84.4	1.3	3.2	3.7	3.0	2.3	1.2
3.	**Zagatala**	80.6	2.0	4.6	4.5	3.7	3.1	2.5
4.	**Qakh**	43.3	3.0	5.1	5.0	4.6	4.5	4.0
5.	**Oghuz**	36.2	4.3	6.05	6.0	3.8	2.4	2.95
6.	**Gabala**	62.8	1.03	2.0	2.06	1.2	1.1	1.2
7.	**Total for the Sheki-Zagatala Econ. Reg.**	423.2	13.33	24.75	24.76	19.1	15.9	13.95

Based on the data in the table, between 2018 and 2023, the level of cocoon production among the rural population in the Sheki region ranged from 1.7% to 3.5%; in the Balaken region, from 1.2% to 3.7%; in the Zagatala region, from 2.0% to 4.6%; in the Qakh region, from 2.5% to 4.6%; in the Oghuz region, from 3.0% to 5.1%; and in the Gabala region, from 1.0% to 2.06%.

The percentage of the rural population engaged in cocoon production in the regions was between 1.03% and 4.3% in 2018, 2.0% and 6.05% in 2019, 2.06% and 6.0% in 2020, 1.2% and 4.6% in 2021, 1.1% and 4.5% in 2022, and 1.2% and 4.0% in 2023. The Qakh and Oghuz regions had a higher percentage during this period, ranging from 3.0% to 6.05%. Based on the amount of silkworm seed distributed in each region, the ratio of the population participating in mulberry production is presented in Figure 3.

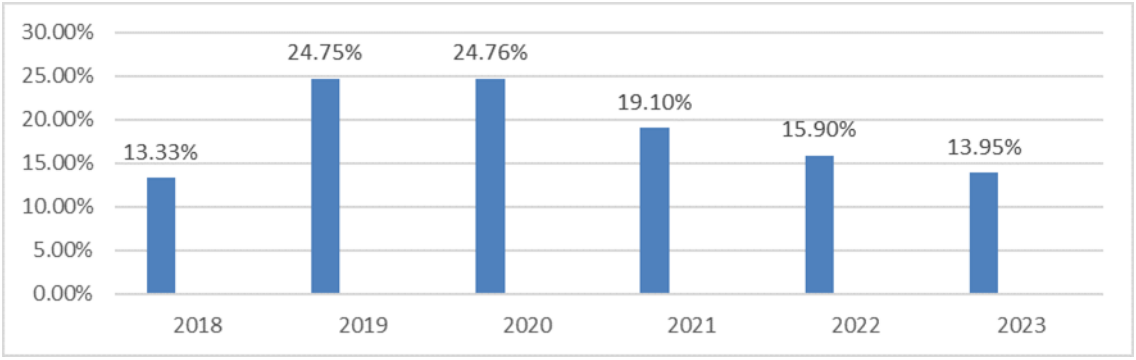

Figure 3. The share of the rural population in employment in the Sheki-Zagatala econ. region from 2018 to 2023 (%)

Şekil 3. 2018-2023 yılları arasında Şeki-Zagatala ekonomik bölgesinde kırsal nüfusun istihdamdaki payı (%)

As shown in the graph, there has been a notable increase in the percentage of the rural population involved in cocoon production across the administrative units of the Sheki-Zagatala economic region, rising from 13.33% in 2018 to 24.76% in 2023. This trend highlights the potential for further development of cocoon production in the region. Engaging a larger segment of the rural workforce in this industry could lead to substantial growth and higher employment rates.

In the next phase of research, expanding mulberry orchards is crucial, as they provide essential raw materials for silkworm cultivation, which is one of the key components of cocoon production. Since 2016, the government has been implementing intensive initiatives to establish new mulberry orchards, utilizing saplings imported from the People's Republic of China. Relevant statistical data are detailed in Table 5.

Table 5. Information on the number of existing and planted mulberry seedlings

Çizelge 5. Mevcut ve dikilen dut fidanlarının sayılarına ilişkin bilgiler

No	Adminstrative districts	The number of mulberry seedlings that existed in 2016	The number of seedlings planted in 2016-2021, no										The number of locally produced mulberry seedlings distributed in 2022, numbers.	Number of mulberry seedlings distributed in 2016-2022 , numbers.
			Also											
			2016		2017		2018		2019		2020	2021		
			Mulberry seedlings imported from China	Native mulberry seedlings	Mulberry seedlings imported from China	Native mulberry seedlings	Mulberry seedlings imported from China	Native mulberry seedlings	Mulberry seedlings imported from China	Native mulberry seedlings	Native mulberry seedlings	Native mulberry seedlings		
1.	Balaken	14095	76000	14215	80000	59500	70000	130000	50000	3620	25530	15000	25000	548505
2.	Qakh	9700	25000	10200	60000	63200	55000	53100	25000	39000	28235	175000	10000	386235
3.	Qabala	15000	20000	5900	40000	1000	50000	80000	10000	15000	25023	9500	10000	266423
4.	Oghuz	3000	28000	3230	25000	28000	10000	35000	20000	9500	9400	5500	10000	183630
5.	Sheki	108250	25000	42670	67000	73400	70000	105000	40000	29960	63424	20000	68100	604554
6.	Zagatala	20000	133000	13920	80000	49000	70000	130000	50000	31130	35800	47300	30000	670150

Source*:* The table was compiled by the author using official report data approved by the Ministry of Agriculture.

As shown in the table, the area of mulberry plantations in each administrative territorial unit of the Sheki-Zagatala economic region has expanded through the use of both local and imported saplings from China between 2016 and 2021, which have been utilized for feeding silkworms. However, our calculations and analysis of the results indicate that the number of planted mulberry saplings and the area of mulberry plantations are limited both across the economic region and within individual administrative units, highlighting a significant need to expand the raw material base. Additionally, it should be noted that there are currently mulberry plantations covering an area of 280 hectares, consisting of 2,659,340 local and imported saplings in the Sheki-Zagatala economic region. Considering the personal gardens of entrepreneurs, farmers, and residents that include mulberry tree saplings on their private land, we can conclude that the total area of mulberry plantations in the region is approximately 350-400 hectares.

As one of the significant clusters for cocoon production, the creation of productive mulberry silkworm breeds and hybrids suitable for the region's soil and climate conditions, as well as the organization of initial seed production, is of special importance and remains a priority of the State Program. Research conducted from 2018 to 2023 indicates that advancements in this field in the country are not satisfactory.

In the "Silkworm Breeding" department of the Sheki Regional Scientific Center of ANAS, high-yielding and quality silkworm breeds and hybrids for the region-particularly the Yagub x Chingiz breeds and the Yagub x Chingiz, Chingiz x Yagub hybrids-have been tested under agricultural conditions, and relevant proposals have been made for their widespread application (Əzimova & Bəkirov, 2011). Since 2018, the country has primarily relied on mulberry silk moth seeds imported from the People's Republic of China, which has led to several issues. To address these problems, measures are being implemented at the Qakh Breeding Silk Station for the cultivation and incubation of mulberry silk moth seeds. However, challenges remain in supplying seeds to the country's main sericulture regions. According to statistical data, in 2022, the station produced and distributed 85 kg of silk moth seeds throughout the year, accounting for 3.1–5% of the demand for sericulture in the country.

Another sub-cluster involves products resulting from the silkworm processing: floss (the layer of silk on top of the cocoon) constitutes 2.5%, while the upper part (the portion remaining after the cocoon is opened), middle part (the section that remains unopened), lower part, and pelade together account for 60-65%. Utilizing these products for the production of toys, souvenirs, household items, accessories, and other products can significantly enhance

employment opportunities in this area while also promoting the creation of ecologically clean and safe household products (Veliyeva, 2021).

One of the important clusters in silkworm farming is the mulberry leaves used for feeding silkworms in Azerbaijan, making the establishment of a feed base a priority. For this reason, state programs have planned the establishment of seedling farms and new mulberry orchards using local mulberry saplings. Since 2016, activities in this field have begun to develop in Azerbaijan, primarily utilizing local mulberry saplings and, to some extent, those imported from China to create new mulberry orchards. Research conducted by specialists has shown that the yield of leaves, cocoon output, and silk percentage vary depending on the variety of mulberry saplings. These results are presented in Table 6 below.

Table 6. Chemical composition of leaves of tested varieties, %

Çizelge 6. Test edilen çeşitlerin yapraklarının kimyasal bileşimi, %

Varieties	Initial Moisture	Hygroscopic Moisture	In the air, on a dry leaf							
			Total Nitrogen (%)	Crude Protein (%)	Fat (%)	Crude Ash (%)	Cellulose (Fiber Material)	Nitrogen-Free Extractive Substances	Total Water Content	Dry Matter (%)
Yunis mulb.	69.33	9.00	3.54	22.13	4.3	8.27	10.31	49.88	72.05	27.95
Khanlar mulb. (control)	72.50	9.92	3.52	21.98	4.2	11.13	9.50	47.38	75.21	24.79

As shown in the table (Sadikhov, & Alakbarova, 2008), the yield indicators for mulberry production in the Khanlar variety are 123.1 s/ha, with mulberry production at 1118.9 kg/ha and silk yield at 173.6 kg/ha, respectively. Notably, these indicators are higher for the 'Azeri' variety, distinguishing it from others. Given that the indicators for other varieties are lower, it is advisable to use both the 'Azeri' and 'Khanlar' varieties when establishing new mulberry orchards. Additionally, the chemical and biochemical composition of the leaves from mulberry varieties used in feeding, which plays a significant role in sericulture, is particularly important.

Considering this, it is recommended to utilize local mulberry varieties for new plantations. Researcher E. Sadigov studied the chemical composition of the "Yunis" and "Khanlar" mulberry varieties and found that their leaves contain 22.13% and 21.98% crude protein, 4.3% and 4.2% fat, and 10.31% and 9.50% fiber, respectively (Sadikhov, 2015).

Table 7. In Azerbaijan, forage selection varieties, chemical composition of leaves, %

Çizelge 7. Azerbaycan'da yem çeşitleri, yaprakların kimyasal bileşimi, %

Variety Name	Leaf Yield		Cocoon Yield		Silk Output	
	s/ha	%	kh/ha	%	kq/ha	%
Jır mulb.	36.0	100.0	304.0	100	49.0	100
Zarif mulb.	51.5	143.1	457.8	150.5	79.3	161.8
Sıkhgoz mulb.	67.1	186.4	510.0	167.8	87.0	177.5
Azeri mulb.	106.0	294.4	911.0	299.7	95.7	195.3
Khanlar mulb.	123.1	341.9	1118.9	368.0	173.6	353.1

Research conducted by the staff of the Sheki Regional Scientific Centre has determined that, although the leaves of mulberry varieties brought from China exhibit high productivity in the experimental field of the Sheki RSC, their chemical and biochemical indicators differ from those of local mulberry varieties. For example, the leaves of the F-892 variety imported from China contain 9.81% crude protein, 7.0% sugars, and 66.0% water. In contrast, these indicators for local varieties are 13.78%-21.58% for crude protein, 9-10% for sugars, and 70-74% for water

(Shukurova et al., 2022).

One of the important aspects of sericulture is ensuring the efficient and ecological use of waste generated during the silkworm breeding process. The feces and by-products produced in the sericulture sub-clusters are used as bioactive additives in the agricultural sector. Research shows that one box (19 g) of silkworms produces 20-25 kg of feces within a month. According to our calculations, when 2000 tons of silkworms are produced in the district and 6000 tons nationwide, the resulting feces will be 800 tons in the district and 2400 tons nationwide.

Studies have shown that the feces of the mulberry silkworm (*Bombyx mori* L.) contain macro- and microelements essential for the organism's life, as well as biologically active substances (Goldsmith & Shimada, 2007). The organization of production in this sub-cluster can play a significant role not only in increasing the use of bioactive additives in the cultivation of fruits, vegetables, and agricultural products in the district's farms and private gardens, but also in improving the provision of ecologically clean food products and expanding employment opportunities.

The results show that the yield and biochemical composition of leaves from different mulberry varieties vary. This difference affects the productivity of the silkworms and the silk yield, enhancing the physical, mechanical, and technological properties of the produced silk fiber (Shukurova et al., 2022). A significant subgroup of sericulture involves the utilization of feces obtained from silkworm breeding, which are typically discarded as waste. Feces is a valuable fertilizer for the production of ecologically clean agricultural products and plays an important role in the preparation of bioactive additives. Research conducted by foreign experts has confirmed that the feces contains high levels of nitrogen, phosphorus, potassium, and other microelements. These microelements give the feces valuable fertilizing properties, enhance soil fertility, improve its structure, and increase both productivity and quality.

Furthermore, silkworm feces can be used to prepare bioactive additives with antioxidant, antimicrobial, antifungal, and antiviral effects, and it can also serve as a key biomaterial for therapeutic purposes. These properties present promising prospects for its wide application in the medical and biotechnological industries. The use of silkworm feces in this sub-cluster can help generate additional income through the production of fertilizers, bioactive additives, and other biotechnological products, and it can significantly increase employment opportunities for the population. Efficient use of this waste raw material is possible (Goldsmith & Shimada, 2007).

The most important cluster of sericulture involves the processing of cocoons and the production of silk thread. Currently, this activity is carried out solely at 'Sheki Silk JSC' in the country, where 2,000 workers are employed year-round. One of the significant subclusters of sericulture is the organization of disinfection and preventive services. These services are currently provided by special groups established by the state. Furthermore, considering the potential for producing food supplements from waste pupae based on foreign experiences, this field of economic specialization could create additional employment opportunities. Silkworm pupae, a byproduct of sericulture that is underutilized in Azerbaijan, represent 60-65% of the total yield. From 2,000 tons of silkworm cocoons, around 1,300 tons of pupae can be expected. Leveraging these two waste products-pupae and feces-could foster the growth of supportive production sectors in the region, promoting both efficient and ecological practices. This initiative would create vital subclusters to supply the community with environmentally friendly food and medicinal products, significantly contributing to sustainable development and enhancing job opportunities for residents.

One of the innovative subclusters of sericulture is the production of biocomposite materials, which is currently very relevant and has extensive potential applications in biomedicine. For this purpose, scientists and researchers at the Sheki Regional Scientific Center have modified protein materials obtained from natural silk using plant-based, high-antioxidant bio extracts, resulting in biocomposites with antioxidant and antibacterial activity, as well as high physical and mechanical properties, which have been patented (Atayeva et al., 2022; 2024).

Additionally, there are opportunities to organize production in this field by utilizing waste products generated during the processes of silkworm cocoon production and processing as raw materials. Based on the research results, it is proposed to present sericulture and cocoon production, which are not currently recognized as a tourism cluster

in Azerbaijan, as an agro-tourism cluster. One of the subclusters of this cluster will involve monitoring the growth and development dynamics of the mulberry silkworm from its initial feeding stage through all life stages, ultimately showcasing the process of silk cocooning to tourists. This will include demonstrations of traditional methods for unraveling the cocoon, twisting the silk thread, and winding it onto spools, allowing tourists to gain insights into the stages of the mulberry silkworm's life cycle from beginning to end.

In another sub-cluster, the process of creating silk fabrics and traditional head coverings, such as kalagays, as well as women's and men's clothing, scarves, and other tourism products will be presented using handlooms made from silk thread. This will provide tourists and guests with the opportunity to familiarize themselves with the craft heritage while also promoting the development of sericulture and cocoon production, thereby ensuring additional employment for the local population.

In conclusion, the results of the conducted scientific research indicate that the main critical issues currently existing in the silkworm farming and sericulture sector of the Sheki-Zagatala economic region are as follows:

1. Increasing agricultural areas and expanding the raw material base by restoring and reconstructing existing orchards and utilizing productive mulberry trees.
2. Developing silkworm seed production, creating and implementing new productive silkworm breeds and hybrids.
3. Organizing cocoon production and the silk industry based on modern technologies in sericulture regions and establishing agro-parks.
4. Strengthening state support for the development of cocoon production and other related fields to improve the living conditions of the population in sericulture areas, create new job opportunities, and ensure the employment of rural residents.
5. The failure to apply logistic clustering in accordance with the paradigm of the development of cocoon production and sericulture in the country and the region, as well as the absence of a unified marketing strategy in these areas.

To accelerate progress in solving the identified problems and enhance efficiency, clusters, subgroups, and relevant logistics services adapted to existing conditions have been identified within the framework of logistical services for cocoon production and sericulture in the following key areas. Recognizing the importance of clustering in services dedicated to the development of cocoon production and sericulture, it is essential to develop a unified conceptual model that contributes to various economic sectors, fosters interaction and cooperation, and promotes sustainable development at every stage of cocoon production.

I. **Silkworm Breeding and Cocoon Production**

- *Seed Preparation*
- *Silkworm Incubation*
- *Silkworm Feeding*
- *Preparation of Branches for Cocoon Spinning*
- *Cocoon Harvesting*

II. **Processing of Silkworm Cocoons**

- *Stifling of Cocoons*
- *Reeling of Cocoons and Production of Silk Thread*
- *Collection of Waste (Floss, Coarse Cocoons, Defective Cocoons, Pupae)*

III. **Production of Silk Products**

- *Silk Fabrics*

- *Men's and Women's Clothing*
- *Silk Carpets*
- *Accessories (Head Coverings, Shawls, Bed Linens, Scarves, etc.)*
- *Silk Thread Craft Products (Embroidery, Weaving)*

IV. **Efficient Use of Silk and Silkworm Waste**
- *Fertilizer production from silkworm waste*
- *Production of biologically active substances and applications in biomedicine*
- *Preparation of food supplements and bioactive compounds from pupae*
- *Creative use of silk waste in artisanal and souvenir products*

V. **Creation of a Feed Base**
- *Development of farms to support feed base for silkworms*
- *Development of high-yield seed varieties*
- *Research into high-yield mulberry tree varieties*
- *Increasing mulberry plantation areas for better feed supply*
- *Organization of Agronomic Services in mulberry tree fields*
- *Integration of technology and research into large agro-parks*

VI. **Education on Prevention and Disinfection**
- *Ensuring biosecurity and disease prevention in farms*
- *Advisory services for best practices in sericulture*

VII. **Development of Biotechnological Tools**
- *Preparation of biocomposite materials from silk fibroin*
- *Production of biomedicines and biotechnological tools using fecal matter*

VIII. **Silkworm Breeding and Agrotourism Cluster**
- *Transforming silk culture into tourism attractions*
- *Promoting cultural heritage through agrotourism*
- *Making silk centers accessible to tourists*

As a result of the extensive research, calculations, and analyses we conducted, the following conclusions have been drawn regarding the current state of sericulture and cocoon production (*Bombyx mori L*.) in the Shaki-Zagatala economic region for the years 2018-2023:

1. The dynamics of total fresh cocoon production across Azerbaijan during the period from 2018 to 2023 have been unsatisfactory. In the Shaki-Zagatala economic region, fresh cocoon production fluctuated between 26.0% and 32.0%, constituting a significant share of the country's overall output.
2. The following changes in fresh cocoon production were observed in individual administrative districts of the Shaki-Zagatala economic region during 2018-2023: in the Shaki district, it ranged from 4.0% to 9.3%; in the Balaken district, from 5.8% to 8.6%; in the Zagatala district, from 6.7% to 9.3%; in the Gakh district, from 2.8% to 4.9%; in the Oghuz district, from 0.7% to 1.8%; and in the Gabala district, from 1.5% to 3.7%.
3. The economic calculations reflecting the employment indicators of rural populations engaged in cocoon production in the Shaki-Zagatala economic region for the years 2018–2023 show that 13.3% of the rural population was involved in cocoon production in 2018, 21.75% in 2019, 24.76% in 2020, 19.1% in 2021,

15.9% in 2022, and 13.95% in 2023.

4. The percentage of rural populations involved in cocoon production across different administrative divisions of the economic region from 2018 to 2023 varied as follows: in the Shaki district, it ranged from 1.7% to 3.8%; in the Balaken district, from 1.2% to 3.2%; in the Zagatala district, from 2.0% to 4.6%; in the Gakh district, from 3.0% to 5.0%; in the Oghuz district, from 2.4% to 6.0%; and in the Gabala district, from 1.03% to 2.06%.
5. The area of mulberry plantations available in the districts engaged in cocoon production within the economic region and across the country is insufficient for cultivating high-quality silkworms. In the coming years, the area of mulberry plantations must be significantly expanded to make progress in sericulture.
6. The analysis of the results and data obtained from cocoon production between 2018 and 2023 across the country, along with economic analyses and calculations, indicates that Azerbaijan possesses all the necessary opportunities and resources to strengthen and develop this sector.
7. Initially, essential measures should be taken to improve seed production in silkworm breeding. Calculations indicate that the Qakh Breeding Silk Station currently produces silkworm seeds that meet only 3.1% to 5% of the country's total demand. This not only increases dependency on imports but also raises the production costs of the final product.
8. As a result of numerous studies and analyses, clusters and subclusters of cocoon production and sericulture have been identified. Based on these findings, a logistics model for cocoon production and sericulture has been developed.
9. The implementation of the proposed model in the country will significantly contribute to the development of sericulture and silk production. It will facilitate the creation of micro, small, and medium-sized enterprises within subclusters and clusters, leading to the production of high-quality, export-oriented products from fresh cocoons and silk. This will increase employment levels in these sectors both regionally and nationwide, ultimately improving the overall economic situation.
10. Utilizing the waste generated in sericulture and cocoon production as raw material will pave the way for the production of additional products, such as biologically active substances, fertilizers, preventive agents, disinfectants, flavor enhancers, biocomposite materials, and other biotechnological products. This will ensure the efficient and environmentally friendly utilization of waste, contributing to the formation of a closed-loop system in these sectors.
11. Positioning sericulture and cocoon production centers in the region as part of an agrotourism cluster will promote them as tourist attractions. Providing school students, university students, tourists, and enthusiasts with the opportunity to observe various stages of cocoon production and actively participate in the silk-making process can make these centers more appealing. Organizing interactive training sessions and master classes at these centers not only helps preserve cultural heritage but also promotes tourism.
12. The monomorphic logistics model applied for the efficient allocation of resources, minimizing inefficiency, organizing production processes more efficiently, reducing costs, and improving product quality is a new approach in the fields of sericulture and cocoon production. This model simultaneously ensures both competition and cooperation among small and medium-sized business entities.

STATEMENT OF CONFLICT OF INTEREST

The authors of the article declare that there is no conflict of interest among them. This study is part of the doctoral thesis of the first (corresponding) author.

AUTHOR'S CONTRIBUTIONS

The authors declare that they have contributed equally to the study.

STATEMENT OF ETHICS CONSENT

Ethical approval is not applicable, because this article does not contain any studies with human or animal subjects.

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