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INTERNATIONAL JOURNAL ON FOOD SYSTEM DYNAMICS

Int. J. Food System Dynamics 12 (2), 2021, 149-163

DOI: http://dx.doi.org/10.18461/ijfsd.v12i2.81

An Experimental Factor Analysis Study Using SAW and TOPSIS to Select and Rank Organic Agriculture Cities in Turkey

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Received January 2021, accepted April 2021, available online May 2021

ABSTRACT

The agriculture sector supports Turkey's GDP portfolio economically and helps establish a sustainable labor force. Turkey has certain competitive advantages in terms of the organic production of agricultural goods like figs and hazelnuts. We conduct a factor analysis using Simple Additive Weighting (SAW) and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) methods combined with a 3-level set (export volume, export value, and adequacy rate) to rank 32 candidate cities of Turkey where organic agriculture activities should be given more emphasis to support overall production and export rates. 18 different sets of importance values were used for this purpose and their combinatorial effects on candidate cities were analyzed. The factor analysis results show that the cities Izmir, Aydin, Adiyaman, Gaziantep, Agri, Mus, and Van have the highest potentials among all Turkish cities in both methods, while Sanliurfa also shows high potential for organic agriculture in the TOPSIS method.

Keywords: Organic agriculture; SAW; TOPSIS; factor analysis; decision making.

1 Introduction

Multi-Criteria Decision Making (MCDM) is a set of methods used extensively in businesses and daily life when attempting to determine the best course in a system with complex and usually conflicting interests and/or criteria. In daily life, preferring to get a cup of coffee from the shop on the corner of the street, postponing an important exam for a social event, or making an investment are all outputs of a decision-making process. One may think of “drinking a cup of coffee” as a free choice, while stopping at a red light is mandatory to prevent any accidents. Functional approaches in decision-making utilize different methods that are usually based on a predefined objective. There can be a single criterion or multiple criteria, each of which may have some kind of priority against the other. If there are multiple criteria and we evaluate alternatives through some series of methods, in essence, what we do is to use MCDM tools. In MCDM, each alternative is evaluated based on the defined criteria and they are ranked by decision-makers.

The agriculture sector may play a crucial role in a country’s strategic plans for the future. It is one of the areas that support the economy, working in tandem with various other industries. Particularly in the last thirty years, the number and total volume of food industries and overall production in developing countries have increased rapidly. However, a subset of producers preferred to supply their goods with cheaper prices when attempting to satisfy the high demand to remain competitive in their respective markets. While the prices went down, this decision also led to a reduction in the quality of agricultural products and secondary products obtained from them. The use of hormones, fertilizers, and other materials to accelerate the growth of plants was later identified as the main issue. It is with the idea of solving these issues that the concept of “organic agriculture” was introduced. The idea of organic agriculture is to provide healthy, hormone- and pesticide-free agricultural products to the public. Public opinion and knowledge regarding the potential risks of cheaper agricultural practices increased, and a demand for organic agricultural products emerged throughout the world. Overall, a significant portion of the public turned out to be willing to pay more for healthy agricultural products. Since Turkey is among the mid-belt countries, it has a competitive advantage in terms of the production of organic agricultural goods. The information regarding the number of farmers and crop types, the surface area used for organic agriculture, and the production amount are provided in Table 1.

Table 1.
Organic Agriculture Information (Ministry of Agriculture and Forestry)

Year	Number of Crops	Number of Holdings	Area (hectares)	Production (tons)
2010	216	42 097	510 033	1 343 737
2011	225	42 460	614 618	1 659 543
2012	204	54 635	702 909	1 750 127
2013	213	60 797	769 014	1 620 466
2014	208	71 472	842 216	1 642 235
2015	197	69 967	515 268	1 829 291
2016	238	67 878	523 777	2 473 600
2017	214	75 067	543 033	2 406 606
2018	213	79 563	626 885	2 371 612

As can be inferred from the table, the production increased more than 1 million tons in 8 years, and the number of farmers nearly doubled. Despite this rapid advance in organic agriculture activities, the numbers have still not reached the desired levels due to previously mentioned reasons.

This study tries to create a ranking of locations in terms of how suitable they are for organic agriculture activities and evaluates these locations using a combined approach of SAW, TOPSIS, and a series of importance values factored in 18 different levels based on three “importance directions”. In that sense, the study is unique as it considers production amount, production value, and adequacy ratio all at the same time. Production value is measured in dollars, and production amount is measured in thousand tons. Given the resources to produce a product, the adequacy ratio is measured numerically to assess whether a product can yield an efficiency to satisfy all the domestic demand while providing extra capacity for exportation. This is also the first study that takes into account all seven geographical regions of Turkey when analyzing the cities in terms of their organic agriculture potential.

The study aims to answer the following research questions:

1. Which cities have more potential in terms of further organic agriculture activities?
2. How do the export volume (EVO), the export value (EVA), and the adequacy rate (AR) affect these city rankings?
3. Do SAW and TOPSIS provide the same rankings even though the two methods are significantly different from each other?

The rest of the article is designed as follows: Chapter 2 provides a general overview of organic agriculture in Turkey. Chapter 3 provides background information for studies regarding SAW and TOPSIS and explains the methodology of the present paper. Chapter 4 presents the findings, and Chapter 5 discusses the results and provides insights regarding future studies.

2 Organic Agriculture and its Development in Turkey

As briefly discussed in the introductory part, organic products are consumed with the idea of protecting our health by offering safe, non-GMO, hormone-free products. Besides the public health aspect of the idea, however, organic agricultural production methods also have a perspective on environmental protection, as some of the traditional or economic methods of agricultural production may endanger certain species, or pollute the soil, water, and/or air (Ministry of Agriculture and Forestry, 2021).

The fırst organic agriculture activities in Turkey were initiated in 1984 to satisfy the demands of foreign companies. Following the regulations imposed by the European Union in 1991, and expanded by livestock farming and apiculture businesses, organic agriculture activities continued to increase in Turkey (Cavdar, 2003). Following the implementations in the European Union, Turkey developed its regulatory system that adhered to EU regulations. In 1994, the "Regulation on the Production of Plant and Animal Products Using Ecological Methods" was published (*T.C. Resmi Gazete*, 1994). Later, to comply with the changes in the EU legislation, the "Regulation on the Principles and Application of Organic Agriculture" was issued on 11.07.2002 (*T.C. Resmi Gazete*, 2002). The Organic Agriculture Law was published on 03.12.2004 and the regulation on the law was published on 10.06.2005 (Aydin et al., 2019). Today, organic farming activities are carried out in Turkey within the scope of the Organic Agriculture Law No. 5262 and the Regulation on the Principles and Application of Organic Agriculture. Accordingly, the Ministry assigns control bodies for every phase of the organic agriculture activities, from the harvesting of the goods to the delivery of the product to the end consumer. All these control bodies are registered in a database and are authorized to monitor and control organic agriculture activities, as well as to provide training and education programs for farmers.

One of the significant challenges is to fight weeds while maintaining organic production. Weeds take over the space of cultivated crops and prevent organic products from growing to their full potential, resulting in economic losses. They can also harbor diseases and pests, and even destroy the cultivation area completely. Since organic agriculture farmers are not using pesticides to fight weeds, experts have developed numerous other ways to suppress the growth of weeds (instead of destroying them), all of which have parallels with the methods in herbology (Onen, 2020). With regulations declared in 2005 for fighting weeds, and also according to the Plant Protection and Agricultural Quarantine Law, the use of pesticides is prohibited and numerous novel soil protecting methods are practiced instead.

There is a tendency to destroy fertile lands and agricultural areas when more economic use-cases for such areas are believed to exist. This situation is particularly common in tourism activities. Even though there is a certain degree of public awareness regarding the significance of agricultural areas and there have been attempts at combining organic agriculture activities with tourism in the last 20 years, many people still do not have the consciousness and knowledge to preserve their fertile terrain for agriculture. Yet still, tourism activities such as in-location seminars, fishing and farming activities in organic farms, and training programs are being conducted to promote organic agriculture through tourism in Turkey (Demirci & Sarikaya, 2020).

Noting that Turkey's overall economy relies heavily on agriculture, Table 2 shows how significant organic agriculture activities have become within agricultural production (Eroglu Pektas, 2019).

As can be seen in Table 2, Turkey has 7 geographic regions and has a significant advantage as it has the means to produce multiple types of products on an organic basis. These numbers are still growing, but there is a potential to grow much more rapidly if the investments and policies are employed wisely.

Table 2.
Number of organic agriculture producers in 7 regions of turkey 2017 (taken from: tarimorman.gov.tr)

Rank	Region	Number of Producers	%	Main Products
1	Aegean	279	35.8	Olive, fig, cotton, grape, barley, cherry
2	Marmara	145	18.6	Artichoke, eggplant, cabbage, tomato, grape, walnut
3	Central Anatolia	89	11.4	Clover, sainfoin, onion, apple, wheat
4	Eastern Anatolia	88	11.3	Clover, wheat, barley, oat, vicia sativa
5	Mediterranean	68	8.7	Pomegranate, citrus fruits, pistachio, apple, wheat, grape
6	Black Sea	65	8.3	Tea, nut, apple, cornelian cherry
7	Southeast Anatolia	46	5.9	Wheat, grape, olive, corn, cotton

3 Materials and Methods

3.1 SAW and TOPSIS Methods

Studies and derived methods that attempt to bring tailored approaches to real-time problems start as early as the 1950s and 1960s (Zavadskas et al., 2014). This chapter introduces two such methods used in the study and provides an overview of the previous work.

Simple Additive Weighting (SAW) is a method preferred commonly since its introduction by Churchman & Ackoff (1954), mostly because of its simplicity and speed in providing a solution for an alternative selection. SAW has previously been used to rank the livable cities in Turkey (Karaatlı et al., 2015). It has also been used to reflect its features in conjunction with COPRAS (Podvezko, 2011). Some studies employed AHP to assess the risks in a pharmaceutical supply chain based on risk priority and hazards (Jaberidoost et al., 2015). For more applications, the reader may refer to Shakouri G., Nabaee, & Aliakbarisani (2014) where SAW was used together with AHP to assess power supply technologies, and an economical study for poverty level grouping (Huda et al., 2018).

The algorithm for SAW is as follows:

1. Normalization of the decision matrix: Having *m* alternatives and *n* criteria, the decision matrix is normalized column by column; either by dividing all values by the maximum value, or by dividing the minimum value by all other values, as given in (1):

$$r_{ij} = \begin{cases} \frac{x_{ij}}{max_i x_{ij}} & \forall i,j \text{ if the maximum value is the best} \\ \frac{min_i x_{ij}}{x_{ij}} & \forall i,j \text{ if the minimum value is the best} \end{cases} \quad (1)$$

2. Evaluation of each alternative: Multiplication of normalized values by their respective criteria provides the value of each alternative, given in (2):

$$V_i = \sum_{j=1}^{n} w_j \; x \; r_{ij} \quad (2)$$

The second method used in the present paper, the "Technique for Order of Preference by Similarity to Ideal Solution" (TOPSIS) was first used by Yoon & Hwang, (1995), and provided a more specific approach to MCDM problems. This method makes use of the definition of a positive ideal solution and tries to select the best alternative in terms of value proximity to this ideal solution. The method was later modified in various ways to fit better into real-life decision problems. It is similar to VIKOR but procedures are different in terms of ideal solution comparisons (Opricovic & Tzeng, 2004). The procedure for TOPSIS is given as follows:

1. Normalization of the decision matrix: Using the formula in (3), the matrix is normalized:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^{2}}} \qquad \forall i, j \tag{3}$$

2. Finding weighted normalized matrix: As in SAW, each value is multiplied by its respective weight to obtain the matrix, denoted by vij.
3. Calculation of positive (PIS) and negative (NIS) ideal solutions: They are given by (4):

$$A^{*} = \{v_1^{*}, v_2^{*}, \ldots . v_n^{*}\} \qquad A^{-} = \{v_1^{-}, v_2^{-}, \ldots . v_n^{-}\} \tag{4}$$

4. Distance of each alternative from PIS and NIS: They are calculated by (5):

$$d_i^{+} = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^{*})^2} \qquad d_i^{-} = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^{*})^2} \tag{5}$$

5. Calculation of proximity of each alternative and ranking: The values are denoted by CCİ and are given by (6):

$$CC_I = \frac{d_i^{-}}{d_i^{-} + d_i^{+}} \quad \forall I \tag{6}$$

TOPSIS is used to compare vertical handover decision schemes (Savitha & Chandrasekar, 2011). It is used also as an extension to fit into different problems as in (Lai et al., 1994) where fuzzy set theory is used and the k-dimensional alternative set is reduced to a 2-dimensional objective. (C.-T. Chen, 2000) also extends TOPSIS to the fuzzy environment and uses fuzzy ideal solutions to compare decision alternatives. To have more information on how fuzzy TOPSIS methods have evolved, the reader may refer to the study of Nădăban & Dzitac (2016), where a general overview has been provided. S.-M. Chen et al. (2016) and Joshi & Kumar (2014) are further studies that deal with the fuzzy environment and fuzzy numbers while selecting alternatives in MCDM. García-Cascales & Lamata (2012) provide an updating scheme based on rank reversal when there exists a new decision alternative while evaluating the initial set of alternatives. Another method to minimize rank reversals is provided by (Mufazzal & Muzakkir, 2018). (Shih et al., 2007) develops a group-based method to include multiple decision-maker preferences at the same time and to save computing time.

3.2 Determination of Alternatives

SAW and TOPSIS methods both require alternatives to be compared with each other in terms of a series of predefined criteria. The alternatives in the present study were initially determined as the cities of Turkey. Based on TUIK (Turkish Statistical Institute) data, as of 2018, there are 68 cities in Turkey where organic agriculture production activities are being performed. 32 of these cities are exporting their products and at the same time, they have a significant share in organic production, while the rest has not been taken into consideration as their total organic production volumes were less than 200 tons. The production activities in those cities were limited to their respective domestic markets, rather than exportation. The organic agricultural production data for 2018 was considered valid for the values of these cities in terms of the defined criteria, which were provided by the Ministry of Agriculture and Forestry and are presented here in Table 3. The provided figures are in tons.

Table 3.
Organic Agricultural Production Data 2018 (tons) (Ministry of Agriculture and Forestry)

Cities	Pistachio	Wheat	Hazelnut	Fig	Apricot	Lentil	Dried Grape
Adiyaman	3691.0	170.8		1.3		69.4	34.5
Agri		34017.1				1288.6	
Ankara		1332.9			46.5	98.7	
Artvin			2262.4				
Aydin	8.8	439.7		66248.3	37.1		
Batman		836.1				288.3	
Bitlis		4000.2			8.8		
Diyarbakir	116.3	1294.7		1.2	0.3	105.4	
Duzce		2.5	1364.2				
Elazig		108.1			2054.6	312.8	
Erzincan		2070.7			506.3	1.8	
Erzurum		19726.0				0.5	
Gaziantep	2875.9	240.8		3.2		31.1	12.5
Isparta		3.3			1969.0		
Izmir	6.9	346.4		19875.6	18.0		981.1
K.Maras	61.8				810.0		
Kars		17102.6			201.7		
Kilis	80.1	7.4				30.0	
Konya		338.7			3.9	8.0	100.8
Malatya		1375.8			51151.5	25.6	54.1
Mardin		2699.9		23.6		797.2	70.9
Mus		40433.1			11.4	134.2	
Nigde		265.2			510.0		
Ordu		15.2	4254.9			0.8	
Rize			265.1	0.5			
Sakarya		7.4	399.0	0.2	0.1		
Samsun		186.9	4448.3	0.5			
Sivas		2459.4			293.9	0.1	
Sanliurfa	726.7	12131.3				4772.6	
Trabzon			1180.1				
Van		50601.7			53.4	71.4	
Zonguldak		2.9	3256.8	0.4			

3.3 Determination of Criteria

The criteria for selecting the areas were defined based on three scales and seven different product types. These three scales are export volume (EVO), export value (EVA), and adequacy rate (AR) and are used to conduct the factor analysis. The products are fig, hazelnut, dried grape, apricot, pistachio, lentil, and wheat. They are determined by the Ministry of Agriculture and Forestry in the organic product exportation portfolio and reported to the public in this format. The data for all scales are given in Table 4, Table 5, and Table 6 in tons, US dollars, and as the ratio, respectively.

Table 4.
Total Export Amounts (tons) (TUIK)

No	Product	2014	2015	2016	2017	2018
1	Fig	4523.9	2636.0	3676.2	7098.7	7996.9
2	Hazelnut	1642.5	1559.0	2465.9	3857.6	5356.8
3	Dried Grape	4118.8	4240.0	3393.4	9595.6	10572.4
4	Apricot	1975.0	1153.0	1844.7	3078.4	4773.7
5	Pistachio	21.8	9.0	22.3	33.4	26.8
6	Lentil	365.1	283.0	133.7	565.2	5229.4
7	Wheat	845.3	1005.1	610.3	1193.1	41633.9

Table 5.
Total Export Value ($) (TUIK)

No	Product	2014	2015	2016	2017	2018
1	Fig	21 626 691	14 302 456	18 665 595	43 581 055	51 980 044
2	Hazelnut	17 046 378	20 577 959	24 975 616	31 941 924	40 015 020
3	Dried Grape	13 557 823	13 929 996	12 456 025	22 965 367	26 430 886
4	Apricot	11 102 466	8 772 244	10 996 054	14 571 024	22 627 358
5	Pistachio	854 089	325 800	492 932	829 797	795 976
6	Lentil	709 020	563 226	310 644	1 208 576	16 054 144
7	Wheat	364 871	434 004	186 877	438 088	131 146 772

Table 6.
Product Adequacy Ratios

No	Product	Adequacy Ratio
1	Fig	4.70
2	Hazelnut	5.10
3	Dried Grape	1.60
4	Apricot	4.00
5	Pistachio	1.10
6	Lentil	0.90
7	Wheat	1.10

3.4 Determination of Weights and Defining Instances

Weights are defined as "importance values". There are two sets of importance values used in the present experimental design. The first set consists of EVO, EVA, and AR. To determine the values in this set, we used the exportation data for the years 2014, 2015, 2016, 2017, and 2018 as presented in Table 3 and Table 4. Since the most recent data is more important, we assigned a coefficient of 2 to 2018 and decreased this number by 0.25 for each year as we went back to 2014. In the end, the year 2014 had a coefficient of 1, the year 2015 had a coefficient of 1.25 (and so on). Once we obtained a weighted average column for each table using these coefficients, we normalized the table to obtain the importance values. We used the same approach for EVO and EVA. For AR, we normalized Table 5. Accordingly, the first set of importance values are computed as presented in Table 7.

Table 7.
Importance Values of EVO, EVA, and AR

		Importance Values		
No	Product	EVO	EVA	AR
1	Fig	0.173	0.243	0.254
2	Hazelnut	0.103	0.212	0.276
3	Dried Grape	0.218	0.140	0.086
4	Apricot	0.088	0.107	0.216
5	Pistachio	0.001	0.005	0.059
6	Lentil	0.051	0.035	0.049
7	Wheat	0.367	0.259	0.059

The second set of importance values are joint importance values, derived from weighted computations of EVO, EVA, and AR. This is the step in which we implemented our experimental design. Since there is no exact way of determining which of EVO, EVA, and AR is more important and should be given more weight, we start by assigning a value of 0.05 to EVO and EVA, and eventually gave (1-0.05-0.05) = 0.9 to AR. Then we incrementally increased the values of EVO and EVA while decreasing the value of AR in a corresponding amount. We used these individual importance values and used also the values in Table 6 to create 18 different instances. To illustrate, we provide instance 1 as an example in Table 8.

Table 8.
Instance 1

	Instance 1	EVO	EVA	AR	Joint Importance Values
No	Product	0.05	0.05	0.9	
1	Fig	0.1732	0.2425	0.2540	0.2494
2	Hazelnut	0.1027	0.2116	0.2756	0.2638
3	Dried Grape	0.2176	0.1397	0.0864	0.0957
4	Apricot	0.0876	0.1070	0.2162	0.2043
5	Pistachio	0.0007	0.0049	0.0594	0.0537
6	Lentil	0.0513	0.0353	0.0486	0.0481
7	Wheat	0.3667	0.2587	0.0594	0.0847

Joint importance values are calculated by multiplying each product's EVA, EVO and AR values by the individual importance values. These joint values are then used as input in SAW and TOPSIS to rank the cities.

4 Findings

City rankings obtained by the SAW method are presented in Figure 1. Based on different instances, the SAW method yields different rankings of cities. However, it has been observed that Izmir, Aydin, Adiyaman, and Gaziantep are the first four cities that have significantly higher potential than the rest of the cities. For each city, the leftmost bar denotes the importance value set EVA=0.05, EVO=0.05, and AR=0.9 corresponding to instance 1, while the rightmost bar denotes the importance value set EVA=0.475, EVO=0.475, and AR=0.05 corresponding to instance 18.

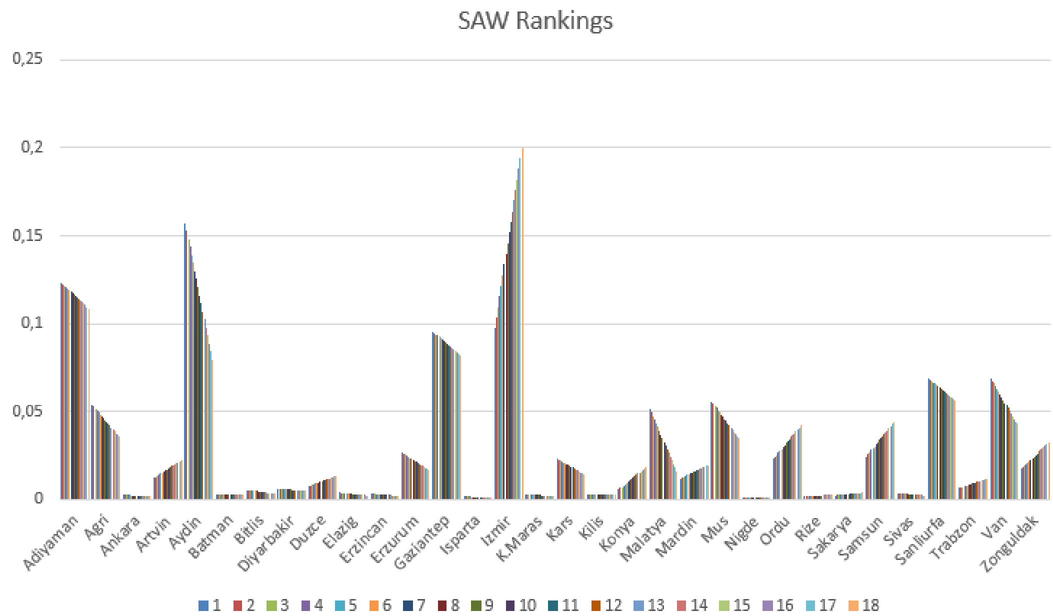

Figure 1. SAW Results

Overall, the obtained values indicate that Izmir, Aydin, Adiyaman, Gaziantep, Agri, Mus, Sanliurfa, and Van have the highest potential in terms of organic agriculture. Looking at the individual values, the following can be observed:

- If we give more importance to the adequacy ratio than EVO and EVA, Aydin has the highest potential (0.157), followed by Adiyaman (0.123) and Izmir (0.097) in instance 1. In other words, Aydin has products that have relatively higher adequacy.
- Contrary to Aydin, as we start to attribute more importance to EVO and EVA, Izmir starts to have an increasing potential in terms of organic agriculture (0.200 in Instance 18), and this value increases as we go from instance 1 to instance 18. That means that Izmir has a high export amount and export value regarding organic agriculture, and its rank is significantly higher than any other city when it comes to EVO and EVA.

- If the bars are increasing from left to right, we can say that the corresponding city is superior in terms of EVO and EVA. For example, Izmir, Artvin, Konya, Ordu, Samsun, and Zonguldak are some examples for which EVO and EVA increases yield more potential for organic agriculture. Similarly, if the bars are decreasing, the cities have products that have higher AR.

- Overall rankings of all cities based on the instances are given in Appendix A.

City rankings obtained with the TOPSIS method are given in Figure 2. This method also yields different rankings of cities based on different importance values as expected. For each city, the leftmost bar denotes the importance value set EVA=0.05, EVO=0.05, and AR=0.9 corresponding to instance 1, while the rightmost bar denotes the importance value set EVA=0.475, EVO=0.475, and AR=0.05 corresponding to instance 18.

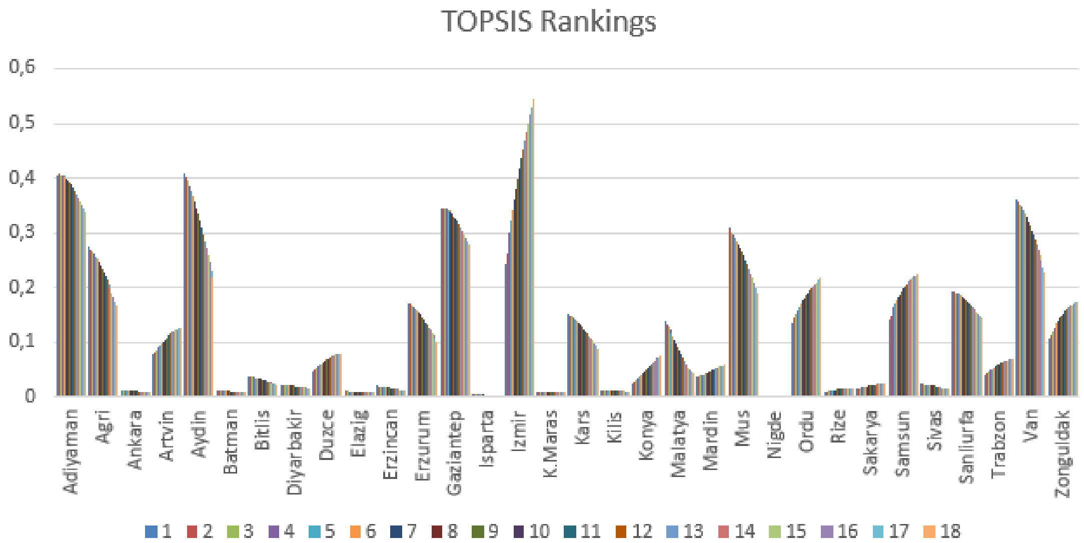

Figure 2. TOPSIS Rankings

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5 Conclusion and Further Discussion

Agriculture activities play an important role in a country's strategic plan. The extent to which planners and producers pay attention to internal factors determines the success in agricultural production. It is therefore the responsibility of governmental authorities and strategists to assist these producers. The tendency to reduce the production costs to remain competitive in the market has led a portion of the agricultural producers to implement farming methods that were cheaper but also less healthy, and in some cases, outright harmful to human health and the environment. A healthier concept, organic agriculture, has emerged as a response to provide healthier food for the public.

In this study, we used SAW and TOPSIS methods and tried to provide a preliminary analysis by determining the city potentials for organic agriculture before executing strategic plans on regional development. Turkey has inherent advantages in soil structure and organic agriculture know-how, so we selected all of the cities in the country as a whole to take into account every region that might have untapped potential for organic agriculture. Several conclusions were reached that can be stated as follows:

> **Result 1:** Izmir, Aydin, Adiyaman, Gaziantep, Agri, Mus, Ordu, Samsun, Sanliurfa and Zonguldak cities were found to have the highest potential in terms of the defined criteria. Izmir and Aydin have the largest amount of production in fig, so their place at the first rank can mostly be explained by their fig production. Erzurum, Agri, Mus, and Sanliurfa have superiority in wheat production, while Gaziantep and Adiyaman are the largest pistachio producers. These results are parallel with Demiryurek's study (2011) where Izmir and Aydin played the pioneering roles in organic agriculture when the first organic farming activities were introduced to a limited number of grape producers in the Aegean Region by the representatives of European organic farming companies. We see that grape and fig are among the first products that are organically produced in Aegean Region, which is the closest region to Europe and which has many ports that make it easier to export the goods. Izmir and Aydin are the largest cities of the Aegean region that have most of the organic agriculture producers, and numerous agricultural industry activities stem from them. We also see that nut, pistachio, and apricot production follow grape and fig in organic agriculture and are mostly produced in the Central Anatolia, Southeast Anatolia, and East Anatolia regions (Demiryürek et al., 2008).

> **Result 2:** Another interesting conclusion was reached in the direction of city potentials as the instances shifted from 1 to 18. Based on the importance values that defined each of the instances, the ranks of a given city could increase or decrease. If a city's rank is decreasing from instance 1 to instance 18, this means it mostly has products that have a high AR value. If its rank is increasing, it shows superior performance in exportation amount and/or value. This result is compatible with the studies of Ataseven & Gunes (2008), Aydin, Eryilmaz & Kilic 2019), and Cobanoglu & Isin (2009). Cobanoglu & Isin (2009), all of whom provided analyses of the cities of Aydin and Izmir and focused on organic agricultural production of fig and dried grape. These researchers used AHP to support their results. Aydin, Eryilmaz & Kilic (2019) provided an extensive analysis of organic nut production in the Black Sea region. Ataseven & Güneş (2008) also mention the latest improvements in organic agricultural marketing and mention the cities that we found in our study as candidates to conduct organic agricultural activities.

It should be kept in mind that we conducted the analyses with the limited data available. Various factors such as soil structure, overall education level of the farmers, the expertise of local labor force in agricultural production, perception towards organic agricultural strategies, and financial support systems such as loans and grants should also be taken into account for better comparison of candidate cities. Only after these comprehensive analyses, problems against organic agriculture can be identified and eliminated efficiently. Regional development in this regard is dependent upon such detailed analyses. It is also suggested to work locally with experts to best explore the organic agriculture potentials in each of the aforementioned cities. Local producers and experts in governmental authorities should assist all these efforts to realize the organic production potential in their region.

In future studies, regional development models can be based on organic agriculture potentials. Since the term "organic" is now well recognized by the rest of the world, having such a tag on the products in the agricultural portfolio would mean competitive advantage, and it would lead to significant financial gaining. However, clear and comprehensive governmental support is always necessary to support organic agriculture. Making input materials cheaper by mass purchases, providing income support, ease in access to agriculture credits, marketing support (especially for local farmers), governmental purchase guarantees are necessary to promote and sustain organic agriculture. Since many regions in Turkey are suitable for organic agriculture, pioneering pilot projects, as well as training programs, should be conducted in these areas. In addition, there should be opportunities for local producers to directly sell their products instead of relying on middleman actors. These intermediate actors tend to buy cheaply from locals and sell for high prices in the market. Overall, local producers need additional governmental support in selling their products to end consumers.

Another recommendation for both the government and individual farmers is "clustering". Clustering is the way of reducing input prices significantly by allowing individuals to purchase main ingredients and input materials together in huge batches from suppliers. Turkey suffers from this problem as there are no mechanisms to bring individual farmers together for such purchases, and as such farmers are unable to achieve a consensus in cooperation. Unfortunate most establishments see each other as competitors and competitors only and act aggressively in the market. This behavior leads to the failure of smaller producers against the bigger ones. The government should therefore support clustering activities and has to make sure that cooperatives regulate and control the competition between producers and support clustered organic agriculture.

Another important aspect in organic agriculture is the value creation by processing organic products, resulting in the capability to compete with foreign substitutes in price and quality. If farmers can do this, they will be able to sell value-added products at higher prices and will not be solely providing raw material for foreign producers. They will be able to act in the international market and product quality will improve by competition. Especially for natural and aromatic products, there is a great potential to produce value-added products while at the same time having them certified by relevant authorities (Derya & Islam, 2014).

It is a well-established fact that product prices in organic agriculture are high due to high production costs. It should therefore be determined what products are more profitable and what customer segments are willing to buy these products. In Turkey, not every household has a sufficient income to pay for organic agriculture products. Geographical, demographical, psychographic, and behavioral aspects of customers play a major role in determining customer segments. Urban and large areas in large cities can afford these products, but only minor classes that give attention to healthy foods and healthy nutrition while having a relatively higher income.

Acknowledgements

No grants or technical or academical support have been received in any means from any party.

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APPENDIX A. **SAW RANKINGS**

	Instances																	
Cities	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Adiyaman	0,1234	0,1225	0,1217	0,1208	0,1199	0,1191	0,1182	0,1173	0,1165	0,1156	0,1147	0,1139	0,1130	0,1121	0,1113	0,1104	0,1095	0,1087
Agri	0,0537	0,0526	0,0516	0,0505	0,0494	0,0483	0,0473	0,0462	0,0451	0,0440	0,0430	0,0419	0,0408	0,0397	0,0386	0,0376	0,0365	0,0354
Ankara	0,0024	0,0024	0,0023	0,0023	0,0023	0,0022	0,0022	0,0021	0,0021	0,0020	0,0020	0,0019	0,0019	0,0018	0,0018	0,0017	0,0017	0,0017
Artvin	0,0123	0,0128	0,0134	0,0140	0,0146	0,0152	0,0158	0,0164	0,0170	0,0176	0,0182	0,0187	0,0193	0,0199	0,0205	0,0211	0,0217	0,0223
Aydin	0,1573	0,1527	0,1481	0,1436	0,1390	0,1344	0,1299	0,1253	0,1207	0,1162	0,1116	0,1070	0,1025	0,0979	0,0933	0,0888	0,0842	0,0796
Batman	0,0029	0,0028	0,0028	0,0028	0,0027	0,0027	0,0026	0,0026	0,0026	0,0025	0,0025	0,0025	0,0024	0,0024	0,0024	0,0023	0,0023	0,0023
Bitlis	0,0054	0,0053	0,0052	0,0051	0,0049	0,0048	0,0047	0,0046	0,0044	0,0043	0,0042	0,0041	0,0040	0,0038	0,0037	0,0036	0,0035	0,0033
Diyarbakir	0,0062	0,0061	0,0060	0,0060	0,0059	0,0058	0,0057	0,0057	0,0056	0,0055	0,0054	0,0053	0,0053	0,0052	0,0051	0,0050	0,0049	0,0049
Duzce	0,0074	0,0077	0,0081	0,0085	0,0088	0,0092	0,0095	0,0099	0,0102	0,0106	0,0110	0,0113	0,0117	0,0120	0,0124	0,0127	0,0131	0,0134
Elazig	0,0039	0,0038	0,0037	0,0036	0,0034	0,0033	0,0032	0,0031	0,0030	0,0029	0,0028	0,0027	0,0025	0,0024	0,0023	0,0022	0,0021	0,0020
Erzincan	0,0033	0,0032	0,0031	0,0030	0,0029	0,0028	0,0027	0,0027	0,0026	0,0025	0,0024	0,0023	0,0022	0,0021	0,0021	0,0020	0,0019	0,0018
Erzurum	0,0267	0,0261	0,0255	0,0249	0,0243	0,0237	0,0231	0,0225	0,0219	0,0213	0,0207	0,0201	0,0195	0,0189	0,0183	0,0177	0,0171	0,0165
Gaziantep	0,0954	0,0946	0,0939	0,0931	0,0923	0,0915	0,0907	0,0899	0,0891	0,0884	0,0876	0,0868	0,0860	0,0852	0,0844	0,0836	0,0829	0,0821
Isparta	0,0018	0,0017	0,0016	0,0015	0,0014	0,0013	0,0012	0,0011	0,0010	0,0010	0,0009	0,0008	0,0007	0,0006	0,0005	0,0004	0,0003	0,0002
Izmir	0,0974	0,1034	0,1095	0,1155	0,1216	0,1277	0,1337	0,1398	0,1458	0,1519	0,1579	0,1640	0,1700	0,1761	0,1822	0,1882	0,1943	0,2003
K.Maras	0,0028	0,0027	0,0027	0,0026	0,0025	0,0025	0,0024	0,0024	0,0023	0,0022	0,0022	0,0021	0,0021	0,0020	0,0020	0,0019	0,0018	0,0018
Kars	0,0233	0,0228	0,0223	0,0217	0,0212	0,0207	0,0201	0,0196	0,0191	0,0185	0,0180	0,0175	0,0170	0,0164	0,0159	0,0154	0,0148	0,0143
Kilis	0,0028	0,0028	0,0028	0,0027	0,0027	0,0027	0,0027	0,0026	0,0026	0,0026	0,0026	0,0025	0,0025	0,0025	0,0025	0,0024	0,0024	0,0024
Konya	0,0056	0,0064	0,0071	0,0079	0,0086	0,0094	0,0101	0,0109	0,0116	0,0124	0,0132	0,0139	0,0147	0,0154	0,0162	0,0169	0,0177	0,0184
Malatya	0,0516	0,0495	0,0474	0,0453	0,0432	0,0411	0,0390	0,0369	0,0348	0,0327	0,0306	0,0285	0,0264	0,0243	0,0222	0,0201	0,0180	0,0159
Mardin	0,0121	0,0125	0,0129	0,0134	0,0138	0,0142	0,0146	0,0151	0,0155	0,0159	0,0164	0,0168	0,0172	0,0176	0,0181	0,0185	0,0189	0,0193
Mus	0,0555	0,0542	0,0530	0,0518	0,0506	0,0493	0,0481	0,0469	0,0456	0,0444	0,0432	0,0419	0,0407	0,0395	0,0382	0,0370	0,0358	0,0345
Nigde	0,0008	0,0008	0,0008	0,0007	0,0007	0,0007	0,0006	0,0006	0,0006	0,0005	0,0005	0,0005	0,0004	0,0004	0,0004	0,0003	0,0003	0,0003
Ordu	0,0231	0,0242	0,0253	0,0264	0,0275	0,0286	0,0297	0,0308	0,0320	0,0331	0,0342	0,0353	0,0364	0,0375	0,0386	0,0397	0,0408	0,0419
Rize	0,0014	0,0015	0,0016	0,0016	0,0017	0,0018	0,0019	0,0019	0,0020	0,0021	0,0021	0,0022	0,0023	0,0023	0,0024	0,0025	0,0025	0,0026
Sakarya	0,0022	0,0023	0,0024	0,0025	0,0026	0,0027	0,0028	0,0029	0,0030	0,0031	0,0032	0,0033	0,0034	0,0035	0,0036	0,0037	0,0038	0,0039
Samsun	0,0244	0,0255	0,0267	0,0278	0,0290	0,0301	0,0313	0,0324	0,0336	0,0347	0,0359	0,0371	0,0382	0,0394	0,0405	0,0417	0,0428	0,0440
Sivas	0,0036	0,0035	0,0034	0,0033	0,0032	0,0032	0,0031	0,0030	0,0029	0,0028	0,0027	0,0026	0,0025	0,0024	0,0024	0,0023	0,0022	0,0021
Sanliurfa	0,0688	0,0680	0,0673	0,0665	0,0658	0,0651	0,0643	0,0636	0,0628	0,0621	0,0613	0,0606	0,0598	0,0591	0,0583	0,0576	0,0568	0,0561
Trabzon	0,0064	0,0067	0,0070	0,0073	0,0076	0,0079	0,0082	0,0085	0,0089	0,0092	0,0095	0,0098	0,0101	0,0104	0,0107	0,0110	0,0113	0,0116
Van	0,0689	0,0674	0,0658	0,0643	0,0627	0,0612	0,0596	0,0581	0,0566	0,0550	0,0535	0,0519	0,0504	0,0489	0,0473	0,0458	0,0442	0,0427
Zonguldak	0,0176	0,0185	0,0193	0,0202	0,0210	0,0219	0,0227	0,0236	0,0244	0,0253	0,0261	0,0270	0,0278	0,0287	0,0295	0,0304	0,0312	0,0321

Appendix B. TOPSIS Rankings

	Instances																	
Cities	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Adiyaman	0,4065	0,4067	0,4064	0,4055	0,4040	0,4019	0,3992	0,3959	0,3920	0,3875	0,3825	0,3771	0,3712	0,3649	0,3583	0,3514	0,3443	0,3371
Agri	0,2735	0,2702	0,2664	0,2621	0,2574	0,2522	0,2467	0,2407	0,2343	0,2276	0,2206	0,2134	0,2060	0,1984	0,1907	0,1829	0,1751	0,1672
Ankara	0,0131	0,0130	0,0128	0,0126	0,0123	0,0121	0,0118	0,0115	0,0112	0,0108	0,0105	0,0101	0,0097	0,0093	0,0089	0,0086	0,0082	0,0078
Artvin	0,0774	0,0816	0,0858	0,0898	0,0937	0,0975	0,1011	0,1045	0,1078	0,1108	0,1136	0,1161	0,1185	0,1206	0,1225	0,1242	0,1257	0,1270
Aydin	0,4090	0,4019	0,3941	0,3856	0,3764	0,3667	0,3564	0,3455	0,3341	0,3223	0,3101	0,2975	0,2847	0,2716	0,2583	0,2449	0,2314	0,2178
Batman	0,0113	0,0113	0,0112	0,0111	0,0110	0,0108	0,0107	0,0105	0,0103	0,0101	0,0099	0,0097	0,0095	0,0092	0,0090	0,0087	0,0084	0,0082
Bitlis	0,0380	0,0375	0,0369	0,0363	0,0356	0,0348	0,0339	0,0330	0,0321	0,0311	0,0300	0,0289	0,0278	0,0267	0,0255	0,0244	0,0232	0,0220
Diyarbakir	0,0218	0,0217	0,0216	0,0214	0,0212	0,0210	0,0207	0,0204	0,0200	0,0196	0,0192	0,0188	0,0183	0,0178	0,0173	0,0168	0,0163	0,0158
Duzce	0,0480	0,0507	0,0533	0,0559	0,0584	0,0609	0,0632	0,0654	0,0675	0,0694	0,0712	0,0729	0,0744	0,0758	0,0770	0,0781	0,0791	0,0799
Elazig	0,0107	0,0105	0,0104	0,0102	0,0101	0,0099	0,0097	0,0095	0,0093	0,0091	0,0088	0,0086	0,0084	0,0082	0,0080	0,0077	0,0075	0,0073
Erzincan	0,0199	0,0197	0,0194	0,0190	0,0186	0,0182	0,0178	0,0173	0,0168	0,0163	0,0157	0,0151	0,0145	0,0139	0,0133	0,0127	0,0121	0,0115
Erzurum	0,1719	0,1697	0,1672	0,1643	0,1612	0,1577	0,1540	0,1500	0,1458	0,1414	0,1368	0,1320	0,1271	0,1221	0,1171	0,1120	0,1069	0,1018
Gaziantep	0,3451	0,3452	0,3447	0,3437	0,3422	0,3400	0,3373	0,3341	0,3303	0,3260	0,3212	0,3161	0,3105	0,3047	0,2986	0,2922	0,2857	0,2791
Isparta	0,0060	0,0057	0,0054	0,0051	0,0048	0,0045	0,0042	0,0039	0,0036	0,0032	0,0029	0,0025	0,0022	0,0019	0,0015	0,0012	0,0009	0,0006
Izmir	0,2430	0,2621	0,2818	0,3018	0,3218	0,3416	0,3612	0,3804	0,3992	0,4175	0,4353	0,4525	0,4692	0,4852	0,5007	0,5156	0,5299	0,5437
K.Maras	0,0097	0,0097	0,0096	0,0096	0,0095	0,0094	0,0093	0,0092	0,0091	0,0089	0,0087	0,0086	0,0084	0,0082	0,0080	0,0078	0,0076	0,0074
Kars	0,1514	0,1494	0,1471	0,1446	0,1418	0,1388	0,1355	0,1320	0,1282	0,1243	0,1202	0,1160	0,1117	0,1072	0,1028	0,0983	0,0938	0,0893
Kilis	0,0122	0,0122	0,0122	0,0121	0,0121	0,0120	0,0119	0,0118	0,0116	0,0114	0,0112	0,0110	0,0108	0,0106	0,0104	0,0101	0,0099	0,0096
Konya	0,0231	0,0267	0,0303	0,0339	0,0375	0,0410	0,0445	0,0480	0,0513	0,0545	0,0576	0,0606	0,0635	0,0662	0,0687	0,0711	0,0734	0,0755
Malatya	0,1381	0,1330	0,1277	0,1221	0,1162	0,1101	0,1038	0,0973	0,0908	0,0842	0,0777	0,0713	0,0652	0,0594	0,0543	0,0499	0,0465	0,0442
Mardin	0,0373	0,0383	0,0394	0,0406	0,0419	0,0432	0,0446	0,0460	0,0474	0,0488	0,0502	0,0515	0,0528	0,0541	0,0553	0,0564	0,0575	0,0585
Mus	0,3091	0,3054	0,3012	0,2965	0,2913	0,2856	0,2794	0,2727	0,2657	0,2583	0,2505	0,2425	0,2342	0,2257	0,2171	0,2084	0,1996	0,1908
Nigde	0,0030	0,0029	0,0029	0,0028	0,0027	0,0026	0,0025	0,0024	0,0024	0,0023	0,0022	0,0021	0,0020	0,0019	0,0018	0,0017	0,0016	0,0015
Ordu	0,1367	0,1437	0,1505	0,1571	0,1635	0,1697	0,1755	0,1810	0,1861	0,1909	0,1954	0,1994	0,2031	0,2065	0,2095	0,2121	0,2144	0,2164
Rize	0,0097	0,0102	0,0108	0,0113	0,0118	0,0123	0,0128	0,0133	0,0137	0,0141	0,0145	0,0149	0,0152	0,0155	0,0157	0,0160	0,0162	0,0163
Sakarya	0,0145	0,0153	0,0161	0,0169	0,0177	0,0185	0,0192	0,0199	0,0205	0,0211	0,0217	0,0222	0,0227	0,0231	0,0235	0,0239	0,0242	0,0244
Samsun	0,1421	0,1494	0,1564	0,1632	0,1698	0,1761	0,1821	0,1878	0,1931	0,1980	0,2026	0,2067	0,2105	0,2139	0,2170	0,2197	0,2221	0,2241
Sivas	0,0236	0,0233	0,0229	0,0225	0,0221	0,0216	0,0210	0,0205	0,0199	0,0192	0,0186	0,0179	0,0172	0,0165	0,0158	0,0151	0,0144	0,0136
Sanliurfa	0,1925	0,1918	0,1909	0,1895	0,1878	0,1858	0,1835	0,1809	0,1779	0,1747	0,1713	0,1677	0,1639	0,1600	0,1559	0,1518	0,1476	0,1435
Trabzon	0,0418	0,0441	0,0464	0,0487	0,0509	0,0530	0,0550	0,0570	0,0588	0,0605	0,0621	0,0636	0,0649	0,0661	0,0672	0,0681	0,0690	0,0697
Van	0,3603	0,3563	0,3517	0,3465	0,3408	0,3345	0,3277	0,3203	0,3125	0,3043	0,2956	0,2866	0,2773	0,2678	0,2581	0,2482	0,2382	0,2281
Zonguldak	0,1080	0,1137	0,1193	0,1247	0,1300	0,1350	0,1399	0,1444	0,1487	0,1527	0,1564	0,1598	0,1629	0,1657	0,1682	0,1705	0,1724	0,1741