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ARAŞTIRMA MAKALESİ **RESEARCH ARTICLE**

Evaluating the performance of organic crop, livestock, and beekeeping in the Provinces of Türkiye using the TOPSIS method

Türkiye'deki illerin organik tarım, hayvancılık ve arıcılık performanslarının TOPSİS yöntemi ile değerlendirilmesi

Selen AVCI AZKESKİN[1], Melike Kübra EKİZ BOZDEMİR[1]

[1]*Kocaeli University, Faculty of Engineering, Department of Industrial Engineering, Kocaeli, Türkiye.*

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Corresponding author/Sorumlu yazar:
Selen Avcı AZKESKİN
selen.avci@kocaeli.edu.tr

ABSTRACT

In recent times, concerns regarding crop and livestock have gained a new dimension as people are becoming increasingly sensitive to health and environmental issues. Conventional farming methods have become a topic of contention due to their potential to give rise to environmental and health-related problems. Consequently, a growing number of producers and consumers have started to place emphasis on organic crop and livestock practices. In this study, the provinces of Türkiye have been assessed and ranked in terms of their performance in organic crop, livestock, and beekeeping for the 2019-2022 period. This evaluation has been conducted utilizing TOPSIS which is a Multi-Criteria Decision Making (MCDM) method. The criteria considered for crop production encompassed "number of farmers", "total production area (ha)", and "production quantity (tons)". For livestock, criteria such as "number of farmers", "number of animals", "meat production (tons)", milk production (tons)", and "number of eggs (units)" were considered. Finally, organic beekeeping activities were assessed based on "number of farmers", "number of hives", and "production quantity (tons)". In conclusion, Aydın province consistently ranked first in organic farming between 2019 and 2022. In organic livestock farming, Çanakkale province demonstrated stability by maintaining a position within the top three across all years. Finally, according to organic beekeeping data, Van province achieved the first place in 2019 and secured the second place in subsequent years, indicating a notable performance.

ÖZET

Son yıllarda, insanların sağlık ve çevre sorunlarına karşı daha duyarlı hale gelmeleriyle tarım ve hayvancılık konularına ilişkin endişeler de yeni bir boyut kazanmıştır. Geleneksel tarım yöntemleri, sağlıkla ilgili sorunlara ve çevreyle ilgili olumsuzluklara yol açma potansiyelleri nedeniyle tartışmalı bir konu haline gelmiştir. Bu nedenle, organik tarım ve hayvancılık uygulamalarına önem veren üretici ve tüketici sayısı giderek artmaya başlamıştır. Bu çalışmada, Türkiye'nin illeri, 20192dan 2022'ye kadar olan dönemde organik tarım, hayvancılık ve arıcılık alanındaki performansları bakımından Çok Kriterli Karar Verme (ÇKKV) yöntemlerinden biri olan TOPSIS ile değerlendirilmiş ve sıralanmıştır. Organik tarım için kullanılan kriterler "çiftçi sayısı", "toplam üretim alanı (hektar)" ve "üretim miktarı (ton)"dır. Organik hayvancılık için ise "çiftçi sayısı", "hayvan sayısı", "et üretimi (ton)", süt üretimi (ton)" ve "yumurta sayısı (adet)" kriterleri göz önünde bulundurulmuştur. Son olarak, organik arıcılık faaliyetleri, "çiftçi sayısı", "kovan sayısı" ve "üretim miktarı (ton)" üzerinden değerlendirilmiştir. Sonuçlara göre, organik tarımda Aydın ili 2019-2022 yılları arasında istikrarlı bir şekilde 1. sırada yer almıştır. Organik hayvancılıkta Çanakkale tüm yıllarda ilk 3 sırada yer alarak istikrar göstermiştir. Organik arıcılık verilerine göre ise Van ili, 2019 yılında 1., diğer yıllarda ise 2. sırada yer alarak iyi bir performans göstermiştir.

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INTRODUCTION

In recent years, the demand for crop and livestock has surged in tandem with the rapid growth of the global population. To meet this demand and boost productivity, crop and livestock practices have increasingly turned to the use of chemical fertilizers, pesticides, and intensive production techniques. However, the adverse effects of these chemicals on human health and the environment have prompted intense debates. Over time, heightened awareness of nutrition, environmental concerns, the emphasis on animal rights, and rising income levels have given rise to new demands in certain societies. As a result, organic crop and livestock have gained significance (Eryılmaz et al., 2019).

Improper and excessive use of chemical fertilizers and pesticides in agriculture is one of the important causes of threats to human health and environmental pollution. Social awareness about the negative effects of agricultural pollution increases the importance of organic agriculture (Boz and Kılıç, 2021). Organic crop embraces production systems that are both human- and environment-friendly, with the goal of re-establishing the natural balance that has been disrupted by flawed practices in the ecological system. Essentially, it offers an alternative production method that prohibits the use of synthetic chemical pesticides, hormones, and mineral fertilizers. Instead, it advocates for the utilization of natural enemies along with organic and green fertilization, ultimately aiming to enhance both production quantity and product quality (Menten et al., 2023). On the other hand, organic livestock farming represents an environmentally conscious form of production that allows farm animals to exhibit their natural behavior. It involves the use of ecological feed and prohibits the use of additives such as hormones and antibiotics to enhance efficiency. This method is subject to inspection by control and certification bodies and it offers consumers healthier products (Ak et al., 2019; Tosyalı, 2023). Likewise, organic beekeeping adheres to the principle of obtaining honey without exposure to any chemicals, cultivating it in areas that are sensitive to pollutants, and subjecting all stages to rigorous control and certification (Demir et al., 2023).

Originating in selected European countries, including Germany, the United Kingdom, and Switzerland, in the 1920s, organic crop has experienced rapid expansion across Europe since the 1960s. Also, its significance is growing day by day in Türkiye, owing to factors such as excessive pollution in soil and water resources, the presence of ecologies conducive to organic crop, a mounting foreign demand, and an increasing recognition of the value of organic products in the domestic market. Initially established in the Aegean Region, production has progressively extended to other regions of Türkiye in response to diverse product demands in various areas. Additionally, regions in Türkiye that remain unpolluted due to limited crop and industry, particularly the Eastern Anatolia Region, hold substantial ecological significance for livestock (Çelikyürek and Karakuş, 2018). Meanwhile, organic beekeeping is emerging as a novel model in Türkiye. According to pertinent legislation, hives must not be coated with chemical dyes; instead, propolis, beeswax, and vegetable oils must be utilized. In this production model, wherein every stage is meticulously monitored, authorized organizations may allow colonies to be nourished with organic honey or organic sugar if they face threats due to climatic conditions (Demir et al., 2023).

Multi-Criteria Decision Making (MCDM) methods have been developed to systematically address decision problems and select the best alternatives under multiple criteria. MCDM methods are frequently applied in performance evaluations. In the literature, MCDM methods have been employed to compare entities such as banks (Gözkonan and Küçükbay, 2019; Şimşek, 2022; Kaya et al., 2024), oil or charcoal companies (Ömürbek and Aksoy, 2016; Rajadurai and Kaliyaperumal, 2024), insurance companies (Bektaş, 2021), coal enterprises (Aksoy et al., 2015), logistics companies (Nila and Roy, 2023), airline transportation companies (Mahtani and Garg, 2018), universities (Zhang et al., 2022), hospitals (Erbay and Akyürek, 2020) and more. Similarly, countries, provinces, and regions within countries have been frequently compared using MCDM methods. For instance, Pekkaya and Dökmen (2019) examined public health expenditures in OECD countries, Ulutaş and Karaköy (2019) evaluated the logistics performance index of G-20 countries, Akandere and Zerenler (2020) assessed the environmental and economic

performance of Eastern European Countries and Karaatlı et al. (2015) compared the provinces of Türkiye in terms of livability.

In the literature, MCDM studies concerning agriculture are available, with examples presented in Table 1. As seen in Table 1, MCDM studies related to agriculture generally focus on topics such as determining cropping patterns, comparing organic and conventional farming, and evaluating various organic farming strategies. It can be said that studies evaluating organic crop, livestock, and beekeeping using MCDM methods for a specific region, province, or state are particularly scarce.

Table 1. Summary of some MCDM studies related to agriculture / organic agriculture
Çizelge 1. Tarım / organik tarım ile ilgili bazı ÇKKV çalışmalarının özeti

Author(s) and Location	Study Topic	Criteria	Method(s)	Alternatives
Poursaeed et al. (2010) / Iran	Partnership models for agricultural sustainability	Reducing farmer migration, collaboration with agricultural engineers, land consolidation, increasing farmer awareness, crop rotation, reducing chemical fertilizer and pesticide use, fertilizer recommendation, allocation efficiency	AHP (Analytic Hierarchy Process)	Private partnership, cooperative partnership, sharing partnership, rental partnership
Emamzadeh et al. (2016) / Iran	Optimizing mixed cropping patterns of organic and non-organic products	Gross margin, chemical fertilizer and toxin consumption	AHP, weighted goal programming	Open-field organic, open-field non-organic, tunnel farming, non-organic greenhouse
Otgonbayar et al. (2017) / Mongolia	Land suitability evaluation for agricultural cropland	Topography, soil properties, vegetation, agro-climatic factors, hydrology, socio-economic factors	AHP, random forest (RF) and partial least square (PLS) regression	-
Seyedmohammadiet al. (2018) / Iran	Priority planning for planting maize, rapeseed, and soybean	Soil depth, gypsum content, calcium carbonate content, pH, electrical conductivity, exchangeable sodium percentage, slope, climate	SAW (Simple Additive Weighting), TOPSIS, Fuzzy TOPSIS, AHP	Maize, rapeseed, soybean
Güngör (2018) / Türkiye	Management strategies for honey production forests	Honey yield from natural forests, organic honey production, pollen quality, high-priced honey production, beekeeping climate and ecology, beekeeping knowledge, migration rate, public and NGO participation, honey production season, bee product demand, organic market, beekeeping finance	A'WOT (SWOT-Strengths, Weaknesses, Opportunities, and Threats and AHP), Conjoint Analysis	Strategy combinations
Talukder & Hipel (2018) / Bangladesh	Sustainability indicators of agricultural systems	Productivity, stability, efficiency, resilience, adaptability, equity	PROMETHEE (Preference Ranking Organization METHod for Enrichment Evaluations) II	Shrimp, shrimp-rice, rice, ıntegrated, traditional

Table 1 (continued). Summary of some MCDM studies related to agriculture / organic agriculture
Çizelge 1 (devamı). Tarım / organik tarım ile ilgili bazı ÇKKV çalışmalarının özeti

Rocchi et al. (2019) / Italy	Sustainability of poultry production systems	Respiratory inorganics, climate change, acidification/eutrophication land use, fossil fuels, biodiversity, occupational safety, movement, stock density, outdoor time, breast blisters, footpad lesions, landscape, net income, feed conversion ratio, mortality rate, meat quality	PROMETHEE, LCA (Life Cycle Assessment)	Intensive system, free-range system, combined system
Balezentis et al. (2020) / Lithuania	Evaluating agricultural sustainability	Total water footprint, Shannon diversity index, total output, yield variability	Mathematical programming, SAW, TOPSIS, EDAS (Evaluation based on Distance from Average Solution)	Base scenario, scenario 1, scenario 2, scenario 3, scenario 4, scenario 5
Namiotko et al. (2022) / EU countries	Agro-environmental status of EU countries	Average organic carbon content in agricultural soil, Ammonia emissions from agriculture, Surface water quality, Groundwater quality, Farmland bird index, Intensive farming areas, Favorable conservation status of agricultural habitats	SAW, TOPSIS, EDAS	Denmark, Germany, Estonia, Ireland, Latvia, Lithuania, Netherlands, Austria, Poland, Finland, Sweden
Mangan et al. (2022)/ India	Land suitability for organic farming	Geology, soil pH, soil texture, land use, land surface temperature, drainage density, road accessibility, slope, soil organic carbon, soil salinity, NDVI, rainfall	AHP	Highly suitable areas, moderately suitable areas, marginally suitable areas, unsuitable areas
Rouyendegh & Savalan (2022) / Türkiye	Evaluation of agricultural production methods	Satisfaction, economy, environment	Buckley's fuzzy AHP (B-FAHP), Fuzzy TOPSIS	Organic farming, conventional farming, genetic engineering
Sabir et al. (2022) / Pakistan	Comparison of organic and inorganic farming	Environmental benefits, health benefits, soil fertility, consumer awareness, production efficiency, economic impacts, fertilizer use, social effects, farmer awareness	AHP, TOPSIS	Organic farming, inorganic farming
Obbineni et al. (2023) / India	Strategies for the development of organic farming	Strengths, Weaknesses, Opportunities, Threats	SWOT, Neutrosophic Cognitive Maps (NCM)	SO, WO, ST, WT strategies

Table 1 (continued). Summary of some MCDM studies related to agriculture / organic agriculture
Çizelge 1 (devamı). Tarım / organik tarım ile ilgili bazı ÇKKV çalışmalarının özeti

Fernández-Portillo et al. (2023) / Paraguay	Strategies for adopting organic farming	Lack of government support, preference for agrochemicals, contamination from adjacent farms, difficulty accessing organic inputs, low farmer knowledge level, increased vulnerability and risks, Lack of financial capacity and support, Lack of organic markets, Specific infrastructure deficiencies	BWM (Best-Worst Method), Fuzzy CoCoSo (Combined Compromise Solution)	Production, trade, supply, organic certification, quality, product presentation, labeling, production quantity, cultivated area, processing/packaging, Diversification, Transport, Input supply, Vertical, and Horizontal contracts, Institutional strengthening, Advocacy
Magableh (2023) / Jordan	Wheat suppliers for Jordan	Quality, cost, delivery time, flexibility, communication, origin, reliability	Fuzzy VIKOR (VlseKriterijumska Optimizacija I Kompromisno Resenje)	Romania, Ukraine, Russia, USA, Canada
Shin et al. (2024) / South Korea	Environmental evaluation of organic farming	Physical and ecological environment of farmland, physical and ecological environment of residential area, farmland landscape, rural life and cultural environment	AHP	-

In this study, all provinces in Türkiye with records of organic crop, organic livestock, or organic beekeeping between 2019 and 2022 were ranked based on their performance. The criteria utilized in the study were “number of farmers”, ”total production area (ha)”, and “production quantity (tons)” for agricultural production. For livestock, factors such as “number of farmers”, “number of animals”, “meat production (tons)”, “milk production (tons)”, and “number of eggs (units)” were considered. Finally, organic beekeeping activities were evaluated based on “number of farmers”, “number of hives”, and “production quantity (tons)”. The study aims to rank the provinces and unveil performance changes between 2019-2022.

MATERIAL and METHODS

MCDM methods are among the best techniques that can be used for ranking alternatives in situations involving multiple and often conflicting criteria and they are frequently used in the 814ort he814re to manage various types of problems. TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution) is one of the most frequently used MCDM methods in ranking problems due to its robust mathematical foundation and simplicity of application. Additionally, with these characteristics, it is a fundamental method that inspires numerous new approaches and comparative analyses (Chakraborty, 2022). Therefore, in this study, the performances of Türkiye’s provinces in organic crop, organic livestock, and organic beekeeping have been analyzed using this method and are explained in this section.

Principle of the TOPSIS method (Technique for order preference by similarity to an ideal solution)

TOPSIS method involves six stages, selecting the alternative that is closest to the positive ideal solution and furthest from the negative ideal solution (Heidarzadeh et al., 2020; Ilham et al., 2024).

In the decision matrix *X* in Eq. (1), where *I*=1, 2,…,*n* represents the criteria and *j*=1, 2,…,*m* represents the alternatives (Heidarzadeh et al., 2020; Ilham et al., 2024).

$$X = \begin{bmatrix} x_{11} & x_{1i} & x_{1n} \\ \vdots & \vdots & \vdots \\ x_{j1} & x_{ji} & x_{jn} \\ \vdots & \vdots & \vdots \\ x_{m1} & x_{mi} & x_{mn} \end{bmatrix} \qquad \textbf{Eq.(1)}$$

The normalized decision matrix is obtained using Eq. (2) (Heidarzadeh et al., 2020; Ilham et al., 2024).

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \qquad \textbf{Eq.(2)}$$

In the third step, the predetermined criterion weights are multiplied with the values in the normalized decision matrix according to the formula in Eq. (3) (Heidarzadeh et al., 2020; Ilham et al., 2024).

$$v_{ij} = w_j \times r_{ij} \qquad \textbf{Eq.(3)}$$

In the fourth step, negative ideal solution values are defined according to Eq. (4) and positive ideal solution values are defined according to Eq. (5). Here, *J* represents the benefit (maximization), J^- represents the criterion that will create the cost (minimization), X^- represents the least preferred, negative ideal solution, and X^+ represents the most preferred, positive ideal solution. For benefit criteria, the ideal solution is the highest value among the alternatives in the dataset for that criterion and the negative ideal solution is the lowest value. For cost criteria, the situation is the opposite. In other words, the ideal solution is the lowest value among the alternatives in the dataset for that criterion and the negative ideal solution is the highest value for the same criterion (Heidarzadeh et al., 2020; Ilham et al., 2024).

$$\mathrm{X}^- = (min_i v_{ij} |\ j \in J),\ (max_i v_{ij} |\ j \in J^{\mathrm{I}}),\ i=1, 2,\ldots,m\} = \{v_1^-, v_2^-, \ldots, v_n^-\} \qquad \textbf{Eq.(4)}$$

$$\mathrm{X}^+ = (max_i v_{ij} |\ j \in J),\ (min v_{ij} |\ j \in J^{\mathrm{I}}),\ i=1, 2,\ldots,m\} = \{v_1^+, v_2^+, \ldots, v_n^+\} \qquad \textbf{Eq.(5)}$$

In the fifth step, Eq. (6) is employed to calculate the distance from the positive ideal solution and Eq. (7) is used to calculate the distance from the negative ideal solution using the Euclidean distance formula which is shown in Equation (8) (Heidarzadeh et al., 2020; Ilham et al., 2024).

$$S_i^+ = \sum_{j=1}^{n} \left(v_{ij} - v_j^+\right)^2 \qquad \textbf{Eq.(6)}$$

$$S_i^- = \sum_{j=1}^{n} \left(v_{ij} - v_j^-\right)^2 \qquad \textbf{Eq.(7)}$$

$$d_{ij} = \sqrt{\sum_{k=1}^{n} \left(x_{ik} - x_{jk}\right)^2}] \qquad \textbf{Eq.(8)}$$

In the sixth and final step, the relative closeness of each alternative value to the ideal solution is found by calculating the C_i^* value using the formula in Equation (9). Here, C_i^* value takes values between 0 and 1. If X_i and X^+ are equal, C_i^* takes the value of 1, which indicates the absolute closeness of the relevant alternative to the positive ideal solution. If X_i and X^- are equal, C_i^* takes the value 0 which indicates the absolute closeness of the relevant alternative to the negative ideal solution. Alternatives are ranked according to their closeness to the ideal solution, starting from the highest (C_i^*) value (Heidarzadeh et al., 2020; Ilham et al., 2024).

$$C_i^* = \frac{s_i^-}{s_i^- + s_i^+} \qquad \textbf{Eq.(9)}$$

RESULTS

In this study, Türkiye's provinces have been ranked using TOPSIS technique, one of the MCDM methods, based on their performance in organic crop, organic livestock, and organic beekeeping from 2019 to 2022. We evaluated the provinces with available data for each year between 2019 and 2022 among the 81 provinces. All criteria were assigned equal weight and data used in the study were obtained from the Ministry of Agriculture and Forestry (2023).

The results obtained from the application of the steps outlined in the 'Methods' section are presented in the tables below. Table 2 illustrates the ranking of provinces according to their organic crop performance based on C_i values 816ort he years 2019-2022. The "performance" mentioned here refers to the relative success of the provinces based on the evaluated criteria. For example, in the case of organic crops, the criteria have been defined as "number of farmers", "total production area", and "production quantity". Consequently, the ranking is determined by the combined assessment of these three criteria.

When examining organic crops (Table 2), it is evident that Aydın province consistently held the 1st position between 2019 and 2022. Rize province, which was ranked 3rd in 2019, ascended to the 2nd position in 2020 and maintained it in the subsequent years. While Kars province held the 2nd position in 2019, it declined to 3rd place in 2020 and 2021 and fell to 6th place in 2022. Manisa, which occupied the 4th position in 2019, 2020, and 2021, rose to the 3rd position in 2022. Van province was ranked 5th in 2019 but experienced a decline in subsequent years. Ağrı province improved from 6th place in 2019 to 5th place in 2020 and maintained its position in the following years. Finally, Niğde province, which was ranked 12th in 2019, made significant progress by rising to 6th place in 2020 and 2021 and to 4th place in 2022.

Table 2. The ranking of provinces based on organic crop performance
Çizelge 2. İllerin organik tarım performanslarına göre sıralanması

Province	2019	2020	2021	2022	Province	2019	2020	2021	2022
Adana	15	13	13	23	Kahramanmaraş	51	41	38	36
Adıyaman	20	29	28	30	Karaman	52	52	51	46
Afyonkarahisar	13	14	10	13	Kars	2	3	3	6
Ağrı	6	5	5	5	Kastamonu	10	9	11	37
Amasya	40	54	54	49	Kayseri	63	62	63	38
Ankara	24	20	21	19	Kırıkkale	64	63	64	61
Antalya	34	30	24	18	Kırklareli	65	64	65	62
Artvin	16	15	14	10	Kırşehir	66	65	66	63
Aydın	1	1	1	1	Kilis	29	27	26	25
Balıkesir	41	34	31	26	Kocaeli	67	66	67	64
Bartın	35	45	42	40	Konya	21	18	20	20
Batman	45	46	43	41	Kütahya	53	67	68	65
Bayburt	55	55	55	50	Malatya	11	10	8	9
Bilecik	46	47	44	42	Manisa	4	4	4	3
Bitlis	18	31	29	27	Mardin	30	23	18	8
Bolu	56	56	56	51	Mersin	38	42	33	29
Burdur	47	48	45	52	Muğla	22	24	22	21
Bursa	48	37	35	43	Muş	8	8	9	14
Çanakkale	25	26	25	24	Nevşehir	68	68	69	66
Çorum	57	57	57	53	Niğde	12	6	6	4
Denizli	36	49	46	54	Ordu	27	21	19	17

Table 2 (continued). The ranking of provinces based on organic crop performance

Çizelge 2 (devamı). İllerin organik tarım performanslarına göre sıralanması

Diyarbakır	28	50	47	44	Rize	3	2	2	2
Düzce	49	38	36	31	Sakarya	54	43	39	39
Edirne	58	58	58	55	Samsun	19	16	16	11
Elazığ	26	17	30	32	Sinop	33	36	40	67
Erzincan	32	32	32	33	Sivas	17	11	12	15
Erzurum	7	22	23	34	Şanlıurfa	14	12	15	12
Eskişehir	37	33	48	28	Tekirdağ	69	69	70	68
Gaziantep	42	39	37	35	Tokat	39	53	34	69
Giresun	59	51	49	56	Trabzon	23	19	17	16
Gümüşhane	60	59	59	57	Tunceli	44	44	52	47
Hatay	43	40	50	45	Uşak	70	70	71	70
Iğdır	61	60	60	58	Van	5	25	41	48
Isparta	50	35	61	59	Yalova	71	71	72	71
İstanbul	62	61	62	60	Yozgat	72	72	53	72
İzmir	9	7	7	7	Zonguldak	31	28	27	22

Figure 1 presents the organic livestock performance of provinces with organic livestock records from 2019 to 2022, while Figure 2 illustrates the organic beekeeping performance for the same years. According to Figure 1, the number of provinces with uninterrupted organic livestock data for four consecutive years is 14, whereas this number is 24 for organic beekeeping, as shown in Figure 2. The C_i value on the vertical axis in the Figures represents the closeness to the ideal solution, calculated using the TOPSIS method with Equations 1-9, and ranges from 0 to 1. Since a C_i value of 1 indicates absolute proximity to the positive ideal solution, a higher C_i value reflects superior performance of the alternative.

According to the results of organic livestock (Figure 1), we observed that Niğde province, which ranked 1st in 2019, declined to 7th, 6th, and 5th place in the subsequent years. Çanakkale province, ranked 3rd in 2019, ascended to 1st place in 2020 and 2021, and secured the 2nd position in 2022. Sakarya province, which was 2nd in 2019, experienced slight declines in other years but consistently remained within the top 5. İzmir province, ranked 7th in 2019, rose to 4th place in 2020, and to 3rd place in 2021 and 2022. Manisa, which ranked 5th in 2019, demonstrated a significant improvement by securing 2nd place in 2020 and 2021, and 1st place in 2022.

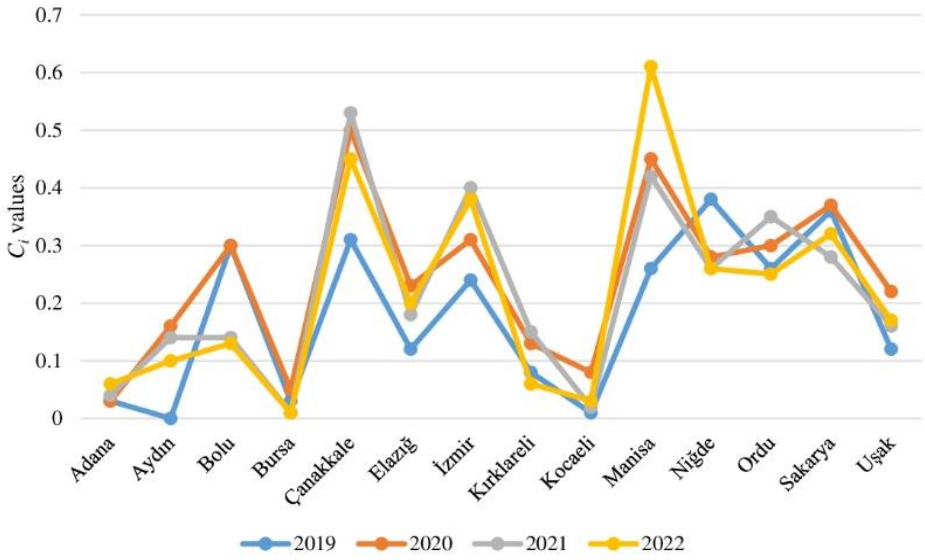

Figure 1. The organic livestock performances of the provinces
Şekil 1. İllerin organik hayvancılık performansları

According to organic beekeeping data (Figure 2), Van province has consistently demonstrated good performance, ranking 1st in 2019 and 2nd in other years. Similarly, Mersin province has shown successful performance akin to Van province, ranking 3rd in 2019 and 2020, and 1st in 2021 and 2022. Sivas province has gradually improved its performance, ranking 8th in 2019 and 2020, 5th in 2021, and 3rd in 2022. Gümüşhane province has generally ranked high, placing 4th in 2019 and 2022, and 6th in 2020 and 2021. Elazığ province, which ranked 2nd in 2019 and 4th in 2020, saw a decline in performance, ranking 10th in 2021. Although Bayburt, Erzurum, and Ordu provinces have occasionally ranked high, they have shown unstable performance over the years.

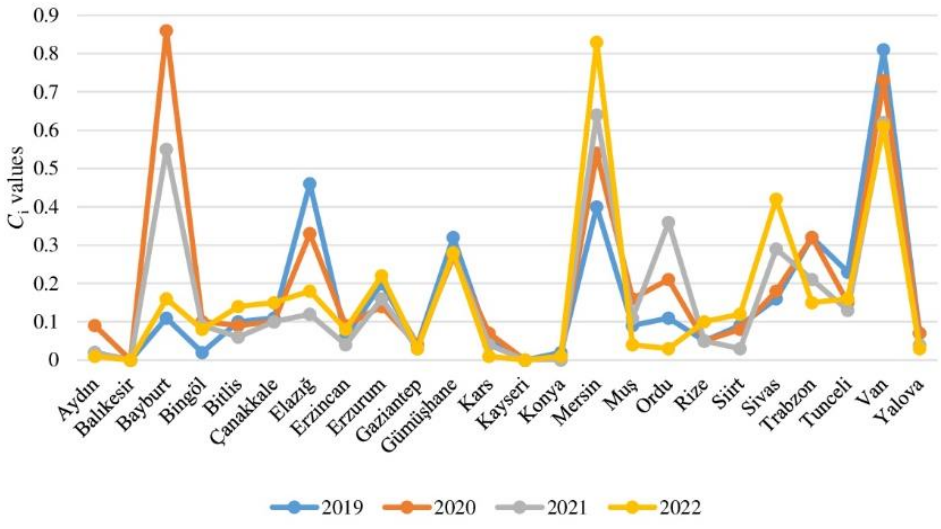

Figure 2. The organic beekeeping performances of the provinces
Şekil 2. İllerin organik arıcılık performansları

Between 2019 and 2022, there are 13 provinces engaging in both organic crop and organic livestock throughout all years. The performance variations of these provinces based on C_i values are demonstrated in Figure 3. Aydın province has consistently performed well, ranking 1st from 2019 to 2021 and 2nd in 2022. Manisa province has been identified as another province with successful performance, ranking 2nd in 2019 and 2020, 3rd in 2021, and 1st in 2022. Çanakkale province, which ranked 5th in 2019, improved its performance to 3rd in 2020 and 2022 and 2nd in 2021. İzmir province, which was 7th in 2019, rose to 4th place in 2020 and maintained this position. Niğde province, ranking 3rd in 2019, experienced a slight decline in performance in subsequent years, ranking 6th, 6th, and 5th respectively.

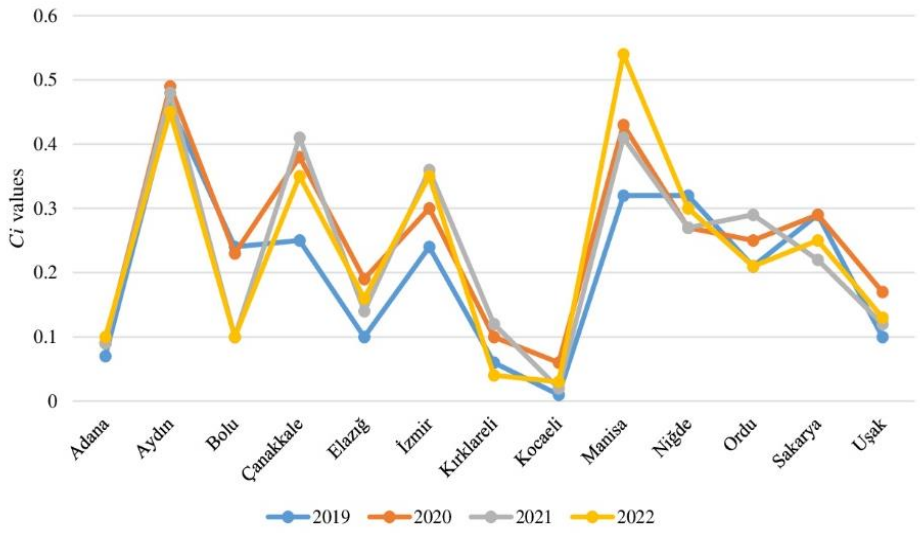

Figure 3. The organic crop and organic livestock performances of the provinces
Şekil 3. İllerin organik tarım ve organik hayvancılık performansları

Between 2019 and 2022, there are only four provinces that have records for all three categories: organic crop, organic livestock, and organic beekeeping. The performance variations of these provinces during the mentioned years are depicted in Figure 4. According to Figure 4, despite minor declines in its performance, Aydın ranked first in all years except 2019. Although Çanakkale saw a decline in 2020 compared to 2019, it improved its performance from 2020 to 2022, ranking just behind Aydın. Elazığ experienced a decline from 2019 to 2021 but improved its performance in 2021. While Ordu showed a slight increase in performance from 2019 to 2021, it faced a significant decline in 2021.

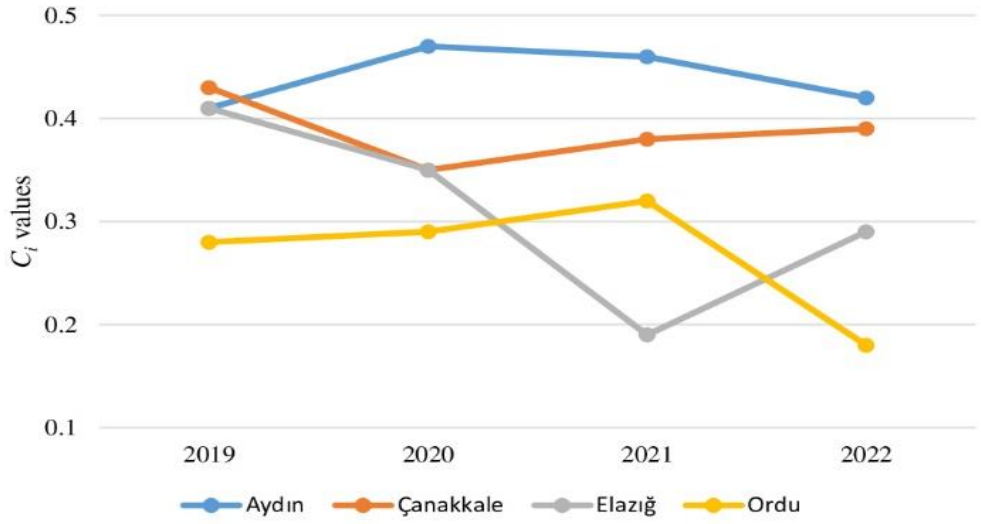

Figure 4. The organic crop, organic livestock, and organic beekeeping performances of the provinces
Şekil 4. İllerin organik tarım, organik hayvancılık ve organik arıcılık performansları

DISCUSSIONS

In the literature, MCDM studies related to agriculture generally focus on topics such as determining cropping patterns, comparing organic and conventional crop, and evaluating various organic farming strategies. In contrast, studies on organic livestock and beekeeping are quite rare. Furthermore, studies on organic farming that analyze and compare regions, provinces, or states are also limited. This study aims to evaluate the performance of organic crop, organic livestock, and organic beekeeping activities at the provincial level in Türkiye. In this regard, the study is original and distinguishes itself from existing literature. The performance differences between various regions in Türkiye have been analyzed and various strategies for provinces for policy-makers presented in the section of "Conclusion and Recommendation".

The data for enterprises under the certification system were collected at the provincial level for the years 2019-2022 and analyzed using the TOPSIS method, which is one of the MCDM methods. According to organic crop data, Aydın, Rize, Kars, Manisa, and Ağrı provinces ranked at the top. Aydın province has consistently ranked first over the four years due to the high production of organic figs, olives, chestnuts, cotton, and apples. Rize ranks high with organic tea production, while Manisa stands out with grapes and olives compared to other provinces. Besides, Kars and Ağrı provinces have excelled in organic feed production. However, although these provinces have excelled in organic feed production, they have not been included in the rankings for organic livestock due to the lack of certifications in this area. Regarding organic livestock data, Aydın province has a high number of cattle and consequently milk production, but no registered meat production. Adana and Kocaeli have a high number of poultry and consequently, organic egg production. Another province with a high number of poultry, Bursa, ranks high due to meat production rather than egg production.

While the ranking of provinces in organic crop and livestock may change slightly over the years, their overall performance tends to be consistent, maintaining their rankings accordingly. Additionally, sustainable performance has been observed in organic beekeeping in Van and Mersin provinces. However, the performances of other provinces have varied significantly over the years, highlighting the importance of measures and efforts against diseases in organic beekeeping. Therefore, it is recommended to provide farmers with training on selecting resilient suitable species, regularly renewing queen bees, systematically inspecting hives for any anomalies, checking male

bee larvae in hives, regularly disinfecting materials and equipment, disposing of contaminated substances or sources, regularly renewing beeswax, and leaving sufficient amounts of pollen and honey in hives (Demir et al., 2023).

The number of provinces engaged in both organic crop and organic livestock is quite limited. Aydın province stands out in both organic crop and organic livestock, thus ranking high when evaluated together. While Manisa province ranks high in organic crop, it ranks low in organic livestock. Çanakkale province ranks average in organic crop but low in organic livestock, thus placing lower in the ranking. Therefore, the ranking is behind the Manisa province. However, due to the limited number of provinces engaged in both organic crop and organic livestock, these provinces are listed. Only four provinces engage in organic crop, livestock, and beekeeping. These, in order of their performance, are Aydın, Çanakkale, Elazığ, and Ordu. Only four provinces have recorded data for organic crop, organic livestock, and organic beekeeping. Among these, Aydın secured the 2nd position in 2019 and consistently held the 1st position in subsequent years. In contrast, Çanakkale province held the 1st position in 2019 and the 2nd position in other years. Elazığ and Ordu provinces alternated between the 3rd and 4th positions.

CONCLUSION and RECOMMENDATION

Due to the increasing global population and the resulting need for food, high productivity has become crucial, leading to the prominence of high-yield farming and livestock practices. However, these practices have negatively impacted human, animal, and plant health, threatening the ecological balance to the extent of endangering all living beings. Therefore, in recent years, production techniques that are harmonious with nature, carry minimal risks to the environment and health, have begun to be adopted, bringing organic crop, organic livestock, and beekeeping to the forefront. In this study, the provinces of Türkiye have been examined and compared in terms of organic crop, livestock, and beekeeping activities between 2019 and 2022 using the TOPSIS method. It is known that the Eastern Anatolia region is prominent in livestock farming and breeding in Türkiye. However, in the study, it was observed that the provinces in Eastern Anatolia were not prominent in terms of organic livestock farming. The limited presence of organic livestock in the Eastern Anatolia Region despite the abundance of organic feed production might be attributed to farmers not participating in the certification process. Therefore, it is important for policymakers to encourage farmers for organic livestock in these provinces for diversity and sustainability.

The expansion of organic farming in Türkiye can enhance consumer awareness about organic products through the production of organic goods accessible to all income groups, the establishment of traceability, and the operation of an effective control and certification system. In this context, the number of organizations authorized to issue official certificates for organic crop and livestock under the Turkish Ministry of Agriculture and Forestry should be increased and expanded nationwide. Currently, these organizations are mostly located in the Aegean Region. Additionally, it is recommended to increase national incentives and make more extensive use of the EU's organic farming incentives. Moreover, especially due to the restrictions on logistic activities among provinces during the Covid-19 pandemic, the importance of diversity in terms of both crop and livestock farming in a region has been realized. Similarly, natural disasters such as earthquakes, floods, fires, etc., occurring in any region can affect many provinces. Additionally, the increasing costs of food and transportation in recent years have demonstrated the importance of product diversity in a province or region. Most regions of Türkiye are suitable for organic crop farming, animal livestock production, and beekeeping due to their climate and vegetation. Therefore, it is recommended that each province or region in Türkiye continue its own organic crop, livestock, and beekeeping activities together. In future studies, similar data can be analyzed using a different MCDM method and the obtained results can be compared. Additionally, different criteria can be included in the study. For instance, if the data is accessible, incorporating cost-related criteria could enhance the study's contribution. These criteria can be added to the study with different weights. These weights can also be determined using an MCDM method.

STATEMENT OF CONFLICT OF INTEREST

The author(s) declare no conflict of interest for this study.

AUTHOR'S CONTRIBUTIONS

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

STATEMENT OF ETHICS CONSENT

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

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