YILDIZ SOCIAL SCIENCE REVIEW

The Role of Cattle Forage Production in Sustainable Cattle Breeding in Turkey through Spatial Statistical Methods

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Abstract

This study is aimed at determining the form of spatial organization that farmers have tried to meet sustainability conditions after the regulatory role of governments on the agricultural industry had been reduced due to financial crises. The roles of forage production on this spatial organization were determined using data from Turkey. The multivariate local indicators of spatial association technique was employed. It was observed that medium-scale enterprises that have 20 or more cattle are capable of meeting sustainability conditions more easily, and that small-scale enterprises have withdrawn from agriculture and changed locations. During the 2000-2010 period, the spatial dependence between livestock and forage crop production has become stronger. The production of forage with high cellulose content has become the indicator that possesses the spillover effect for the development of livestock production. Farmers adapted themselves to the economic crisis conditions by preferring cattle breeds with higher milk productivity and genetic quality.

Keywords: Geographical information systems; Livestock systems; Spatial autocorrelation; Sustainable agriculture, Self-sufficiency

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1 Introduction

Sustainability aims to ensure biological diversity, economic growth and intergenerational social equality (WCED, 1987). Among many parameters of sustainability, food safety is of great significance OECD Workshop, 2009; (Henrioud, 2011; Martinez, Dabert, Barrington, and Burton, 2009; Mushtaq, Maraseni, Maroulis, and Hafeez, 2009). In food production, the relationship of dependency between agricultural products and livestock is shaped through geography, which determines livestock systems. There are three main livestock production systems: mixed crop-livestock systems, grassland-based systems, and landless industrialized systems (FAO, 2007;(Nardone, Ronchi, Lacetera, Ranieri, and Bernabucci, 2010). While livestock is totally dependent on the geography in grassland-based system and mixed system, the dependency vanishes in the industrialized system. These three systems differ in terms of sustainability and self-sufficiency.

The self-sufficiency model of the mixed system could be summarized as follows: fertilizer from livestock to agriculture; forage from agriculture to livestock; and food from livestock to the society

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Schiere, Ibrahim, and Van Keulen (2002). The mixed system, which has a significant share in farmers' crop and livestock production in developing countries (Tarawali, Herrero, Descheemaeker, Grings, and Blümmel, 2011) increases the efficiency of forage and livestock management especially in places that experience water scarcity (Descheemaeker, Amede, and Haileslassie, 2010).

In grassland-based systems, which are mainly prevalent in certain regions of Africa, Asia, Australia, the Americas and Europe both forage cost is lower and sustainability is higher due to flexibility and adjustment capacity and self-sufficiency (Nardone, Ronchi, Lacetera, Ranieri, and Bernabucci, 2010). In these systems, decline in the population negatively affects sustainability. Besides, grassland-based systems are more environmentally-friendly in that they have the carbon-reducing potential, partly balance methane emission and provide a better distribution in soil (Bernués, Ruiz, Olaizola, Villalba, and Casasús, 2011; de Faccio Carvalho and Batello, 2009). Damaging of soil surface properties depending on climate changes also negatively affects the grassland-based system (Yong-Zhong, Yu-Lin, Jian-Yuan, and Wen-Zhi, 2005). This system, which is totally dependent on geography, has a significant place in European Union (EU) policies especially due to the organic opportunities it offers and its contribution to animal welfare (Kristensen, Søegaard, and Kristensen, 2005).

In developed countries, especially in areas with higher population density, landless livestock systems are exist as they offer higher livestock production efficiency (Kruska, Reid, Thornton, Henninger, and Kristjanson, 2003). Landless livestock production threatens the planet's biological diversity and raises concerns about animal welfare (FAO, 2007).

The increase in external inputs in production complicates sustainability as it hinders self-sufficiency (Schiere, Ibrahim, and Van Keulen, 2002). The production of animal products is decisive in the link between self-sufficiency and sustainability. When animal products are not valuable enough, the forage cost cannot be afforded and the animals are slaughtered for food purposes. For this reason, egg, milk and other animal products function as insurance for farmers in difficult times (Herrero, Thornton, Notenbaert, Wood, Msangi, Freeman, Bossio, Dixon, Peters, van de Steeg, et al., 2010). The fact that milk is produced depending on animals' fertility and it is raw material in many food industries renders it indispensable for food sustainability (Sumberg, 1999). Farmers withdraw from the agriculture when milk productivity is not adequate for small-scale farms with animals with low breeding values (Rougoor, Sundaram, and Van Arendonk, 2000).

Global warming reduces animals' weights and reproductive performances, distorts their immune systems, decreases meat, milk and egg productivity, and accelerates desertification. The process of desertification, on the other hand, reduces grasslands' capacity and causes shortages of forage and water. Therefore, especially grassland-based and mixed livestock production systems will be affected more by global warming (Nardone, Ronchi, Lacetera, Ranieri, and Bernabucci, 2010).

The fact that animals are at risk due to heat stress also complicates sustainability conditions (Nienaber and Hahn, 2007). Nienaber, Hahn, and Eigenberg (1999), by performing risk analyses using computer models that are used for environmental management decisions to evaluate the affects of climatic possibilities on animals, determined the critical temperature limits for pig, cattle and sheep. They demonstrated that the climate change negatively influences the productive performances of farm animals throughout the world.

Livestock contributes to the global greenhouse gas emission (18%) more than transportation does. Fermentation of ruminant animals comprises 37% of methane gas (FAO, 2006). Of the wastes produced as a result of livestock activities, nitrate causes water pollution through eutrophication, ammonia causes air pollution and methane causes greenhouse effect. Besides, over-fertilization causes heavy metal accumulation in soil. For this reason, animal waste management becomes important for sustainability (Herrero, Thornton, Gerber, and Reid, 2009; Martinez, Dabert, Barrington, and Burton, 2009).

The biological diversity of those animals, which form a component of wide agricultural ecosystems and which are domesticated for food, is decreasing steadily. The process of extinction of domestic breeds is accelerated by the fact that meat, milk and egg production, used in most profitable industrial production systems, causes development in breeds and homogenization in species due to ever-increasing demand. (FAO (2007).

When one considers the theories on livestock production systems and sustainability, serious differentiations and contradictions are observed with respect to countries' income levels. Since mixed systems have the largest share in all income groups, differentiation between countries are not too clear. While developed countries' share of population growth and agricultural employment is lower, the food demand and their damage to the environment are higher due to the prevalence of industrialized landless production. Besides, they are affected less by global warming for the same reason. On the other hand, countries with lower incomes have higher population growth rates, lower rates of industrialization and food demand, and lower shares of industrialized livestock production. They are affected more by global warming as grassland-based production systems that are fully dependent on soil are more widespread. In these countries, biological diversity is at high risk. The geography is decisive in the selection and productivity of the production system related to the livestock-sustainability relationship.

The study seeks answers for the following questions: "What are the limits of sustainability for farmers in Turkey especially in cattle-breeding?", "How does the preferences of animal breeds differ with respect to geography?", and "How decisive is this in overcoming economic crises?". The fact that livestock farmers produce their own roughage with high cellulose content is an important indicator of sustainability in terms of self-sufficiency. In this study, the relationship between forage production and livestock was explored using spatial statistical methods, and the most suitable investment promotion regions in terms of forage and livestock were determined.

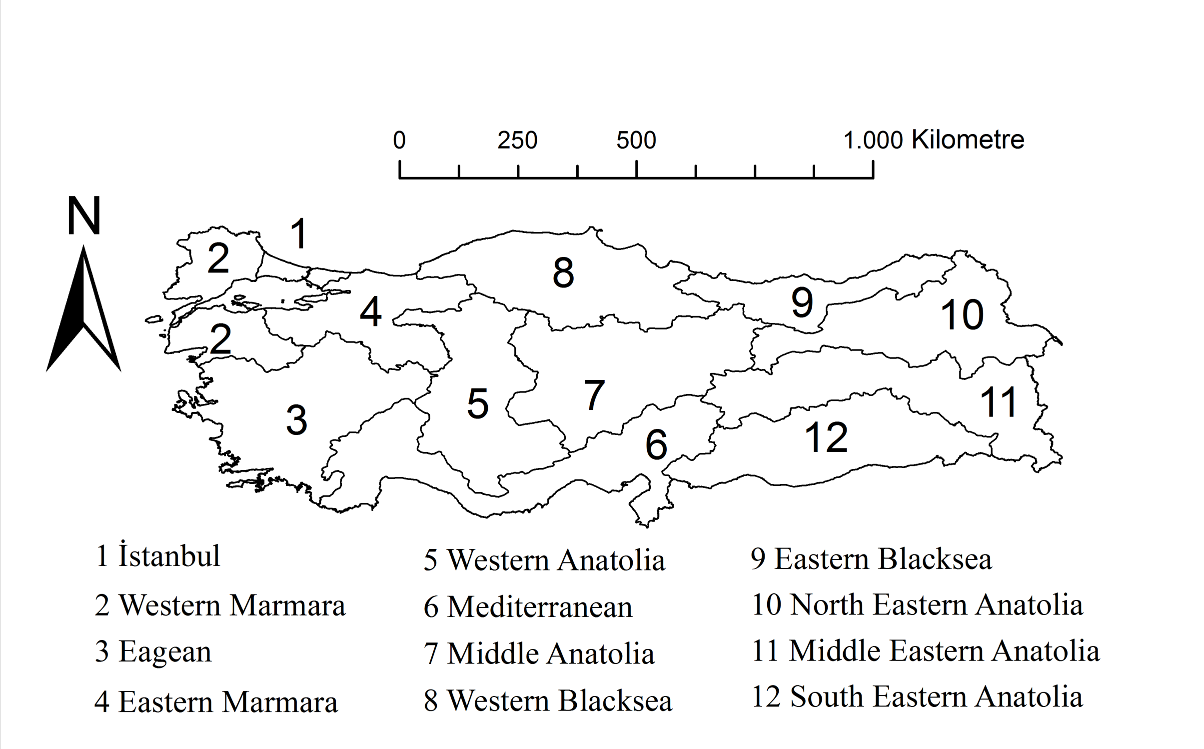
2 Material and methods

The data was obtained from the Turkish Statistical Institute for the years between 2000 and 2010. Local districts were taken as the units of analysis. Performing analysis on the basis of districts rather than of provinces is quite advantageous in explaining differences. 923 districts were used in Local indicators of spatial association (LISA) Moran analyses (Anselin, 2005). Regions are shown in Figure 1.

The year 2000 was selected as the starting point in this research due to the financial crisis, since striking differences have been observed in spatial organization after the crisis. Cattle variables are divided into three groups: Culture-bred cattle reproduced through artificial insemination, domestic cattle, and hybrid-bred cattle reproduced as domestic cattle are crossed with culture-bred cattle. The number of cattle in each district was included in the analysis. The "forage" variable is roughage with high cellulose content, which is essential for milk production. On the other hand, the "forage crop" variable consists of the total areas (decare) cultivated in districts for alfalfa, green grass, clover, corn, fig and sainfoin. Since roughage has a low commercial share in the market, it is consumed in the same place it is produced. It was investigated in this study through spatial statistical techniques if this peculiarity of roughage has a spatial distribution effect. Since it takes nearly one year to cultivate, produce and consume animal feed, numbers of cattle were included in the analysis with one year lag. In the analyses, GeoDA was employed as the Geographical information systems program (Anselin, 2005). It was investigated in this study through spatial statistical techniques if this peculiarity of roughage has a spatial distribution effect or if it contributes to sustainability. When forage production is performed alongside stockbreeding, it becomes an important indicator of sustainability in terms of self-sufficiency. Spatial econometic analaysis is useful aspect of agricultural issues (Göçer, 2015; Göçer et al., 2015).

It is important in geographical analyses if the spatial distribution of data is random or not. If the data distribution is not random and if there is spatial dependence, the clusters that this dependence

Figure 1: Map of Turkey's regions and provinces



forms produce significant information for geographical analyses. In this respect, the use of Moran's I technique is highly widespread in assessing spatial dependence (Moran, 1950). Moran's I index helps measure how randomly a spatial data set is widespread. If each spatial data has a relationship of dependence with its neighbors, the similarity or difference in the cluster that emerges as a result of this relationship is determined using the technique developed by Anselin (1995) and called Local indicators of spatial association LISA Moran. LISA Moran is defined as follows

$$I_i = \frac{x_i - \bar{x}}{\sum_i^n (x_i - \bar{x})^2} \sum_j^n w_{ij}(x_j - \bar{x})^2$$

Here, n refers to the number of observations, w_{ij} to the weight between locations i and j, x_i and x_j to the values in locations i and j, and x to the averages of the variable in all locations. Lisa map shows the types of spatial associations between the neighbors of each location. The local spatial associations between the neighbors of locations have five different types, which are located in the form of dots on each quarter of the scatter graph. High values surround high values in the High-High cluster, high values surround low values in the Low-High cluster, low values surround low values in the Low-Low cluster, and low values surround high values in the High-Low cluster. Insignificant clusters, on the other hand, consist of points from all zones close to the coordinate center. While High-High and Low-Low indicate positive spatial autocorrelation, High-Low and Low-High show negative spatial autocorrelation.

Multivariate LISA shows spatial dependence between two separate variables. Multivariate coefficient of spatial autocorrelation was first developed by Wartenberg (1985). In this model of multivariate spatial autocorrelation between two standardized random variables. Multivariate LISA is a bivariate extension of univariate LISA Moran analysis. It gives us the spatial correlation between one variable's value in the location and the other's value in the neighbor location. Positive autocorrelation refers to the similarity between the two variables; which means both of the variables have either high or low values together. On the other hand, negative autocorrelation refers to the dissimilarity between the two variables; while one of them has a high value, the other one has a low value (Anselin, 2005).

3 Results

Impact of Agricultural Policies in Turkey on Livestock: Adoption of more liberal agricultural policies' in Turkey replacing planned development has brought about significant changes in agriculture after 1980 .(Ediger and Huvaz, 2006; Hasanov, Araç, and Telatar, 2010; Özmucur, 2007; Türkekul and Unakıtan, 2011). Livestock production has taken its share from the radical transformations in agriculture in the post-1980 period. While there were 355 cattle per 1000 people in 1980, there were only 148 cattle per 1000 people in 2010 (TUIK 2011). Figure 2 shows the striking changes in breed distribution of cattle. While domestic cattle formed more than half of the pie in 1991, it fell behind hybrid-bred cattle in 1998 and culture-bred cattle in 2007 (TUIK 2011; TUIK 2012).

Figure 2: Change over time in cattle breeds and share of harvested forage in field crops.

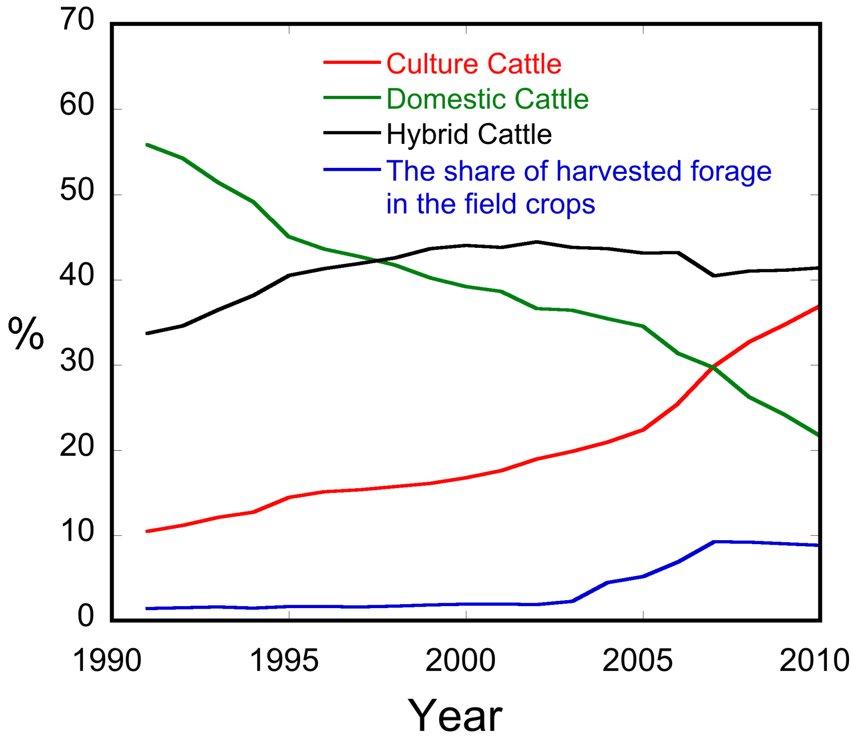


Figure 2 shows the share of harvested forage in the field crops. It is observed that it follows a course parallel to the culture-bred cattle. How a spatial dependency that this parallelism has shown is an issue addressed by this study.

Lower milk productivity has played a significant role in the downtrend of domestic cattle. As is seen in Table 1, the rise in the percentage of culture-bred cattle is a result of very high milk productivity. Besides, among the most important issues for livestock is forage, which is a significant cost item (TUIK 2011).

High costs of forage have unsurprisingly rendered livestock unsustainable for small-scale enterprises. Figure 2 shows the share of harvested forage in the field crops. It is observed that it follows a course parallel with culture-bred cattle. How a spatial dependency that this parallelism has shown is an issue

Table 1: Milk productivity of cattle breeds

Milk Yield	Years		
	1991	**2000**	**2010**
Culture cattle	2,94	2,91	3,87
Domestic cattle	0,74	0,74	1,3
Hybrid cattle	2	1,96	2,72

addressed by this study. As is seen in Table 2, the share of the group with 10-19 cattle did not change between 2001 and 2006 in small and medium sized farms. In small farms, shares of the groups with 1-4 and 5-9 cattle dropped, whereas groups with 20 and more cattle increased (TUIK 2008).

Table 2: Distribution of Numbers of Cattle 2001 - 2006

Holding size according to number of cattle animals	**Bovine animals 2001 %**	**Bovine animals 2006 %**
1-4	27.7	21.58
5-9	28.91	21.34
10-19	25.16	25.36
20-49	14.67	22.92
50+	3.55	8.79

This indicates that, with the post-2001 restructuring in agriculture, traditional family enterprises rapidly withdrew from agriculture and only big firms could meet sustainability conditions.

Application on the Sustainability of Cattle Breeds : In this study, through exploratory spatial data analyses, the spatial dependence between forage production and cattle was determined and thus recommendations pertaining to sustainability were developed.

4 Cattle Raising in Pastoral Areas

Figure 3 shows the overlap between the distribution of cattle with respect to their biological diversities among districts and the percentages of pastoral areas within provinces. The largest pastoral areas are in MEA, MA and NEA regions. In the first group; percentages of pastoral areas range between 25% and 51%, they are located above sea level, they mostly consist of mountainous areas, and naturally the percentage of plant production areas is lower than those in other regions. In the second group; percentages of pastoral areas range between 12% and 24%, and it is the neighbor of the first group. The share of pastoral areas gets smaller towards the west and closer to sea, except for the EBS region. The number of culture-bred cattle increases from the east to the west, while the number of domestic cattle increases towards the opposite direction. Hybrid cattle are mostly found in western regions and the Black Sea region, and they are distributed throughout the country in a more balanced manner compared to other breeds.

As is seen in Table 3, which was prepared using the map data in Figure 3, the fact that fertile but idle areas rank first in the first group points to a significant potential for forage production. As the number of cattle in enterprises goes up, these enterprises become more sustainable (Rougoor, Sundaram, and Van Arendonk, 2000). Although it is an advantage for the first group to have the rate of 20 or more cattle in the first rank, the sustainability of the structure that is based on the pastoral system is difficult since families living in this region have lower income levels and thus the

Figure 3: Distribution by provinces of the share of pastoral areas in province surface area

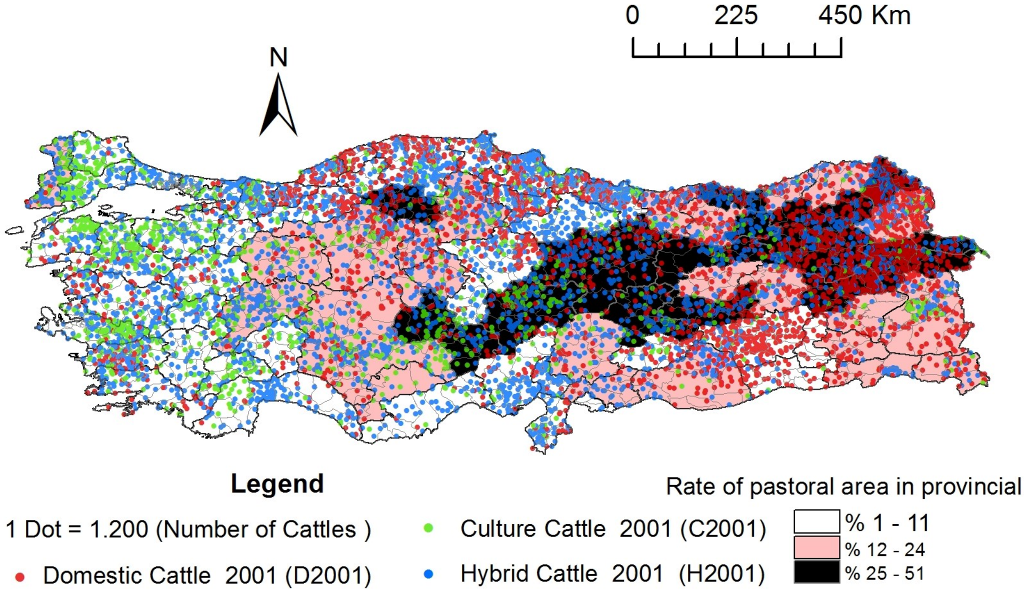


Table 3: Characteristics of groups formed according to the distribution of pastoral areas within provinces

Variables	Year	1.Group 15 Provincial	2.Group 24 Provincial	3.Group 42 Provincial	Total
Rate of Unused and undeveloped potentially productive land	2001	13,71	9,66	11,79	11,5
Rate of enterprises with 20 or more cattle	2001	21,53	13,92	12,4	14,5
Rate of enterprises that insure cattle	2001	0,85	0,76	1,64	1,23
Rate of enterprises that perform artificial insemination	2001	0,56	0,78	1,74	1,23
Rate of desertified lands	2001	2,96	0,76	0,49	1,03
Net internal migration	2010	-5438,2	-1542,58	2823,69	

net migration is negative. Desertification caused by global warming is on the rise in all regions and it poses a risk for sustainability (Nardone, Ronchi, Lacetera, Ranieri, and Bernabucci, 2010).

Figure 4 shows the results of multivariate LISA analysis that was performed to determine the relationship of spatial dependence between cattle groups and forage production. The cluster high-high indicates that the number of cattle is high in and around districts where forage production is high. In this multivariate LISA analysis, negative autocorrelation clusters (low- high and high-low) mean that when one of the two variables has a low value, the other one has a high value in neighboring district. Investments made in the variable with the lower value in these clusters could easily turn the relationship into a high-high cluster. In the multivariate LISA, which was performed using 2006 forage and 2010 domestic cattle statistics, the low-highcluster was found to be distributed in Southeastern Anatolia and the west of Middle Eastern Anatolia (Figure 4a-4d). In these districts, the numbers of domestic cattle are high although forage production is low. The high-high clusters were found to be distributed in the east of North Eastern Anatolia, Middle Eastern Anatolia and West Black Sea regions in the analyses performed for years 2001 and 2010 (Figure 4a-4d).

Since the number of hybrid-bred cattle increases after 2001 in the east replacing domestic cattle, high-high clusters slightly extended in North Eastern Anatolia and the east of Middle Anatolia (Figure 4b-4e). In the multivariate LISA analysis that shows the relationship between forage production and culture-bred cattle, whose numbers are on the rise in all regions; the districts that had high-high clusters are located in Aegean and in the western parts of Western Marmara and Western Anatolia (Figure 4c-4f). The turning of low-high and high-low clusters (2001), which show negative autocorrelation between forage production and culture cattle, into high-high in 2010 is an advantage in terms of sustainability. For this reason, a partial increase was observed in the Moran's I statistics stemming from the positive autocorrelation (Figure 4f). In these analyses, high-high clusters are the best places that point to sustainability.

In the west of South Easter Anatolia , partially in North Eastern Anatolia and largely in Easter Black Sea; there are districts where forage production is high but in their neighboring areas culture of cattle farming is low. These finding show that culture-bred cattle are inadequate despite the forage potential. Therefore, these districts should be given priority in agricultural incentives for sustainability in livestock.

Figure 4: Distribution of clusters according to multivariate LISA analysis performed between cattle breeds and forage areas with data of 2001 and 2007. The LISA clusters obtained through performing analyses in GeoDA were shown graphically in ArcGIS software.

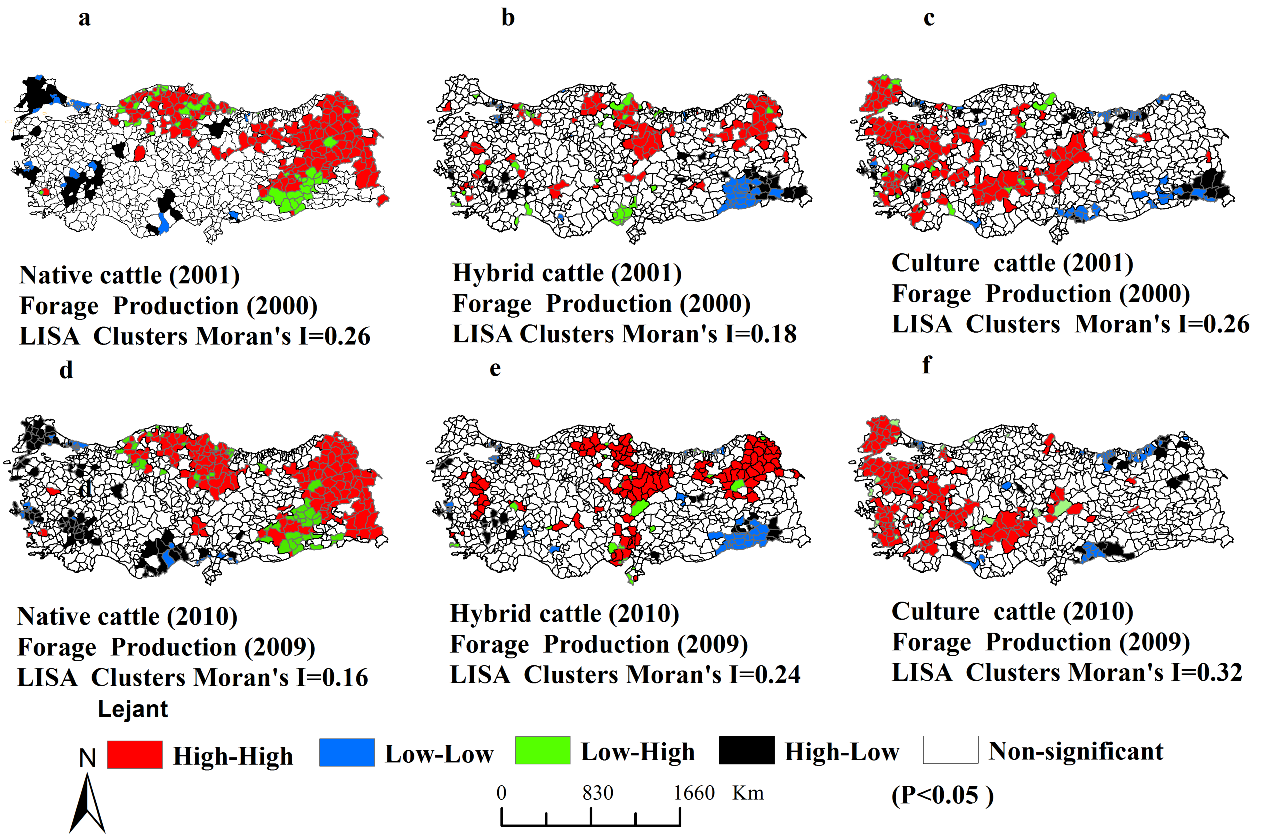


Table 4 shows the means of the selected variables, which belong to high-high and high-low clusters in districts, emerged after the multivariate LISA Moran analysis performed for forage production and culture-bred cattle (Figure 4c-4f). High-high clusters have the advantage of forage and milk in terms of sustainability. However, although high-low clusters possess the forage advantage, they have a percentage of culture-bred cattle lower than the country average. Such districts are observed especially in the North Eastern Anatolia region. The fact that districts in this cluster have large fertile lands for forage crop production and large pastoral areas indicates that there exists a significant potential for culture cattle farming. However, there are also risks for sustainability such as the negative net migration, high rates of erosion and desertification, and low number of enterprises having insurance and performing artificial insemination (TUIK 2001).

Table 4: Regional characteristics of clusters of multivariate LISA performed for the relationship between culture-bred cattle and forage production

Variables	**LCMYE2007 Lisa Moran groups**		
	High-High	**High-Low**	**Total**
Rate of Unused and undeveloped potentially productive land	6,97	11,17	10,41
Rate of Unused and undeveloped potentially productive land area Irrigated area	0,29	1,13	0,53
Rate of Pasture land	43,77	76,63	60,14
Rate of desertified lands	1,58	0,8	0,86
Rate of enterprises that insure cattle	2,59	0,93	1,48
Rate of enterprises that perform artificial insemination	2,63	0,61	1,5
Rate of erosion	2,63	7,04	3,3
Net internal migration 2010	4465	-683	

5 Conclusions

Agricultural products cannot be replaced by something else and they also supply raw materials continuously to agriculture-based industries. The agricultural sector is a vital source of employment especially in underdeveloped countries. However, the decline of support provided by governments of underdeveloped and developing countries to farmers and economic crises make sustainable agriculture extremely difficult and they negatively affect especially pastoral agriculture areas.

The fact that population growth and industrialization increase demand for food and at the same time cause global warming that negatively influences food production causes stress on geography and complicates sustainable development. Yet another source of stress on geography is the environmental damage caused by greenhouse gas emission of ruminant cattle that are inevitable for the sustainability of food safety.

The process of population decline in pastoral areas, which is observed in underdeveloped countries, is observed in Turkey, too. This process hinders the contribution of the pastoral livestock system to the protection of the ecosystem. The mixed livestock production system is prevalent in regions where pastoral areas are widespread in Turkey. Mixed systems increase productivity in water, forage and livestock production management in places with water scarcity. It could be argued that sustainable livestock production is at risk in Turkey since droughts increase more in poorer regions especially in the east of the country where stockbreeding is traditionally strong.

The regulatory role of the state in the favor of farmers has diminished rapidly. Farmers attempted to cope with and adapt to these new conditions by rising sustainability limits through new spatial organizations.

The measures that farmers have taken in this spatial organization can be juxtaposed as follows: Farmers living in the east who have higher income levels concentrated on milk productivity, which is an important means for sustainability. The share of forage crops among arable crops increased in all regions. Domestic cattle, which have the lowest milk productivity, dropped from the first to the last rank. Farmers with low income levels who live in the northeast bred domestic cattle with culture cattle and thus tried to meet sustainability requirements with more-productive cross-bred cattle. Farms with 20 or more cattle formed the sustainable operational level.

In the results of the LISA Moran analysis performed to determine the spatial dependence between livestock and forage production, strong spatial relationships were found for all the three cattle breeds. Forage is an important indicator that has a strong spillover effect for livestock production.

Since especially culture-bred cattle developed to the detriment of domestic cattle, the sustainability of domestic cattle is at risk. In the multivariate LISA analysis performed for culture livestock production, the high-high clusters located in the west are the most advantageous clusters in terms of sustainability since they provide the relationship between milk productivity and forage production in the best manner. Although the percentages of fertile but unused lands were high in high-high cluster areas of all cattle breeds, these lands are not used for forage purposes, and this indicates that a highly important opportunity is missed.

In the multivariate LISA, the low-high and high- low clusters were found to be distributed in many regions. In these regions, Investment made in the variable with the lower value in these clusters could easily turn the relationship into a high-high cluster.

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