CLUSTER ANALYSIS OF DISTRICTS IN BULGARIA ACCORDING TO THE DEVELOPMENT OF THE LIVESTOCK SECTOR

Tsvetana HARIZANOVA – METODIEVA

Institute of Animal Science, Kostinbrod, Bulgaria, 2232, E-mail: ts_harizanova@abv.bg

Corresponding author: ts_harizanova@abv.bg

Abstract

The aim of the research is to group the districts in Bulgaria according to the development of the livestock sector. A hierarchical cluster model was developed based on the indicators for the number of cattle and buffalo, sheep, pigs and poultry by district in Bulgaria. Data on the number of farm animals were taken from the Register of Farmers for the 2020/2021 business year. A dendrogram was constructed showing the distribution of districts by clusters. Average values of the studied indicators for each cluster were calculated. The districts can be divided into 4 clusters according to the considered indicators. The first cluster includes 6 districts: Burgas, Haskovo, Kardzhali, Sliven, Blagoevgrad and Plovdiv. The second cluster includes 17 districts: Kyustendil, Pernik, Sofia-grad, Vidin, Smolyan, Montana, Lovech, Vratsa, Silistra, Gabrovo, Sofia, Yambol, Pazardzhik, Shumen, Razgrad, Targovishte and Pleven. The third cluster includes only one district - Veliko Tarnovo. The fourth cluster includes 4 districts: Stara Zagora, Dobrich, Varna and Ruse.

Key words: *hierarchical cluster model, livestock sector, districts*

INTRODUCTION

The livestock sector in Bulgaria is of key importance for supplying and feeding the population with irreplaceable and quality products. It provides employment for the population mainly from the rural areas of the country and helps to reduce unemployment among the people with a lower level of education.

In the last years (2012 - 2022), according to the statistics [6], [8], [10] the number of cattle was: 526,112 heads in 2012, and in 2022 – 559,544 heads, or their number increased by 6.4%. On the other hand, the number of buffaloes in the country has grown 2.2 times: from 9,212 heads in 2012 to 20,317 heads in 2022.

The number of sheep in the country has also undergone a change during the considered period in the direction of a decrease of 19.5%: from 1,361,545 heads in 2012 to 1,096,399 heads in 2022 [8], [10].

The number of pigs increased by 13.3%: from 530,945 in 2012 to 601,702 in 2022 [8], [10].

The number of poultry also has changed during the studied period: from 15.260 million in 2012 to 15.507 million in 2022 [7], [9]. There was a slight increase of 1.6% in 2022 compared to 2012.

In the current study, the method of cluster analysis was applied, which is widely used in analyses of the agrarian sector in the country ([1], [4], [5]).

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MATERIALS AND METHODS

A hierarchical cluster model was developed based on the indicators for the number of cattle and buffalo, sheep, pigs and poultry by district in Bulgaria. Data on the number of farm animals were taken from the Register of Farmers for the 2020/2021 business year [12]. The indicators refer to the business year 2020/2021 and show the distribution of the number of different types of farm animals by districts in Bulgaria. The hierarchical cluster model was developed using the statistical software *R* [11], *factoextra* package [2], [3]. The number of clusters was determined with *eclust()* function from *factoextra* package [14]. Districts were clustered based on the Euclidean distance between them [13]. A dendrogram was constructed showing the distribution of districts by clusters. The average values of the studied indicators by clusters were calculated.

RESULTS AND DISCUSSIONS

Table 1 shows the number of different types of farm animals by district for the 2020/2021 business year [12] and their percentage share of the total number of the respective type of farm animals in the country:

-The total number of studied farm animals in the country for the 2020/2021 business year is as follows: 534,119 cattle and buffalo; 987,488 sheep; 552,975 pigs; 29,716,611 poultry number.

-The largest number of cattle and buffalo are raised in the districts: Plovdiv (60,539 heads or 11.33%), Haskovo (44,507 heads or 8.33%) and Blagoevgrad (42,624 heads or 7.98%); and the smallest number – in the districts: Sofia-grad (3,430 heads or 0.64%); Vidin (4,322 heads or 0.81%) and Pernik (5,072 heads or 0.95%).

-The largest number of sheep are raised in the districts: Blagoevgrad (96,645 heads or 9.79%), Burgas (93,102 heads or 9.43%) and Plovdiv (87,606 heads or 8.87%), and the least number - in the districts: Sofia-grad (4,185 heads or 0.42%); Vidin (5,764 heads or 0.58%) and Gabrovo (7,680 heads or 0.78%).

-The largest number of pigs are raised in the districts: Dobrich (95,921 heads or 17.35%), Stara Zagora (79,553 heads or 14.39%) and Ruse (71,440 heads or 12.92%), and the smallest number - in the districts: Pernik (1 head) and Sofia-grad (4 heads). In the Smolyan district there is not a single registered pig according to the Register of farmers for the 2020/2021 business year.

-The largest number of poultry are raised in the districts: Veliko Tarnovo (6,635,452 numbers or 22.33%), Razgrad (3,111,016 numbers or 10.47%) and Targovishte (2,258,707 numbers or 7.60%), and the smallest number - in the districts: Sofia-grad (22,612 numbers or 0.08%); Pernik (23,010 numbers or 0.08%) and Blagoevgrad (46,815 numbers or 0.16%).

The favourable forage base can be noted as the reason for the largest number of animals in some of the districts - these districts are traditionally one of the largest producers of cereals in the country due to their suitable soil and climate conditions (Dobrich, Plovdiv, Ruse, Veliko Tarnovo, Varna).

Based on the analysis, 4 clusters of districts were formed (Fig. 1). The first cluster includes 6 districts: Burgas, Haskovo, Kardzhali, Sliven, Blagoevgrad and Plovdiv. The second cluster includes 17 districts: Kyustendil, Pernik, Sofia-grad, Vidin, Smolyan, Montana, Lovech, Vratsa, Silistra, Gabrovo, Sofia, Yambol, Pazardzhik, Shumen, Razgrad, Targovishte and Pleven. Only 1 district, Veliko Tarnovo, is included in the third cluster. The fourth cluster includes 4 districts: Stara Zagora, Dobrich, Varna and Ruse.

From Fig. 1 it can be seen the pairs of districts that share the most common characteristics with each other based on the investigated indicators. These are: Kardzhali and Sliven (Kardzhali district is most similar to Sliven district according to the studied indicators); Blagoevgrad and Plovdiv; Kyustendil and Pernik; Sofia-grad and Vidin; Lovech and Vratsa; Silistra and Gabrovo; Pazardzhik and Shumen; Targovishte and Pleven; Stara Zagora and Dobrich; Varna and Ruse.

Fig. 2 and Fig. 3 present the average number of the respective type of farm animals by clusters. In the first cluster, the average number of cattle and buffalo per district is the largest (41.2 thousand heads); in the third and fourth clusters, the average number of cattle and buffalo are similar in value (17.5 thousand heads for the third and 16.8 thousand heads for the fourth cluster). The value of the indicator is the lowest in the second cluster (11.9 thousand heads).

The average number of sheep in the first cluster is the largest (78.6 thousand sheep), followed by Veliko Tarnovo district (31.2 thousand sheep).

In the last place are the second and fourth clusters with a similar average number of sheep (23.1 thousand heads in the second and 23.2 thousand sheep in the fourth cluster).

In the districts from the first cluster, on average, 3.4 times more sheep are raised than in the districts in the second cluster.

Table 1. Indicators for analysis of the development of livestock sector at the district level

District	Cattle and buffalo		Sheep		Pigs		Poultry	
	total number	%	total number	%	total number	%	total number	%
Blagoevgrad	42,624	7.98	96,645	9.79	886	0.16	46,815	0.16
Kardzhali	35,260	6.60	59,503	6.03	36	0.01	262,773	0.88
Haskovo	44,507	8.33	70,004	7.09	589	0.11	1,111,936	3.74
Plovdiv	60,539	11.33	87,606	8.87	4,641	0.84	1,091,131	3.67
Burgas	31,086	5.82	93,102	9.43	46,245	8.36	96,827	0.33
Sofia	22,273	4.17	45,495	4.61	5,245	0.95	198,477	0.67
Sliven	33,265	6.23	64,464	6.53	2,697	0.49	768,847	2.59
Stara Zagora	23,517	4.40	28,277	2.86	79,553	14.39	1,446,707	4.87
Pazardzhik	14,669	2.75	31,773	3.22	31,622	5.72	652,854	2.20
Yambol	22,031	4.12	28,335	2.87	25,659	4.64	617,722	2.08
Lovech	11,726	2.20	23,930	2.42	1,895	0.34	505,850	1.70
Kyustendil	7,598	1.42	14,552	1.47	33	0.01	122,304	0.41
Smolyan	6,871	1.29	29,560	2.99		0.00	103,066	0.35
Veliko Tarnovo	17,493	3.28	31,226	3.16	19,477	3.52	6,635,452	22.33
Varna	9,354	1.75	25,001	2.53	57,576	10.41	956,664	3.22
Montana	14,581	2.73	23,235	2.35	107	0.02	961,753	3.24
Pernik	5,072	0.95	12,820	1.30	1	0.00	23010	0.08
Targovishte	14,197	2.66	40,855	4.14	10,354	1.87	2,258,707	7.60
Shumen	16,427	3.08	28,907	2.93	36,909	6.67	953,896	3.21
Pleven	16,154	3.02	33,156	3.36	2,086	0.38	1,598,433	5.38
Vratsa	12,770	2.39	23,782	2.41	37	0.01	592,403	1.99
Sofia-grad	3,430	0.64	4,185	0.42	4	0.00	22,612	0.08
Dobrich	23,947	4.48	26,299	2.66	95,921	17.35	1,494,355	5.03
Razgrad	14,199	2.66	16,995	1.72	35,503	6.42	3,111,016	10.47
Ruse	10,417	1.95	13,133	1.33	71,440	12.92	1,852,416	6.23
Silistra	9,071	1.70	21,204	2.15	18,310	3.31	959,833	3.23
Gabrovo	6,719	1.26	7,680	0.78	1,725	0.31	1,034,398	3.48
Vidin	4,322	0.81	5,764	0.58	4,424	0.80	236,354	0.80
Total	**534,119**	**100**	**987,488**	**100**	**552,975**	**100**	**29,716,611**	**100**

Source: data from the "Register of farmers for the 2020/2021 business year" [12] and own calculations.

The largest average number of pigs falls on the districts of the fourth cluster (76.1 thousand). Next is Veliko Tarnovo district (19.5 thousand).
In the first and second clusters, the average number of pigs is the lowest: 9.2 thousand heads for the first and 10.2 thousand heads for the second.

In the Veliko Tarnovo district, the highest number of poultry are raised (6,635.5 thousand), which is 11.8 times more than the average number for the first cluster (563.1 thousand poultry), in which the lowest number of poultry are raised.
In the fourth cluster, the average value of the indicator is 1,437.5 thousand, and in the second cluster – 820.7 thousand.
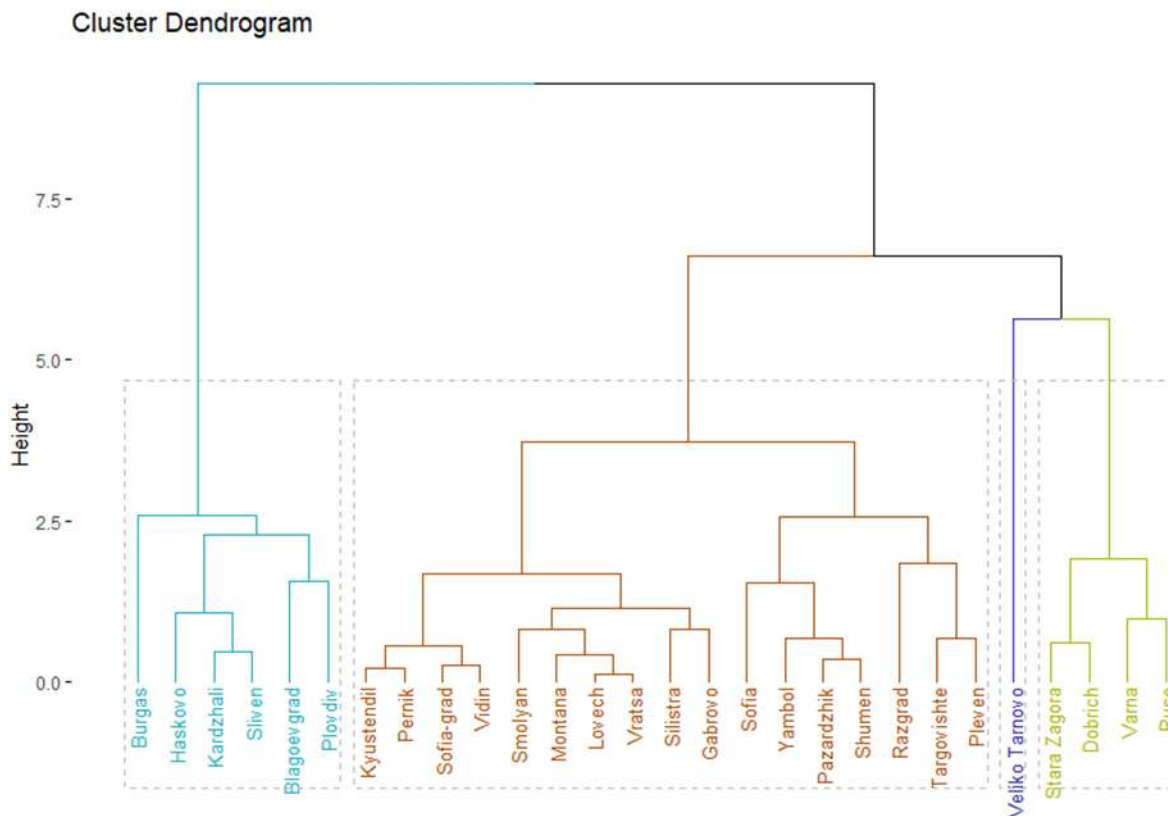
Fig 1. Cluster dendrogram of districts
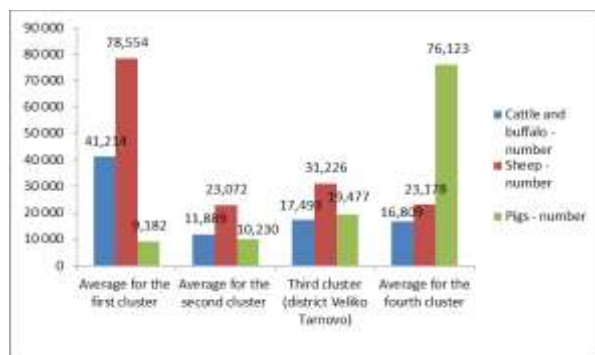Source: Generated with *R* program, *factoextra* package [3], [11]

Fig. 2. Average values by clusters - cattle and buffalo; sheep and pigs
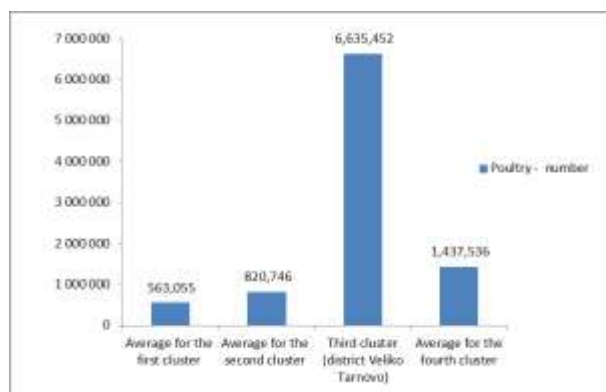Source: Own calculations.

Fig. 3. Average values by clusters – poultry
Source: Own calculations and data [12].

CONCLUSIONS

The largest number of cattle and buffalo are raised in the districts: Plovdiv (11.33% of the total number), Haskovo (8.33%) and Blagoevgrad (7.98%). Sheep are most numerous in the districts: Blagoevgrad (9.79% of the sheep population), Burgas (9.43%) and Plovdiv (8.87%). Pig farming is most prevalent in the districts: Dobrich (17.35% of the pigs), Stara Zagora (14.39%) and Ruse (12.92%). It is noted that in the Smolyan district there is not a single registered pig according to the data source [12] and in the Pernik district there is 1 animal registered, in the Sofia-grad district - 4 animals. The largest number of poultry are raised in the districts: Veliko Tarnovo (22.33%), Razgrad (10.47%) and Targovishte (7.60%).

The districts can be divided into 4 clusters according to the considered indicators. The first cluster includes 6 districts: Burgas, Haskovo, Kardzhali, Sliven, Blagoevgrad and Plovdiv. The second cluster includes 17 districts: Kyustendil, Pernik, Sofia-grad, Vidin, Smolyan, Montana, Lovech, Vratsa,

Silistra, Gabrovo, Sofia, Yambol, Pazardzhik, Shumen, Razgrad, Targovishte and Pleven. The third cluster includes only one district - Veliko Tarnovo. The fourth cluster includes 4 districts: Stara Zagora, Dobrich, Varna and Ruse.

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In the first cluster, the average number of raised cattle and buffalo and sheep is the largest when compared to the average values of the other clusters (41.2 thousand cattle and buffalo and 78.6 thousand sheep). The largest number of poultry (6,635.5 thousand) are raised in the Veliko Tarnovo district. The largest average number of pigs falls on the districts of the fourth cluster (76.1 thousand heads).

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