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Ranking G-20 Countries by Human Development Index Using Objective MCDM Techniques: An Integrated MEREC–EDAS Approach

Nesnel Çok Kriterli Karar Verme Teknikleriyle G-20 Ülkelerinin İnsani Gelişmişlik Düzeylerine Göre Sıralanması: Entegre MEREC–EDAS Yaklaşımı

V. Sinem ARIKAN KARGI[1]

Abstract

The Human Development Index (HDI) is a composite indicator that encompasses the fundamental dimensions of human development, namely health, education, and standard of living. This study aims to objectively rank G-20 countries according to their HDI indicators using 2023 data published by the United Nations Development Programme (UNDP). An integrated Multi-Criteria Decision-Making (MCDM) framework combining the MEREC and EDAS methods was applied. Criterion weights were determined using the MEREC method, which assesses the marginal effect of each indicator, identifying gross national income per capita as the most influential criterion. Based on these weights, countries were ranked through the EDAS method. Results indicate that the United States, Germany, and Australia occupy the highest positions, while South Africa, Indonesia, and India rank lowest. These findings highlight the decisive role of economic prosperity, education, and health standards in shaping human development outcomes. Furthermore, the high consistency between EDAS-based rankings and the official HDI order confirms the validity and robustness of the proposed integrated approach, demonstrating its potential for objective, data-driven evaluation of multidimensional development performance.

Keywords: Human development index, multi-criteria decision-making method, MEREC, EDAS

Öz

İnsani Gelişme Endeksi (İGE), insan gelişiminin temel boyutları olan sağlık, eğitim ve yaşam standardını kapsayan bileşik bir göstergedir. Bu çalışma, G-20 ülkelerini 2023 yılı verilerine göre İGE göstergeleri açısından nesnel biçimde sıralamayı amaçlamaktadır. Bu amaçla, Birleşmiş Milletler Kalkınma Programı (UNDP) tarafından yayımlanan 2023 İnsani Gelişme Raporu'ndan elde edilen veriler kullanılmış ve bütünleşik bir çok kriterli karar verme (ÇKKV) yaklaşımı uygulanmıştır. Kriterlerin ağırlıkları, marjinal etkileri esas alan MEREC yöntemiyle belirlenmiş; kişi başına düşen gayrisafi milli gelir en önemli kriter olarak tespit edilmiştir. Bu ağırlıklar kullanılarak, ülkelerin sıralaması EDAS yöntemiyle gerçekleştirilmiştir. Bulgulara göre, Amerika Birleşik Devletleri, Almanya ve Avustralya en yüksek insani gelişme düzeyine sahipken; Güney Afrika, Endonezya ve Hindistan son sıralarda yer almıştır. Bu sonuçlar, ekonomik refah, eğitim düzeyi ve sağlık göstergelerinin insani gelişmedeki belirleyici etkisini vurgulamaktadır. Ayrıca, EDAS yöntemiyle elde edilen sıralamalar ile UNDP'nin resmi İGE sıralamaları arasındaki yüksek tutarlılık, önerilen yaklaşımın geçerliliğini ve güvenilirliğini desteklemektedir.

Anahtar Kelimeler: İnsani gelişme endeksi, Çok kriterli karar verme yöntemi, MEREC, EDAS

[1] Associate Prof. Ph.D., Bursa Uludağ Universty, vesa@uludag.edu.tr, https://orcid.org/0000-0003-3255-0165, https://ror.org/03tg3eb07

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Introduction

In recent decades, the inadequacy of GDP-focused assessments in capturing the full scope of development has led to increased interest in multidimensional indices such as the HDI, which integrate social and economic dimensions. Therefore, a comprehensive evaluation of human development requires not only technical indicators but also an understanding of their broader policy relevance and societal impact.

The Human Development Index (HDI) is a multidimensional indicator developed by the United Nations Development Programme (UNDP) in 1990 as an alternative to development assessments focused solely on economic growth. Unlike traditional approaches that rely on macroeconomic indicators such as gross domestic product (GDP), the HDI aims to assess human well-being through a broader lens by incorporating both social and economic dimensions. The index consists of three fundamental components: health, education, and standard of living. These are measured respectively by life expectancy at birth, expected and mean years of schooling, and gross national income (GNI) per capita (Karabulut et al., 2009; Orakçı & Özdemir, 2017). Each of these indicators represents a distinct aspect of human development, while GNI per capita adjusted for purchasing power parity (PPP) provides a more realistic reflection of individuals' average economic capacity within a country. By integrating these dimensions, the HDI offers a more comprehensive and comparative assessment of development. It enables meaningful cross-country comparisons and facilitates long-term monitoring of development performance. Moreover, by highlighting key areas such as access to education, healthcare, and economic resources, the HDI serves as a valuable decision support tool for policymakers, researchers, and international organizations. Beyond comparative assessments, the HDI serves as a critical policy tool by informing national development strategies, guiding international aid allocation, and monitoring progress toward the Sustainable Development Goals (SDGs).

This study aims to assess the human development levels of G-20 countries based on HDI indicators and to rank the countries using MCDM approach grounded in objective criteria. A fully data-driven methodology is adopted to eliminate the need for subjective input. Although human development has been examined in the literature through various MCDM techniques, studies that utilize HDI data in combination with objective weighting methods remain relatively limited. To ensure an objective and multidimensional evaluation of HDI performance, this study integrates the MEREC and EDAS methods, which offer complementary advantages in weight determination and ranking. The combined use of MEREC and EDAS in this study is not arbitrary but is grounded in their methodological complementarity and suitability for HDI-based evaluation. MEREC was selected due to its unique ability to derive objective weights by assessing the sensitivity of overall performance to the exclusion of individual criteria. This feature makes it particularly appropriate for HDI analysis, where all indicators are benefit-type but may contribute unequally to the overall index. Unlike alternative objective weighting methods such as CRITIC or Entropy, MEREC accounts for both inter-criteria redundancy and the marginal effect of each indicator, enabling greater sensitivity to subtle performance differences among countries (Keshavarz Ghorabaee et al., 2021). EDAS, on the other hand, was chosen for the ranking phase because it evaluates alternatives based on their distances from the average solution rather than ideal or anti-ideal values. This property aligns well with the HDI structure, which emphasizes balanced development across multiple dimensions rather than extreme performance in a single indicator. Compared to methods like TOPSIS or VIKOR, which may disproportionately favor outliers, EDAS penalizes deviations from the central tendency, thereby promoting a more stable and representative ranking (Ghorabaee et al., 2015). Together, MEREC and EDAS form a coherent and mutually reinforcing framework: MEREC generates robust, data-driven weights, while EDAS applies them to yield rankings that are both equitable and reflective of multidimensional development. This integration eliminates subjectivity, ensures methodological consistency between weighting and ranking phases, and enhances the transparency and interpretability of the results. Moreover, the high correlation between EDAS-based rankings and the official HDI scores, along with the robustness confirmed through sensitivity analyses using CRITIC and Entropy weights, further validates the appropriateness of this methodological pairing. By applying this fully data-driven framework to recent HDI indicators of G-20 countries, the study provides reliable and comparable results across nations and offers valuable insights for policymakers. In particular, it highlights the most influential dimensions of human development, such as health, education, and income, thus contributing to the formulation of more targeted and balanced development strategies at both national and international levels.

The study is structured into five main sections. The first section presents the conceptual framework of the Human Development Index. The second section provides a review of the relevant literature. The third section introduces the dataset and outlines the methodological framework, covering HDI calculation, MEREC, and EDAS. The fourth section includes the empirical analysis, and the fifth section discusses the findings and concludes the study.

1. Literature Review

To provide a theoretical foundation for the study, the literature review is structured under two main subheadings. The first part presents a review of recent studies that employ MEREC and EDAS methods in various fields such as performance evaluation, ranking, and selection problems. The second part focuses on studies that apply MCDM techniques in the context of the HDI, highlighting methodological similarities and differences relevant to the present study.

1.1. Review of the Literature on MEREC and EDAS Techniques

The literature review was conducted using Google Scholar as an academic search engine. The keywords used included ‘MEREC’, ‘EDAS’, and the combined term ‘MEREC and EDAS’. To highlight the most recent developments, particular emphasis was placed on studies published in the last five years. Table1 summarizes recent applications of these methods in contexts such as selection, ranking, and performance evaluation. Notably, studies that apply both MEREC and EDAS together are listed separately at the bottom of Table 1 to highlight their combined use and methodological significance.

Table 1: Overview of Previous Research on the MEREC and EDAS Methods

Author	Year	Method	Research Topic
Ayçin, E. and Arsu, T.	2022	MEREC	Evaluation of countries based on the social progress index: An application using the MEREC and MARCOS methods
Ulutaş et al.	2023	MEREC	Evaluating natural fibres for insulation in commercial buildings
Ecer and Ayçin	2023	MEREC	Innovation performance evaluation of G7 countries with MEREC
Lukić	2023	MEREC	Performance analysis of Serbian economy

Table 1. (continue)

Author	Year	Method	Research Topic
Kara et al.	2024	MEREC	Sustainable competitiveness assessment of Turkey with MEREC-AROMAN
Mastilo et al.	2024	MEREC	Banking sector evaluation in Bosnia and Herzegovina with MEREC-MARCOS
Wang et al.	2024	MEREC	Underground mine safety evaluation with MEREC–CoCoSo
Okursoy and Tezsürücü	2024	MEREC	Zero-emission electric vehicle selection using MEREC–CoCoSo
Elsayed	2024	MEREC	Evaluation of green fuel alternatives using hybrid MEREC–TODIM approach
Özekenci, E.K	2025	MEREC	Evaluation of the logistics performance index Of OECD countries based on hybrid MCDM methods
Çınaroğlu	2022	EDAS	Performance evaluation of pension companies using Entropy-based EDAS and CODAS methods
Mijalkovski et al	2024	EDAS	Warehouse site selection with EDAS
Süzülmüş and Yakut	2024	EDAS	Financial performance comparison of banks using CRITIC-based PROMETHEE and EDAS methods
Ramachandran et al.	2024	EDAS	Electric motor vehicle selection using the EDAS technique
Li and Sun	2024	EDAS	Marine ranching site selection using cloud model-based CRITIC–EDAS with linguistic information
Goswami et al.	2025	EDAS	Multi-model MCDM framework for sustainable renewable energy selection in India: integrating CRITIC-EDAS-CODAS-CoCoSo
Özçekiç, E.	2025	EDAS	Electric vehicle charging station positioning problem: multi-criteria decision making analysis with Entropy, CoCoSo and EDAS methods
Bektaş	2022	MEREC and EDAS	Turkish insurance sector performance analysis with MEREC, LOPCOW, CoCoSo, and EDAS
Duran	2023	MEREC and EDAS	Supply chain resilience evaluation of N-11 countries using MEREC-based EDAS, MARCOS, and WASPAS
Kumar, S., and Singh, R.	2024	MEREC and EDAS	An integrated MEREC–taxonomy methodology for multi-criteria decision analysis.
Salam,A	2024	MEREC and EDAS	Selection of appropriate UAV-integrated with mobile edge computing for ensuring safety and security of smart cities
Ma, X.	2025	MEREC and EDAS	New approach single valued neutrosophic sets for teaching quality challenges evaluation in college public english broad impacts
Kara, M.A	2025	MEREC and EDAS	An Analysis of the economic freedom index of NATO member countries using MEREC, GRA, and EDAS methods
Chen, X., and Li, Y.	2025	MEREC and EDAS	A new approach based on single valued neutrosophic sets for evaluating teaching quality challenges in college public English: Broad impacts of MEREC and EDAS methods

As presented in Table1, the MEREC and EDAS methods have previously been applied to a wide range of decision-making problems. These include studies on a wide range of applications, such as natural fibre selection for insulation in buildings, evaluation of innovation performance among G7 countries and analysis of national economic performance. Other areas of application comprise sustainable competitiveness assessment, banking sector evaluation, underground mine safety, selection of electric vehicles and green fuels, marine ranching site selection, warehouse location decisions and financial performance comparisons in the insurance and pension sectors. These applications demonstrate the multi-domain applicability of both methods and their adaptability to a wide range of real-world decision-making problems in sustainability, industry, transportation, energy, finance, and strategic planning.

1.2. MCDM Applications Related to the Human Development Index

Building on the findings from the literature on MEREC and EDAS methods, this section reviews recent multi-criteria decision-making studies that utilize HDI indicators. These studies are summarized in terms of the applied methods, selected criteria, and key findings. Lee, Lin, and Fang (2006) criticized the traditional equal weighting approach of the HDI and proposed an alternative model using a fuzzy multi-objective DEA method. The study introduced flexibility to the weighting structure under uncertainty, adding sensitivity to the method. However, the analysis was conducted with a limited sample, and the resulting rankings were not compared with the UNDP's official HDI data. Safari et al. (2013) proposed a new approach for multi-criteria decision-making problems based on a modified similarity method and tested it on various decision matrices. The method performs a similarity-based ranking without incorporating criterion weights. However, the applicability of the proposed method to real-world problems and its comparative effectiveness against traditional MCDM techniques were discussed only to a limited extent. Safari and Ebrahimi (2014) applied a modified similarity-based MCDM method to rank countries according to their HDI values and analyzed the top ten most developed countries based on 2011 data. However, the criterion weights were not clearly defined, and the extent to which the resulting rankings aligned with the official UNDP HDI rankings was not evaluated. While the study contributes to the ranking methodology, it remains limited in terms of methodological consistency and objective weighting. Paksoy (2015) conducted an analysis using the VIKOR method to evaluate the development levels of Turkey and European Union countries and compared the resulting rankings with the official UNDP HDI data. In the study, the criterion weights were determined based on expert opinions, which introduces potential subjectivity and decision-maker influence. Although ranking validation was performed, the subjectivity in the weighting process limits the objectivity of the method. Orakçı and Özdemir (2017) developed an extended index to evaluate the development levels of Turkey and EU countries by incorporating indicators from the European Quality of Life Survey (EQLS) in addition to the standard HDI criteria. Grey Relational Analysis (GRA) and the MOORA method were used for ranking, while criterion weights were determined using the ENTROPY and CRITIC methods. However, the study diverges from the classical HDI structure, as the selected indicators include additional social dimensions beyond those defined by the UNDP's standard HDI framework. Carvalhal Monteiro, Pereira, and Costa (2018) developed an alternative classification approach to the HDI by using the ELECTRE TRI method to categorize countries into five levels of development. In this classification, Norway, Australia, and Switzerland were placed in the highest category, while Niger, Chad, and the Central African Republic were placed in the lowest. While the study makes a valuable contribution by offering flexibility in classification, the weighting process is based on subjective preferences, and the resulting groupings show only partial consistency with the UNDP's official HDI classifications. Kılıç Depren and Bağdatlı Kalkan (2018) evaluated the quality of life levels of OECD countries using the ENTROPY-based MULTIMOORA method, relying on indicators from the Better Life Index (BLI). Criterion weights were objectively determined through the Entropy method, and the resulting rankings were compared with the UNDP HDI rankings using the Spearman rank correlation coefficient. A statistically significant consistency was observed between the two rankings, demonstrating the methodological reliability of the analysis. However, the index used in the study is based on OECD's social indicators and differs from the core components of the traditional HDI framework. Krylovas et al. (2019) evaluated the development levels of European countries by considering the interdependence between HDI and internal security indicators, employing the Simple Additive Weighting (SAW) method. In the study, HDI components were analyzed as a separate group, and within this group, GNI per capita was explicitly identified as the most influential criterion. GNI was followed by life expectancy at birth, expected years of schooling, and mean years of schooling. However, since the set of indicators used in the study also included internal security dimensions, the overall ranking results were not directly compared with the official UNDP HDI rankings. Omrani, Alizadeh, and Amini (2020) assessed the development levels of provinces in Iran by determining criterion weights using the Best Worst Method (BWM) and performing the ranking with the MULTIMOORA method. In the study, a semi-human development index was constructed, incorporating broader social indicators similar to, but extending beyond, those of the HDI. According to the results, Tehran, Isfahan, and Mazandaran ranked among the most developed provinces. However, the set of criteria used deviates from the standard HDI structure defined by the UNDP, and the resulting rankings were not directly compared with official HDI values. In the study by Altıntaş (2020), the human development levels of European Union member countries in Eastern Europe were evaluated using entropy-based EDAS and ARAS methods. The analysis was based on the HDI criteria defined by the UNDP, and the criterion weights were determined using Entropy, an objective weighting method. The results revealed that GNI per capita was the most heavily weighted criterion. Additionally, the consistency between the resulting rankings and the official UNDP HDI rankings was tested using the Spearman rank correlation coefficient, and a strong correlation was found. Akyüz and İpekçi Çetin (2022) evaluated the human development levels of provinces in Turkey using the VIKOR method, conducting the analysis based on 14 sub-indicators related to the dimensions of the HDI. In the study, the criterion weights were subjectively assigned, and equal weight was given to all indicators. According to the results, Ankara was identified as the most developed province.

In conclusion, although there are various studies in the literature that evaluate human development levels using MCDM methods, a review of the existing literature reveals no study that integrates the MEREC and EDAS methods directly within the framework of the HDI. Most previous studies tend to employ subjective weighting techniques or assume equal weights for all criteria. Additionally, some of these studies rely on alternative or expanded sets of indicators rather than the standard HDI dimensions defined by the UNDP, and methodological validation is addressed only to a limited extent. In this context, the present study focuses exclusively on the official HDI indicators specified by the UNDP, calculates objective weights using the MEREC method, ranks countries through the EDAS method, and evaluates the results statistically by comparing them with the official 2023 HDI rankings using the Spearman rank correlation coefficient. The identification of GNI per capita as the most influential criterion aligns with the findings of prior studies such as Altıntaş (2020) and Krylovas et al. (2019). Altıntaş applied the EDAS and ARAS methods based on HDI indicators and emphasized the significance of GNI, while Krylovas et al. reached similar conclusions using the SAW method. Although Kılıç Depren and Kalkan (2018) also adopted an objective weighting approach, their analysis was based on alternative indicators from the BLI. However, since the country sets used in these studies differ from the one employed in the present research, the resulting rankings are not directly comparable. Considering all these aspects, this study provides a meaningful contribution to the literature by applying an integrated, data-driven, and methodologically sound approach to the objective evaluation and ranking of HDI-based indicators, supported by statistical validation.

2. Methodology

2.1. Dataset

In the study aimed at assessing the level of human development in G-20 countries, data were gathered from the latest reports published by the United Nations Development Programme (UNDP) in 2023. The G-20 countries were selected as the sample group because they represent the world's largest economies, accounting for approximately 85% of global GDP and over two-thirds of the global population. As such, their human development performance has a significant influence on global development trends, making them a relevant and impactful group for comparative analysis. The criteria considered in calculating Human Development Index values are life expectancy at birth, expected years of schooling, mean years of schooling, and gross national income (GNI) per capita. Detailed descriptions of these criteria are provided in Table 2. The alternatives evaluated in the study consist of 19 member countries of the G-20.

Table 2: Criterion information

Criterion Code	Criterion	Decision Attributes	Descriptions
C1	Life Expectancy at Birth	Benefit	This indicator reflects the average number of years a newborn is expected to live under current health conditions. It serves as a key measure of the overall health and well-being of a population, influenced by access to healthcare, living standards, and public health initiatives.
C2	Expected Years of Schooling	Benefit	This criterion represents the total number of years of education a child entering the school system is expected to complete, assuming current enrollment rates. It highlights the accessibility and quality of educational opportunities available in a country.
C3	Mean Years of Schooling	Benefit	This metric refers to the average number of years of education completed by individuals aged 25 and older. It provides insights into a country's historical investments in education and the level of educational attainment within the population.
C4	Gross National Income (GNI) per Capita	Benefit	Adjusted for purchasing power parity (PPP), this indicator measures the average income of individuals in a country. It reflects the economic dimension of development, encompassing income levels, resource availability, and living standards.

Source: Prepared by the author based on the UNDP Human Development Report (2023) and relevant literature.

2.2 HDI Calculation

In accordance with the UNDP methodology, each HDI indicator is normalized using fixed minimum and maximum threshold values to obtain a value between 0 and 1. This normalization ensures comparability among countries and enables meaningful aggregation of criteria with different units. Specifically, the GNI per capita indicator is logarithmically transformed to reflect diminishing marginal returns of income to human development. The normalized scores of the three dimensions (health, education, and income) are then combined using the geometric mean to compute the final HDI value, as expressed by the following formula:

$$HDI = (I_{Health} * I_{Education} * I_{Income})^{1/3}$$

According to the HDI classification system, countries are grouped into four development levels based on their scores: values between 0 and 0.522 are categorized as low, 0.522–0.698 as medium, 0.698–0.793 as high, and 0.793–1 as very high human development (Nartgün et al., 2013: 83). These thresholds provide a meaningful basis for interpreting country performance.

2.3. Transition to MEREC and EDAS Methods

In this study, objective weighting methods were preferred over subjective techniques in order to eliminate decision-maker bias and ensure that the importance weights of the criteria were determined solely based on data. Given the multidimensional nature and global comparability of the HDI, a neutral and data-driven evaluation approach was considered more appropriate. Accordingly, the MEREC method was selected as the initial step. This method determines the importance of each criterion by analyzing the change in overall performance when the criterion is removed, and it offers more sensitive and insightful results compared to other objective techniques such as Entropy and CRITIC (Goswami et al., 2022: 1155). Furthermore, its algorithm is straightforward and easy to implement. The weights obtained from the MEREC method were then used as input for the EDAS method, which was employed for the ranking process. EDAS was chosen due to its simplicity and the fact that it does not require the separate calculation of best and worst values. Instead, it evaluates alternatives based on their average solution distances for each criterion, enabling practical, robust, and effective decision-making (Ghorabaee et al., 2015: 439).

2.4. Integrated MEREC- EDAS Framework

2.4.1. MEREC Method

The MEREC (Method based on the Removal Effects of Criteria) method, one of the objective criteria weighting methods, was proposed by Keshavarz Ghorabaee et al. in 2021. This method determines criterion weights based on the removal effects of the criteria. In other words, when calculating the importance weight for any criterion, the change in the total criterion weight is observed by excluding the criterion being weighted. This feature distinguishes this method from other objective weighting methods such as CRITIC and ENTROPY.

The MEREC method consists of six steps. The steps related to the MEREC method are summarized below (Keshavarz Ghorabaee et al., 2021).

Initially, the decision matrix is formed as shown below

$$X = \begin{bmatrix} x_{11} & x_{12} & . & . & x_{1m} \\ x_{21} & x_{22} & . & . & x_{2n} \\ . & . & . & . & . \; . \\ . & . & . & . & . \\ x_{n1} & x_{n2} & . & . & xnm \end{bmatrix} \tag{1}$$

Then, it is normalized using the equation provided below.

$$n_{ij}^{x} = \begin{cases} \dfrac{\min x_{ij}}{x_{ij}} & \text{if } j \in \text{benefit criteria} \\ \dfrac{x_{ij}}{\max x_{ij}} & \text{if } j \in \text{cost criteria} \end{cases} \tag{2}$$

After that, the total performance value (S_i) of each alternative is determined. The total performance value is calculated using Equation (3).

$$S_i = \ln\left(1 + \left(\frac{1}{m}\sum_j \left|\ln\left(n_{ij}^{x}\right)\right|\right)\right) \tag{3}$$

At this step, the performance of the alternatives ($S_{ij}^{'}$) is determined. Each alternative's performance is computed individually by deducting the value of each criterion from the overall performance, using Equation (4) for this purpose.

$$S'_{ij} = \ln\left(1 + \left(\frac{1}{m}\sum_{k,k\neq j} \left|\ln\left(n_{ik}^{x}\right)\right|\right)\right) \tag{4}$$

In the fifth step, the impact of criteria removal/deviation is assessed based on the sum of absolute deviations. Equation (5) is employed to calculate this sum.

$$Ej = \sum_i \left|S_{ij}^{'} - S_i\right| \tag{5}$$

At last step, criteria weights are calculated. Equation (6) outlines the process for calculating these weights.

$$wj, merec = \frac{E_j}{\sum_k E_k} \tag{6}$$

2.4.2. EDAS Method

The EDAS (Evaluation based on Distance from Average Solution) method, introduced into the literature by Ghorabaee et al. in 2015, is a method used to evaluate decision alternatives based on calculations of their distance from an average solution to determine the best option. The EDAS method consists of six steps. The steps of the EDAS method are as follows (Ghorabaee et al., 2015: 439-440):

As a first step, the decision matrix is formulated according to Equation (7)

$$X = \begin{bmatrix} x_{11} & x_{12} & . & . & x_{1m} \\ x_{21} & x_{22} & . & . & x_{2n} \\ . & . & . & . & . \; . \\ . & . & . & . & . \\ x_{n1} & x_{n2} & . & . & xnm \end{bmatrix} \tag{7}$$

Then, the average solution vector (AV) is obtained by calculating the average of each criterion across all alternatives, as shown in Equation (8).

$$AV_j = \frac{\sum_{i=1}^{m} x_{ij}}{m}, \qquad j=1,2\ldots m \tag{8}$$

In the equations, i denotes the alternatives (the G-20 countries), and j represents the criteria (HDI indicators, such as life expectancy, education, and income). Each element x_{ij} in the decision matrix reflects the performance score of alternative i under criterion j.

In the third step, positive and negative distance matrix values are calculated differently depending on whether the criteria are benefit or cost oriented. Positive (PDA_{ij}) and negative (NDA_{ij}) distance from the average are used to represent these distances. For benefit-oriented criteria, Equation (9) and Equation (10) formulas are utilized to calculate the values, while for cost-oriented criteria, the values are determined using the formulas provided in Equation (11) and Equation (12).

$$PDA_{ij} = \frac{X_{ij} - AV_j}{AV_j} \tag{9}$$

$$NDA_{ij} = \frac{AV_j - X_{ij}}{AV_j} \tag{10}$$

$$PDA_{ij} = \frac{AV_j - X_{ij}}{AV_j} \tag{11}$$

$$NDA_{ij} = \frac{X_{ij} - AV_j}{AV_j} \tag{12}$$

In the fourth step, the weighted sums of positive and negative deviations from the mean, computed individually for each decision alternative, are determined using the equations given below:

$$SP_i = \sum_{j=1}^{n} w_j PDA_{ij} \tag{13}$$

$$SN_i = \sum_{j=1}^{n} w_j NDA_{ij} \tag{14}$$

In the fifth step, Equations 15 and 16 are utilized to normalize the SP and SN values across all alternatives.

$$NSP_i = \frac{SP_i}{\max(SP_i)} \tag{15}$$

$$NSN_i = 1 - \frac{SN_i}{\max(SN_i)} \tag{16}$$

Final step of the method, evaluation scores (AS_i) for each decision alternative are calculated using Equation (17). The evaluation scores computed for each decision alternative are arranged in descending order. The decision alternative with the highest score is determined as the best alternative.

$$AS_i = \frac{1}{2}(NSP_i + NSN_i) \tag{17}$$

$$0 \le AS_i \le 1$$

3. Empirical Findings and Discussion

The weights of the criteria considered in this study will be calculated using the MEREC method. After calculating the weights, the ranking of countries according to their level of human development will be determined using EDAS method. And after that to determine the weights of this criteria using MEREC method, a decision matrix is first created using data obtained from reports published by the UNDP. The decision matrix, where alternatives are listed in rows and criteria are listed in columns, is provided in Table 3 below.

Table 3: Decision Matrix

Alternatives	C1	C2	C3	C4
USA	78.2	16.4	13.6	65564.9
Germany	81.0	17.3	14.3	55340.2
Australia	83.6	21.1	12.7	49257.1
Argentina	76.1	19.0	11.1	22048.0
United Kingdom	82.2	17.6	13.4	46623.9
Brazil	73.4	15.6	8.3	14615.9
China	78.6	15.2	8.1	18024.9
Indonesia	68.3	14.0	8.6	12045.6
France	83.2	16.0	11.7	47378.7
South Africa	61.5	14.3	11.6	13185.6
Korea	84.0	16.5	12.6	46026.5
India	67.7	12.6	6.6	6950.5
Italy	84.1	16.7	10.7	44284.2
Japan	84.8	15.5	12.7	43643.9
Canada	82.8	16.0	13.9	48444.4
Mexico	74.8	14.5	9.2	19138.0
Russian Federation	70.1	15.7	12.4	26991.8
Saudi Arabia	77.9	15.2	11.3	50620.4
Türkiye	78.5	19.7	8.8	32833.5

Source: http://hdr.undp.org/en/reports/global/hdr2023

In the second step, taking into account the direction of the criteria, the decision matrix is normalized. The created matrix is provided below.

Table 4: Normalized Decision Matrix

Alternatives	C1	C2	C3	C4
USA	0.786	0.767	0.484	0.106
Germany	0.759	0.726	0.461	0.126
Australia	0.736	0.597	0.516	0.141
Argentina	0.808	0.663	0.590	0.315
United Kingdom	0.748	0.714	0.490	0.149
Brazil	0.837	0.808	0.794	0.476
China	0.782	0.827	0.811	0.386
Indonesia	0.901	0.900	0.768	0.577
France	0.739	0.787	0.562	0.147
South Africa	1.000	0.882	0.566	0.527
Korea	0.732	0.762	0.521	0.151
India	0.908	1.000	1.000	1.000
Italy	0.731	0.755	0.612	0.157
Japan	0.725	0.814	0.519	0.159
Canada	0.742	0.788	0.474	0.143
Mexico	0.822	0.868	0.713	0.363
Russian Federation	0.877	0.803	0.529	0.258
Saudi Arabia	0.789	0.829	0.581	0.137
Türkiye	0.783	0.639	0.746	0.212

The total performance values of countries are calculated using Equation 3. Then, for each criterion, the performance values when that criterion is removed are computed using Equation 4. Subsequently, the removal effect of each criterion is determined based on the sum of absolute deviations as described in Equation 5, and the corresponding Ej values are obtained. The results of all these steps are summarized in Table 5 below.

Table 5: S_i , $S_{ij}^{'}$ and E_j Values

		$S_{ij}^{'}$			
Alternatives	**Si**	**C1**	**C2**	**C3**	**C4**
USA	0.625	0.272	0.277	0.361	0.053
Germany	0.621	0.219	0.228	0.314	0.044
Australia	0.621	0.178	0.221	0.25	0.04
Argentina	0.455	0.052	0.098	0.125	0.024
United Kingdom	0.594	0.193	0.203	0.277	0.021
Brazil	0.294	0.072	0.08	0.084	0.039
China	0.336	0.129	0.117	0.122	0.055
Indonesia	0.228	0.044	0.044	0.082	0.014
France	0.565	0.244	0.231	0.296	0.008
South Africa	0.288	0.013	0.018	0.121	0.105
Korea	0.578	0.216	0.208	0.283	0.017
India	0.024	0	0.024	0.024	0.024
Italy	0.550	0.239	0.233	0.274	0.025
Japan	0.563	0.218	0.195	0.283	0.032
Canada	0.591	0.214	0.202	0.301	0.051
Mexico	0.352	0.125	0.113	0.156	0
Russian Federation	0.461	0.118	0.137	0.224	0.069
Saudi Arabia	0.553	0.273	0.263	0.33	0.029
Türkiye	0.491	0.185	0.226	0.195	0.022
Ej		5.784	5.671	4.690	8.118

According to the MEREC method results shown in Figure 1, the GNI per capita (C4) is determined to be the most important criterion. This is followed by the criteria of life expectancy at birth (C1), expected years of schooling (C2), and mean years of schooling (C3), respectively.

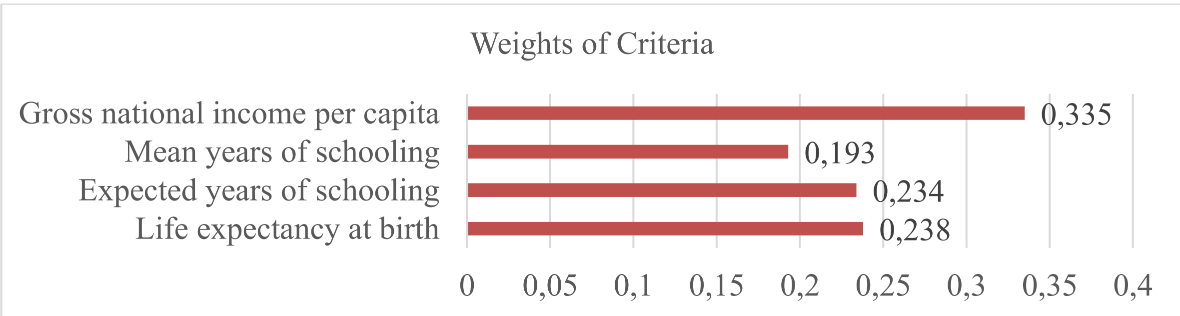

Figure 1. Weights of criteria

In the second part of the findings, the ranking of countries according to their level of human development is calculated using EDAS method. Firstly, the decision matrix is created using Equation 7. This matrix is previously shown in Table 3 within the context of the MEREC method. And secondly, the average solution values for each criterion are obtained using Equation (8) and are shown in Table 6.

Table 6: Average Solution Values

	C1	C2	C3	C4
V_j	77.41	16.25	11.13	34.895,69

Due to the benefit-oriented nature of the criteria, PDA (Positive Distance from Average) and NDA (Negative Distance from Average) matrices are obtained as shown in Table 7 and Table 8 using Equation (10) and Equation (11), respectively.

Table 7: PDA Matrix

Alternatives	C1	C2	C3	C4
USA	0.010	0.010	0.219	0.879
Germany	0.046	0.068	0.280	0.586
Australia	0.080	0.298	0.143	0.412
Argentina	0.000	0.168	0.001	0.000
United Kingdom	0.061	0.085	0.204	0.336
Brazil	0.000	0.000	0.000	0.000
China	0.015	0.000	0.000	0.000
Indonesia	0.000	0.000	0.000	0.000
France	0.075	0.000	0.050	0.358
South Africa	0.000	0.000	0.042	0.000
Korea	0.085	0.016	0.133	0.319
India	0.000	0.000	0.000	0.000
Italy	0.086	0.025	0.000	0.269
Japan	0.096	0.000	0.138	0.251
Canada	0.070	0.000	0.246	0.388
Mexico	0.000	0.000	0.000	0.000
Russian Federation	0.000	0.000	0.115	0.000
Saudi Arabia	0.006	0.000	0.016	0.451
Türkiye	0.014	0.212	0.000	0.000

Table 8: NDA Matrix

Alternatives	C1	C2	C3	C4
USA	0.000	0.000	0.000	0.000
Germany	0.000	0.000	0.000	0.000
Australia	0.000	0.000	0.000	0.000
Argentina	0.017	0.000	0.000	0.368
United Kingdom	0.000	0.000	0.000	0.000
Brazil	0.051	0.041	0.257	0.581
China	0.000	0.063	0.272	0.483
Indonesia	0.118	0.140	0.232	0.655
France	0.000	0.016	0.000	0.000
South Africa	0.206	0.122	0.000	0.622
Korea	0.000	0.000	0.000	0.000
India	0.125	0.225	0.410	0.801
Italy	0.000	0.000	0.035	0.000
Japan	0.000	0.049	0.000	0.000
Canada	0.000	0.018	0.000	0.000
Mexico	0.033	0.107	0.172	0.452
Russian Federation	0.094	0.036	0.000	0.226
Saudi Arabia	0.000	0.066	0.000	0.000
Türkiye	0.000	0.000	0.209	0.059

After obtaining the distance from the average values, the weighted total values for all countries must be calculated. To perform this calculation, the criterion weights determined by the MEREC method are incorporated into the EDAS method at this stage. The weighted total positive values (SP_i) are calculated using Equation (13), and these total values are then normalized using Equation (15). The weighted total positive values and their normalization are presented in Table 9.

Table 9: The Weighted Total Positive Values and Normalization Matrix

Alternatives	C1	C2	C3	C4	SP_i	NSP_i
USA	0.002	0,002	0,042	0,294	0.341	1.000
Germany	0.011	0.016	0.054	0.196	0.277	0.851
Australia	0.019	0.070	0.028	0.138	0.254	0.692
Argentina	0.000	0.039	0.000	0.000	0.039	0.086
United Kingdom	0.015	0.020	0.039	0.112	0.186	0.572
Brazil	0.000	0.000	0.000	0.000	0.000	0.000
China	0.004	0.000	0.000	0.000	0.004	0.007
Indonesia	0.000	0.000	0.000	0.000	0.000	0.000
France	0.018	0.000	0.010	0.120	0.147	0.399
South Africa	0.000	0.000	0.008	0.000	0.008	0.043
Korea	0.020	0.004	0.026	0.107	0.157	0.461
India	0.000	0.000	0.000	0.000	0.000	0.000
Italy	0.020	0.006	0.000	0.090	0.116	0.289
Japan	0.023	0.000	0.027	0.084	0.133	0.403
Canada	0.017	0.000	0.047	0.130	0.194	0.620
Mexico	0.000	0.000	0.000	0.000	0.000	0.000
Russian Federation	0.000	0.000	0.022	0.000	0.022	0.115
Saudi Arabia	0.002	0.000	0.003	0.151	0.155	0.413
Türkiye	0.003	0.049	0.000	0.000	0.053	0.113

The total negative values (SN_i) are calculated using Equation (14), and these total values are then normalized using Equation (16). The weighted total negative values and their normalization are presented in Table 10.

Table 10: The Weighted Total Negative Values and Normalization Matrix

Alternatives	C1	C2	C3	C4	SN_i	NSN_i
USA	0.000	0.000	0.000	0.000	0.000	1.000
Germany	0.000	0.000	0.000	0.000	0.000	1.000
Australia	0.000	0.000	0.000	0.000	0.000	1.000
Argentina	0.004	0.000	0.000	0.123	0.127	0.743
United Kingdom	0.000	0.000	0.000	0.000	0.000	1.000
Brazil	0.012	0.010	0.050	0.194	0.266	0.369
China	0.000	0.015	0.053	0.162	0.229	0.433
Indonesia	0.028	0.033	0.045	0.219	0.325	0.275
France	0.000	0.004	0.000	0.000	0.004	0.994
South Africa	0.049	0.029	0.000	0.208	0.286	0.453
Korea	0.000	0.000	0.000	0.000	0.000	1.000

Table 10: (continue)

Alternatives	C1	C2	C3	C4	SN_i	NSN_i
India	0.030	0.053	0.079	0.268	0.430	0.000
Italy	0.000	0.000	0.007	0.000	0.007	0.972
Japan	0.000	0.011	0.000	0.000	0.011	0.981
Canada	0.000	0.004	0.000	0.000	0.004	0.993
Mexico	0.008	0.025	0.033	0.151	0.217	0.504
Russian Federation	0.022	0.008	0.000	0.076	0.107	0.797
Saudi Arabia	0.000	0.015	0.000	0.000	0.015	0.974
Türkiye	0.000	0.000	0.040	0.020	0.060	0.796

In the final stage of the EDAS method, the assessment scores (AS_i) for each country are calculated using Equation (17). Table 11 presents the EDAS-based assessment scores of the countries, along with their corresponding rankings and the actual Human Development Index (HDI) rankings.

Table 11: EDAS Scores and Country Rankings Compared with Actual HDI Rankings

Alternatives	AS_i	Actual HDI Ranking	Model-Based Ranking (EDAS)
USA	1.000	6	1
Germany	0.906	1	2
Australia	0.872	2	3
Argentina	0.410	12	12
United Kingdom	0.773	3	5
Brazil	0.191	16	16
China	0.239	14	15
Indonesia	0.122	18	18
France	0.711	8	7
South Africa	0.179	17	17
Korea	0.729	5	6
India	0.000	19	19
Italy	0.663	9	10
Japan	0.682	7	9
Canada	0.780	4	4
Mexico	0.247	15	14
Russian Federation	0.408	13	13
Saudi Arabia	0.710	10	8
Türkiye	0.507	11	11
	Sperman rho:	0.96	
	P-value:	< 0.001	

The findings presented in Table 11 indicate that the rankings obtained through the EDAS method are generally consistent with the official HDI rankings, though some meaningful deviations are observed. Most notably, the United States ranks first according to the EDAS method, despite being sixth in the HDI list. This can be explained by the country's outstanding performance in the GNI per capita criterion (C4), which received the highest weight (33.5%) in the MEREC weighting process. This clearly demonstrates the decisive influence of economic capacity on the final rankings within the EDAS framework. Similarly, Saudi Arabia, which ranks 10th in the HDI list, rises to 8th place in the EDAS ranking, reflecting its strong performance in the economic criterion. Conversely, countries such as Germany and Australia, although among the top-ranked in the HDI, fall behind the United States in the EDAS results due to relatively lower scores in income-related indicators. The downward shifts of countries like Japan, South Korea, and the United Kingdom can be attributed to slightly weaker outcomes in health or education indicators. On the other hand, Canada maintains its position (4th) in both rankings, reflecting a balanced performance across all HDI dimensions. Countries such as India, Indonesia, and South Africa appear at the bottom of both rankings, indicating a more general deficiency in overall human development performance.

These variations are not only rooted in country-level performance but also reflect differences in methodological structure. While the HDI is calculated based on the geometric mean of three dimensions (health, education, and income), the EDAS method evaluates each alternative based on its positive and negative distances from the average solution for each criterion. This structure favors countries that demonstrate balanced and strong performance across all indicators, while also allowing countries with particularly high values in specific criteria to stand out in the rankings.

To assess the statistical relationship between the EDAS-based and official HDI rankings, Spearman's rank correlation coefficient was calculated. The resulting coefficient was 0.96 and statistically significant, indicating a very strong positive correlation between the two ranking systems. These findings confirm that the EDAS method, when combined with objective weights derived from the MEREC technique, produces results that are largely consistent with HDI-based assessments while also offering a more nuanced reflection of the relative influence of each indicator on country rankings. While these findings are based on the MEREC weighting scheme, additional analyses using CRITIC and Entropy weights were conducted to test the sensitivity of the EDAS rankings to the weighting method, as discussed in the subsequent section.

3.1. Sensitivity of EDAS Rankings to Different Objective Weighting Methods

The previous findings revealed that the EDAS rankings obtained using the MEREC method were largely consistent with the official HDI rankings. While this result demonstrates the reliability of the method, it also underscores the necessity of examining the influence of alternative weighting techniques. Therefore, to more comprehensively assess the impact of weighting on the outcomes, the EDAS method was applied not only with MEREC but also with two additional objective weighting methods, CRITIC and Entropy.

Within this framework, sensitivity analysis was conducted specifically for the weighting methods (MEREC, CRITIC, and Entropy) to evaluate how changes in the importance of criteria would affect the final rankings. The focus on weighting arises from the fact that it is often the most subjective and influential component in MCDM applications. EDAS, on the other hand, was kept constant due to its methodological alignment with HDI data, particularly its emphasis on balanced development and distance from the average solution, thus enabling the isolation of weight-related effects. Nevertheless, it is acknowledged that analyzing the sensitivity of rankings to alternative decision-making methods (e.g., TOPSIS, VIKOR) would further strengthen the robustness of the findings. This has been noted as a limitation in the conclusion section and is recommended as a potential avenue for future research.

Consequently, the resulting country rankings are summarized in Table 12, which provides a comparative assessment of the sensitivity of the EDAS method to different weighting schemes.

Table 12: EDAS-Based Country Rankings Under Different Objective Weighting Methods

	MEREC		ENTROPY		CRITIC	
Alternatives	As_i	Ranking	As_i	Ranking	As_i	Ranking
USA	1.000	1	1.000	1	1.000	1
Germany	0.906	2	0.847	2	0.962	2
Australia	0.872	3	0.748	3	0.955	3
Argentina	0.410	12	0.296	13	0.485	12
United Kingdom	0.773	5	0.705	6	0.832	4
Brazil	0.191	16	0.145	16	0.210	17
China	0.239	15	0.200	15	0.248	15
Indonesia	0.122	18	0.101	18	0.141	18
France	0.711	7	0.701	7	0.708	8
South Africa	0.179	17	0.143	17	0.238	16
Korea	0.729	6	0.688	8	0.759	6
India	0.000	19	0.000	19	0.000	19
Italy	0.663	10	0.646	10	0.655	10
Japan	0.682	9	0.649	9	0.711	7
Canada	0.780	4	0.734	5	0.828	5
Mexico	0.247	14	0.224	14	0.260	14
Russian Federation	0.408	13	0.378	12	0.458	13
Saudi Arabia	0.710	8	0.745	4	0.675	9
Türkiye	0.507	11	0.455	11	0.528	11

Table 12 presents the country rankings obtained using the EDAS method with three different objective weighting techniques: MEREC, CRITIC, and Entropy. Overall, a high degree of consistency is observed among the rankings, with leading countries such as the United States, Germany, Australia, and Canada maintaining top positions across all methods. Some fluctuations are noted among mid-ranked countries. For example, Saudi Arabia is ranked 8th using MEREC weights, rises to 4th under the Entropy method, and is positioned 9th with CRITIC weights. Japan and South Korea experience slight declines in their rankings depending on the weighting technique applied. Additionally, countries like the United Kingdom and France exhibit minor ranking variability associated with the weighting changes.Countries at the lower end of the rankings, including India, Indonesia, and South Africa, show relatively stable positions regardless of the weighting method used. These findings highlight the influence of weighting methods on country rankings while demonstrating the robustness and reliability of the EDAS method across different objective weighting scenarios.

To complement the tabular results, Figure 2 visually compares the country rankings obtained under the three different weighting methods.

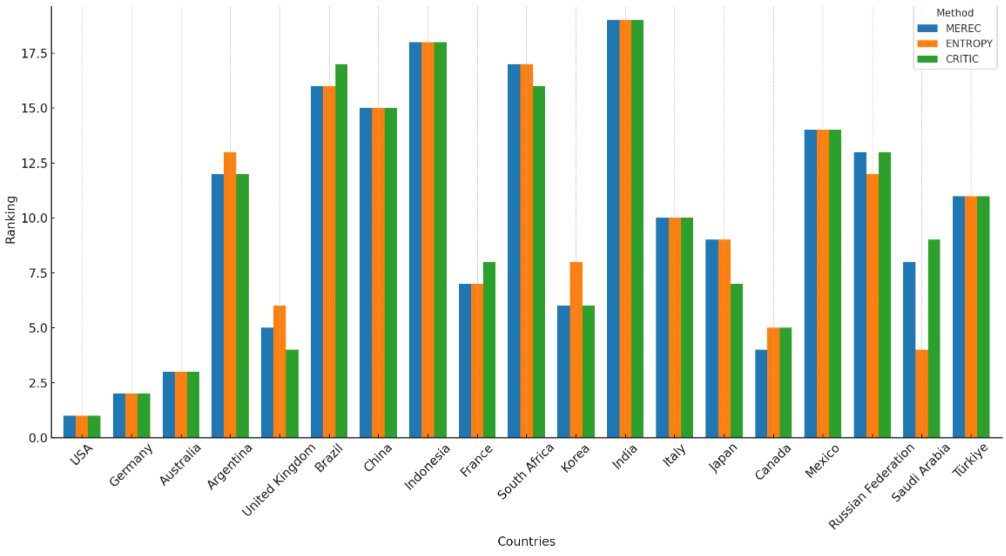

Figure 2. Visual Comparison of EDAS-Based Country Rankings Across Different Objective Weighting Methods

The ranking differences observed across the three objective weighting methods, as detailed in Table 13, are effectively illustrated in the accompanying grouped bar chart. This visualization highlights the relative stability of the top three countries,United States, Germany, and Australia, as they consistently maintain leading positions regardless of the weighting technique applied. Similarly, the last three countries, India, Indonesia, and South Africa, also exhibit stable rankings across all methods. The chart further facilitates the identification of countries with more variable rankings, predominantly those positioned in the middle of the distribution, thereby providing a clear visual complement to the tabular data.

Table 13: Spearman Correlations of EDAS Rankings with Different Weighting Methods

Spearman ρ	MEREC-EDAS	ENTROPY-EDAS	CRITIC-EDAS
MEREC-EDAS	1		
ENTROPY-EDAS	0.979*	1	
CRITIC-EDAS	0.991*	0.963*	1

*Correlation is significant at the 0.01 level.

A Spearman's rank correlation analysis was conducted to evaluate the sensitivity of the EDAS rankings to variations in objective weighting methods. As shown in Table 13, the high correlation coefficients exceeding 0.96 indicate that the rankings remain largely stable despite changes in the weighting techniques. These findings confirm the robustness of the EDAS method and its low sensitivity to changes in weighting.

4. Conclusion

This study evaluated the human development levels of G-20 countries based on the HDI indicators defined by the UNDP, using MCDM approach. The criterion weights were determined using an objective weighting technique, the MEREC method, and the countries were subsequently ranked through the EDAS method. This approach differs from traditional indexing methods by enabling the evaluation of each indicator according to its data-driven significance.

According to the weights calculated by the MEREC method, GNI per capita emerged as the most influential criterion with a weight of 33.5%, followed by life expectancy at birth (23.8%), expected years of schooling (23.4%), and mean years of schooling (19.3%). This distribution highlights the dominant role of economic capacity in shaping human development levels. In the EDAS-based ranking, countries such as the United States, Germany, Australia, and Canada performed highly across all criteria and ranked at the top, while Turkey was positioned 11th. Countries like India, Indonesia, and South Africa were ranked lowest due to persistent issues in income distribution, healthcare, and educational infrastructure. While GNI per capita had the highest influence, the contribution of education and health components, as shown in the MEREC-derived weights, was also substantial. This demonstrates that the proposed model successfully incorporates all three dimensions of human development, preserving the index's multidimensional character.

The consistency between the EDAS-based ranking and the official HDI order was also supported by statistical evidence. A Spearman rank correlation coefficient of 0.96 statistically confirms this alignment. However, the computational logic of the two methods differs significantly. While HDI aggregates the three main dimensions using a geometric mean, EDAS evaluates alternatives based on their positive and negative distances from an average solution. This structure enables EDAS to more sensitively highlight countries with balanced and strong performance across all criteria. Additionally, the integration of MEREC-based weights, especially those related to economic indicators, significantly shaped the ranking results.

To further examine the impact of weighting techniques on the ranking results, a sensitivity analysis was conducted using additional objective weighting methods, namely CRITIC and Entropy. The EDAS-based rankings derived from these alternative schemes showed a high degree of consistency with those obtained using the MEREC method. This consistency confirms the robustness of the proposed model and shows that the rankings are not overly sensitive to the choice of weighting method, thereby enhancing the credibility of the results for policy and comparative assessment.

When compared with prior studies, the criterion importance weights obtained in this research are consistent with those reported by Krylovas et al. (2019) and Altıntaş (2020). In both studies, GNI per capita was identified as the most influential indicator, followed by education and health components.

Moreover, the integration of MEREC and EDAS methods significantly strengthened the methodological coherence of the study. By using MEREC to generate objective weights and applying them within the EDAS framework, the study ensured consistency between the weighting and ranking stages. This dual-method approach allowed for more transparent and stable rankings by reducing subjectivity and enhancing differentiation among alternatives. As such, the combined use of these techniques contributed directly to the robustness and clarity of the HDI-based country comparisons.

This study also has certain limitations. First, the analysis was limited to the three HDI indicators defined by the UNDP; broader dimensions such as gender inequality, environmental sustainability, and digital access were not considered, which may restrict the comprehensiveness of the assessment. However, this deliberate focus on the UNDP's core HDI dimensions was intended to ensure methodological consistency and enable a direct comparison with the official HDI rankings. Second, the data used represent only a single year (2023), providing a static snapshot that does not capture temporal dynamics. Future research should consider longitudinal data to analyze trends in human development more accurately. Third, the study did not rely on a single weighting method; instead, it employed multiple objective techniques, specifically MEREC, CRITIC, and Entropy. The comparison of these methods provided valuable insights into the stability of the weights and allowed for testing the robustness of the results. Further comparative studies incorporating other objective or subjective weighting methods may offer a deeper understanding of methodological diversity and its implications. In addition, another limitation of the study is that the sensitivity analysis was limited only to the weighting methods, while the ranking method (EDAS) was kept constant. Although EDAS was chosen due to its conceptual compatibility with HDI data, future studies could compare it with alternative ranking methods such as TOPSIS, VIKOR, or MARCOS to more comprehensively evaluate the robustness of the resulting rankings. Lastly, expert judgments and uncertainty were not incorporated into the decision-making process. Integrating fuzzy logic or group decision-making approaches could enhance the flexibility and applicability of the methodology, especially in complex decision environments.

In addition, the findings of this study may offer valuable insights for policymakers, particularly in designing more effective and equitable human development strategies. By highlighting the relative importance of each HDI component, the proposed model has the potential to support more data-driven and priority-oriented decisions in national development planning.

Değerlendirme/ *Evaluation:*
Çift Taraflı Kör Hakemlik Sistemi
Double Blind Refereeing System

Etik Beyan Metni/ *Ethics Declaration Text:*
Çalışmanın hazırlanma sürecinde bilimsel ve etik ilkelere uyulduğu ve yararlanılan tüm çalışmaların kaynakçada belirtildiği beyan olunur.

It is hereby declared that scientific and ethical principles were adhered to during the preparation of this study and that all studies used are cited in the references.

Etik Bildirim/Ethics Notification: info@esosder.org

Yapay Zekâ Kullanımı /Use of Artificial Intelligence:
Bu çalışmanın hazırlanma sürecinde yapay zekâ tabanlı herhangi bir araç veya uygulama kullanılmamıştır. Çalışmanın tüm içeriği, yazar(lar) tarafından bilimsel araştırma yöntemleri ve akademik etik ilkelere uygun şekilde üretilmiştir.

No artificial intelligence-based tools or applications were used in the preparation of this study. All content of the study was produced by the author(s) in accordance with scientific research methods and academic ethical principles.

Çıkar Çatışması Beyanı/ *Declaration of conflict of interest:*
Bu çalışmada herhangi bir potansiyel çıkar çatışması bulunmamaktadır.

There is no potential conflict of interest in this study.

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