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Linking Spatial Patterns of Livestock to the Geographical Variances in Turkey

Türkiye'deki Hayvancılık Alanının Mekansal Kalıplarını Coğrafi Varyanslarla Bağlama

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ABSTRACT

The livestock sector is considered as an essential economic source in the economic policies of many developing countries in the world. The present research aims to analyse the spatial association and dependence of livestock in Turkey by using the exploratory spatial data analysis (ESDA) technique. Livestock data of 966 cities from 2004 to 2017 have been used to detect spatial distribution, clusters and hotspot areas of cattle and small ruminants' populations. It has been revealed that livestock production is strongly associated with the natural environmental characteristics of spatial units throughout the country. Spatial autocorrelation has shown the positive values for both cattle and small ruminants, but stronger for the latter. Besides, a change in the clusters of cattle populations has also been observed over the selected period. Apart from the natural environmental factors, several socio-economic issues like rural outmigration, government policies, industrial requirements and regional disparities have also been found responsible for the change in the spatial patterns of livestock. The research provides significant outcomes for better allocation of resources in priority areas to develop the livestock sector. Moreover, it also facilitates pointing out the potential areas of livestock development in the future.

Keywords: Livestock, Spatial Analysis, Turkey

ÖZ

Hayvancılık sektörü, dünyada gelişmekte olan birçok ülkenin ekonomi politikalarında önemli bir ekonomik kaynak olarak kabul edilmektedir. Bu araştırma, Türkiye'de hayvancılığın mekansal ilişkisini ve bağımlılığını araştırmacı mekansal veri analizi (ESDA) tekniği ile analiz etmeyi amaçlamaktadır. 2004'ten 2017'ye kadar 966 şehrin hayvancılık verileri, sığırların ve küçük ruminant popülasyonlarının mekansal dağılımını, kümelerini ve sıcak nokta alanlarını tespit etmek için kullanılmıştır. Bu hayvancılık üretimi güçlü ülke çapında mekansal birimlerin doğal çevre özellikleri ile ilişkili olduğu ortaya çıkmıştır. Mekansal otokorelasyon hem sığırlar hem de küçük geviş geviş ve görenler için olumlu değerler göstermiştir ancak daha sonra için daha güçlüdür. Ayrıca, sığır popülasyonlarının kümelerinde bir değişim de seçilen dönemde gözlenmiştir. Doğal çevresel faktörlerin yanı sıra, kırsal göç, hükümet politikaları, endüstriyel gereksinimler ve bölgesel eşitsizlikler gibi çeşitli sosyo-ekonomik sorunlar da hayvancılığın mekansal kalıplarının değişmesinden sorumlu bulunmuştur. Araştırma, hayvancılık sektörünün gelişmesi için öncelikli alanlarda kaynakların daha iyi tahsisi için önemli sonuçlar sağlamaktadır. Türkiye, birkaç yıllarında hayvancılık sektöründe ciddi azalma göstermiştir. Bu araştırmanın sonuçlarına göre hayvancılık sektörün gelişebilmesi için en uygun alanların belirlenmesi bu alanlarında yatırım yapmasında ve politika geliştirmesinde önemli katkı sağlayacaktır. Ayrıca, gelecekte hayvancılık geliştirme potansiyel alanlara işaret kolaylaştırır.

Anahtar kelimeler: Hayvancılık, Mekansal Analizi, Türkiye

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1. INTRODUCTION

The world population is projected to be 9.6 billion in the year 2050 (Robinson et al., 2015). In order to cope with the needs of food for such a large population, comestible sources require a steady increase. Livestock has been considered a vital source of food and energy for the world human population throughout history. Moreover, it plays an important role in the economic sector of many countries, especially developing ones. Besides, livestock has also a direct impact on the livelihoods of many rural communities (Robinson et al., 2014). By the year 2027, total meat production is projected to be 367 metric tonnes, while the meat consumption is expected to increase by 8% and 21% in developed and developing countries respectively (FAO & OECD, 2018). A well planned and organized livestock sector contributes not only to food security but also to the economic profitability of a region (Lemaire, Franzluebbbers, Carvalho, & Dedieu, 2014; Tichenor et al., 2017; Williams et al., 2017). It is found that livestock distribution has a strong spatial association in terms of the natural environment and human population (Neumann et al., 2009; Cecchi et al., 2010). Spatial dependence and association of livestock have been analysed in various empirical research works ((Ojiako & Olayode, 2008; Saizen, Maekawa, & Yamamura, 2010; Fu, Zhu, Kong, & Sun, 2012; Klimek, Lohss, & Gabriel, 2014; Leta & Mesele, 2014).

Livestock is an integral part of the agricultural economy in Turkey. It is considered as the most important economic activity in many regions of the country (Vural & Fidan 2007; Kaymakçı et al., 2000; Gürsoy, 2009). Livestock has been carried out as extensive form, i.e., in pastures and meadows for many years. However, in the late 1960s, a shift from extensive to an intensive form of livestock was started. Rural-urban migration and conversion of pastures to agricultural land have negatively affected the livestock activity in many areas of Turkey. Besides, lack of public interest, decrease in pasture areas, insufficient government support and security issues in the pasture areas also play a negative role in the decrease of livestock (Gürsoy, 2009). As a result, Turkey started to import livestock products like meat and milk, which were once exported (Karakuş, 2011). The analysis of statistical data has revealed that sheep and goat grazing is more prevalent in Turkey, as compared to cattle. Sheep and goat represent 75% of the total livestock sources in the country. The livestock sector faced many upheavals since the 1990s, and a decline continued until the year 2000. However, livestock production started to improve after 2000 as the government began to provide incentives and subsidies to support the sector (Hayvancılık, 2017).

Livestock development in any area depends on many natural and human geographical factors, including topography, climate, vegetation, land use, population, urbanization and economic incentives, etc (Tibbo, 2012). In other words, spatial dependence plays a critical role in the planning and development of the livestock sector. The present study is aimed to describe the spatial patterns of distribution, relationship and association of livestock in 966 cities of 81 provinces of Turkey. In recent years, Geographical Information System (GIS) and associated technique of exploratory spatial data analysis (ESDA) has gained much scholarly attention in various fields of natural and social sciences (Gallo & Ertur, 2003; Dormann et al., 2007; Celebioglu & Dall’erba, 2010; Tsai, 2011; Chhetri, Chhetri, Arrowsmith, & Corcoran, 2017). The spatial techniques are being used in various scientific disciplines to encompass the role of spatial dependence including health sciences, tourism studies, urban and regional planning, and many other multidisciplinary studies. Agricultural activities have a strong dependence on the natural and physical environment, and thus, are much prone to any changes and variances in the natural ecosystem.

Several empirical studies are found in the current literature with the aim to provide useful and valid information to enhance the production and management of livestock in various regions of the world. (Tichenor et al., 2017) conducted an empirical study to test land use ratio for beef system production. They used land-use suitability analysis to compare the production efficiency of crop production vs livestock forage. They concluded that conversion of grass land into food crop farms would provide more protein sources as compared to the beef production. In another study conducted by (Williams et al., 2017), land use strategies were modelled to produce a clear picture of balancing scenario between agricultural and livestock production and ecosystem conservation. The study concluded that land sparing would positively affect the species conversation and stocks of carbon. (Bonaudo et al., 2014) highlighted the role of agroecological principles in sustainable production of agriculture and livestock production. The integrated production system was found helpful for increased production and management of livestock in the study areas. (T. P. Robinson et al., 2014) created a global database of livestock production in the form of the Gridded Livestock of World map. The mapping provided a detailed insight into the global livestock sector to deal with multilevel scenarios of livestock.

The present study has used the spatial autocorrelation technique to analyse the spatial patterns of livestock in Turkey. Moreover, ESDA also allows hot spot analysis which further

helps to identify the areas of intensive livestock activities. The hotspot analysis enables the detection of the priority areas for allocation of funds, incentives and investments in the livestock sector of Turkey. Turkey needs to boost the livestock sector to achieve the target of achieving self-sufficiency in dairy production. The country is rich in agrobiodiversity, and there is a strong potential for production of almost all kinds of livestock. The review of the literature has revealed that no empirical study has been conducted in the past demonstrating a spatial aspect of livestock in Turkey at the city level. The spatial analysis yields more valid results if small units of areas are included, as compared to the larger one. Therefore, detailed research on spatial characteristics of livestock using innovative methods is necessary to capture the shortcomings of the sector and to find the new potential for improvements. The outcomes of the present study are expected to assist the sector while contributing to the literature.

Dynamics of Livestock Sector in Turkey

The livestock sector has shown dramatic changes in Turkey since the start of the Republic in 1923. The livestock statistics show a significant increase from the 1960s until the beginning of 1980. However, **Figure 1** shows drastic changes in the number of livestock after the 1980s, that continues until the 2000s. The reasons behind this decline include migration to large cities, strict agricultural policies and a shift towards industrialization. The sector started to gain momentum after 2010, as structural and financial changes were brought up along with the start of incentives provided by the government. The agriculture sector

once served as a major contributor to the gross domestic product of the country, has declined in its relative importance with the development of industrial and service sectors. Today, the agriculture sector has a share of about 6% in total GDP, with a 19.39% share in total employment. The percentage of livestock in the total agriculture production value is 35%.

The livestock sector in Turkey is based on small scale holdings. According to the Turkish Bureau of Statistics (TUİK), 83.7 % of cattle farms have less than 20 heads of animals, while only 0.06% of the farms have more than 150 heads of animals. The local breeds of animals are decreasing with time, and are mostly used for ceremonial slaughter and meat products, while the hybrid breeds are increasing and preferred for milk and meat production (Çevik, 2018). The pastoral system in Turkey is divided into Quasi-nomadic, with seasonal migration to highland pastures, and Sedentary systems. The sedentary system is further divided into extensive (based on natural pastures), semi extensive (based on both pastures and hand-feed) and intensive (based entirely on hand feeding) (Fırıncıoğlu, 2004). The grazing of small ruminants is largely conducted on pasture lands.

2. MATERIAL AND METHODS

Exploratory Spatial Data Analysis (ESDA) provides an insight to visualize the spatial data by looking at the distribution, patterns, clusters, homogeneity and heterogeneity (Haining, Wise, & Ma, 1998; Anselin, 1999; Hu, Neelam, & Green, 2016). In other words, ESDA implies sets of spatial statistic tools to

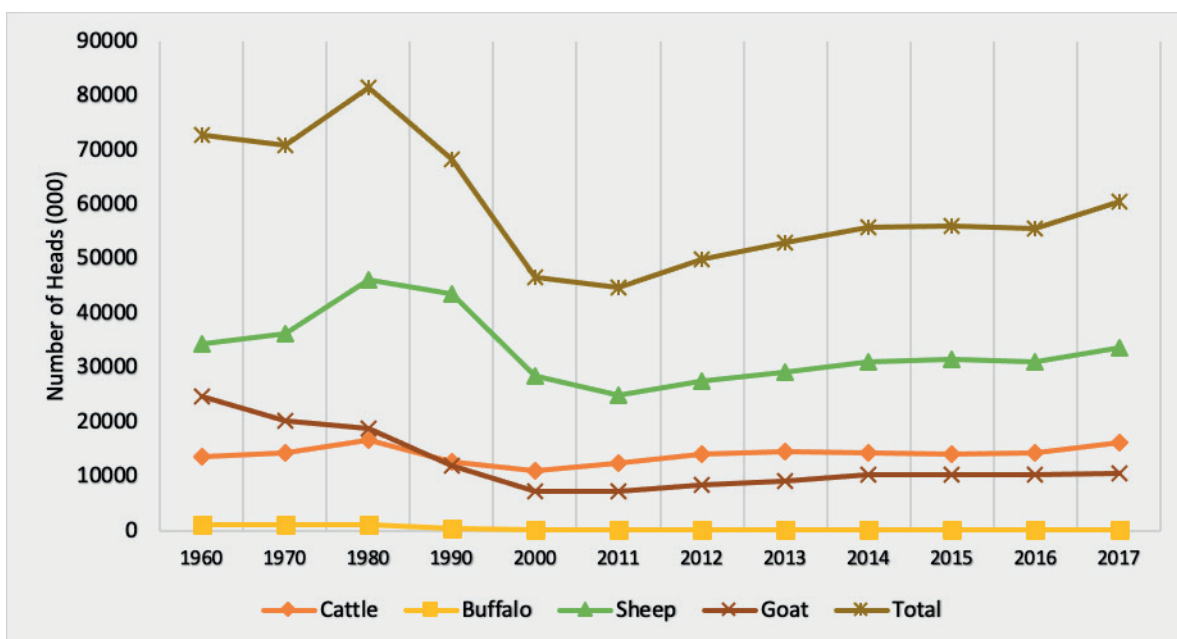


Figure 1: Dynamics of Livestock Population in Turkey (1960-2017).

measure the spatial characteristics of the data (Kang, Kim, & Nicholls, 2014) (Kang, Kim, & Nicholls, 2014) (Kang, Kim, & Nicholls, 2014) (Kang, Kim, & Nicholls, 2014) (Anselin, Syabri, & Kho, 2006; Kang, Kim, & Nicholls, 2014). Spatial autocorrelation, inferred through ESDA, measures the coincidence of similarity in value and spatial position of any variable (Griffith, Scott Morris, & Thakar, 2016; Zhou, Tu, Chen, & Wang, 2017). The spatial autocorrelation shows a positive value if the high or low values of any variable depict spatial clusters, while the negative value is associated to group of dissimilar neighbouring values of spatial units (Ord & Getis, 1995). Moran's I statistics is used to measure the spatial autocorrelation. There are two categories of Moran's I statistics that are global statistics which measure the overall spatial patterns and local statistics, which is also known as a local indicator of spatial autocorrelation (LISA), which shows the local attributes of data by indicating local clusters.

Global Moran's I statistics is measured by the following equation;

$$I = \frac{z}{P_0} \sum_j \sum_k \frac{(w_{jk} |x, y)(y_x y_y)}{\sum_x y_x^2}$$

Here, the symbol n depicts the total number of spatial units (cities in present case) and the sum of the all spatial weights of the units is represented by P_0 , w_{xy} denotes the spatial weight between x and y city y_x shows the deviation of log number of livestock (small ruminants and cattle) for city a from its mean ($T_a - \bar{y}$). The Moran's I value ranges between 1 and -1. Accordingly, the value of 1 in Moran's statistics shows a strong positive correlation, and value of -1 shows strong negative autocorrelation, while a value of 0 shows no autocorrelation. In the present study, we have used Rook's case adjacency weight matrix to define neighbours of cities having common borders.

As discussed earlier, Global Moran's I statistics is useful only to describe the overall pattern and general pattern of spatial association, and does not provide any detail of local spatial clusters and hotspots of the variables. Therefore, LISA statistics are found necessary to find out the local clusters and hotspot areas in detailed visualization of spatial patterns. The calculation of the local Moran's I indicator is made by using the following equation;

$$I = \frac{x}{\sum x^2} \sum y w_{x,y}(y)$$

The present research has used the Monte Carlo permutation approach to check the level of significance in the likelihoods of equal observation of data from each location. Therefore, the process of LISA calculation was repeated for each permutation after shuffling the observed values in all locations randomly.

Moreover, the significance level of LISA statistics is ascertained by generating a reference distribution at 9999 random permutations. The resultant significant map enables us to visualize the high local clusters and hotspot areas of the distribution of livestock. In this research, ArcGIS and GeoDa software have been used for geospatial analysis.

In addition, a detailed insight of spatial association among different cities in terms of livestock distribution is inferred by analysis of Moran's scatter plot. In this technique, the log number of livestock values of each spatial unit, or city, in this case, is placed on the horizontal axis against the standardized spatial weighted log number of neighbouring places on the vertical axis. In short, the spatial dependence is visualized by the scatters plots which help depict the variable of interest (livestock) in a very consistent manner. Hence, Moran's scatterplot helps to identify both global and local spatial associations of each variable that are displayed in the form of dots.

The spatial analysis technique has been found useful to find out spatial variation and patterns of any variable of interest for better understanding the changes over time. The technique has been used in many empirical studies with valuable findings that help policy formation. The data for the current study was gathered from the Turkish Statistical Bureau from the year 2004 to 2018. The log numbers of the livestock population were used for spatial analysis to avoid any skewing in the distribution patterns.

3. RESULTS AND DISCUSSION

The distribution of cattle and small ruminants in the regions with provinces and districts of Turkey is shown in choropleth maps (Figures 2 and 3). The maps show a clear core and periphery distribution of livestock. The cities with higher concentrations of livestock populations are shown in a darker colour, followed by lower concentrations with lighter colours. The analysis of the maps has revealed that there is a difference in the distribution of cattle and small ruminants throughout the country. The cities laying in the East Anatolia, South East Anatolia and Mediterranean regions have shown large populations of small ruminants. On the other hand, the cattle population is found more concentrated in the Black Sea, East

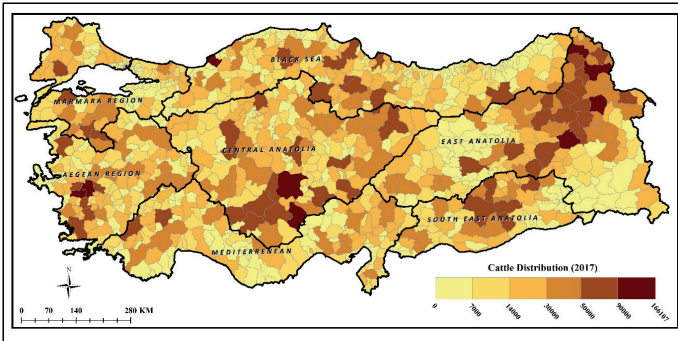


Figure 2: Distribution map of cattle in Turkey (2017).

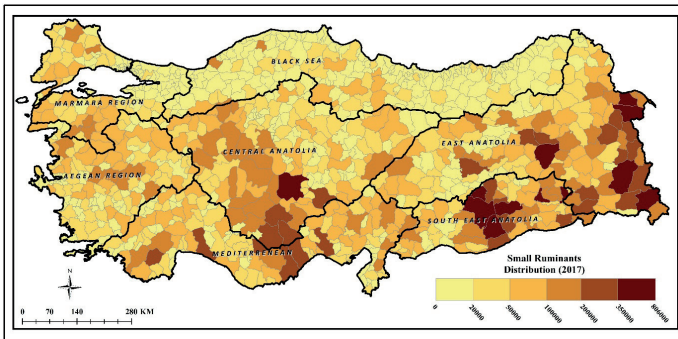


Figure 3: Distribution map of small ruminants in Turkey (2017).

Anatolia, parts of Central Anatolia, Aegean and southeast Anatolia regions. The livestock in the East and Southeast Anatolian regions is based on the extensive type and largely depends upon the pastures. Most of the small farms in these regions meet domestic needs only. However, livestock in the Central Black Sea, Aegean and Central Anatolia is of intensive type, and used for industrial purposes.

Table 1 shows the values of Moran's I for Cattle and small ruminants over the period from 2004 to 2017. The values indicate a positive autocorrelation of spatial units in terms of the livestock population in Turkey. Further, it is also revealed that the autocorrelation is stronger in the population of small ruminants than in the cattle populations. The reason behind a weaker correlation in the cattle population is related to its dispersed geography throughout the country. As discussed earlier, cattle production is intensive mainly in nature and produced for industrial purposes. It has been found that the growing number of cattle and buffalo in the Marmara Region is associated with the industrial requirements of meat, milk and hides (Akbaş, 2005; Atasever & Erdem, 2008; Khan & Coşkun, 2017;). The intensive livestock is popular within the vicinity of the large metropolis, to meet the growing needs of larger populations. Therefore, the weaker spatial association is found in the cattle population of Turkey.

Table 1: Moran's I values for cattle and small ruminants (2004-2017)

Year	Cattle		Small Ruminants	
	Moran's I	St. Deviation	Moran's I	St. Deviation
2004	0.151	0.016	0.230	0.024
2005	0.149	0.016	0.236	0.024
2006	0.128	0.016	0.220	0.024
2007	0.138	0.016	0.235	0.024
2008	0.126	0.016	0.234	0.024
2009	0.141	0.016	0.141	0.024
2010	0.118	0.016	0.223	0.024
2011	0.121	0.016	0.224	0.024
2012	0.128	0.016	0.235	0.024
2013	0.112	0.016	0.235	0.024
2014	0.120	0.016	0.237	0.024
2015	0.106	0.016	0.232	0.024
2016	0.100	0.016	0.203	0.024
2017	0.096	0.016	0.223	0.024

On the other hand, a strong positive autocorrelation is found in spatial units depicting the population of small ruminants. Small ruminants are dominant in East and Southeast Anatolia along with some areas of the Mediterranean Regions of Turkey because of several reasons, of which a higher percentage of the rural population is the most important. Besides, the availability of enough pasture areas, provision of government subsidies and incentives and topography also affect the concentration of livestock in these regions. The quasi nomadic and extensive type of livestock is more prevalent in these areas, where animals are grazed in the mountain pastures.

The analysis of Moran's I value from 2004 to 2017 has shown very little or no change in the livestock clusters. Cattle population has shown a slightly weaker autocorrelation in the year 2017, as compared to previous years. This situation is because of the abandoning of the subsistence livestock in some areas and the growing trend of intensive livestock near the larger urban centres. There is no change in the clusters of small ruminants over the selected period. The livestock clusters remain almost the same during the chosen period, showing consistency in a spatial association.

Moran's scatterplots have shown the spatial clusters of livestock in four quadrants that are associated with the values of neighbouring spatial units. If an area is surrounded by higher values, it will be denoted as a High High (HH) cluster, followed by a cluster of lower values as Low Low (LL), clusters of high and low values as (HL) and low and high values as (LH). The positive autocorrelation is found in the areas denoted by HH or LL, while HL and LH show a negative autocorrelation or no

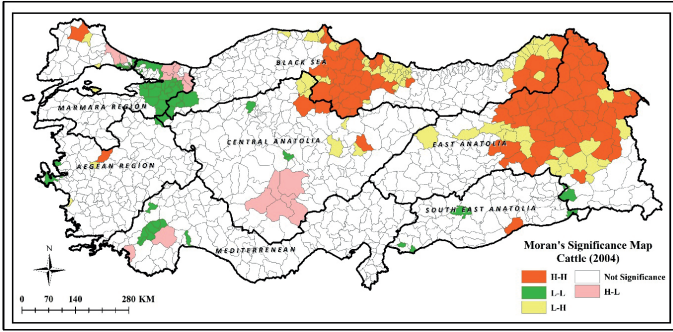


Figure 4: Moran's Significance map for cattle (2004).

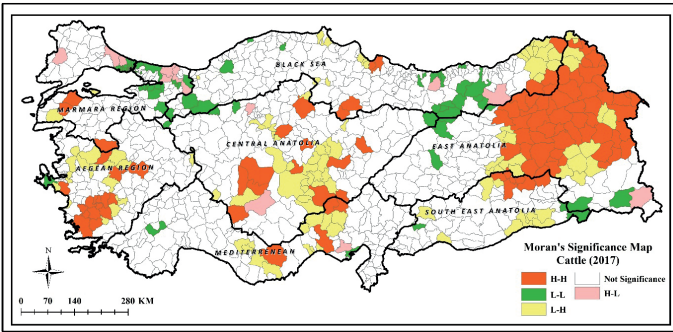


Figure 5: Moran's Significance map for cattle (2017).

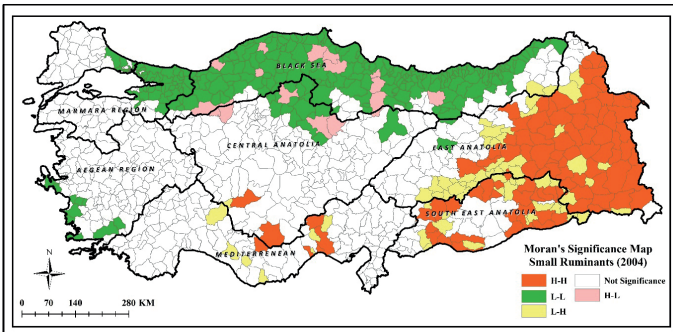


Figure 6: Moran's Significance map for small ruminants (2004).

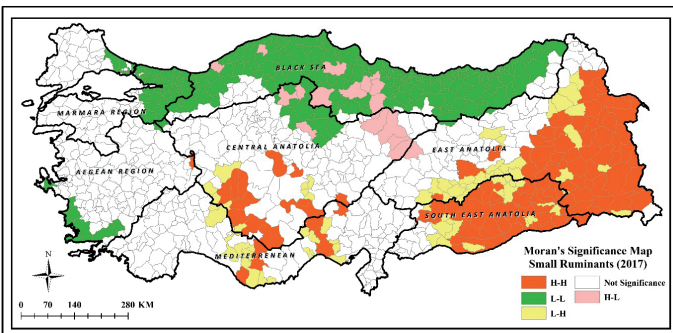


Figure 7: Moran's Significance map for small ruminants (2017).

spatial association. **Figures 4, 5, 6 and 7** show Moran's scatter plots of cattle and small ruminants. It has been found that in the year 2004, the small ruminant scatter plots showed 33% of all the cities falling in the LL and HH quadrant, while 8% was divided into HL and LH quadrants, and 57% found non-significant. However, the cattle population showed only 15% of cities falling in the categories of HH and LL. In the year 2017, the small ruminant and cattle populations showed a slight increase in percentages of HH and LL quadrants, reaching 35.8% and 16.8% respectively.

As mentioned earlier, the local indicator of spatial association (LISA) is necessary to locate the clusters of variables as global Moran's I does not help in discovering the local clusters. LISA statistics and related significance maps are given in **Figures 8, 9, 10 and 11**. Moran's significance maps indicate the location of clusters of livestock throughout the country and changes in those clusters over time. According to the significance maps, the spatial autocorrelation is positive and stronger in terms of small ruminant livestock clusters, as compared to cattle. The significance map of cattle for the year 2004 showed the cluster of livestock in Central and Northern parts of the East Anatolia and Central Black Sea regions. However, new small clusters were observed in parts of the Central Anatolia and Aegean regions in the year 2017, that showed a change in the livestock sector to the intensive type. On the other hand, very little change is observed on comparing the significance maps of small ruminants for the years 2004 and 2017.

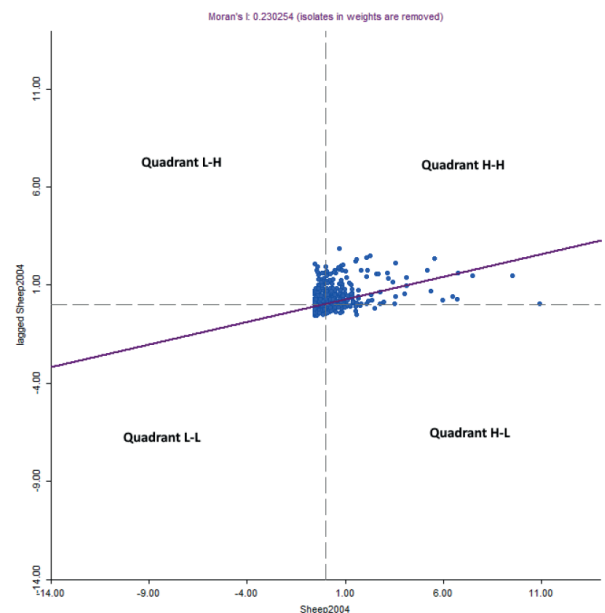


Figure 8: Moran's scatter plot for small ruminants (2004).

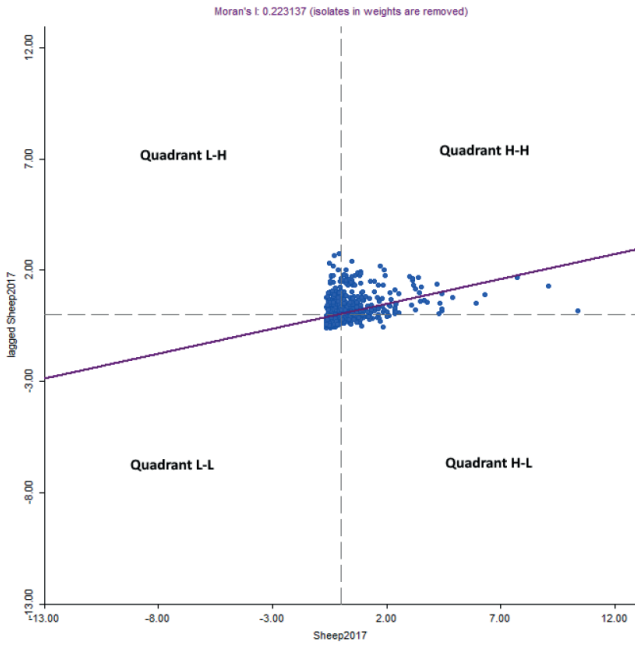


Figure 9: Moran's scatter plot for small ruminants (2017).

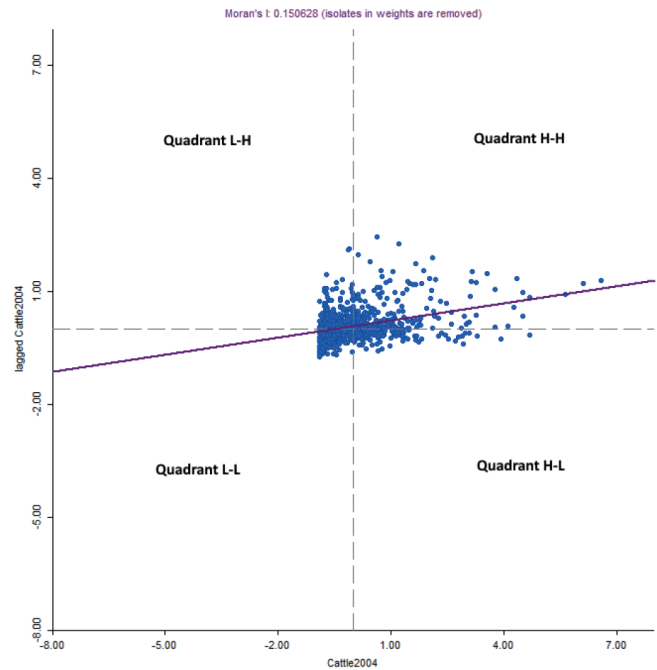


Figure 11: Moran's scatter plot for cattle (2017).

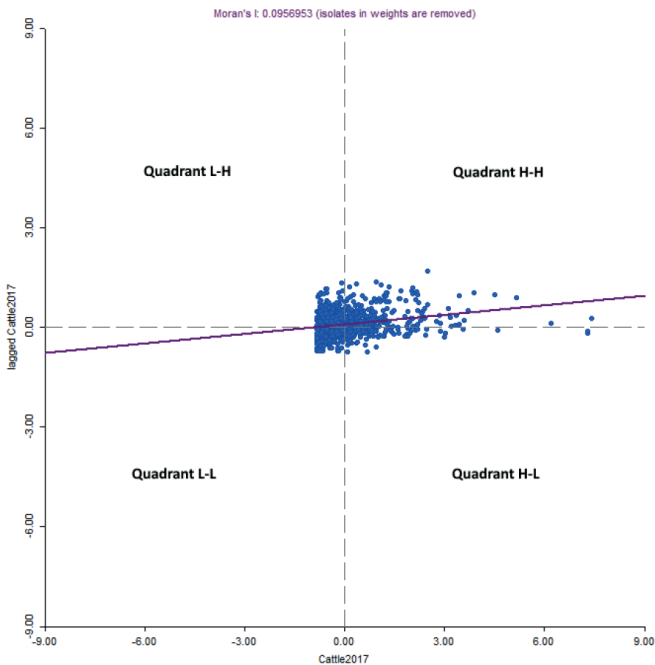


Figure 10: Moran's scatter plot for cattle (2004).

The presence of vast pasture areas and higher percentages of the rural population is related to the concentration of livestock activity in East and Southeast Anatolia. However, the Aegean and Mediterranean Regions are mostly associated with industrial demands.

4. CONCLUSION

Growing demands of livestock-based products require the collection of sophisticated knowledge for a better management of the sector by using new methodologies. The present research has tried to reveal the spatial patterns of livestock in Turkey, for the determination of priority areas to develop the sector more efficiently. Turkey has faced serious declines in the livestock population in recent decades, increasing economic dependence. However, a steady increase has also been observed in the last few years, but is required to be more stable. There is a great need to use to the maximum potential of the country's livestock to achieve self-sufficiency in meeting the needs of a larger population. The result of the study has revealed the spatial dependence of livestock by applying the autocorrelation technique with the help of Geographic Information System and GeoDa. It has been found that Turkey has a strong potential to improve the livestock sector in the areas of the East and Southeast Anatolia, Mediterranean and Black Sea Regions. However, many socio-economic problems are found, which serve as great hurdles for the development. Increased migration, lack of financial support and incentives, smallholdings and decline in pasture areas are some of the important problems that require to be addressed immediately.

The development of livestock depends on several natural factors like climate and physiography. However, manmade

changes bring serious consequences to the natural settings of any environment. Increased urbanization, clearing of forests and pastures, and other development-related activities affect the natural environment negatively. The changes in the natural settings of spatial units also change the livestock sector. Spatial autocorrelation has a great ability to detect the spatial patterns and variations in any given variable like livestock in the present study. The local indicator of spatial association (LISA) has provided deep insights into the local clusters of livestock. Besides revealing the HH and LL clusters, it also enables us to predict future potential areas of livestock development by locating the HL clusters. Hence, the spatial units with higher values near the lower values can become a cluster of higher values in the coming days. Besides, the analysis also helps to identify the priority areas for resource allocation in the development of the livestock sector. The present study is limited to a specific variable of the number of livestock, and further studies are required to analyse the topic in more detail by adding more variables.

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