



SAKARYA ÜNİVERSİTESİ

FEN BİLİMLERİ ENSTİTÜSÜ DERGİSİ

Sakarya University Journal of Science
SAUJS

e-ISSN 2147-835X | Period Bimonthly | Founded: 1997 | Publisher Sakarya University |
<http://www.saujs.sakarya.edu.tr/en/>

Title: A GIS Based Comparison of Statistical Methods for Identifying Quality of Life
Index in The Provinces of Turkey

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Received: 2021-01-25 00:00:00

Accepted: 2021-03-21 12:52:00.995000

Article Type: Research Article

Volume: 25

Issue: 2

Month: April

Year: 2021

Pages: 571-583

How to cite

Cem KIRLANGIÇOĞLU; (2021), A GIS Based Comparison of Statistical Methods for
Identifying Quality of Life Index in The Provinces of Turkey. Sakarya University
Journal of Science, 25(2), 571-583, DOI:

<https://doi.org/10.16984/saufenbilder.867361>

Access link

<http://www.saujs.sakarya.edu.tr/en/pub/issue/60672/867361>

New submission to SAUJS

<https://dergipark.org.tr/en/journal/1115/submission/step/manuscript/new>

A GIS-Based Comparison of Statistical Methods for Identifying Quality of Life Index in The Provinces of Turkey

Cem KIRLANGIÇOĞLU*¹

Abstract

Throughout history, human beings have lived to survive, have struggled to have a job and have enough income for a better life. But at the point we have reached today, people's quality of life not only depends on wealth and employment but also on many subjective factors, including the conditions of the environment in which they live, physical and mental health, education, recreation, security, leisure, freedom, human rights, social belonging and happiness level. Although this situation is related to the individuals at the micro scale, it is one of the important focal points of central and local governments on the macro scale. For administrators, revealing regional differences in well-being is an important criterion for eliminating social inequalities. There are many different multi-criteria decision making based studies that calculated the index of quality of life in 81 provinces of Turkey following 11 dimensions and 41 indicators determined by Turkstat. This study aims to compare the quality of life studies and rankings of cities based on six different statistical methods. GIS-based IDW interpolation technique was used to understand the spatial distribution of the well-being index and make an accurate comparison of the calculation methodologies. As a result of the study, it was seen that different methods performed on the same data gave very different results from each other.

Keywords: Quality of Life Index, Statistics, GIS, MCDM, IDW

1. INTRODUCTION

Today, one of the most significant problems of countries is to ensure the equal distribution of resources to citizens, thus to regions. However, this is not always possible due to geographical, political, or economic reasons. The ability of decision-makers and policy-makers to see inequalities in the regions and to determine the source and even the amount of inequalities are

important steps in the solution of the problems. As a result, the living conditions of individuals play a decisive role in revealing regional inequalities. Therefore, the quality of life in the regions should be measured by objective and subjective indicators [1].

The World Health Organization (WHO) defines the quality of life as individuals' perception of their position in life concerning their goals,

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expectations, standards, and concerns within the context of the culture and value systems they live in. Quality of life is a comprehensive concept that is complexly affected by a person's physical health, psychological status, level of independence, social relationships, personal beliefs, and relationships with his environment [1].

Şeker [2] supports this view and says that; quality of life is the sum of quantitative and qualitative values of an individual's lifestyle, health and relationship with society. Besides, Geray [3] claims that quality of life is related to the opportunities of people to live in a healthy environment, to meet their nutrition, protection and shelter needs, to find opportunities suitable for their physical and spiritual development, to use their creative power, to reflect the balanced harmony of natural and artificial living environments.

The definition of quality of life varies from person to person and from time to time. For instance; while the growth rate of national income was accepted as an indicator of welfare in the 1950s, per capita income was accepted as an indicator of development in the 1960s. The approach of Meeting Basic Needs developed by Simon Kuznets in the 1970s diversified the welfare criteria in development, and starting from this period, there was a lot of variability in the measurement of social welfare. In the 1980s, for measuring development or underdevelopment, meeting social and individual basic needs was taken into account and monetary and non-monetary indicators were used together in the measurement of quality of life [4]. In this study, indicators of the Turkish Statistical Institute (Turkstat) has been used to determine the geographical distribution of quality of life in Turkey.

This study aims to compare the results of different statistical methods using the same indicators and measuring the quality of life indexes in 81 provinces of Turkey in a GIS (Geographic Information Systems) based environment. The statistical methods compared in this study are

VIKOR, TOPSIS, Data Envelopment Analysis, EDAS, WASPAS, and Min.-Max. method which is used by Turkstat for calculating the well-being index of the provinces.

2. DATA

Turkstat conducted a quality of life index study in the year 2015 to measure, compare and monitor the lives of individuals and households at the local level in terms of life dimensions by using objective and subjective criteria. The main purpose of the study is to develop an indicator system that will form a basis for monitoring and increasing life quality in the provinces with 11 basic dimensions which are; housing, health, income and wealth, social life, work-life, education, safety, environment, civic engagement, life satisfaction and access to infrastructure services [5].

These 11 basic dimensions have 41 indicators in total. While there are indicators that affect life positively in the study, there are also indicators that have a negative contribution to the index. The dimension, indicator, and contribution direction of the indicators are given in Table 1.

Table 1
The Dimensions and Indicators used in Turkstat Quality of Life Index

DIMENSIONS	INDICATORS	DIRECTION
CIVIC ENGAGEMENT	Participation rate in local government elections	Positive
	Membership rate of political parties	Positive
	Percentage of those involved in union / association activities	Positive
ACCESS TO INFRASTR. SERVICES	Internet subscribers (per hundred people)	Positive
	Access rate to sewerage and mains water	Positive
	Access rate to the airport	Positive
	Satisfaction rate of the municipality with public transport services	Positive
SOCIAL LIFE	Cinema and theater audience number	Positive
	Shopping center area per thousand people	Positive
	Social relations satisfaction rate	Positive
	Social life satisfaction rate	Positive

Source: TURKSTAT (2020)

Turkstat [5] says that each dimension has a critical and unique role in affecting the quality of life degrees of people. Housing is a basic life dimension used by people as a shelter and living space, where individuals meet their vital needs and enter into social relationships. The residence must have the minimum qualifications in terms of the basic needs of an individual and household. Ownership of toilets in the house, an independent room or sufficient living space for the privacy of the individual, physical characteristics of the house, adequate heating, being protected against external influences, and being able to receive sufficient daylight are some of these features. Work-Life has significant effects on people's mental, physical and financial life.

The factors that improve the working life enable people to live a life in which they have access to more financial resources, more opportunities to improve their lives by improving their skills, realizing their goals, feeling useful in society, and increasing their self-confidence. The Income and Wealth dimension is another important determinant in meeting the needs and desires of individuals and providing protection against economic and personal risks. Better health and education, higher satisfaction with life, and the likelihood of living in cleaner and safer places

will increase in parallel with the rise in income and wealth.

Health is one of the most important dimensions that is directly proportional to the quality of life of individuals. Health opportunities, longevity, subjective health status, satisfaction with health services received, a life without disease, and disability are important values for individuals. These values are also of great importance for issues such as education, social life, social relations, the participation of the individual in the workforce, and raising healthy generations.

Education plays a key role in providing people with the knowledge, skills, and competencies needed to participate effectively in society and the economy. Studies show that educated people live longer, participate more effectively in politics and society where they live, commit fewer crimes, and are less dependent on social assistance. Environment, in which people live directly, affects their current and future health and sustainable life. Air and water quality is a source of satisfaction for the environment and provides opportunities to improve mental health, relieve the stress of daily life and perform physical activities.

The Security dimension is of great importance when examining the social development of an administrative unit or a region. Individuals need to feel safe to continue their other vital activities. Murder rate, number of fatal and injured traffic accidents, percentage of those who feel safe walking alone at night, etc. factors affect the lives of individuals directly. Civic Engagement is another important social issue that concerns all segments of society. For the individuals; being involved in the management system and contributing to the issues that concern their life are important factors to make them feel better. People's demands, desires, and voices are heard only if they contribute to management. Access to Infrastructure dimension may be measured by the prevalence and accessibility of municipalities and the general infrastructure services in the province. Factors such as rate of internet subscribers, access rate to sewerage and mains water, access rate to

the airport, and satisfaction rate of the municipality with public transport services may severely affect the quality of daily life in a city. Social Life is an important part of human life that includes activities such as cultural, artistic, sports, and entertaining activities. Having strong social relations, rich and diverse social life offers positive effects on the quality of life. Life Satisfaction is the last dimension of Turkstat to measure the quality of indexes of different provinces in Turkey. Life satisfaction arises from having the needs and desires of people at different times and areas of their lives. Subjective well-being reflects the concept of how people experience their living conditions in terms of their assessment of health, education, income, personal integrity, and social conditions. Besides, life satisfaction surveys, in particular, provide a measure of satisfaction and happiness. Life satisfaction means that a person evaluates his / her life as a whole.

3. METHODOLOGY

In literature, Multi-Criteria Decision Making (MCDM) methods are available to be used for determining the livability of cities based on many different factors. MCDM provides support to decision makers in evaluating decision options based on multiple criteria that affect each other, hence affecting the final decision to be applied. There are many particular MCDM based statistical methods to calculate the quality of life levels in different cities. MULTIMOORA (The Multi-Objective Optimization by Ratio Analysis), DEA (Data Envelopment Analysis), TOPSIS (The Technique for Order of Preference by Similarity to Ideal Solution), SAW (Simple Additive Weighting), Min.-Max. Method, EDAS (Evaluation based on Distance from Average Solution), WASPAS (Weighted Aggregated Sum Product Assessment), GRA (Grey Relational Analysis), VIKOR (Vlse Kriterijumska Optimizacija I Kompromisno Resenje), and COPRAS (COmplex PROportional ASsessment) are generally used by researchers in quality of life related studies. Just six of them will be used and compared to each other in this study because the others do not have detailed results and

index values prepared for all 81 provinces of Turkey.

3.1. TURKSTAT (Min. – Max.) Method

Turkstat use a composite index application to calculate the quality of life index for different cities in Turkey. Composite indices are generally used in the comparison of cities, regions, and countries. It consists of different stages such as a selection of indicators, normalization, weighting, and aggregation of indicator values. The indicator values should be normalized to make the data set comparable to each other.

The Min-Max method was used to normalize the Quality of Life Index indicators in the provinces [5]. Min-Max is a method that normalizes indicators in the range of 0 and 1. Indicators with a negative contribution to the index (such as unemployment rate, homicide rate) are included in the index calculation as reverse coded.

$$I_i = (X_i - X_{\min}) / (X_{\max} - X_{\min}) \quad (1)$$

$$\hat{I}_i = 1 - (X_i - X_{\min}) / (X_{\max} - X_{\min}) \quad (2)$$

x_i : Indicator Value

x_{\min} : The minimum value of an indicator

x_{\max} : The maximum value of an indicator

Composite index calculation has been made according to the hierarchical equal weighting method in which dimensions and indicators under the same dimension are equally weighted. According to this method, dimension and indicator weights are as follows;

$$\text{Dimension Number (N)} \rightarrow w_D = 1/N \quad (3)$$

$$\text{Indicator Number (n)} \rightarrow w_I = 1/n \quad (4)$$

Dimension score value was obtained by multiplying each normalized indicator value by the indicator weight in the dimension and aggregating these multiplications. The aggregation method used in obtaining the

dimension score value can be expressed as follows;

$$\text{Dimension Score Value} = \sum (w_{li} * I_i) \quad (5)$$

w_{li} = Weight of Indicator

I_i = Normalized Indicator Value

The overall score value was obtained by multiplying each normalized indicator value by the dimension weight and the indicator weight and by aggregating these results together. The aggregation method used in obtaining the general score value can be expressed as follows;

$$\text{General Score Value} = \sum (w_{Di} * w_{li} * I_i) \quad (6)$$

w_{Di} = Weight of Dimension

w_{li} = Weight of Indicator

I_i = Normalized Indicator Value

Geographic Information Systems (GIS) based maps have been prepared to see the spatial distribution of each dimension Turkstat uses to define the quality of life indexes all around Turkey. Figure 1 shows the spatial distribution of 11 dimensions and overall index score as compared to each other.

GIS, which was used to prepare these thematic maps, is a decision support system that allows operations such as collecting geographic information for a specific purpose, storing, updating, controlling, analyzing, and displaying in a computer environment [6]. It is a geographical database that expresses the world in geographical terms and helps to understand and transform data into information and knowledge. GIS enables the integration of tabular and geographical data and allows both thematic visualizations and detailed analyses. By using GIS, it is possible to make geographically weighted analyses instead of just numerical based statistical calculations.

IDW (Inverse Distance Weighted) interpolation method is widely used in GIS studies. Both the ease of calculation and the solution accuracy are the most important factors in the widespread use of the method. The point value to be estimated is a function of the distance and size of the neighboring points around this point, and the effect of neighboring points on the estimated value depends on the change in distance. In the IDW method, as the distance to the anchor points increases, the effect of the far point on the value to be estimated decreases.

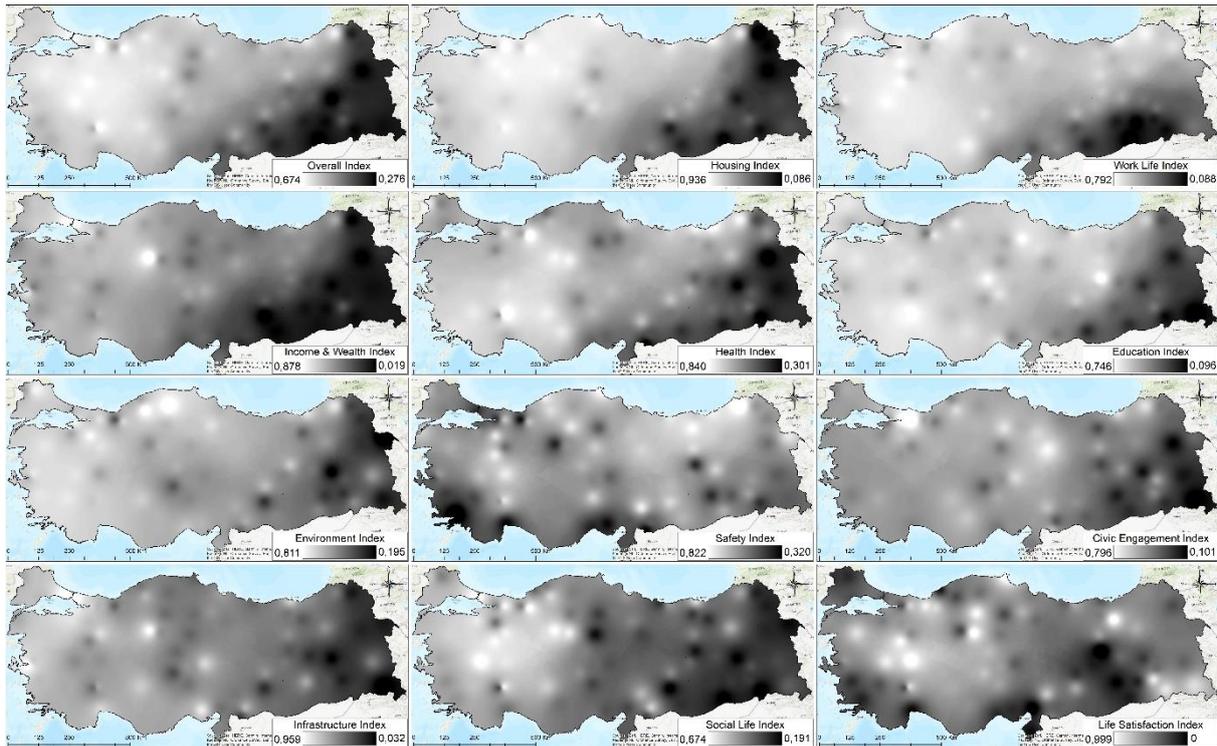


Figure 1 Spatial Distribution of Quality of Life Dimensions in Turkey

Alpaykut [4] says that; the well-being index ranking of Turkstat is based on the assumption that the dimensions affecting the overall quality of life index score have equal weight. Although the assumption that all dimensions have equal weight is a relevant method, all dimensions can have different weights at the same time. Therefore, he suggests using the idea that the factors affecting the quality of life index should have different weights and TOPSIS Method should be used to calculate the quality of life index of each province in Turkey.

3.2. TOPSIS Method

The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) is a Multi-Criteria Decision Making (MCDM) method applied in many different areas. The evaluation of alternatives (decision options) is based on two basic points: positive ideal solution and negative ideal solution. In the TOPSIS method, it is aimed to determine the decision option at the shortest distance from the positive ideal solution and the

furthest distance from the negative ideal solution [7]. The application process of the TOPSIS process is given below.

The first step is to create a decision matrix having $n \times m$ dimensions. In this matrix; the rows are decision options while the columns show the criteria.

$$D = \begin{bmatrix} d_{11} & d_{12} & \dots & d_{1m} \\ d_{21} & d_{22} & \dots & d_{2m} \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ d_{n1} & d_{n2} & \dots & d_{nm} \end{bmatrix} \quad (7)$$

n = Number of Decision Options

m = Number of Evaluation Criteria

The second step is to create a normalized decision matrix (R matrix). The standard decision matrix is obtained by taking the square root of the sum of squares (sum of squares of column values) of the

values belonging to each criterion of the decision matrix and dividing the related element of the column by the resulting value.

Then the remaining steps are calculating the criteria weighted matrix, finding the weighted normalized decision matrix, determining the positive ideal and negative ideal solution, finding the separation of each alternative from a positive and negative ideal solution, and finally calculating the relative closeness to the ideal solution [8]. The greatest relative closeness to the ideal solution gives us the best alternative. In this study, it gives us the highest and lowest quality of life indexes in Turkish provinces.

Alpaykut [4] used Principal Components Method (PCM) for giving weights of variables in the TOPSIS method to rank the cities following their quality of life degrees. All 41 indicators, previously determined by Turkstat, have been weighted by PCM to be used in TOPSIS calculations in the study. GIS-based results of this study are given in Figure 2 as compared to the results of the other statistical methods.

3.3. DEA Method

Turkstat uses the min.-max. method and gives equal weight to each indicator under each dimension while calculating the quality of life index of the provinces. TOPSIS method gives weight to each indicator in accordance with their importance degree. Çağlar [9] used a Data Envelopment Analysis (DEA) based statistical model to find out the quality of life index of each province in Turkey.

In the model, it is aimed to present an approach that both evaluates the cities relatively and eliminates the problem of determining the weights of the indicators used in the index calculation. In the proposed method, there is no need to determine the indicator weights, it is possible to use the indicators without normalization.

Charnes, Cooper, & Rhodes [10] propose Data Envelopment Analysis (DEA), which measures the relative efficiency of decision-making units in case of many inputs and multiple outputs. DEA is a linear programming based non-parametric method that does not need any pre-assumptions. In DEA, the efficiency criterion is obtained by dividing the weighted sums of the outputs by the weighted sums of the inputs. Figure 2 gives a GIS-based comparison of DEA model results produced by Çağlar [9] and five different methods.

3.4. VIKOR Method

VIKOR (Vlse Kriterijumska Optimizacija I Kompromisno Resenje in Serbian) is a Multi-Criteria Decision Making (MCDM) method first introduced by Opricovic in 1998 and it means multicriteria optimization and compromise solution. Also, it was firstly used by Opricovic and Tzeng [11] in solving multi-criteria decision-making problems [12]. VIKOR is a popular statistical model because of its computational simplicity and solution accuracy. The basis of the method is to create a compromise solution within the framework of alternatives and within the scope of evaluation criteria.

This compromise solution is the closest one to the ideal solution [13]. In the method, it is possible to make the closest decision to the ideal solution under certain conditions by creating a multi-criteria ranking index for alternatives. The consensual ranking is achieved by comparing the values of proximity to the ideal alternative [14].

Yüce [15] used the VIKOR method to define a sorting index for the provinces of Turkey in terms of livability. In the ranking; Well-Being Index in Turkey (2015) data are used. He has weighted all 11 dimensions separately and prepared a ranking table sorting all 81 provinces from best to worst in terms of livability.

Each province has a VIKOR based score in the table. These scores have been transferred to a GIS-based mapping algorithm and given in Figure 2 as compared to the other methodologies.

3.5. EDAS Method

EDAS (Evaluation based on Distance from Average Solution) method was introduced to the literature by Ghorabae, Zavadskas, Olfat and Turskis [16] in 2015. EDAS method is similar to some other MCDM methods such as MOORA,

TOPSIS, and VIKOR in terms of trying to find solutions based on distance. However, it is not necessary to calculate the best and worst values in the EDAS method. The best alternative in the method is found by calculating the average solution distances of the alternatives according to each criterion [17]. Besides, there are two measures in the method regarding the acceptability of alternatives.

The first one is the positive distance from the average (PDA) and the second one is the negative distance from the average (NDA). The alternative evaluation process is made according to higher values of PDA and lower values of NDA [18]. Thus, higher values of PDA and/or lower NDA values indicate that the alternative solution is better than the average solution.

3.6. WASPAS Method

WASPAS (Weighted Aggregated Sum Product Assessment) is an MCDM method based on Weighted Sum Model (WSM) and Weighted

Product Model (WPM) methods [19]. The WASPAS method, developed by Zavadskas et al. [20] in 2012, gives the performance values of the options according to the criteria by using the criterion weights in the solution of MCDM problems. As a result of the solution, the options are ranked from best to worst. Also, the method tries to achieve high consistency in estimation by optimizing the weighted integrated function [21].

Özbek [22] used EDAS and WASPAS methods to evaluate the quality of life in the Turkish provinces within the framework of the determined criteria. In this way; the central government, local governments, and relevant institutions may improve the quality of life in all the provinces with low quality of life. The results of his study are mapped for 81 provinces and given in Figure 2 as compared to GIS-based maps of the other statistical methods used in this study.

Quality of Life Index distribution in Turkey is mapped on ArcGIS software-based on six different statistical methods compared in this study. In Figure 2, the red-colored areas have higher rates, yellow areas have medium rates and blue areas have lower rates than the other areas.

All statistical methods show that the Eastern and Southeastern regions of Turkey have a lower quality of life indexes than the Western regions. In GIS-based maps, the TOPSIS method gives significantly different results than the others while DEA method has slightly particular results. Figure 3 shows the five best cities and five lowest rated cities for living in accordance with each statistical method.

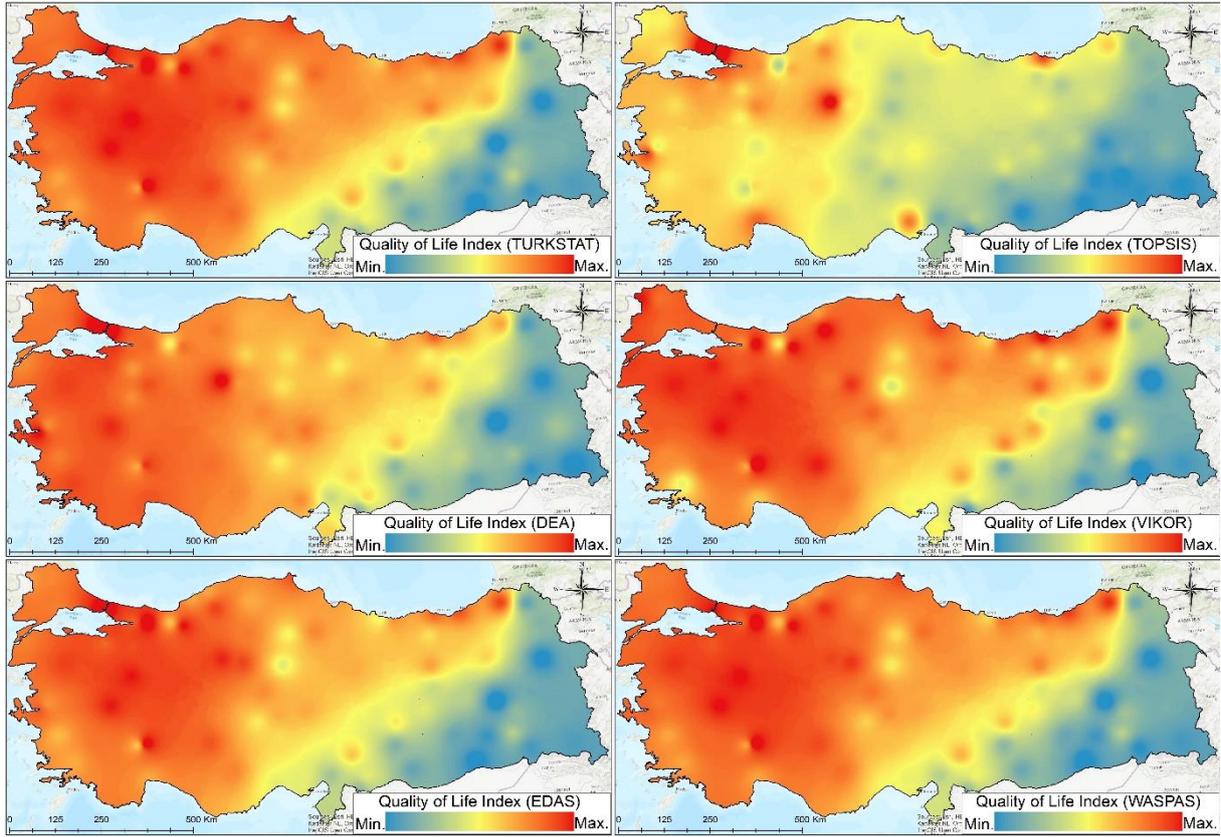


Figure 2 GIS-Based Comparison of Statistical Methods Identifying Quality of Life Distribution in Turkey

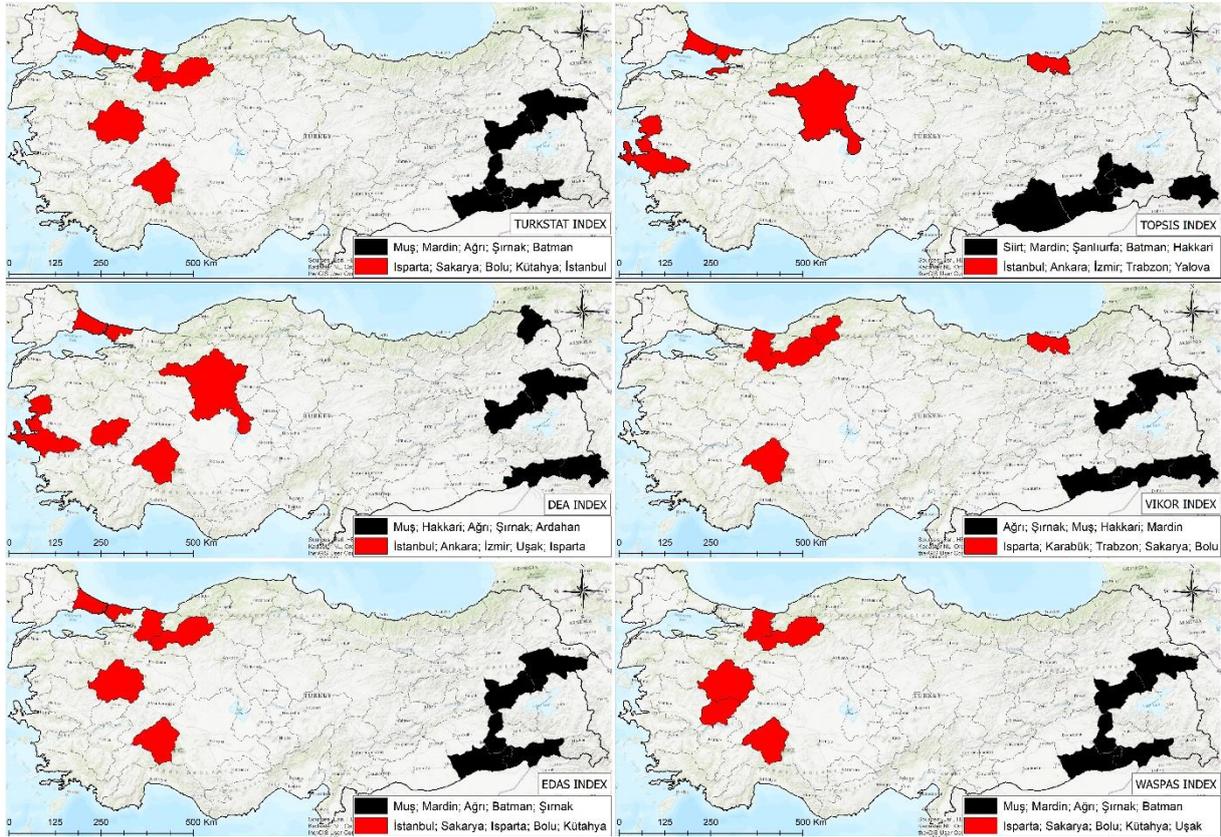


Figure 3 Comparison of Statistical Methods Based on the Highest and Lowest Rated Cities

As it is seen in Figure 2 and Figure 3, different methods give different results. Today, Turkey uses the Min.-Max. method applied by Turkstat. The other ones have been applied by different researchers based on the same data, same dimensions, and same indicators. Alpaykut [4] applied the TOPSIS method, Yüce [15] applied the VIKOR method, Çağlar [9] applied the DEA method, Özbek [22] applied the EDAS and WASPAS methods. Table 2 shows the ranking of each province following the statistical method applied.

Quality of Life Rankings of Provinces by Applied Statistical Methods (Top 10 Cities)

Province Name & Rank	TURKSTAT (Min.-Max.)	TOPSIS	DEA	VIKOR	EDAS	WASPAS
Isparta	1	19	5	1	3	1
Sakarya	2	11	14	4	2	2
Bolu	3	12	17	5	4	3
Kütahya	4	30	28	8	5	4
İstanbul	5	1	1	30	1	6
Uşak	6	22	4	6	6	5
Balıkesir	7	20	7	12	8	9
Artvin	8	18	42	9	12	7
Kırkkale	9	27	37	14	11	10
Afyonkrhrsr	10	40	15	15	14	11

Table 2

Same data, same dimensions, same indicators but different results. While Turkstat claims that Isparta is the best city in Turkey in terms of quality of life; according to the TOPSIS method it is 19th and according to DEA it is 5th city to live. While TOPSIS method shows that İstanbul is the 1st city to live, VIKOR method shows it as the 30th one. Kütahya is 4th city in Turkstat ranking, while it is 30th in TOPSIS and 28th in DEA methods. EDAS and WASPAS give the closest results to Turkstat method but they also have slightly different results than each other. While the EDAS method shows İstanbul as the best city to live, the WASPAS method shows it as the 6th one. As it can be seen in Table 2, especially for top cities the results of statistical methods severely different from each other in general. Table 3 shows the lowest rated 10 cities according to Turkstat statistics and their ranks under other statistical methods.

Table 3
Quality of Life Rankings of Provinces by Applied Statistical Methods (Lowest Rated 10 Cities)

Province Name & Rank	TURKSTAT (Min.-Max.)	TOPSIS	DEA	VIKOR	EDAS	WASPAS
Iğdır	72	70	72	72	71	72
Şanlıurfa	73	79	74	71	73	74
Ardahan	74	66	77	70	74	73
Diyarbakır	75	64	65	68	75	75
Hakkari	76	77	80	78	76	76
Batman	77	78	69	74	78	77
Şırnak	78	76	78	80	77	78
Ağrı	79	73	79	81	79	79
Mardin	80	80	76	77	80	80
Muş	81	75	81	79	81	81

Table 3 shows that different statistical methods give results similar to each other for the lowest-

rated cities. There are slightly different results among the methodologies. For example; while Muş is the lowest-rated city in Turkstat, DEA, EDAS, and WASPAS rankings; it is 75th in TOPSIS and 79th in VIKOR methods. Diyarbakır is the 75th city in Turkstat ranking but it is 64th in TOPSIS and 65th in DEA rankings.

4. CONCLUSION

As a result of the study, it is seen that the ranking of the provinces in terms of quality of life dramatically changes by the applied weights, chosen statistical methods, and the pre-assumptions of the decision-makers. It is clear that, for quality of life studies, the statistical method must be independent of these factors as much as possible. It should be suitable for determining dimensions and sub-indices by combining the information of different indicators. No guesswork should be required for indicators. The model should allow for a relative assessment of the best when evaluating the provinces. Prior information should not be needed in determining the weight for indicators and if there is definite prior information, it should be allowed to be added to the model. Therefore, Data Envelopment Analysis (DEA) seems like the best statistical method to calculate the quality of life index of the provinces.

Besides, all the statistical methods show that the lowest-rated cities are located in the Eastern Anatolia and the Southeastern Anatolia Regions of Turkey. That means; while the quality of life degree is higher in Western cities, it is lower in Eastern cities in Turkey. There are many different factors such as economic, political, and demographic factors at the root of this situation. Central and local governments should take the necessary steps to eliminate this inequality between provinces.

Funding

The author has not received any financial support for the research, authorship, or publication of this study.

The Declaration of Conflict of Interest/ Common Interest

No conflict of interest or common interest has been declared by the author.

The Declaration of Ethics Committee Approval

This study does not require ethics committee permission or any special permission.

The Declaration of Research and Publication Ethics

The author of the paper declares that he complies with the scientific, ethical and quotation rules of SAUJS in all processes of the paper and that he does not make any falsification on the data collected. Also, he declares that Sakarya University Journal of Science and its editorial board have no responsibility for any ethical violations that may be encountered and that this study has not been evaluated in any academic publication environment other than Sakarya University Journal of Science.

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