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Araştırma Makalesi

Discovering Sericulture Clusters Through the Use of Local Indicators of Spatial Association (LISA)

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ABSTRACT

The aim of this study is to analyze the spatial pattern of sericulture in Türkiye with spatial analysis approaches, taking into account the data of 81 provinces, by creating a database based on Geographic Information Systems (GIS). This study employed data from the TURKSTAT, which included the amount of fresh cocoon produced and the silkworm egg boxes opened, between 2004-2022. In order to evaluate the relationship between the cocoon yield in each province and the cocoon yield in neighboring provinces, Moran's I measurements were made for the relevant time periods, and each period's Moran's I scatter plot was created. The Local Spatial Association Indicator (LISA) was used to assess the spatial structure of fresh cocoon yield. There was determined spatial clustering and a positive spatial association for cocoon yield, and all of the Moran's I values were found to be more than 0. The LISA maps were demonstrated the distinct local clustering patterns in the cocoon yield. More local clusters were identified (High-High or Low-Low) compared to local spatial outliers (High-Low or Low-High). High-High clusters were generally identified in the Marmara Region. Important implications have been obtained in terms of sustainability, such as how to take advantage of hotspot spillover effects and prioritize hotspot locations when allocating resources. As a result, spatial relations should be taken into account in the policies to be developed for sericulture and more activities should be carried out on sericulture.

Key words: Cocoon yield, LISA, Moran's I, Silkworm, Spatial Analysis.

Mekânsal İlişkilendirmenin Yerel Göstergelerini (LISA) Kullanarak İpek Böcekçiliği Kümelenmelerini Keşfetmek

ÖZ

Bu çalışmanın amacı, Coğrafi Bilgi Sistemlerine (CBS) dayalı bir veri tabanı oluşturarak, Türkiye'deki ipek böcekçiliğinin mekânsal yapısını, 81 ilin verileri dikkate alınarak mekânsal analiz yaklaşımlarıyla analiz etmektir. Bu çalışmada 2004-2022 yılları arasında üretilen yaş koza miktarı ve açılan kutu sayısını içeren TÜİK verileri kullanılmıştır. Her ildeki koza verimi ile komşu illerdeki koza verimi arasındaki ilişkinin değerlendirilmesi amacıyla ilgili zaman dilimleri için Moran's I ölçümleri yapılmış ve her döneme ait Moran's I dağılım grafiği oluşturulmuştur. Yaş koza veriminin mekânsal yapısını değerlendirmek için Yerel Mekânsal İlişki Göstergesi (LISA) kullanılmıştır. Koza verimi için mekânsal kümelenme ve pozitif mekânsal ilişki belirlenmiş olup, Moran's I değerlerinin tamamı 0'dan büyük bulunmuştur. LISA haritaları koza verimindeki farklı yerel kümelenme modellerini göstermiştir. Yerel mekansal aykırı değerlere (Yüksek-Düşük veya Düşük-Yüksek) kıyasla daha fazla yerel küme (Yüksek-Yüksek veya Düşük-Düşük) belirlenmiştir. Yüksek-Yüksek kümeler genel olarak Marmara Bölgesi'nde tespit edilmiştir. Sıcak nokta yayılım etkilerinden nasıl yararlanılacağı ve kaynaklar tahsis edilirken sıcak nokta konumlarının nasıl önceliklendirileceği gibi sürdürülebilirlik açısından önemli çıkarımlar elde edilmiştir. Sonuç olarak ipekböcekçiliğine yönelik geliştirilecek politikalarda mekânsal ilişkiler dikkate alınmalı ve ipekböcekçiliği konusunda daha fazla faaliyet yürütülmelidir.

Anahtar kelimeler: Koza verimi, LISA, Moran's I, İpek böceği, Mekânsal analiz.

INTRODUCTION

Sericulture is an endeavor that includes all stages from growing mulberries, which are the sole food source of silk, to obtaining raw silk. Although sericulture is considered as an auxiliary branch of agriculture, it is actually a profession and art in itself (Davulcu, 2018). The silkworm belongs to the Bombycidae family (Bombyx mori) and was first discovered in China around 2600 BC. The silkworm produces silk, which is an important and expensive textile industry raw material (Başkaya, 2013; Camuz and Gül, 2022). According to the information obtained from the oldest sources, it was not allowed to leave the borders of China, but it was able to enter Anatolia in 552 AD (Başkaya, 2013). Raw silk obtained from silkworm cocoon; it is used in different areas such as silk fabric, silk carpet, surgical rope, parachute rope, souvenirs and military steel vest manufacturing (Başkaya, 2013; Davulcu, 2018; Güler, 2021).

Today, silkworm farming is practiced in nearly 60 countries in the world, especially in the Far Eastern countries of China, India and Japan. According to FAO's data, China ranks first in fresh cocoon production, and India ranks second. In recent years, sericulture and related industries have begun to be established in Brazil, Bulgaria, Egypt and Madagascar. Although silkworm breeding is generally carried out as an auxiliary agricultural activity, it plays a crucial role in the employment of the rural population and is very useful in preventing migration to cities (ISC, 2020; Yakişan and Yılmaz, 2022).

Türkiye is one of the countries whose climate is suitable for mulberry tree and silkworm cultivation. Sericulture can be done wherever mulberry trees grow. The natural conditions of our country have provided our country with an important place in silkworm farming compared to other countries.Silkworm breeding and cocoon production depend on the existence of the mulberry tree. The mulberry tree, which is not sensitive in terms of climate and soil requirements, can easily grow in all parts of our country except very high and cold places (Camuz and Gül, 2022). A box of cocoons can be fed with one ton of mulberry leaves, and approximately 25-30 kg of fresh cocoons can be obtained from a box of silkworms (Tuigong et al., 2015). The decrease in the young population in the villages due to the increase in migration from villages to cities has revealed the lack of labor force. As a result of the destruction of mulberry gardens, cultivation areas decreased and with the decrease in production, the demand for alternative products began to increase (Şahinler and Şahinler, 2002; Başkaya, 2013; Taşkaya Top et al., 2014; Barıtcı et al., 2017). It is very important to ensure the continuity of silkworm breeding. Because ensuring rural development, increasing national income and especially protecting cultural heritage and genetic resources is possible by ensuring breeding sustainability (Taşkaya Top et al., 2014). It is also important because it plays a role in other agricultural activities and employment with low capital investment (Mattigatti et al., 2009; Balasaraswathi et al., 2010; Lakshmanan et al., 2012).

Various academic studies have been carried out in world literature in order to determine the general situation of silkworm farming and to determine its problems (Kumaresan et al., 2008; Başkaya, 2013; Ishtiaque et al., 2013; Li and Tao, 2014; Tuigong et al., 2015; Davulcu, 2018; Güler, 2021; Camuz and Gül, 2022; Yakişan and Yılmaz, 2022). It has been reported that silkworm embryonic development and current environmental conditions should be taken into consideration in cocoon quality parameters such as cocoon weight and silk richness. For this reason, the environment; It has been reported that temperature, humidity, light and air, as well as quality mulberry leaves, genetic structure and growing time affect cocoon quality (Rahmathulla, 2012). In Türkiye, silkworm breeding can be done twice a year in spring and autumn, and when examined from an economic perspective, breeding in the spring season yields more positive results (Şahan, 2011). In addition, factors such as price, feeding place, labor force, leaf supply, climate, natural conditions and environmental pollution may affect fresh cocoon production (Güler, 2021). Due to these factors, sericulture; It varies significantly according to provinces and regions. In line with this information, the aim of this study is to analyze the spatial pattern of sericulture in Türkiye with spatial analysis approaches by creating a database based on Geographical Information Systems (GIS).

MATERIALS and METHODS

Data collection

The number of opened silkworm egg boxes and the amount of fresh cocoons produced at the provincial level used in this study were taken from the Turkish Statistical Institute (TURKSTAT). Fresh cocoon yield was calculated using the silkworm egg boxes opened and the amount of fresh cocoons produced by province.

Spatial analysis

Spatial analysis was performed during the whole study period (2004-2022). Calculated fresh cocoon yield was used to create catographic maps. A database built on Geographic Information Systems (GIS) was made for this purpose. Data from shape files with the.shp extension at the provincial level was used in GIS applications for output mapping and spatial analysis. The WGS 84 EPSG:4326 coordinate reference system was used to define the data. Visualizing of the fresh cocoon yield spatial distribution for all analyzed years was done with the open-source QGIS version 3.18.3 program.

Exploratory Spatial Data Analysis (ESDA)

The present study implemented exploratory spatial data analysis (ESDA) to detect the existence of spatial dependence and variability in fresh cocoon yield throughout the provinces of Türkiye. ESDA analysis was performed using GeoDa software (version 1.8) based on the shape-files. A collection of techniques known as ESDA is used to describe and visualize spatial distribution patterns, identify outliers and clustering, uncover patterns of spatial linkages, and propose spatial structures (Anselin, 1988; Anselin, 1999). Depending on the extent or scale of the investigation, spatial autocorrelation statistics are classified as global or local scales. A well-known statistic for examining spatial autocorrelation and identifying global spatial clustering is Moran's I (Moran, 1948; Moran, 1950). The Moran's I statistic, which measures general clustering, is assessed by testing the null hypothesis, which states that there is no clustering to the spatial pattern. The Global Moran's I statistic can be expressed as follows:

$$I = \frac{n}{\sum_{i=1}^{n}(x_i-\bar{x})^2} X \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(x_i-\bar{x})(x_j-\bar{x})}{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}} \quad (1)$$

where w_{ij} is the queen contiguity matrix, x_i , x_j calculated fresh cocoon yield at province i and j, $\bar{x}$ is the average calculated fresh cocoon yield in the nation, I is global spatial autocorrelation statistics.

Spatial autocorrelation cannot exist if the spatial distribution is entirely random. A nonrandom spatial pattern known as spatial autocorrelation appears when the null hypothesis is rejected. Values for Moran statistics range from -1 to 1. There isn't any spatial autocorrelation if this statistic is 0. Perfect positive autocorrelation occurs when this statistic is +1, and perfect negative autocorrelation occurs when this statistic is -1. In the present study, positive spatial autocorrelation is observed when provinces exhibiting parallel fresh cocoon yield likely to be situated adjacent to one another. Conversely, negative spatial autocorrelation is observed when provinces with dissimilar fresh cocoon yields occur side by side (Anselin, 1996; Anselin, 1999).

The Local Spatial Association Indicator (LISA) was used to assess the spatial structure of fresh cocoon yield. High-High, Low-Low (Clusters) and High-Low, Low-High (Outliers) cities were identified. Statistical evaluations were made using the Monte Carlo permutation method and 95% confidence interval. The Local Moran's I statistic can be expressed as follows:

$$I_i = n \times \frac{x_i \sum_{j=1}^{n} w_{ij}(x_j-\bar{x})}{\sum_{j=1}^{n}(x_j-\bar{x})^2} \quad (2)$$

where I_i is local spatial autocorrelation statistics. LISA maps with information on the significance of local spatial patterns were created. High-High, which is depicted in red, shows high-value areas encircled by the high value cluster areas. Low-Low, which is depicted in dark blue, shows low-value areas encircled by the low-value cluster areas. High-Low, which is depicted in pink, shows high-value areas encircled by low-value areas. Low-High, which is depicted in light blue, shows low-value areas encircled by high-value areas (Anselin, 1988; Anselin, 2003).

RESULTS and DISCUSSION

In the present study, the historical evaluation of sericulture between 2004 and 2022 was examined with spatial analysis methods. This study highlights several implications. One of its most important highlights is the integration of the most up-to-date data calculated on cocoon yield in Türkiye. Another important point is that the whole of Türkiye was taken into account in this study. It is feasible to obtain more precise and dependable results with a wider perspective on a national scale as opposed to a global one by employing data at the province level. Also, keeping the time period wide is an extra important issue. Studies conducted generally consist of research conducted in a limited time or region. The catographic and clustering maps obtained in this study may provide more important input for subsequent initiatives.

Sericulture variable data for years are given in Table 1. Depending on the ratio of fresh cocoon production (kg) to opened silkworm egg boxes for each province, different colors are shaded on the maps. Six levels were used to evaluate cocoon yield. Classification was made using natural breaks classification (Figure 1 a and b). The number of provinces where seed distribution is made has increased in Türkiye. Similarly, the number of provinces with production has also increased, although there has been fluctuation (Table 1).

Table 1. The number of silkworm egg boxes opened, the amount of fresh cocoon produced, the cocoon yield by years, the number of provinces with production and the number of provinces where seeds were distributed (boxes) (2004-2022).

Year	The amount of fresh cocoon produced (kg)	The number of silkworm egg boxes opened	The cocoon yield (%)	The number of provinces where seeds were distirubuted	The number of provinces with production
2004	143 408	5 161	27.79	24	18
2005	156 940	5 669	27.68	22	17
2006	127 108	5 699	22.31	22	18
2007	124 661	5 273	23.64	25	16
2008	124 640	5 564	22.40	26	16
2009	136 463	5 683	24.01	28	17
2010	126 315	5 477	23.06	26	20
2011	150 651	5 808	25.94	35	27
2012	133 711	5 576	23.98	29	26
2013	121 481	5 261	23.09	33	24
2014	80 058	3 739	21.41	37	27
2015	114 789	4 674	24.56	37	28
2016	102 840	5 303	19.39	42	35
2017	101 826	5 686	17.91	52	43
2018	93 705	6 238	15.02	58	48
2019	89 616	5 890	15.21	59	51
2020	89 671	5 775	15.53	63	51
2021	76 129	6 029	12.63	60	43
2022	68 517	5 577	12.29	53	41

Silk cocoon production in Türkiye started to decline rapidly after 1990, and decreased by nearly 90% in a short period of 5 years until 1995. Raw silk production has also decreased significantly due to the decrease in cocoon production and factors affecting cocoon production. After 2000, the increase in state support for livestock farming and efforts to prevent the extinction of sericulture have yielded results. In 2005, silk cocoon production and raw silk production increased. In 2010, cocoon production and raw silk production decreased again, and this increase did not continue much. It showed that production is in a downward trend again (Başkaya, 2013). Similarly, in this study, it was determined that production decreased. The reasons for the decrease in production can be listed as follows: poisoning from pesticides; an aging population in the villages and a labor shortage as a result of village to city migration; destruction of mulberry gardens; rapid growth in China; low-cost cocoon production; and the development of substitute products.

In this study, it was determined that production was carried out in a very small number of provinces in the Central Anatolia, Black Sea, Mediterranean and Southeastern Anatolia regions between 2004 and 2010. It was determined that production was mostly done in the western parts of the country, but in the last five years, production was also made in the eastern parts. Diyarbakır province, located in the Southeastern Anatolia Region, has become an important place in terms of productivity in the 2000s, especially after 2015. When the average yield between 2004 and 2022 was evaluated, Ankara, Eskisehir, Bolu, Bilecik, Bursa, Antalya and Diyarbakır were determined as the provinces with the highest yield (Figure 1 a and b). Başkaya (2013) stated in his study that the provinces where the highest silk cocoon production is made are Diyarbakır, Antalya and Bilecik, followed by Ankara, Sakarya, Bolu and Eskişehir.

In order to evaluate the relationship between the cocoon yield in each province and the cocoon yield in neighboring provinces, Moran's I measurements were made for the relevant time periods, and each period's Moran's I scatter plot was created. All of the Moran's I values were higher than 0, indicating that there was spatially clustering and a positive spatial connection for the cocoon yield (Figure 2). To increase the cocoon productivity, it is crucial to ensure that provinces interact with one another. Local Moran I statistics results have shown that, in addition to Diyarbakır province, which produced the most production during the examined period, many provinces in the Marmara region are provinces that can make significant contributions to sericulture.

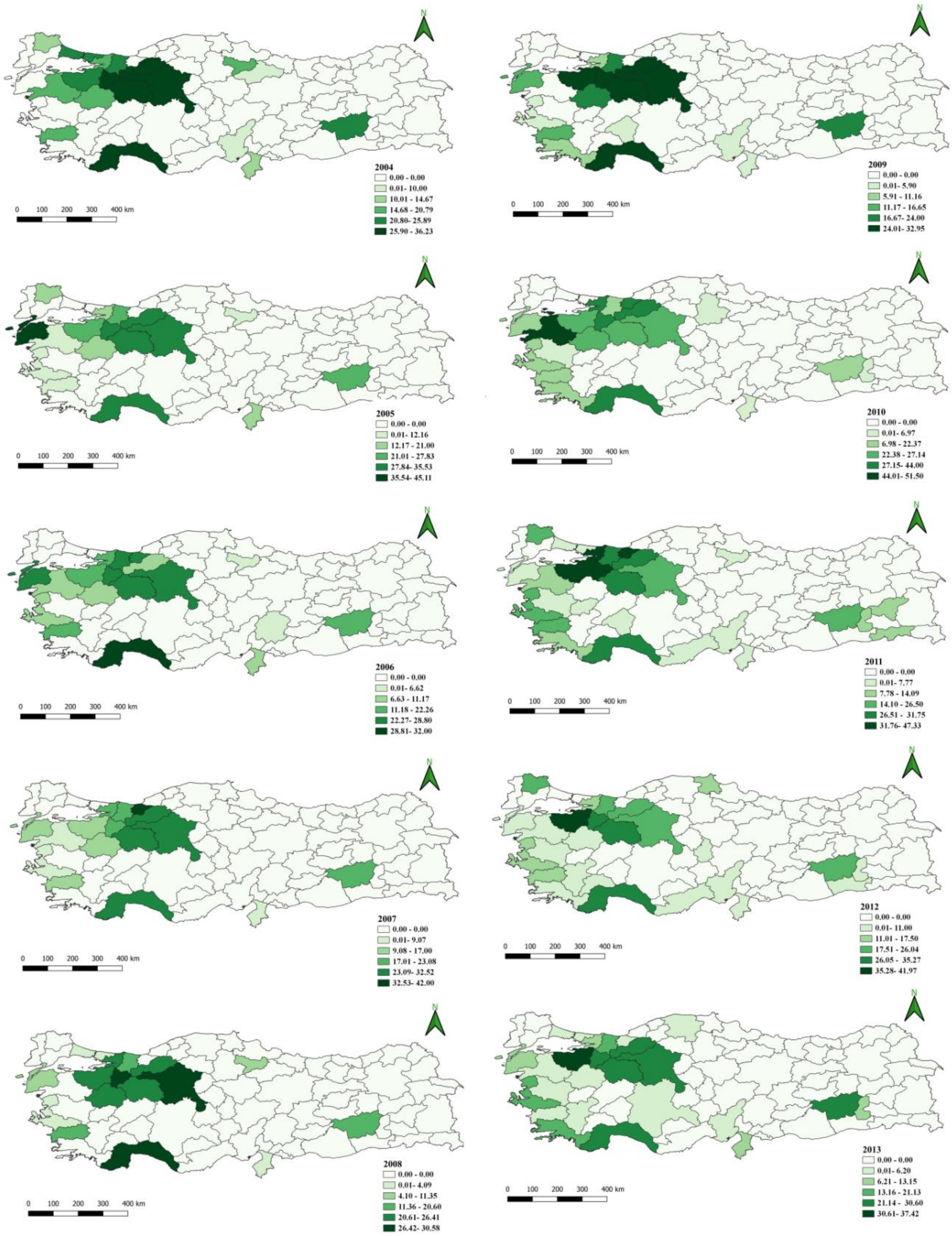

Figure 1a. Distribution of fresh cocoon yield at province level in Türkiye (2004-2022).

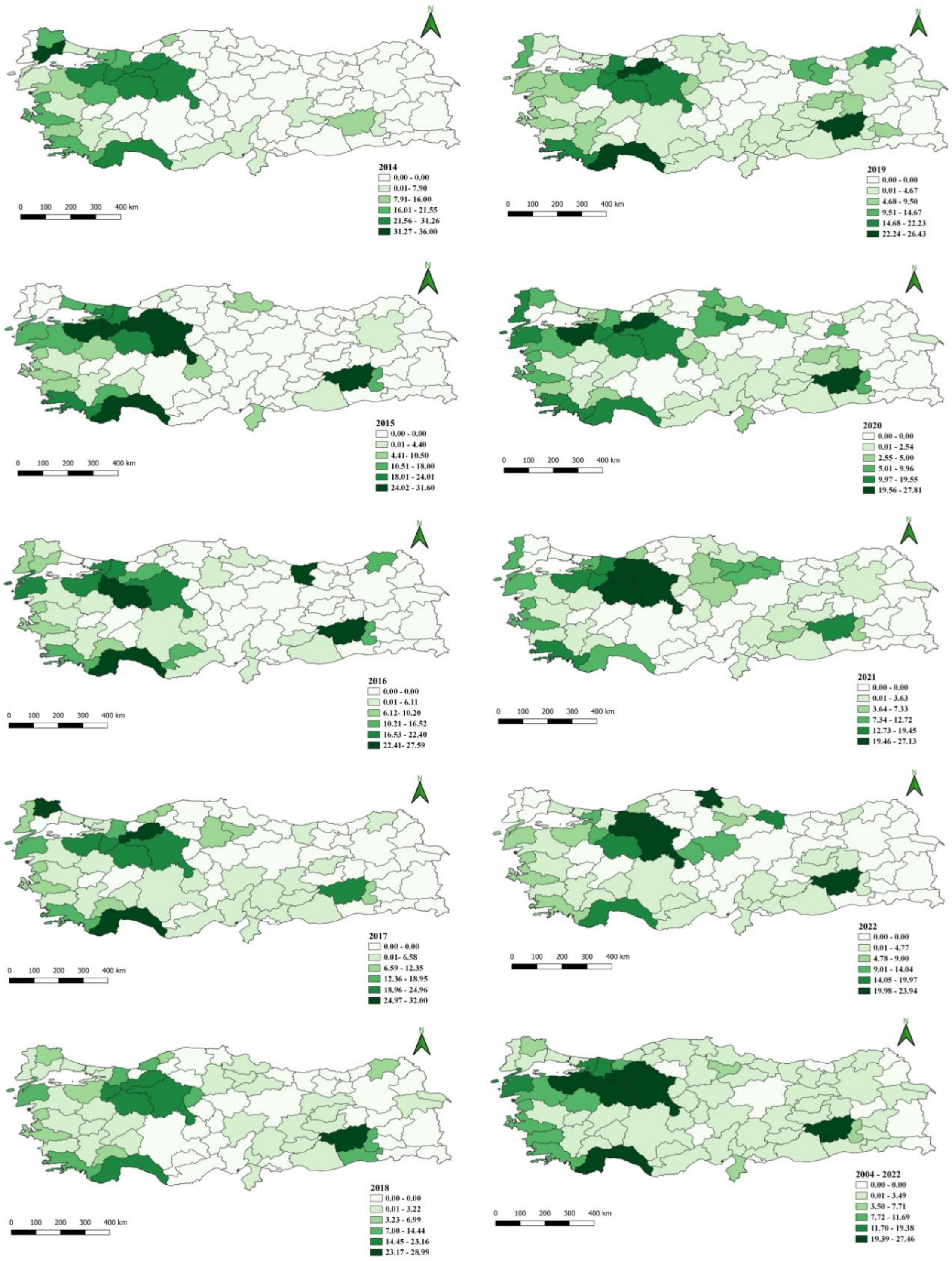

Figure 1b. Distribution of fresh cocoon yield at province level in Türkiye (2004-2022).

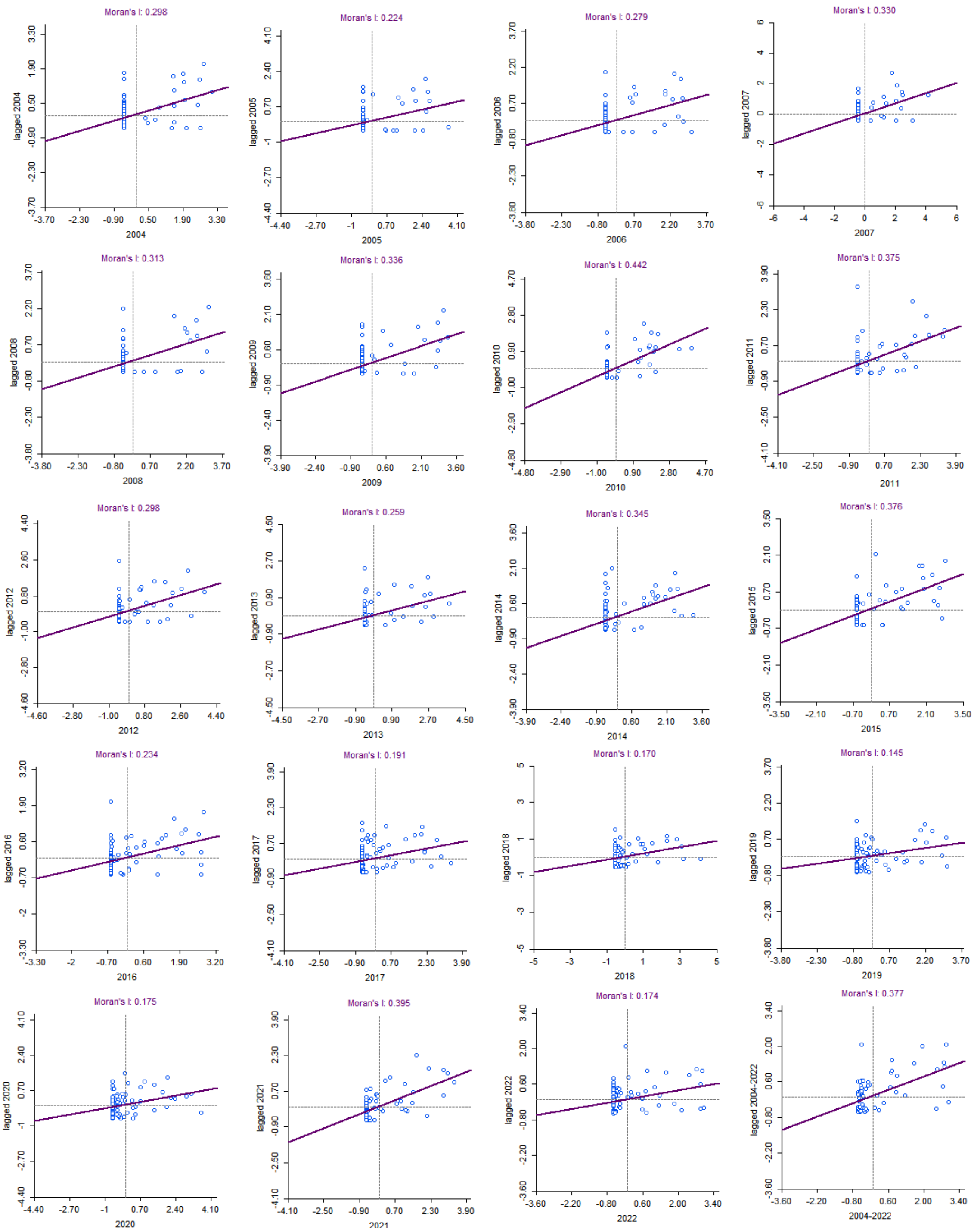

Figure 2. Moran's I scatter plot of fresh cocoon yield in Türkiye (2004-2022).

The LISA maps demonstrate the distinct local clustering patterns in the cocoon yield. In comparison to local spatial outliers (High-Low or Low-High), there are more local clusters (High-High or Low-Low). High-High clusters were generally identified in the Marmara Region. High-High clusters were not observed in Eastern Anatolia, Southeastern Anatolia and the Mediterranean region. Low-Low clusters were seen in all regions except the Marmara and Aegean regions. Generally evaluated, Low-Low clusters were determined in the eastern parts of Türkiye (Figure 3).

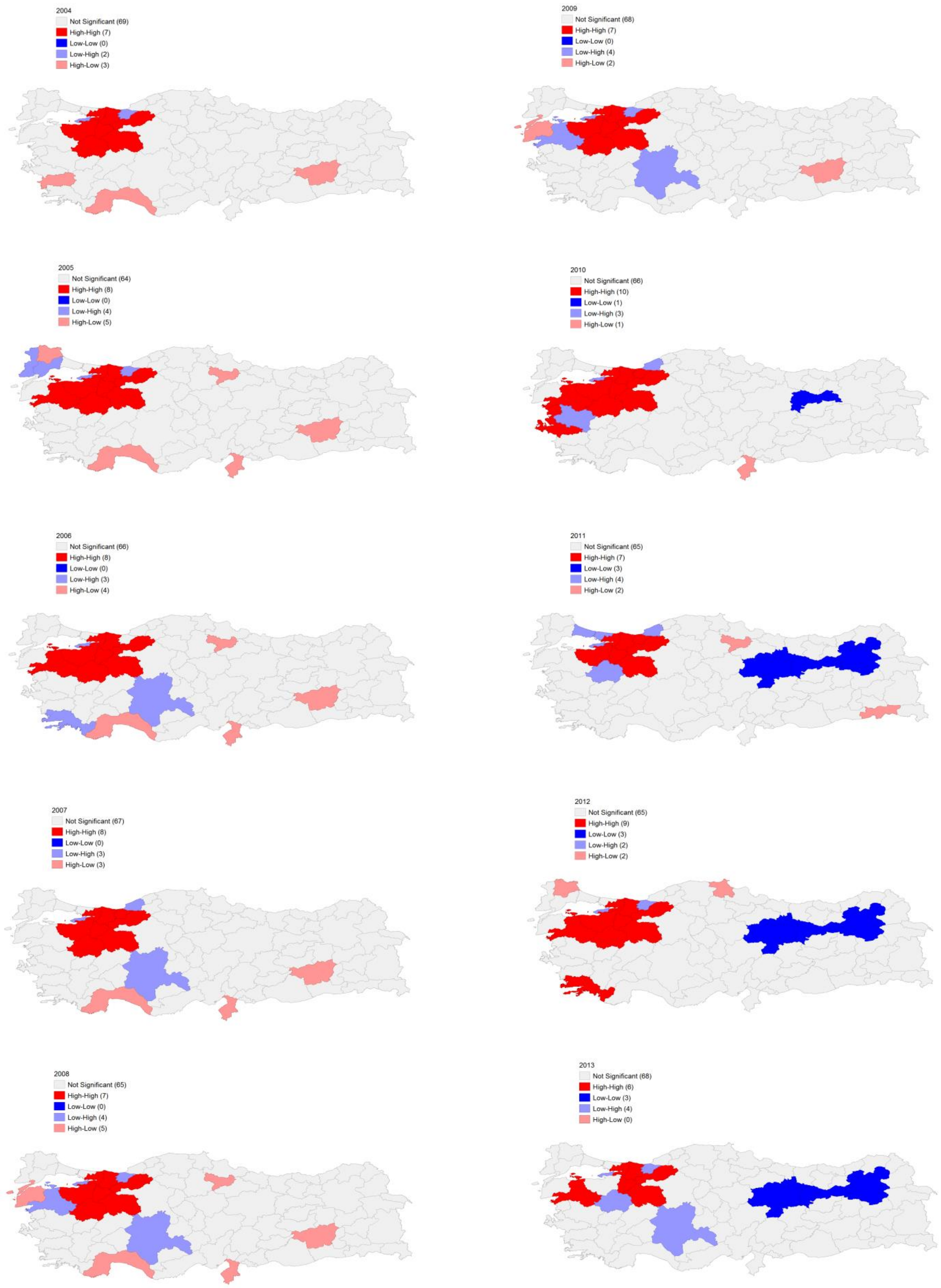

Figure 3. Spatial clustering and outliers of fresh cocoon yield using LISA clustering (95% confidence interval).

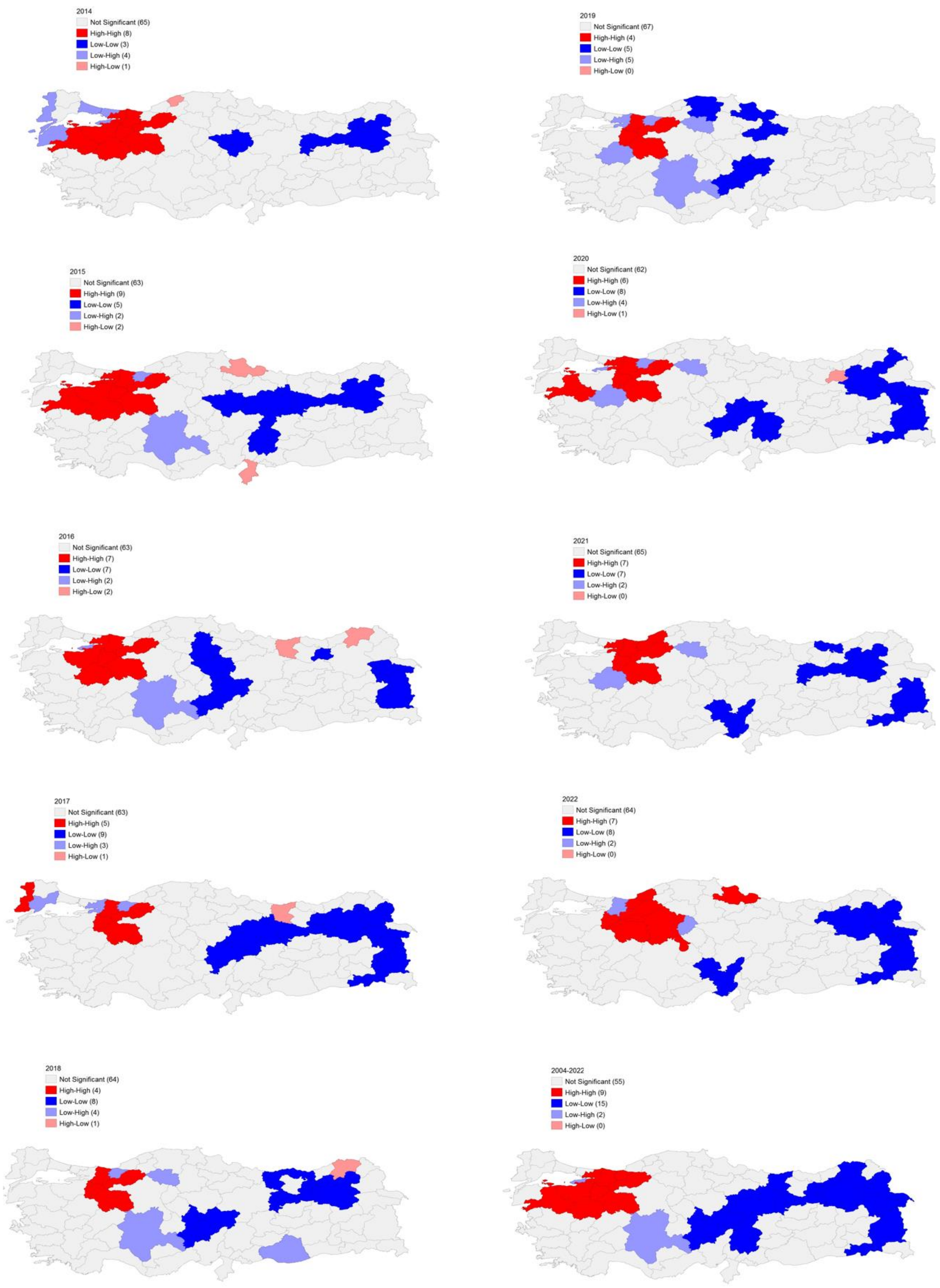

Figure 3. Spatial clustering and outliers of fresh cocoon yield using LISA clustering (95% confidence interval).

Güler (2021) stated in his research that the region that contributed the most to sericulture was the provinces of Şanlıurfa and Diyarbakır, but the contribution to sericulture came largely from the province of Diyarbakır. LISA clustering results obtained in this study showed that there was no High-High clustering in Diyarbakır province. The reason for this is that production is low or non-existent in the provinces neighboring Diyarbakır. In this case, it only confirms the effectiveness of Diyarbakır province. Similarly, the low productivity in the neighboring provinces of Antalya province, which has an important place, did not create a High-High cluster in this area. But, a positive spatial correlation was identified for cocoon yield. In this context, many benefits can be obtained from these regions by increasing the activities in the neighbors of Diyarbakır and Antalya.

In 2004, fresh cocoon production ranked first in Diyarbakır province. The reason for the rapid increase in production in Diyarbakır province is the implementation of the Sericulture Breeding Project. The aim of this project is to prevent the migration and unemployment of people in rural areas, especially the Kulp district, from villages to cities, to revitalize sericulture and to create alternative sources of income. With the implementation of the project, cocoon production began to increase rapidly in Diyarbakır province in 2003. Where sericulture and silk cocoon production has been constantly increasing since this year, silk cocoon production in 2011 exceeded 50 thousand kg and reached 52,600 kg (Başkaya, 2013). Thus, reverse migration from cities to villages took place during the wet cocoon production periods in the region, and alternative income opportunities were provided, especially with the participation of women in production (Barıtcı et al., 2017; Güler, 2021). The findings obtained in this study showed that Diyarbakır is an important center in sericulture and that the region can be more effective by increasing production in the surrounding provinces.

In the Marmara Region, where sericulture is most intense, industrialization and the construction brought about by this industrialization, unconscious and excessive use of pesticides may have negatively affected sericulture. However, the findings obtained in this study showed that although there was a decrease in the Marmara Region, sericulture has an important place.

CONCLUSIONS and RECOMMENDATIONS

This study, was investigated the spatial relationships of cocoon yield at the province level in Türkiye in the periods of 2004-2022. With these analysis emphasized that how crucial spatial analysis are to agricultural research. The outputs of the amount of fresh cocoon produced (kg) and the number of silkworm egg boxes opened in 81 provinces of Türkiye were used as an indication to look into the spatial correlations of cocoon yield. This study shows positive global spatial autocorrelation with High-High clusters and Low-Low clusters; this suggests that the province with high (or low) cocoon production outputs tends to cluster close to other provinces with high (or low) production. These results show that regions tend to differ in silkworm cultivation. When the spatial distribution of the outputs of all periods is evaluated, the absence of a cluster in eastern Anatolia, southeastern Anatolia and the Mediterranean region can be an important reference for policy making in the management of the silk production sector. In addition, the absence of clusters in Diyarbakır and Antalya, which are important production areas, may also reveal the effectiveness of the LISA statistical technique. By providing more resources to neighboring provinces, these regions can become important production areas.

Silkworm breeding has a significant trade volume in the world. Silkworm farming is an important production area because it prevents unemployment in rural areas, reduces migration from village to city and provides high income in a short time. However, the amount of cocoons obtained from silkworm breeding is decreasing every year. Silkworm farming varies spatially depending on environmental conditions. For this reason, production can be further increased by taking spatial relations into account in the policies to be developed for sericulture and by increasing cooperation with neighboring provinces in provinces with high production. More effective sustainability models can be developed by taking spatial relations into consideration. Therefore, more comprehensive studies need to be conducted that take into account the environmental factors affecting silkworm breeding.

Conflicts of Interest: The author declare that there is no conflict of interest regarding the publication of this article.

Author contributions: Authors declare that they have contributed equally to the article.

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