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ORIGINAL ARTICLE

Ranking the organisation for economic co-operation and development (OECD) countries according to compatibility to sustainable development goal 6

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Abstract
Protecting water resources, expanding access to safe drinking water, reducing water pollution, recycling wastewater, and increasing the sustainability of water resources are important imperatives for the countries. In this study, Organisation for Economic Co-Operation and Development (OECD) countries' data on sustainable water and sanitation indicators of Sustainable Development Goal (SDG) 6 were collected and multiple attribute decision-making (MADM) methods were used to propose a ranking model. This model included finding the weights of indicators that are selected SDG 6 targets based on data availability and ranking OECD countries according to their compatibility with SDG 6. Entropy, CRITIC, and equal weights were used for weighting the indicators. VIKOR, MOORA, and MABAC methods were used for ranking OECD countries. The relationship between the rankings obtained from the applied methods was examined by calculating Spearman's rho correlation coefficient. Spearman rho values were high and all correlations were significant at the 0.01 level of significance, showing the similarity and consistency of the ranking results from the applied methods. The ranking results from all methods indicated that Switzerland was ranked first being the most compatible country to SDG 6 and Mexico was ranked last being the least compatible country to SDG 6. Switzerland and Mexico are separated from other OECD countries according to air pollution levels and country-specific environmental policy stringency index which are strongly associated with the obtained ranking index. The results also indicated that the compatibility of the DACH countries (Germany, Austria, and Switzerland) and Nordic Region countries (Denmark, Norway, Sweden, and Finland) to SDG 6 was high. For future studies, the proposed model for finding indicator weights and ranking countries can also be applied to cities and locations (rural and urban areas) based on SDG indicators.

Keywords Clean water · Sanitation services · Sustainable water management · Sustainable development goal (SDG 6) · Multiple attribute decision making (MADM) · Organisation for economic co-operation and development (OECD) countries

Introduction

The most basic necessity for existence is water. There is 1.4 billion km3 of water on the surface of the Earth. About 2.5 percent of this entire volume is made up of freshwater resources. Of this total, 30.1% (8 million km3) is stored as groundwater, while 68.7% is found in mountainous areas, Antarctica, and the Arctic as ice and snow (Water Science School 2019). Freshwater supplies are gradually being depleted due to climate change brought on by global warming, an increase in the frequency of extreme weather events, and pollution of clean water sources. For all living things, the loss or deterioration of water quality will surely provide serious challenges. Protecting water resources, expanding access to safe drinking water, lowering water pollution, recycling wastewater, and advancing the sustainability of water resources are therefore imperative.

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In semi-arid and arid regions water scarcity cause severe effects on food security and livelihoods (Gupta and Mishra 2021). In many countries the balance between water availability and water demand has risen to critical levels and as a result worldwide more than two billion people are living in water-scarced regions (Chakkaravarthy and Balakrishnan 2019). Water-related conflicts among countries and transboundary water issues likely cause tensions and potential wars over water (Dunn 2013; Gupta and Mishra 2021). Groundwater is essential to achieve sustainability goals, and its over-extraction is a global problem. Groundwater sources are in danger due to pollution, urbanization, population growth, over-extraction and climate change (Gupta and Mishra 2021). Strict regulatory policies of countries are necessary to promote sustainability of groundwater (Karandish et al. 2025).

In 2015, the United Nations approved a set of 17 global goals known as the Sustainable Development Goals (SDGs). These objectives serve as a path for reducing global vulnerability, eradicating inequality, ensuring system sustainability, and advancing universal peace and development by 2030. The sixth of them, known as SDG 6, focuses on clean water and sanitation. Access to basic water and sanitation services has been acknowledged as an essential human right. This is emphasized by the SDGs of the United Nations in Goal 6 (ensuring universal access to water and sanitation) and Goal 10 (reducing inequalities and promoting inclusivity) (Setty et al. 2020; Sciarra et al. 2021). Multidisciplinary and intricate elements, such as social, cultural, technical, economic, and political aspects, are all part of water supply and sanitation (WSS) services. Due to operational and maintenance problems, high infrastructure expansion and upgrade costs, and technical constraints, many nations struggle to provide WSS services. As a result, untreated contaminated water causes many ailments, and millions of dollars are spent on healthcare since these services are non-existent or of poor quality. Globally, an estimated 2.2 billion people lack safe drinking water, and 4.2 billion people lack access to safe sanitation (Adams et al. 2021). Ensuring affordable WSS services is one of the targets of SDG 6, as it is closely linked to the fulfillment of other human rights (Fagundes et al. 2023). By 2030, SDG 6 aims to guarantee that everyone has access to clean water and that water resources are used sustainably (Pereira et al. 2021). Supporting and enhancing local communities' involvement in bettering water and sanitation management is particularly called for in Target 6B. In order to meet the needs and desires of people in developing and underdeveloped nations, this goal is especially important (Bayu et al. 2020; Miao et al. 2023). The global effort to eradicate open defecation by 2030 is in progress. However, the current rate of advancement must double in order to provide basic water and sanitation services to everyone by that time. It would need a tenfold rise in existing rates in low-income and middle-income nations to achieve universal access to safely managed drinking water by 2030 (Rajapakse et al. 2023).

For SDG 6, quantitative data is available for three dimensions of sustainability (social, environmental, economic) and for most OECD countries. SDG 6 is directly related to quality and saving lives. Human beings, animals, plants and other living organisms need water to live as well as ensuring food security, conserving the environment and biodiversity, implementing production and service activities (Chakkaravarthy et al. 2019). While demand for water increases across countries, it becomes scarcer due to the adverse effects of climate change, hence water will become even more important in the future. There are also interdependencies between water, energy, food, and ecosystems (Rhouma et al. 2025). Therefore, SDG 6 was selected among the SDGs for this study. The conducted literature review indicates that there is a limited number of studies related to SDG 6 (Russell-Bennett et al. 2024). With the aim of contributing by this research study to the literature, the Organisation for Economic Co-Operation and Development (OECD) countries' data on sustainable water and sanitation indicators of SDG 6 are collected and multiple attribute decision making (MADM) methods are used to propose a ranking model. The ranking aims to shed light on the lowest-ranked countries by identifying OECD countries with better environmental practices and regulatory policies.

Proposed methodology

Data collection and preparation

This section demonstrates the systematic approach that has been used to rank OECD countries based on SDG 6. Figure 1 presents a flowchart summarizing the key steps of the methodology. Each step is explained in the subsequent sections to provide a comprehensive understanding of the approach.

The data collection process for this study was designed to gather reliable and relevant information to evaluate OECD countries based on their compatibility with SDG 6. The indicators selected include proportion of population using safely managed drinking water, proportion of population using safely managed sanitation services, proportion of bodies of water with good ambient water quality, change in water-use efficiency over time, level of water stress, degree of integrated water resources management implementation and proportion of transboundary basin area with an operational arrangement for water cooperation. These indicators

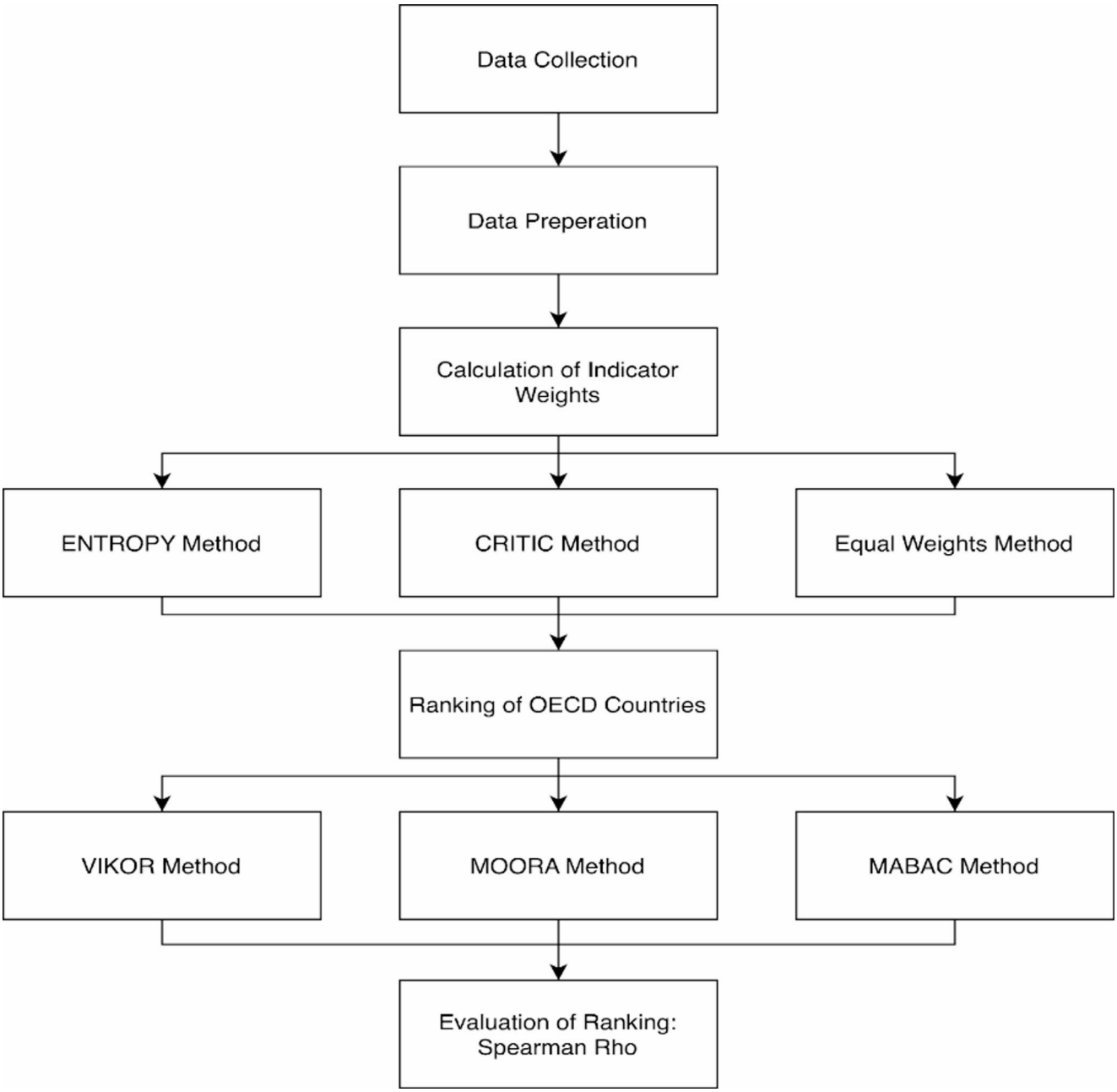

Fig.1 Ranking methodology applied

were chosen for their alignment with SDG 6 targets and their data availability across OECD countries.

The data has been sourced from the WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation, the global freshwater quality database GEMStat and the IWRM Data Portal operated by the United Nations Environment Programme, the global information System AQUASTAT by the Food and Agriculture Organization of the United Nations, the United Nations Economic Commission for Europe and the United Nations Educational, Scientific and Cultural Organization. The sources have been selected due to their credibility and comprehensive coverage of SDG-related metrics. The focus of the data collection has been on the most recently available years to ensure relevance and accuracy. To ensure consistency and comparability across countries, the data underwent a standardization process. While this study initially aimed to include all 38 OECD countries as of 2024, only 25 countries were ultimately included due to constraints on data availability. For 13 countries (Australia, Czech Republic, Iceland, Israel, Japan, South Korea, Luxembourg, New Zealand, Turkey, United Kingdom, United States, Colombia, and Japan), key

indicators were either unavailable or insufficiently reported, making it impossible to include them in this study. Since the data regarding selected SDG 6 indicators were available for different years the final dataset included 25 OECD countries' data for 2021, 2022, and 2023. This approach ensures that the collected data is accurate, reliable, and suitable for ranking OECD countries according to their performance on SDG 6.

Selected SDG 6 indicators

Based on the literature review, 7 different compromising SDG 6 targets are defined as indicators for this study (Table 1), which are "6.1.1 Proportion of population using safely managed drinking water services, 6.2.1a Proportion of population using safely managed sanitation services, 6.3.2 Proportion of bodies of water with good ambient water quality, 6.4.1 Change in water-use efficiency over time, 6.5.1 Degree of integrated water resources management implementation (0–100), 6.5.2 Proportion of transboundary basin area with an operational arrangement for water cooperation" as maximization indicators and " 6.4.2 Level of water stress: freshwater withdrawal as a proportion of available freshwater resources" as minimization indicator.

Table 1 Selected SDG 6 indicators

SDG Target	Indicator	Maximizing/ Minimizing
Target 6.1: Achieve universal and equitable access to safe and affordable drinking water for all	6.1.1 Proportion of population using safely managed drinking water services	Maximizing
Target 6.2: Achieve access to adequate and equitable sanitation and hygiene for all and end open defecation	6.2.1a Proportion of population using safely managed sanitation services	Maximizing
Target 6.3: Improve water quality by reducing pollution in water and significantly increasing safe reuse	6.3.2: Proportion of bodies of water with good ambient water quality	Maximizing
Target 6.4: Increase water-use efficiency and ensure freshwater supplies	6.4.1: Change in water-use efficiency over time	Maximizing
	6.4.2: Level of water stress: freshwater withdrawal as a proportion of available freshwater resources	Minimizing
Target 6.5: Implement integrated water resources management	6.5.1: Degree of integrated water resources management implementation (0–100)	Maximizing
	6.5.2: Proportion of transboundary basin area with an operational arrangement for water cooperation	Maximizing

Healthy and safe water, which is the cornerstone of life, is of great importance for the construction of sustainable societies, and its coverage by safety standards is essential; therefore, SDG 6.1, which covers access to safe and healthy drinking water, is defined as one of the indicators which is expected to be maximized for this study (Akhmouch et al. 2019; Guo 2024; Rhouma et al. 2025).

Sanitation, hygiene, safety and quality are the four main components of water poverty. SDG 6.2.1a considers sanitation and hygiene, which are closely related, and aims to increase the population reaching the cleaned, recycled and reused water. Therefore, SDG 6.2.1a is determined as one of the maximizing indicators. Whereas SDG 6.3.2 is associated with quality of water and aims to provide good ambient water quality for function of ecosystem and health of people (Acosta-González and Chafla 2024; Karandish et al. 2025), hence, it is identified as a maximizing indicator.

SDG 6.4.1 and SDG 6.4.2, which are sub-targets of SDG 6.4, are identified as two compromising indicators to be maximized and minimized, respectively. While SDG 6.4.1 monitors the development of water use efficiency over time, SDG 6.4.2 is related to the amount of fresh water withdrawn and the objective is to minimize this rate (Ge and Wang 2024). Managing integrated water resources cooperatively by the countries which have common water resources is a crucial issue, maintaining relationships in a balanced and sustainable manner in economic, social and environmental terms should be considered (Bertule et al. 2018). SDG 6.5 target is about water resources management in general, sub-target SDG 6.5.1 deals with implementation of integrated water resources management by all stakeholders, while sub-target SDG 6.5.2 addresses water resources management through relations between regions or countries, and both sub-targets are identified as maximizing indicators.

Since the data regarding SDG 6 indicators were available for Austria, Belgium, Canada, Chile, Costa Rica, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Italy, Latvia, Lithuania, Mexico, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, these 25 OECD countries were included in this study.

Determining indicators' weights

For determining indicators' weights, two weighting methods (Entropy and Criteria Importance Through Inter-criteria Correlation (CRITIC)) and equal weights were used. Equal weights are given to attributes for the purpose of conducting a sensitivity analysis (Ersoy 2022). Equal weight is assumed for each indicator. There are 7 selected SDG 6 indicators, and each indicator is assumed equal weight of 1/7.

Entropy method for weighting indicators

The steps of the Entropy method to determine the weights of attributes are as follows (Congjun and Yong 2009; Zhang 2020; Das et al. 2021):

1) Constructing the Decision Matrix $X = [x_{ij}]_{mxn}$.

where, x_{ij} represents the performance value of the ith alternative on the jth attribute, while *m* refers to the total number of alternatives and *n* indicates the total number of attributes.

2) Unitless Decision Matrix (Eq. (1)).

$$R = [r_{ij}]_{mxn} \text{ where } r_{ij} = \frac{x_{ij} - x_j^{worst}}{x_j^{best} - x_j^{worst}} \tag{1}$$

x_j^{best} = the best performance of attributej^{th}

x_j^{worst} = the worst performance of attributej^{th}

Calculating the normalized decision matrix (Equation (2)). Normalization makes the data with different unit unitless.

$$F = [f_{ij}]_{mxn} \text{ where } f_{ij} = \frac{r_{ij}}{\Sigma_{i=1}^{m} r_{ij}} \tag{2}$$

3) Computing entropy values.

The entropy of the jth attribute: $H_j = -k \sum_{i=1}^{m} f_{ij} \ln f_{ij}$ where k is Boltzman's constant when $f_{ij} = 0, f_{ij} \ln f_{ij} = 0$. Boltzman's constant k guarantees that $0 \leq H_j \leq 1$.

4) Diversification calculations for each attribute.

The degree of diversification is $1 - H_j$. The weighting of attributes by entropy is determined by diversification. As a result, more trustworthy and impartial outcomes are possible. The decision to diversify is straightforward.

5) Calculating weights (Eq. (3)).

The weight of entropy of the jth:

$$w_j = \frac{1 - H_j}{n - \Sigma_{j=1}^{n} H_j} \text{or } w_j = \frac{1 - H_j}{\Sigma_{j=1}^{n} (1 - H_j)} \tag{3}$$

where $0 \leq w \leq 1$ and $\Sigma_{j=1}^{n} w_j = 1$.

Criteria importance through inter-criteria correlation (CRITIC) method for weighting indicators

The basis of the CRITIC method is based on standard deviation, and the correlation between the attributes is also effective while determining the attributes weights, and impartiality is increased due to reduction in the biased evaluations of decision makers (Ersoy 2022).

1) Normalization of decision matrix $X = [x_{ij}]_{mxn}$.

The normalized decision matrix is obtained by using Eqs. (4)-(5).

$$r_{ij} = \frac{x_{ij} - x_j^{min}}{x_j^{max} - x_j^{min}}; \text{for benefit/maximization attribute} \tag{4}$$

$$r_{ij} = \frac{x_j^{max} - x_{ij}}{x_j^{max} - x_j^{min}}; \text{for cost/minimization attribute} \tag{5}$$

2) Evaluation of correlation coefficients (ρ_{jk}).

To measure the degree of relationship between the attributes, linear correlation coefficients ρ_{jk} are calculated (Eq. (6)).

$$\rho_{jk} = \frac{\sum_{i=1}^{m} (r_{ij} - r_j^-)(r_{ik} - r_k^-)}{\sqrt{\sum_{i=1}^{m} (r_{ij} - r_j^-)^2 \sum_{i=1}^{m} (r_{ij} - r_j^-)^2}}; \tag{6}$$

where$j, k = 1, 2, 3, \ldots, n$

The conflict between attributes can be examined by correlation, the higher the correlation determines that the less conflict (Wei et al. 2024).

3) Evaluation of standard deviation (σ_j).

σ_j is obtained by using Eq. (7).

$$\sigma_j = \sqrt{\frac{\sum_{i=1}^{m} (r_{ij} - r_j^-)^2}{m}} \tag{7}$$

4) Evaluation of total information (C_j).

C_j is obtained by using Eq. (8).

$$C_j = \sigma_j \sum_{k=1}^{n} (1 - \rho_{jk}) \tag{8}$$

5) Evaluation of attribute weights (w_j).

The weights (w_j) of the attributes are calculated by using Eq. (9).:

$$w_j = \sqrt{\frac{c_j}{\sum_{j=1}^{n} c_j}} \text{ where} j = 1, 2, 3, \ldots, n \tag{9}$$

Ranking alternatives with MADM methods

After determining indicators' weights, three different MADM methods were used for ranking the 25 OECD countries.

Ranking with VIKOR

The VIKOR (Vlse Kriterijumska Optimizacija I Kompromisno Resenje) method has been introduced in 1998 by Opricovic to solve MADM problems. It can be particularly effective in scenarios with conflicting attributes, where decision-makers try to achieve a solution that balances different competing objectives. The method has been especially recognized for its computational simplicity and its ability to provide a compromise ranking with maximum group utility and a minimum individual regret (Opricovic and Tzeng 2004). VIKOR can be used to rank and select from a finite set of alternatives by determining a compromise solution. The solution considers the trade-off between attributes while minimizing the distance from the ideal solution. It is especially useful in cases where a decision maker cannot indicate their preferences explicitly at the start or when conflicting objectives are present (Chatterjee and Chakraborty 2016).

The method includes the following steps:

1) Identify best (f_i^*) and worst (f_i^-) values of every criterion function ($i = 1, 2, ...n$). If the criterion function represents a benefit, the values can be identified by:

$$f_i^* = \max_j (f_{ij})$$

$$f_i^- = \min_j (f_{ij})$$

2) Calculate utility (S_j) and regret (R_j) (Eqs. (10)-(11), with w_i representing the weight of each criterion:

$$S_j = \sum_{i=1}^{n} w_i \frac{f_i^* - f_{ij}}{f_i^* - f_i^-} \tag{10}$$

$$R_j = max_i \left[w_i \frac{f_i^* - f_{ij}}{f_i^* - f_i^-} \right] \tag{11}$$

3) Calculate the compromise index (Q_j) using Eq. (2).

$$Q_j = v \frac{S_j - S^*}{S^- - S^*} + (1 - v) \frac{R_j - R^*}{R^- - R^*} \tag{12}$$

$S^* and S^-$: Maximum and minimum value of S_j
$R^* and R^-$: Maximum and minimum value of R_j
v : Weight for group utility

4) Rank alternatives based on ascending values of Q_j, S_j and R_j. The best compromise solution therefore minimizes Q_j.

5) The best ranked alternative is chosen if it can satisfy the following two conditions:

Acceptable Advantage: The difference between the best and the second-best alternative exceed a threshold $\Delta Q = 1/(m-1)$
Acceptable Stability: The best ranked alternative must rank as highest either in S_j or in R_j.

If the conditions are not satisfied, a set of compromise solutions is proposed.

Ranking with MOORA

The MOORA (Multi-Objective Optimization on the Basis of Ratio Analysis) method is a multi-objective optimization method (Chakraborty 2011) that was first introduced by Brauers (2013) and is applied to solve various complex decision-making problems. Multi-objective optimization can also be defined as multi-attribute or multi-criteria optimization and aims to optimize multiple conflicting attributes simultaneously with certain constraints (Chakraborty 2011).

1) The MOORA method begins with a decision matrix that represents the performance of various alternatives across multiple attributes.

$$X = [x_{ij}]_{mxn}$$

2) MOORA method has a ratio system in which each response of an alternative to a goal is compared to a denominator representing all alternatives to that goal. The decision matrix is normalized to make it unitless by Eq. (13).

$$x_{ij}^* = \frac{x_{ij}}{\left[\sum_{i=1}^{m} x_{ij}^2\right]^{\frac{1}{2}}} (j = 1, 2, \ldots, n) \tag{13}$$

where x_{ij}^* is a dimensionless value within the range [0,1], representing the normalized performance of the ith alternative on the jth criterion.

3) For multi-objective optimization, the normalized performances are summed for maximization (beneficial attributes) and deducted for minimization (non-beneficial attributes). Thus, the optimization problem transforms into Eq. (14).

$$y_i = \sum_{j=1}^{g} x_{ij}^* - \sum_{j=g+1}^{n} x_{ij}^* \tag{14}$$

where g is the count of attributes to be maximized, $n-g$ is the count of attributes to be minimized, and y_i represents the normalized evaluation value of the ith alternative across all attributes.

4) In calculating the final ranking (Eq. (15)), the importance of the attributes is taken into account by their corresponding weights.

$$y_i = \sum_{j=1}^{g} w_j x_{ij}^* - \sum_{j=g+1}^{n} w_j x_{ij}^* \, (j = 1, 2, \ldots, n) \tag{15}$$

where w_j is the weight value of the jth criterion. The y_i value can be positive or negative depending on the sum of the maximums (beneficial attributes) and minimums (non-beneficial attributes) in the decision matrix. The best alternative has the highest y_i value, while the worst alternative has the lowest y_i value. The rank order of y_i indicates the final ranking (Chakraborty 2011).

Ranking with MABAC

The MABAC (Multi-Attributive Border Approximation Area Comparison) method, developed by Pamučar and Ćirović (2015), has many areas of application in real-world problems. The MABAC method is suitable for solving multi-indicator problems that include a large number of alternatives and attributes. The formulation of the method is based on determining the distance from the border approximation area of the alternatives (Torkayesh et al. 2023a; b).

The method includes the following steps (Pamučar and Ćirović 2015):

Constructing a normalized initial definition matrix (N), Eqs. (16)-(17) are used.

$$\text{Benefit typeattributes} : \Upsilon_{ij} = \frac{x_{ij} - x_i^-}{x_i^+ - x_i^-} \tag{16}$$

$$\text{Cost typeattributes} : \Upsilon_{ij} = \frac{x_{ij} - x_i^+}{x_i^- - x_i^+} \tag{17}$$

$x_i^+ =$ Represents the highest value of the observed attribute among the alternatives

$x_i^- =$ Represents the lowest value of the observed attribute among the alternatives

1) Computation of the weighted initial decision matrix (V) (Eq. (18)).

$$x_{ij} = w_j \, (\Upsilon_{ij} + 1) \tag{18}$$

The elements of the weighted matrix (V) are computed.

2) Computation of the matrix for boundary approximation area (Ω) (Eq. (19)).

$$\mathrm{G} = [g_1 g_2 \ldots g_n] \, g_i = \left(\prod_{j=1}^{m} x_{ij} \right)^{\frac{1}{m}} \tag{19}$$

Determining the distance of alternatives from Ω (Equation (20)).

$$Q = \begin{bmatrix} x_{11} - g_1 x_{12} - g_2 \ldots x_{1n} - g_n x_{21} - g_1 x_{22} \\ -g_2 \ldots x_{2n} - g_n x_{m1} - g1 x_{m2} - g_2 \ldots x_{mn} - g_n \end{bmatrix} = [\vartheta_{11} \vartheta_{12} \ldots \vartheta_{1n} \vartheta_{21} \vartheta_{22} \ldots \vartheta_{2n} \vartheta_{m1} \vartheta_{m2} \ldots \vartheta_{mn}] \tag{20}$$

Selection of the optimal alternative from the set of considered alternatives (Equation (21)).

$$S_i = \prod_{j=1}^{n} \vartheta_{ij} \, (j = 1, 2, \ldots, n, i = 1, 2, \ldots, m) \tag{21}$$

Implementation of MADM methods

The decision matrix consisting of 25 alternatives and 7 indicators is given in Table 2.

Indicators' weights after applying Entropy and CRITIC methods and assuming equal weights are given in Table 3.

MADM methods are implemented using the decision matrix and indicators' weights, and then the ranking index of each method is calculated (Q_j for VIKOR, y_i for MOORA and S_i for MABAC). Based on the ranking indices, the lower the better for VIKOR, and the higher the better for MOORA and MABAC, the countries are ranked. The ranking of 25 OECD countries a VIKOR, MOORA and MABAC with assuming Entropy, CRITIC and equal weights is given in Table 4.

Results and discussion

The ranking from all methods indicates that Switzerland is ranked first, and Mexico is ranked last. Switzerland has the most compatibility to SDG 6 and Mexico has the least compatibility to this goal. Compatibility of the DACH countries (Germany, Austria and Switzerland) and Nordic Region countries (Denmark, Norway, Sweden, and Finland) to SDG 6 is high based on their rankings.

The finding for Mexico being ranked as the worst in meeting SDG 6 targets, consistent with the finding that a key industrial and agricultural hub in Mexico faces severe

Table 2 Decision matrix

Country	Code	Indicator 1	Indicator 2	Indicator 3	Indicator 4	Indicator 5	Indicator 6	Indicator 7
Austria	AT	98.90	99.67	82.26	113.89	8.68	91.00	100.00
Belgium	BE	99.74	94.48	26.25	99.42	51.88	82.00	100.00
Canada	CA	99.04	83.93	87.95	45.56	3.73	73.00	69.69
Chile	CL	98.77	95.29	73.06	7.54	8.98	26.00	78.60
Costa Rica	CR	80.51	25.17	63.92	17.13	5.88	51.00	14.46
Denmark	DK	99.92	98.72	29.31	301.60	26.40	95.00	100.00
Estonia	EE	97.02	90.42	18.50	24.74	10.82	89.00	100.00
Finland	FI	99.64	89.85	59.71	61.86	7.11	80.00	100.00
France	FR	99.70	89.59	85.26	91.13	21.60	100.00	53.27
Germany	DE	99.92	96.88	76.70	123.55	35.35	88.00	100.00
Greece	GR	98.88	92.08	20.37	17.04	20.68	85.00	52.56
Hungary	HU	100.00	87.81	12.98	26.34	8.07	76.00	100.00
Italy	IT	92.71	79.03	50.66	48.61	29.65	78.00	97.11
Latvia	LV	97.11	85.24	83.76	144.28	1.07	62.00	97.06
Lithuania	LT	94.98	94.79	22.36	172.59	1.83	61.00	34.06
Mexico	MX	43.04	60.02	56.89	12.28	45.02	41.00	33.19
Netherlands	NL	99.97	97.50	12.67	91.83	16.08	90.00	100.00
Norway	NO	98.82	77.99	100.00	139.70	2.01	71.00	89.45
Poland	PL	88.91	97.86	67.59	51.69	32.08	75.00	79.26
Portugal	PT	95.16	92.19	52.94	29.90	12.32	76.00	100.00
Slovakia	SK	99.18	82.49	61.44	152.76	2.44	57.00	81.50
Slovenia	SI	98.27	83.83	86.81	48.30	6.29	83.00	100.00
Spain	ES	99.57	89.97	21.60	37.78	43.25	92.00	100.00
Sweden	SE	99.74	95.55	48.37	239.19	3.58	86.00	100.00
Switzerland	CH	96.70	99.81	79.41	432.42	6.50	84.00	90.23

Table 3 SDG 6 Indicators' Weights

	Indicator 1	Indicator 2	Indicator 3	Indicator 4	Indicator 5	Indicator 6	Indicator 7
Entropy Weights	0.04	0.05	0.23	0.42	0.11	0.07	0.08
CRITIC Weights	0.09	0.10	0.22	0.13	0.19	0.13	0.14
Equal Weights	1/7	1/7	1/7	1/7	1/7	1/7	1/7

aquifer depletion and pollution (Nava 2025). Mexico has severe problems with sanitation (García-Searcy et al. 2022). The result for Switzerland being ranked as the best in meeting SDG 6 targets supports the literature that the proportion of households connected to a central wastewater treatment plant in Switzerland is 97%; between 1960 and 1990, water-related systems were created with intensive infrastructures and investments; in 2016, Switzerland launched a national policy to upgrade treatment plants with a fourth treatment stage to remove micropollutants (Aubert et al. 2022). Switzerland, which attaches great importance to the protection of water resources and clean water, has strict regulations on wastewater management and micropollutants, also many water treatment plants use advanced treatment systems to ensure high water quality in lakes and rivers (Velasco et al. 2023).

Figure 2 and Fig. 3 indicate that there is strong association between MABAC ranking index and emissions of air pollutant (OECD Data Explorer 2022) and environmental policy stringency index (OECD Data Explorer 2020). Emissions of air pollutant sulphur oxides which mostly include sulphur dioxide are harmful pollutants for ecosystems by causing acid smog and acid rain that damage water resources (Wan Nuzi et al. 2025). Therefore, sulphur oxides emissions are taken into account as air pollutants in this study. Switzerland and Mexico are separated from other OECD countries according to air pollution levels and country-specific environmental policy, which supports the findings in the literature (Rhouma et al. 2025).

High Spearman rho values given in Table 5, show the similarity of the ranking results from applied methods. All correlations are significant at the 0.01 level and the high values of correlations being at least 0.79 (correlation between MOORA-ENTROPY and VIKOR-CRITIC) indicate that ranking results are consistent.

Table 4 Ranking by MADM methods

Countries	VIKOR CRITIC	VIKOR ENTROPY	VIKOR EQUAL WEIGHTS	MOORA CRITIC	MOORA ENTROPY	MOORA EQUAL WEIGHTS	MABAC CRITIC	MABAC ENTROPY	MABAC EQUAL WEIGHTS
Austria	3	6	3	5	7	4	2	2	3
Belgium	22	17	22	24	19	22	22	19	21
Canada	8	12	12	8	12	10	7	11	10
Chile	14	19	21	15	17	18	14	16	19
Costa Rica	21	23	24	21	20	24	24	23	24
Denmark	15	3	7	10	2	6	12	5	7
Estonia	17	20	15	17	21	16	16	20	15
Finland	7	13	11	9	13	9	8	12	8
France	9	9	10	11	10	11	10	10	11
Germany	11	8	6	12	9	12	9	7	9
Greece	24	24	23	22	24	21	23	24	23
Hungary	19	21	18	18	22	17	18	21	16
Italy	16	18	17	20	18	20	19	18	18
Latvia	4	5	5	3	5	5	5	6	6
Lithuania	20	10	19	14	8	13	20	13	22
Mexico	25	25	25	25	25	25	25	25	25
Netherlands	18	14	14	16	14	15	15	17	14
Norway	2	4	4	2	4	3	3	3	4
Poland	13	15	16	19	15	19	17	15	17
Portugal	12	16	13	13	16	14	13	14	13
Slovakia	10	7	8	7	6	8	11	8	12
Slovenia	5	11	9	6	11	7	4	9	5
Spain	23	22	20	23	23	23	21	22	20
Sweden	6	2	2	4	3	2	6	4	2
Switzerland	1	1	1	1	1	1	1	1	1

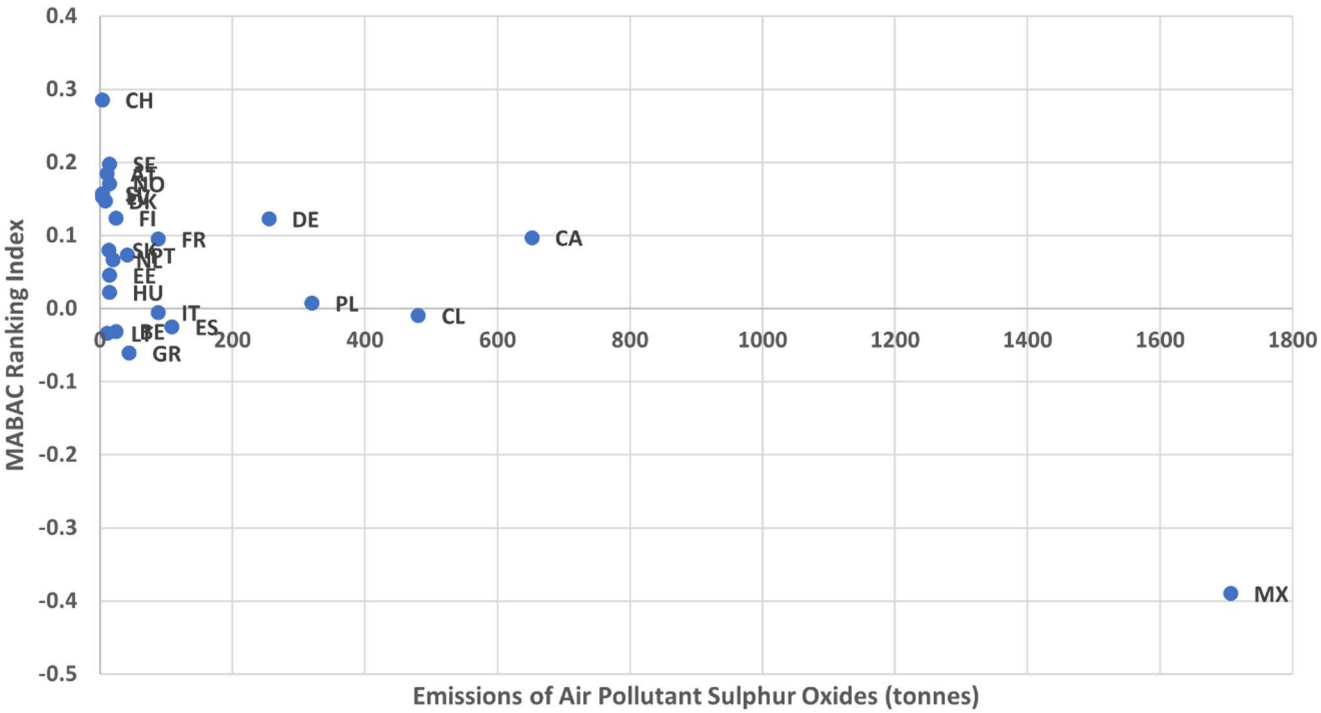

Fig.2 Graph of MABAC ranking index versus emissions of air pollutant

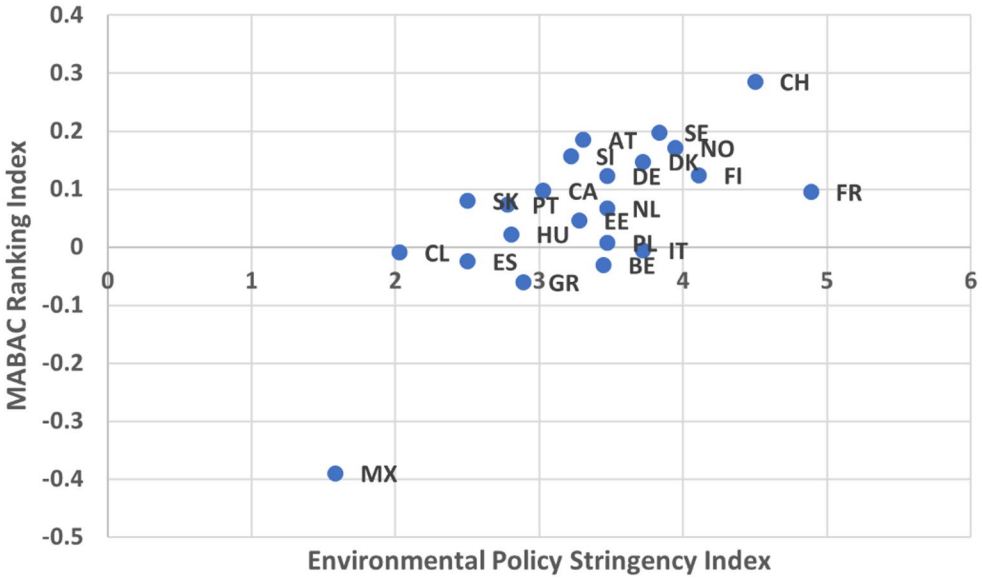

Fig.3 Graph of MABAC ranking index versus environmental policy stringency index

Table 5 Spearman rho calculations

	VIKOR CRITIC	VIKOR ENTROPY	VIKOR EQUAL WEIGHTS	MOORA CRITIC	MOORA ENTROPY	MOORA EQUAL WEIGHTS	MABAC CRITIC	MABAC ENTROPY	MABAC EQUAL WEIGHTS
VIKOR CRITIC	1.00								
VIKOR ENTROPY	0.81	1.00							
VIKOR EQUAL WEIGHTS	0.90	0.92	1.00						
MOORA CRITIC	0.94	0.89	0.92	1.00					
MOORA ENTROPY	0.79	0.99	0.89	0.89	1.00				
MOORA EQUAL WEIGHTS	0.90	0.93	0.95	0.98	0.92	1.00			
MABAC CRITIC	0.97	0.84	0.93	0.95	0.81	0.93	1.00		
MABAC ENTROPY	0.90	0.97	0.95	0.93	0.96	0.95	0.91	1.00	
MABAC EQUAL WEIGHTS	0.92	0.86	0.97	0.92	0.82	0.94	0.96	0.91	1.00

Conclusion

Water is becoming more and more important, access to clean water and sanitation services are crucial issues in today's world. In this study, access to clean water and sanitation services of the 25 OECD countries which data were available within the scope of SDG 6 were ranked using MADM methods in terms of their capabilities and competencies regarding clean water and sanitation services. Entropy, CRITIC and equal weights were used for weighting. VIKOR, MOORA, and MABAC were used for ranking OECD countries. The findings indicated that most compatible country was Switzerland, and least compatible country was Mexico in terms of SDG 6. The geographic location of the OECD countries also had an effect on the ranking.

High-ranked countries can guide lowest-ranked countries for developing better practices and policies in providing water availability and quality and in preventing environmental degradation. This study can provide a guideline for future development plans and policies of OECD countries according to SDG 6 for managing water resources sustainably and providing sanitation, hygiene and quality. It is possible to build a better and healthier future by taking more environmentally friendly actions about water management and progressing towards SDG 6 aims for 2030. The proposed model for finding indicator weights and ranking countries can be applied not only countries but also cities, locations (rural and urban areas) based on indicators of SDGs. The limitation of this study is the data availability. For future study, when data becomes available for recent years, methods used in this study can be applied and changes in Water Supply and Sanitation for OECD countries can be monitored. The methods and approach used in this study can be applied to other SDGs and other countries.

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Schmohl, Bilge Nur Gunes, Guher Turkan; Analysis: Marvin Schmohl, Bilge Nur Gunes, Guher Turkan, Bahar Sennaroglu; Methodology: Bahar Sennaroglu; Writing: Marvin Schmohl, Bilge Nur Gunes, Guher Turkan; Review and Editing: Bilge Nur Gunes, Guher Turkan, Bahar Sennaroglu. All authors read and approved the manuscript for submission.

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Declarations

Conflict of interest The authors have no conflicts of interest to declare.

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