RESEARCH ARTICLE

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Evaluation of the environmental sustainability performance of Eastern European countries with integrated MCDM methods

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Abstract

Especially in recent years, the environmental problems of countries have been increasing due to the acceleration of industrialization, increasing population, continuous increase in the consumption and energy requirements of the society and the development of technology. In order to eliminate these problems, countries take many measures and precautions. This study aims to compare Eastern European countries by evaluating their positions in the environmental sustainability performance index (EPI). For this purpose, the importance levels of the criteria were found with ENTROPY, which is in the objective category of multi-criteria decision making (MCDM) methods, and then the ranking of the countries in the environmental sustainability performance index was determined with Complex Proportional Assessmnet (COPRAS) and Weighted Aggregated Sum Product Assessment (WASPAS) methods. The data used in the evaluation of the environmental sustainability performance index "The 2022 Environmental Performance Index (EPI)" ranking of Eastern European countries is the data prepared by Yale University and obtained from the relevant web address. According to the results obtained, the ranking of the criteria in terms of their importance levels were ranked as water resources, waste management and agriculture, and the rankings obtained according to COPRAS and WASPAS methods differed in the environmental sustainability performance ranking of the countries, and it was determined that the WASPAS method gave more consistent results.

Keywords: Environmental Performance Index (EPI), ENTROPY, COPRAS, WASPAS

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INTRODUCTION

The increase in population, the acceleration of industrialization and urbanization, and the increase in the need for energy with increasing production and consumption lead to environmental problems. With the increase in environmental problems, the necessity to take environmental measures has emerged and studies on environmental protection have been initiated. In 1972, the United Nations Conference on the Human Environment and in 1992 the United Nations Conference on Environment and Development (Earth Summit) were convened. In 2000, 2001, 2002 and 2005, studies on the Environmental Sustainability Index (EPI) were conducted in cooperation with the Yale Center for Environmental Law and Policy and the Center for International Earth Science Information Network (CIESIN) in partnership with the World Economic Forum and the European Commission Joint Research Center. Environmental Sustainability Index studies have been carried out regularly every two years since 2006 (Savaş, 2012: p. 135).

Organized in 11 sub-categories under the main criteria of "climate, environmental

health and ecosystem vitality", the EPI ranks the environmental sustainability performance of 180 countries. This ranking shows the extent to which countries are achieving their environmental policy goals at the national level. The EPI provides guidance to countries that want to move forward for a sustainable future, showing leading countries and other countries according to their environmental performance (Enviromental Performance Index, 2020). The EPI is not only an average ranking of data, but also provides separate quantitative assessments and measurements according to specific issues (Karaman, 2018: p. 80). The data and analysis can enable government officials to develop policies, facilitate communication with stakeholders, and maximize returns on environmental investments. Overall EPI rankings also present who best addresses the environmental challenges faced by countries (Uca and Yüncü, 2020: p. 302).

The aim of this study is to make a comparison by evaluating the environmental sustainability performance indices of Eastern European countries. In the selection of the countries to be compared with Turkiye; Eastern European countries were chosen due to the fact that there are very few studies on this subject in the literature. In addition, since the environmental sustainability performance evaluation subject is suitable for the use of methods that can evaluate a large number of criteria together, the study utilized MCDM methods. The importance levels of the criteria were found using ENTROPY, and then the countries were ranked according to the environmental sustainability performance index using COPRAS and WASPAS methods. Although different MCDM methods have been used in the literature on the environmental sustainability performance index ranking of countries, this is the first paper to combine ENTROPY based COPRAS and WASPAS models. In the Turkish literature, only one study (Akandere and Zerenler, 2022) was found on the environmental sustainability performance index ranking of Eastern European countries using MCDM methods. However, in this study, the environmental sustainability performance and economic performance of Eastern European countries are considered together. It is thought that this study, which deals only with the environmental sustainability performance index ranking of Eastern European countries, will contribute to the literature.

The study consists of five chapters: after the introduction, the second chapter presents the literature review, the third chapter presents the materials and methods, the fourth chapter presents the findings, and the fifth chapter presents the conclusions and recommendations.

LITERATURE REVIEW

When the literature is examined, there are different studies on environmental sustainability performance. Among these studies, the studies on the environmental sustainability performance of countries using the MCDM method are summarized in Table 1. When the studies in the literature on environmental performance related to Turkiye, which do not use MCDM methods, are analyzed; Savaş (2012) aimed to evaluate Turkiye's environmental performance according to the index; Karaman (2018) aimed to reveal Turkiye's environmental performance against the EU. Bek (2019) analyzed the environmental performance of Switzerland and Turkiye and compared the two countries. Uca and Yüncü (2020) analyzed the ecological performance and sustainability competitiveness of the countries bordering the Mediterranean Sea by using the environmental performance index with multidimensional scaling analysis. Yiğit (2020) investigated the impact of globalization on the environmental performance of countries.

When the studies on countries other than Turkiye are examined in the literature; Färe et al., (2004) aimed to develop a method to measure the environmental performance of OECD countries for 1990. Zhou et al., (2007) used Data Envelopment Analysis (DEA) based model to compare the multilateral environmental performance of OECD countries and Malmquist index of environmental performance to model the change in environmental performance. Ave and Babolsar (2010) aimed to estimate and evaluate the relationship between EPI and economic growth in selected developing countries. Djoundourian (2012) examined environmental performance in developed countries and analyzed the differences between regions using ANOVA test. Chandrasekharan et al., (2013) aimed to develop a methodology to rank states based on EPI scores. Olafsson et al., (2014) developed a theoretical model to measure the environmental sustainability performance of countries and tested the model on Iceland. Sima and Gheorghe (2014) aimed to make a comparison of the EPI results calculated for 2014 between Romania and Switzerland. Bucher (2016) aimed to measure the EPI in Europe. Zuo et al., (2017) used the EPI to assess China's environmental performance at the provincial level between 2006 and 2011. Topal and Hayaloğlu (2017) examined the economic development levels of 124 countries by using data from the years 2000-2014 and evaluated how institutional quality affects environmental performance with Panel Data Analysis. Chowdhury and Islam (2017) investigated whether the relationship between EPI and Gross Domestic Product (GDP) growth rate is valid in BRICS countries. Pimonenko et al., (2018) conducted a study to analyze the relationship between environmental performance and ecological, social and economic welfare. Botetzagias et al., (2018), economic the impact of the crisis on the environmental performance of EU member states impact of environmental quality indicators and environmental policy Hierarchical Linear Modeling under the indicators by using the same method. Tunçarslan (2018) compared the climate and environmental policies of BRICS countries using the Climate Change and EPI data. Chandrasekharan and Srinivasan (2020) aimed to rank Indian

states according to the EPI for 2020. Liu et al., (2021) applied the proposed method to evaluate the environmental performance of 30 provincial administrative regions of China. Nguyen et al., (2022) aimed to measure the progress of Vietnam's provinces towards achieving national environmental performance targets. Ding and Beh (2022) evaluated the effectiveness of regional efforts of ASEAN countries on climate change and sustainability. Ha et al. (2022) used the EPI data of 25 European countries for the years 2015-2020 to measure the impact of digitalization on environmental performance. Signes et al. (2022) aimed to measure the relationship between environmental performance and risk scores of 163 countries with regression analysis.

Table 1. Literature review

Author(s)	Objective	Method	Finding(s)
Altuntaş ve Kaya (2023)	Comparing the sustainable development of the European Union member states and the sustainable performance of enterprises constitutes the theme of the study.	ENTROPY, TOPSIS	There is no significant relationship between country sustainability level and corporate sustainability level.
Akandere and Zerenler (2022)	The aim of this study is to evaluate the EPI of Eastern European countries with the help of MCDM techniques.	CRITIC, TOPSIS	According to the CRITIC method, the most important criterion is ecosystem services; the least important criterion is ecosystem vitality; and according to the assessment of environmental and economic performance, Romania was the most successful and Bosnia and Herzegovina was the least successful.
Alkaya (2022)	OECD countries with DEA relative effectiveness in terms of their environmental performance.	DEA	The efficiency score for Denmark, Finland, Iceland, Colombia, Lithuania, Luxembourg, Latvia, Iceland, Colombia, Lithuania, Luxembourg, Latvia and Sweden is determined as 1; these countries are OECD countries that are efficient according to environmental performance.
Doğan (2022)	To measure the environmental performance of OECD and EU member countries using CRITIC and MABAC methods, taking into account the criteria included in the Climate Change Performance Index (CCPI) and EPI.	CRITIC, MABAC	It was determined that the criterion with the highest importance was ecosystem services. Among the selected countries, Denmark, Sweden and Finland perform better than other countries.
Akandere (2021)	It is aimed to evaluate ENTROPY and TOPSIS methods according to logistics performance index (LPI) and EPI criteria in Belt and Road countries.	TOPSIS, ENTROPY	Air quality was identified as the most important criterion in 2014, water and sanitation in 2016, water resources in 2018, and efficiency of customs control procedures as the least important criterion in 2014, 2016 and 2018.
Altıntaş[a] (2021)	It is aimed to measure the environmental performance of the G7 group countries in 2018 with CODAS and TOPSIS methods using EPI data.	CODAS, TOPSIS	According to the CODAS method, the environmental performance ranking of the countries is determined as UK, France, Japan, Germany, Canada, Italy and USA; according to the TOPSIS method as UK, France, Germany, Japan, Canada, Italy and USA.
Altıntaş[b] (2021)	For 2020, it is aimed to calculate the significance levels of the EPI components of the G20 countries with the ENTROPY method and to measure the environmental performance of the countries with ENTROPY based ROV, ARAS and COPRAS methods.	ENTROPY, ROV, ARAS, COPRAS	It has been determined that the most important criterion in environmental performance for countries is water resources and the countries with the best environmental performance are Germany, Japan, the UK, France and Japan.
Baloch et al. (2020)	It is aimed to calculate the environmental performance efficiency of the BRICS group countries according to their EPI values between 2011-2016 with DEA.	DEA	It was found that all countries achieved environmental performance efficiency and the ranking was determined as Brazil, Russia, South Africa, China and India.

Matsumoto et al. (2020)	This study evaluated the environmental performance of European Union (EU) countries using DEA approach and the global Malmquist-Luenberger index.	DEA	The empirical results revealed that the trends in the environmental performance of the entire EU and its individual countries were similar under all examined models. Environmental performance was indeed negatively affected by the financial crisis of 2007-2008; this impact was mainly observed in eastern EU countries.
Ayçin and Çakın (2019)	It is aimed to introduce a model that measures the environmental performance of countries with the integrated use of MCDM methods.	ENTROPY, GİA, MOORA, Fuzzy Logic	Forests, agriculture and water resources were identified as the criteria with the best importance level, and Austria, Denmark and France as the countries with the best performance.
Aksu and Gencer (2018)	It is aimed to analyze the environmental performance of OECD countries according to the EPI data.	DEA	According to the results, Iceland was the most efficient country, followed by Sweden and Estonia.
Ozkan and Ozcan (2018)	Environmental performance of OECD countries in selected environmental according to the indicators with DEA evaluation was aimed.	DEA	It has been determined which countries should be taken as an example for increasing efficiency in OECD countries and making those with inefficient efficiency scores efficient.
Sözen et al. (2016)	It is aimed to examine the correspondence between the effectiveness of tourism indicators and environmental performance.	DEA	Luxembourg was found to be the most efficient country, while the improvement in total factor productivity of the 27 selected countries, including Turkiye, remained limited.
Ab-rahim (2015)	It is aimed to measure the environmental performance of Southeast Asian countries.	DEA	According to the results of the study, smaller economies such as Laos, Cambodia and Brunei were found to be environmentally efficient.
García Sánchez et al. (2015)	It is aimed to calculate the integrated EPI of countries between 2004-2009.	CRITIC, SAW	The criteria with the best level of importance are urban population growth, fertilizer use, agricultural area and protected coasts, while the best countries in terms of performance are Iceland, Norway and Sweden, and the worst countries are Nigeria, Burundi and Bangladesh.
Bilbao-Terol et al. (2014).	It is aimed to evaluate the countries' Adjusted Net Savings (ANS), Ecological Footprint (ECF), EPI and Human Development Index (HDI) data with TOPSIS method.	TOPSIS	France, Italy and the Netherlands were identified as the most successful countries.
Ismail and Abdullah (2012)	Analytic Hierarchy Process (AHP) was used to determine the EPI ranking of ASEAN countries.	AHP	The analysis revealed that Brunei has the highest EPI ranking among ASEAN countries, followed by Singapore.
Roggea (2012)	For 2010, the EPI components of Finland, Brazil, Canada, Guinea, Costa Rica, Mexico, Indonesia and the United Arab Emirates were used to measure the environmental performance of these countries by DEA.	DEA	Finland, Canada, Costa Rica and the United Arab Emirates are found to be efficient in terms of their environmental performance; Brazil is close to environmental performance efficiency and Guinea and Indonesia are found to be inefficient in terms of environmental performance efficiency.

When the studies in Table 1 are examined, it is seen that different MCDM methods are used in the evaluation of the environmental sustainability performance of countries. However, it is noteworthy that DEA is used more than other methods in the studies conducted. In addition, the studies were conducted on different country groups "OECD, BRICS, G20, G7, South East Asia and Eastern European" countries. Among these country groups, OECD countries have been addressed in more studies.

MATERIALS AND METHODS

In this section, information on the data set used, the analysis methods used, the criteria used in the analysis and the countries where the comparisons were made are provided.

Data set used

The data for the study was obtained from the web address where "The 2022 Environmental Performance Index (EPI)" is presented, Environmental Performance Index 2023. The most recent data belongs to 2022 and the data for 2023 has not been published yet. In addition, due to the lack of data on the "fisheries" criterion, which is a sub-criterion of the "ecosystem vitality" criterion, this sub-criterion was not included in the analysis.

Analysis methods used

In the study, MCDM methods were used. In the EPI ranking of the Eastern European countries and the comparison of the countries, the importance levels of the criteria were first found with the ENTROPY method, and then the ranking of the countries was obtained with the COPRAS and WASPAS methods. In the ENTROPY method, the data in the decision matrix are used to calculate the weights of the criteria in the decision problem. The method is very easy to apply since there is no need for any other subjective evaluation. This is the most powerful aspect of the method. Objective results are obtained by using data on decision alternatives without the need for evaluations by decision makers. When comparing decision alternatives, the COPRAS method indicates in percentage terms how much better or worse one alternative is than the other. The method can perform multi-criteria evaluation in order to maximize the values of the criteria if it is a maximization (benefit) criterion and minimize the values of the criteria if it is a minimization (cost) criterion. The COPRAS method, which can address both quantitative and qualitative criteria, is a method that allows the full ranking of decision alternatives to be obtained. The ability of the WASPAS method to provide more accurate results compared to other methods has led to its acceptance in the literature in recent years as an effective MCDM method. The most important advantages of the method are that the application process is shorter and easier compared to other MCDM methods and that it does not require specific computer programs to perform the calculations. The methods and application steps are given briefly below.

ENTROPY method

The ENTROPY method is one of the objective methods for calculating the weights of the criteria (Ayçin, 2019: p. 122). The application steps of the method are given in 5 steps.

1. First, a decision matrix with all alternatives and criteria is created. The decision matrix is given in equation 1:

$$E = [Z_{ij}]_{m\times n} = \begin{bmatrix} z_{11} & z_{12} & \cdots & z_{1n} \\ z_{21} & z_{22} & \cdots & z_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ z_{m1} & z_{m2} & \cdots & z_{mn} \end{bmatrix} \quad (1)$$

2. The values in the decision matrix are standardized using equation 2 (benefit-side criteria) and equation 3 (cost-side criteria). The r_{ij} values in the equations are the standardized version of the Z_{ij} value in the decision matrix.

$$r_{ij} = \frac{z_{ij}}{max_j(z_{ij})} \quad (2)$$

$$r_{ij} = \frac{min_j(z_{ij})}{z_{ij}} \quad , \quad min_j\,(z_{ij}) \neq 0 \quad (3)$$

3. Using Equation 4, the standardized values are normalized. The value of t_{ij} in Equation 4 is the normalized value of r_{ij}.

$$t_{ij} = \frac{r_{ij}}{\sum_{i=1}^{m} r_{ij}} \quad (4)$$

4. The entropy values of the criteria (H_j) are calculated by equation 5.

$$H_j = -\frac{\sum_{i=1}^{m} t_{ij} \ln(t_{ij})}{\ln(m)} \quad (5)$$

5. In the last application step, the weight of each criterion (w_j) is found by equation 6.

$$w_j = \frac{1-H_j}{\sum_{j=1}^{n}(1-H_j)} \quad (6)$$

COPRAS method

The COPRAS method is one of the methods for ranking decision alternatives (Ayçin, 2019: p. 122). The implementation steps of the COPRAS method consist of 6 steps.

1. In the first stage, the decision matrix consisting of x_{ij}, denoted by D, is created as shown in Equation 1.

$$D = [Z_{ij}]_{m\times n} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ x_{m1} & x_{m2} & \ldots & x_{mn} \end{bmatrix} \quad (1)$$

2. The normalization process is created using Equation 2.

$$x_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \quad , \forall_j = 1,2,\ldots\ldots n \quad (2)$$

3. The normalized decision matrix (D′) is obtained using Equation 3.

$$D' = \begin{bmatrix} d_{11} & d_{12} & \cdots & d_{1n} \\ d_{21} & d_{22} & \cdots & d_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ d_{m1} & d_{m2} & \ldots & d_{mn} \end{bmatrix} \quad (3)$$

4. Equation (4) is used to weight the normalized decision matrix.

$$d_{ij} = x_{(ij)^*} . w_j \quad (4)$$

5. The sum of the values of the weighted normalized decision matrix for maximization-based criteria is given by "S_{+i}" and the sum of the values of the weighted normalized decision matrix for minimization-based criteria is given by "S_{-i}". Equations (5) and (6) are used to calculate these values.

$$S_{+i} = \sum_{j=1}^{k} d_{+ij} \; ; J = 1,2, \ldots\ldots, k \quad (5)$$

$$S_{-i} = \sum_{j=k+1}^{n} d_{-ij} \; ; J = k+1, k+2, \ldots\ldots, n \quad (6)$$

6. The relative importance of the decision alternatives, Q_i, is calculated using Equation (7).

$$Q_i = S_{+i} + \frac{S_{-min} \sum_{i=1}^{m} S_{-i}}{S_{-i} \sum_{i=1}^{m} \frac{S_{-min}}{S_{-i}}} \quad (7)$$

In terms of the Q_i values found by Equation (7), the decision alternative with the largest Q_i value is determined as the alternative with the highest relative importance (Q_{maks}).

7. In the final stage, the performance index values (P_i) of the decision alternatives are calculated using Equation (8).

$$P_i = \frac{Q_i}{Q_{maks}} .100 \quad (8)$$

The decision alternative with a performance index of 100, symbolized as () in Equation (8), is identified as the best alternative.

WASPAS method

The WASPAS method is one of the first MCDM methods presented to the literature by Zavadskas et al. (2012). The method is a method developed with the integrated use of the weighted sum model and the weighted product model (Ayçin, 2019: p. 254). The solution steps of the WASPAS method are as follows:

1. The decision matrix consisting of X_{ij} and denoted by X is obtained using Equation (1).

$$X = [X_{ij}]_{mxn} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ x_{i1} & x_{i2} & \cdots & x_{in} \\ \cdots & \cdots & \cdots & \cdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \quad (1)$$

2. The normalization process is based on Equation (2) for benefit-based criteria and Equation (3) for cost-based criteria.

$$x_{ij}^{*} = \frac{x_{ij}}{maks_i x_{ij}} \quad (2)$$

$$x_{ij}^{*} = \frac{min_i x_{ij}}{x_{ij}} \quad (3)$$

3. In terms of the Weighted Sum Method, the total relative importance of alternative i is obtained as the weighted sum of the criteria values using Equation (4).

$$Q_i^{(1)} = \sum_{j=1}^{n} x_{ij}^{*} w_j \quad (4)$$

4. In terms of the Weighted Multiplication Method, the total relative importance of alternative i is calculated by calculating the power of the normalized value of an alternative with respect to the criterion by the weight of the criterion and multiplying the obtained values for each alternative using Equation (5).

$$Q_i^{(2)} = \prod_{j=1}^{n} \left(x_{ij}^{*}\right)^{w_j} \quad (5)$$

5. Equation (6) gives the weighted overall criterion value Q_i.

$$Q_i = 0.5Q_i^{(1)} + 0.5Q_i^{(2)} \quad (6)$$

6. Equation (7) is used to find the total relative importance of alternatives. Alternatives are ranked in terms of their Q values. The best alternative is the one with the highest Q value. Equation (6) transforms the WASPAS method into WPM when λ is set to 0 and into WSM when λ is set to 1. Decision makers can use the value of λ as they wish.

$$Q_i = \lambda Q_i^{(1)} + (1-\lambda) Q_i^{(2)} \quad (7)$$

In order to determine the final ranking of the alternatives, Q_i values are ranked in descending order. The most suitable alternative is ranked first.

7. Sensitivity analysis is performed using different λ values and the ranking of the alternatives is determined.

8. Using Equation (8), the optimal λ is calculated to determine whether the ranking is correct.

$$\lambda = \frac{\sum_{i=1}^{m} Q_i^{(2)}}{\sum_{i=1}^{m} Q_i^{(1)} + \sum_{i=1}^{m} Q_i^{(2)}} \qquad (8)$$

Criteria used

The EPI data consists of three main criteria and eleven sub-criteria. The relevant decision criteria are given in Table 2. Information about the criteria was obtained from EPI 2023. The sub-criterion "fisheries", which is a sub-criterion of the "ecosystem vitality" criterion, was not included in the analysis due to lack of data on this sub-criterion. In the study, "mitigating climate change" was used as a sub-criterion of the "climate" criterion, "air quality, water sanitation, heavy metals, waste management" as sub-criteria of the "environmental health" criterion and "ecosystem services, biodiversity, acid rain, agriculture and water resources" as sub-criteria of the "ecosystem vitality" criterion.

Table 2. Environmental sustainability performance index criteria

Main Criteria	Sub-Criteria	Sub-Criterion Codes
Climate (C1)	Mitigating Climate Change	C11
Environmental Health (C2)	Air quality	C21
	Water Sanitation	C22
	Heavy Metal	C23
	Waste Management	C24
Ecosystem Vitality (C3)	Ecosystem Services	C31
	Biological Diversity	C32
	Acid Rain	C33
	Agriculture	C34
	Water Resources	C35

Determination of alternatives used in the analysis

The scarcity of studies in the literature guided the identification of Eastern European countries to be compared with Turkiye in the study. In this context, 19 Eastern European countries were included in the study. Countries are considered as decision alternatives according to the MCDM methods. The codes related to the countries are given in Table 3.

Table 3. Eastern European countries for comparison

Countries	Alternative Code
North Macedonia	A1
Slovenia	A2
Latvia	A3
Croatia	A4
Cyprus	A5
Slovakia	A6
Czech Republic	A7
Albania	A8
Montenegro	A9
Estonia	A10
Romania	A11
Greece	A12
Bulgaria	A13
Hungary	A14
Lithuania	A15
Bosnia-Herzegovina	A16
Serbia	A17
Poland	A18
Turkiye	A19

RESULTS AND DISCUSSION

After determining the criteria used in the environmental sustainability performance index ranking and the alternatives to be compared, the data on the countries shared by Yale University in the EPI 2023 was obtained from the relevant web page for the year 2022. This data is the decision matrix given in Table 4. The benefit-oriented sub-criteria in this matrix are shown as "maximization (max)" and the cost-oriented sub-criteria are shown as "minimization (min)".

Table 4. Environmental sustainability performance index decision matrix

	C11 (max)	C21 (max)	C22 (max)	C23 (min)	C24 (max)	C31 (max)	C32 (max)	C33 (min)	C34 (max)	C35 (max)
North Macedonia (A1)	69,8	22,6	61,1	46,1	42,1	24	57,9	24	41,9	0,8
Slovenia (A2)	62,9	55,1	74,7	87,2	66,7	34,1	84,5	34,1	55	92,2
Latvia (A3)	58,6	51,1	59,1	77,5	63	15,8	84,3	15,8	64,4	90,7
Croatia (A4)	56,6	45,8	70,3	74,2	55,3	34,4	81,5	34,4	68,9	69
Cyprus (A5)	53,8	68,3	94	68,6	58,9	32,5	78,3	32,5	13,9	50
Slovakia (A6)	53,5	50,9	71,9	68,4	62,2	19,9	82,7	19,9	68	44,7
Czech Republic (A7)	52,8	53,3	76,5	75,5	74,9	19,1	83,3	19,1	37,4	61,5
Albania (A8)	52,5	37,5	54,1	45,5	13,4	24,2	63,9	24,2	28,9	1,9
Montenegro (A9)	52,3	30,7	65,6	64,4	15,5	36,7	52,6	36,7	34,7	8,4
Estonia (A10)	52	74,6	61,9	86,5	66,7	15,8	86	15,2	61,8	70,4
Romania (A11)	51,3	39,2	56	50,8	45,6	35	81,1	35	53,8	25,7
Greece (A12)	50,8	62	98,2	68,6	59,9	28,1	69,1	28,1	38,9	81,7
Bulgaria (A13)	49,8	28,6	68,4	45,2	58,8	37,4	75,1	37,4	55,8	13,9
Hungary (A14)	48,1	38,2	62,2	67,4	43,4	28	78	28	53	55,3
Lithuania (A15)	47,1	58,4	58,4	83	67,4	21,9	84,4	21,9	65,6	52,3
Bosnia-Herzegovina (A16)	45,1	27,8	61,5	42,3	30,9	45,4	34,1	45,4	21,3	1,1
Serbia (A17)	41,7	29,4	65,6	50,4	40,3	39,7	46,7	39,7	45,3	0,7
Poland (A18)	38,8	40,4	71,8	64,5	63,7	17,7	87,3	17,7	42,7	61,5
Turkiye (A19)	21,5	44,6	52,7	60,8	40,6	22	7,5	22	39,1	30,5

Using the ENTROPY method, the importance levels of the ten criteria given in Table 2 were found. The importance levels of the criteria are shown in Table 5. In terms of the results obtained, the most important criteria are water resources (C35), waste management (C24) and agriculture (C34).

Table 5. Importance levels of the criteria

C11	C21	C22	C23	C24	C31	C32	C33	C34	C35
0,0278	0,0674	0,0198	0,0367	0,0895	0,0652	0,0816	0,0710	0,0818	0,4586

According to the importance levels calculated in Table 5, the environmental sustainability performance index ranking of the countries was calculated using the COPRAS method. The ranking is given in Table 6. Accordingly, five countries shared the first highest score in the environmental sustainability performance index of Eastern European countries, namely Slovenia, Latvia, Greece, Poland and Turkiye.

Table 6. Ranking of alternatives according to COPRAS method

Alternatives	Pi	Ranking
Greece (A12)	1	100
Turkiye (A19)	1	100
Slovenia (A2)	1	100
Poland (A18)	1	100
Latvia (A3)	1	100
Lithuania (A15)	2	98,5016
Estonia (A10)	3	95,3029
Hungary (A14)	4	94,1021
Croatia (A4)	5	93,7709
Czech Republic (A7)	6	85,3863
Cyprus (A5)	7	75,9589
Slovakia (A6)	8	75,0473

Bulgaria (A13)	9	60,9348
Romania (A11)	10	58,2443
Serbia (A17)	11	42,5583
Bosnia-Herzegovina (A16)	12	37,8637
Montenegro (A9)	13	37,1809
Albania (A8)	14	30,9096
North Macedonia (A1)	15	30,2575

Table 7. Ranking of alternatives according to WASPAS method

Alternatives	Qi	Ranking
Latvia	0,8609	1
Slovenia	0,8604	1
Estonia	0,7849	2
Greece	0,7805	3
Croatia	0,7411	4
Czech Republic	0,6993	5
Poland	0,6839	6
Lithuania	0,6713	7
Slovakia	0,6292	8
Hungary	0,6278	9
Cyprus	0,5954	10
Romania	0,4746	11
Turkiye	0,3982	12
Bulgaria	0,3961	13
Montenegro	0,2704	14
North Macedonia	0,2083	15
Albania	0,2063	16
Serbia	0,1994	17
Bosnia-Herzegovina	0,1836	18

Table 8. Comparison of countries' environmental sustainability performance in terms of methods

Countries	EPI Values	Ranking	COPRAS	Ranking	WASPAS	Ranking
Slovenia	67,3	1	100	1	0,8604	1
Estonia	61,4	2	95,3029	3	0,7849	2
Latvia	61,1	3	100	1	0,8609	1
Croatia	60,2	4	93,7709	5	0,7411	4
Slovakia	60,0	5	75,0473	8	0,6292	8
Czech Republic	59,9	6	85,3863	6	0,6993	5
Cyprus	58,0	7	75,9589	7	0,5954	10
Greece	56,2	8	100	1	0,7805	3
Romania	56,0	9	58,2443	10	0,4746	11
Lithuania	55,9	10	98,5016	2	0,6713	7
Hungary	55,1	11	94,1021	4	0,6278	9
North Macedonia	54,3	12	30,2575	15	0,2083	15
Bulgaria	51,9	13	60,9348	9	0,3961	13
Poland	50,6	14	100	1	0,6839	6
Albania	47,1	15	30,9096	14	0,2063	16
Montenegro	46,9	16	37,1809	13	0,2704	14
Serbia	43,9	17	42,5583	11	0,1994	17
Bosnia-Herzegovina	39,4	18	37,8637	12	0,1836	18
Turkiye	26,3	19	100	1	0,3982	12

According to Table 8, the EPI values of the countries and the results of the environmental sustainability performance values found by WASPAS and COPRAS method are compared. Slovenia ranked 1st according to all methods. Estonia ranked 3rd according to COPRAS method and 2nd according to WASPAS and EPI values. Latvia ranked 3rd according to EPI value and 1st according to COPRAS and WASPAS methods. Bosnia and Herzegovina ranked last according

to EPI values and WASPAS method. Turkiye's ranking is almost similar in terms of WASPAS method and EPI values. Turkiye ranked 19th according to the EPI value and 12th according to the WASPAS method. When the environmental sustainability performance ranking of the countries according to the ENTROPY based COPRAS method is compared with the EPI values, it has shown consistency for 3 countries. These countries are Slovenia, Czech Republic and Cyprus. Slovenia ranked 1st, Czech Republic ranked 6th and Cyprus ranked 7th. On the other hand, when the environmental sustainability performance ranking of the countries according to the ENTROPY based WASPAS method is compared with the EPI values, it has shown consistency for 6 countries. These countries are Slovenia, Estonia, Croatia, Serbia and Bosnia and Herzegovina. Slovenia ranked 1st, Estonia 2nd, Croatia 4th, Serbia 17th and Bosnia and Herzegovina 18th. According to the results obtained, it was observed that the EPI values of the ENTROPY based WASPAS method and the EPI values gave more consistent and similar results than the ENTROPY based COPRAS method in the environmental sustainability performance ranking of countries.

CONCLUSION

Especially with the recent increase in environmental awareness, countries have been developing various policies to solve their environmental problems. In order to evaluate the effectiveness of the policies developed and to analyze the situation of countries against other countries, environmental performance evaluations are regularly conducted. According to the results of the analysis conducted in this study, the criteria are ranked as "water resources", "waste management" and "agriculture" according to their importance levels. When we look at the main criteria to which the sub-criteria are linked, it is observed that the "ecosystem vitality" criterion stands out in the environmental performance index, followed by the "environmental health" criterion.

In a similar study in the literature, Akandere and Zerenler (2022) conducted to evaluate both the environmental and economic performance of Eastern European countries, firstly, the importance levels of the criteria were found by CRITIC method, and the most important criterion was found as "ecosystem services" and the least important criterion as "ecosystem vitality". When the importance levels of the criteria were compared, it was determined that the importance levels of the criteria obtained in this study differed with the studies of Akandere and Zerenler (2022). In this study, in which the environmental sustainability performance index ranking of countries was made, it was determined that the "water resources" criterion under the main criterion of "ecosystem vitality" was the most important criterion. In addition, in the study of Altıntaş[b] (2021), in which the environmental performance index of the countries in the G20 group was evaluated, the most important criterion was determined as "water resources" according to the ENTROPY method in environmental performance according to countries. The results of this study in the literature also support each other with this study. This is thought to be due to the fact that countries have realized the importance of this issue for future generations in ensuring the efficiency of water resources.

On the other hand, according to the environmental and economic performance assessment of Akandere and Zerenler (2022), Romania was found to be the most successful and Bosnia and Herzegovina the least successful countries. Turkiye ranked 8th among 19 European countries in the study. In our study, Turkiye ranked 1st according to the ENTROPY based COPRAS method and 12th according to the ENTROPY based WASPAS method in the environmental sustainability index performance ranking. Turkiye ranked 19th in the ranking according to the EPI value. Turkiye has obtained the closest ranking to the EPI value in the environmental sustainability index performance ranking with the WASPAS method. According to this result, it is seen that the result of Turkiye's environmental sustainability index performance ranking obtained by ENTROPY based WASPAS method is more consistent than the result obtained by ENTROPY based COPRAS method. Although there has been an increase in the installation of renewable energy sources, progress in wastewater management, increase in environmental taxes and increasing environmental investments of the private sector in Turkiye in recent years, it can be said that it is still not at the desired level. In order to eliminate the disadvantageous situations of countries, it is obvious that it is necessary to use the country's resources with an environmentalist perspective, to make more use of renewable energy sources such as solar, wind and biomass, and to work on recycling waste through zero waste studies. In order to prevent environmental destruction and protect the environment, it is very important to cooperate within and between countries, to create environmental public awareness in the international arena and to carry out environmental policies and activities.

In future studies, new and different studies can be conducted by using integrated forms of different MCDM methods. The environmental sustainability performance of countries can be determined by using methods such as CODAS, OCRA, ROV, MABAC and MOOSRA, which are not included in the literature summary given in Table 2. For the ten criteria used in this study, 2022 data which is the most recent data based on years, was utilized. However, since regular data on the "fisheries" criterion in the main criterion of "ecosystem vitality" could not be obtained for 2022, this criterion was not included in the study. In future studies, comparisons can be made with previous studies by using the data for 2023, which will be published.

On the other hand, in this study, sub-criteria related to all three dimensions, namely "climate", "environmental health"

and "ecosystem vitality", were included for environmental sustainability performance index ranking. In addition, objective methods were preferred in this study. In addition to these three dimensions, the literature can be enriched by adding dimensions related to countries' economic performance, innovation index and tourism indicators ranking. In addition, the results obtained by using subjective methods where expert opinions are taken can be compared with the results obtained in the studies conducted.

Compliance with Ethical Standards

Peer-review

Externally peer-reviewed.

Conflict of interest

The authors declare that they have no competing, actual, potential or perceived conflict of interest.

Author contribution

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