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# Performance analysis of the Next Eleven countries regarding climate change for the selected years

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## Abstract

**Purpose** – In the Next Eleven (N-11) countries, which are considered emerging investment markets, energy consumption is increasing in parallel with the growing economy. This situation negatively affects global warming and climate change, which are the biggest environmental problems of today. From this point of view, the purpose of the study is to determine the performance of the N-11 countries in terms of energy use and climate change for the period between 2010 and 2022 based on the indicators of Sustainable Development Goal (SDG) 7 and SDG 13 to be reached until 2030.

**Design/methodology/approach** – Grey relational analysis (GRA), one of the multi-criteria decision-making techniques, was used to assess the performance of the N-11 countries in the study. Additionally, the entropy method was employed in determining weights needed in GRA. The indicators were obtained from the World Development Indicators database, World Bank. Performance analyses were conducted for the years 2010, 2015 and 2022, respectively.

**Findings** – According to the results obtained, it has been found that Bangladesh, the Philippines and Egypt have the three highest scores, while Mexico, Indonesia and Iran have the three lowest scores. In 2022, Nigeria is placed instead of Mexico in this group. It is observed that the performance scores of the countries have either remained the same or increased slightly over the years. This indicates that it is difficult to reach the 2030 targets.

**Originality/value** – This study is the first attempt to measure the performance of N-11 countries on climate change using multi-criteria decision-making. In this study, the performance scores obtained for the selected years were compared. Thus, it is observed whether there is an improvement in the performance scores of the countries during the analysis period.

**Keywords** The Next Eleven countries, Energy use, Climate change, Grey relational analysis

**Paper type** Research paper

## 1. Introduction

The term "Next Eleven (N-11)" defines a group of eleven developing countries with emerging markets, Bangladesh, Egypt, Indonesia, Iran, Mexico, Nigeria, Pakistan, the Philippines, Turkiye, South Korea and Vietnam, and these countries have the potential to become the largest economies in the world. This identification was made by Goldman Sachs Investment Bank in 2005, and they are considered the new BRIC (Brazil, Russia, India and China) countries of the future (Lawson *et al.*, 2007; Wilson and Stupnytska, 2007; O'Neill and Stupnytska, 2009).

The N-11 countries have about 20% of the world's population and account for about 10% of the world's imports and exports (Sandalcılar *et al.*, 2022), and they can also be regarded as the leading countries in terms of energy consumption. Six of the top 20 countries in terms of carbon emissions in the world are the N-11 countries (Statista, 2024b). Although the N-11



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countries have been playing a significant role in the global economy, it is clear that their excessive energy consumption causes environmental degradation across the world.

On the other hand, climate change is one of the most important problems experienced throughout the world over the last two decades, and its consequences are becoming threatening to human life. Rising temperatures, droughts, water scarcity, severe fires, melting polar ice, catastrophic storms and declining biodiversity have been results of climate change. The world's temperature is continuing to rise, the number of catastrophes is expected to increase by 40% between 2015 and 2030, and energy-related carbon dioxide emissions increased by 6% in 2021. If current trends continue, the sea level will have increased by 30–60 cm by the year 2,100 (United Nations, 2022). According to the researchers, by 2060, the surface temperature will increase by 1.6 °C under a very low greenhouse gas emission scenario and by 2.4°C under a very high greenhouse gas emission scenario (Statista, 2024b). These forecasts show how the effects of climate change could be dangerous. Moreover, based on the Sustainable Development Goals (SDGs) report 2023, the world's time is running out, and therefore countries have to take various measures on this issue (United Nations, 2023).

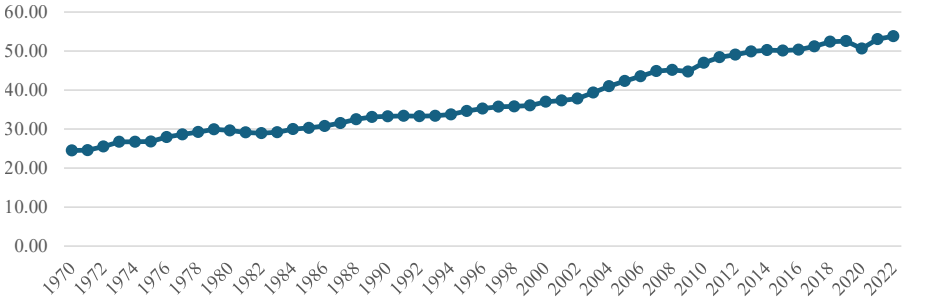
One of the most important factors causing global warming and climate change is the greenhouse gas (GHG) emissions that consist of carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$) and fluorinated gases released by human activities. GHG emissions have caused a rising global temperature of 1.2° C since 1850, and the rising of the temperature to about 1.5° C is regarded as the beginning of irreversible climate change (United Nations, 2024a).

As can be seen in Figure 1, GHG emissions have doubled from 1970 to 2022 globally. In parallel, from 1990 to 2022, $CO_2$ emissions have increased by more than 60%, $CH_4$ emissions by more than 32% and $N_2O$ by more than 30% since 1990 (Statista, 2024b).

The N-11 countries play an important role in the world economy. However, the environmental degradation they cause negatively affects sustainability. This study aims to determine the performance of the N-11 countries in terms of energy use and climate change based on indicators of the SDGs framework for the selected years. The remaining part of this study is arranged as follows: Second part presents the literature review; the following part gives the visualization about some energy and climate change indicators. Fourth part presents the dataset, indicators and the method used. In the following part, results obtained from the analysis are provided, and the last part is dedicated to discussion and conclusion.

## 2. Literature review

There are many studies about the energy consumption of the N-11 countries and its impact on global warming or the environmental degradation that the N-11 countries have caused.




**Note(s):** In billion metric tons of $CO_2$ equivalent
**Source(s):** Statista (2024b)

**Figure 1.**
Annual GHG emissions worldwide from 1970 to 2022

In the N-11 countries, Ampofo *et al.* (2021) examined the cointegration and causative links between energy consumption, carbon emissions and economic growth between 1972 and 2013. They found a causal relationship between carbon emissions and energy consumption in South Korea, Pakistan, Egypt and Bangladesh. In addition to this, unidirectional and bidirectional causal relationships between carbon emissions and energy consumption were identified in Turkiye and in Vietnam, respectively.

Chien (2022) studied the impact of renewable energy on the environmental degradation in N-11 countries based on the method of movement quantile regression. According to the findings, it is founded that renewable energy consumption decreases environmental degradation.

Shao *et al.* (2021) examined the relationship between green technology innovation and renewable energy with $CO_2$ emissions for the period 1980–2018. Findings indicated the negative effect of green technology innovation and renewable energy on $CO_2$ emissions in the long run.

Another study regarding renewable energy was fulfilled by Wang *et al.* (2022a, b). In this study, the moderating effect of financial development on the relationship between renewable energy and $CO_2$ emissions in N-11 countries between 1990 and 2005 was investigated, and the results indicated that the interaction between financial development and renewable energy significantly reduced $CO_2$ emissions. In addition, Xie *et al.* (2023) found that there is a positive and statistically significant influence of renewable energy on the GDP in the N-11 countries. On the other hand, Yang *et al.* (2022) proved that renewable energy consumption increases economic growth in the short term whereas decreases in the long term.

When the N-11 countries are analysed in terms of natural resources, which are considered an important variable in the literature on global warming and climate change, it is seen that natural resources have an increasing effect on environmental degradation (Liu *et al.*, 2023).

Li *et al.* (2023a, b) investigated the effect of green finance and natural resources rents (NRR) on environmental sustainability using panel cointegration tests between 2001 and 2018. The findings indicated that green financing reduces carbon emissions and NRR negatively affects environmental sustainability.

Nathaniel (2021) explored the relationship between human well-being and ecological footprint in the N-11 countries based on econometric analyses between 1990 and 2016. Additionally, biocapasity, financial development, globalization, NRR and urbanisation variables were included in the study. The findings showed that biocapacity and financial development increase the ecological footprint whereas natural resources and globalization decrease ecological footprint. Also, human well-being increases the ecological footprint in all the countries except in Egypt.

Wang *et al.* (2022a, b) examined the nexus between ecological footprint, democracy, environmental regulations, economic growth, renewable energy and globalization in the N-11 countries. In this study conducted from 1990 to 2018, cross-sectional autoregressive distributed lags methods were used. The findings indicated that environmental regulations reduce ecological footprint while economic growth positively affects ecological footprint in these countries. Additionally, this study showed that democratic quality, renewable energy consumption and globalization increase environmental quality.

Sultana *et al.* (2023) studied the relationship between globalization and environmental degradation in selected N-11 countries between 1990 and 2019 using the method of moments quantile regression. The study also examined the impact of the GDP per capita, population growth and renewable energy consumption variables on carbon emissions. According to the findings, globalization deteriorates the environment by increasing $CO_2$ emissions.

As can be seen, in the studies conducted so far on environmental sustainability in N-11 countries, the impact of variables on environmental degradation or the relationships between variables have been examined with various models such as panel autoregressive lag

distributed, quantile regression, fully modified ordinary least squares linear or panel cointegration. Unlike previous studies, this study measures the environmental performance of N-11 countries for selected years over a 12-year period based on multiple criteria decision-making. Moreover, variables that are defined as indicators in multiple criteria decision-making are determined based on SDGs.

## 3. Overview of the N-11 countries

### *3.1 Economic indicators*

The N-11 countries have different income levels. Bangladesh, Egypt, Nigeria, Pakistan, the Philippines and Vietnam are the lower-middle income, while Indonesia Iran, Mexico and Turkiye are the upper-middle-income countries. Only South Korea has the highest income among the countries (World Bank, 2024a). Table 1 presents some economic indicators of the N-11 countries. GDP per capita varies among the countries. While Bangladesh has the lowest value, Korea has the highest value. On the other hand, Vietnam ranks first in terms of foreign direct investment and exports of goods and services.

As can be seen from Table 2, the N-11 countries differ in many ways. Population, land area, population density and NRR values vary across the countries. The population is over 100 m people in 7 of the 11 countries. While the land of Korea is approximately 100,000 square km, Mexico is approximately two million square km. Total natural resources rents (TNRR) value of Iran is quietly different from the other countries. Urbanization varies about between 35 and 82% level. This spread in the values of the countries creates difficulties in making comparisons.

According to the Democracy Index declared by the Economist Intelligence Unit, countries are classified as four groups based on their regime type: full democracy, flawed, hybrid and authoritarian. This classification is made based on five dimensions that are electoral process and pluralism, functioning of government, political participation, political culture and civil liberties. Accordingly, the classification score is obtained between 10 and 0 (Economist Intelligence Unit, 2024). As of 2023, among the N-11 countries, only South Korea is a full democracy, while the Philippines and Indonesia are flawed democracies. Other countries are either in a hybrid regime or in an authoritarian regime as of 2023.

**Table 1.**
Economic indicators of the N-11 countries*

| | GDP growth (annual %) | GDP per capita, PPP (current international $) | Foreign direct investment, net inflows (% of GDP) | Exports of goods and services (% of GDP) |
|---|---|---|---|---|
| Bangladesh | 6.38 | 5282.29 | 0.91 | 15.12 |
| Egypt | 3.94 | 12667.74 | 1.94 | 15.71 |
| Indonesia | 4.73 | 11210.27 | 2.03 | 21.99 |
| Iran | 2.16 | 15819.52 | 0.62 | 23.91 |
| Korea | 2.92 | 40865.94 | 0.82 | 44.94 |
| Mexico | 1.98 | 20084.69 | 2.67 | 35.58 |
| Nigeria | 3.18 | 5358.55 | 0.86 | N.A. |
| Pakistan | 3.54 | 4894.53 | 0.63 | 10.40 |
| The Philippines | 5.24 | 7756.78 | 1.99 | 27.93 |
| Turkiye | 5.85 | 27454.98 | 1.51 | 27.94 |
| Vietnam | 6.02 | 9410.46 | 4.61 | 77.10 |

**Note(s):** *Average values from 2010 to today are stated in Table 1
**Source(s):** World Development Indicators (WDI) database

**Table 2.** N-11 countries based on selected indicators*

| | Population, total | Population density (people per sq. km of land area) | Land area (sq. km) | Total natural resources rents (% of GDP) | Urban population (% of total population) | Regime type | Democracy index score (10–0) |
|---|---|---|---|---|---|---|---|
| Bangladesh | 160,729,345 | 1220.24 | 130,170 | 0.96 | 35.47 | Hybrid | 5.87 |
| Egypt | 100,410,980 | 98.95 | 995,450 | 7.13 | 42.86 | Authoritarian | 2.93 |
| Indonesia | 262,255,828 | 138.32 | 1,878,772 | 4.64 | 54.29 | Flawed | 6.53 |
| Iran | 83,013,054 | 50.45 | 1,626,152 | 23.41 | 74.07 | Authoritarian | 1.96 |
| Korea | 51,057,262 | 522.87 | 97,443 | 0.07 | 81.61 | Full democracy | 8.09 |
| Mexico | 121,482,575 | 61.94 | 1,943,950 | 3.82 | 79.71 | Hybrid | 5.14 |
| Nigeria | 191,608,784 | 204.97 | 910,770 | 9.64 | 49.02 | Hybrid | 4.23 |
| Pakistan | 216,261,444 | 275.80 | 770,880 | 1.67 | 36.41 | Authoritarian | 3.25 |
| The Philippines | 105,899,621 | 349.27 | 298,170 | 1.34 | 46.67 | Flawed | 6.66 |
| Turkiye | 79,678,915 | 102.34 | 769,630 | 0.60 | 74.30 | Hybrid | 4.33 |
| Vietnam | 93,412,089 | 295.38 | 313,359 | 4.57 | 34.89 | Authoritarian | 2.62 |

**Note(s):** *Average values from 2010 to today are stated in Table 2
**Source(s):** World Development Indicators (WDI) database

### 3.2 Energy-related indicators

In parallel with their economic growth, the energy use of the N-11 countries is also increasing. In 2000, energy use per capita was approximately 12,026 (kg of oil equivalent per capita) and reached 15,618 (kg of oil equivalent per capita) in 2014. This situation has also led to an increase in carbon dioxide emissions. As of 2022, the N-11 countries account for about 10% of the world's total energy consumption and about 11% of $CO_2$ emissions (Energy Institute, 2023). As can be seen in Figure 2, $CO_2$ emissions have gradually increased in the last two decades.

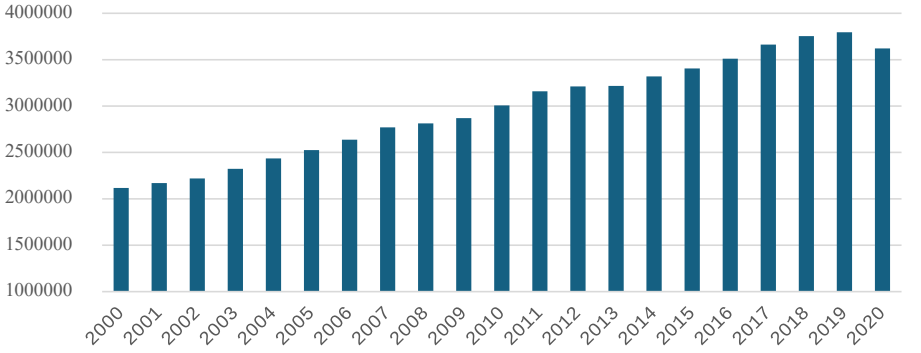
When other energy indicators are examined, it is observed that while the share of fossil fuels in total energy consumption in N-11 countries has increased, the share of renewable energy has decreased. This situation shows that caution should be exercised in the policies pursued in relation to climate change and prevention of global warming. The change in indicators is given in Figure 3.

In the literature, there have been several studies regarding the impact of the TNRR on climate change and environmental degradation. As can be seen in Table 2, this value seems to be very different in some countries. Especially Iran, Nigeria and Egypt have the higher value than the other countries. Accordingly, TNRR and urbanisation positively affect GHG emissions and cause environmental degration (Adams and Klobodu, 2017; Dua and Xiab, 2018; Koirala and Pradhan, 2020; Sánchez and Ortega, 2020; Chien *et al.*, 2023; Alhassan and Kwakwa, 2023). However, TNRR can be a blessing or a curse for countries. The main factors determining whether TNRR will be a blessing or a curse are the level of democracy in the countries and the resilience of their institutions (Ploeg, 2011). Li *et al.* (2023a, b) founded that the existence of resource curses in the N-11 countries and information communication technologies reduce the negative effects of TNRR in these countries.

Regarding TNRR, Figure 4 provides information about the status of the countries between 2010 and 2021. Iran, Nigeria and Egypt have the higher rate among the N-11 countries. Especially, Iran is one of the leading countries that has the highest NRR value in the world. Additionally, NRR values of the countries decreased between 2011 and 2016, but after that time they started to increase. In 2020, this value decreased again due to the COVID-19 pandemic that emerged across the world. Bangladesh, Korea, Turkiye, Pakistan and the Philippines have the lowest value for this indicator.

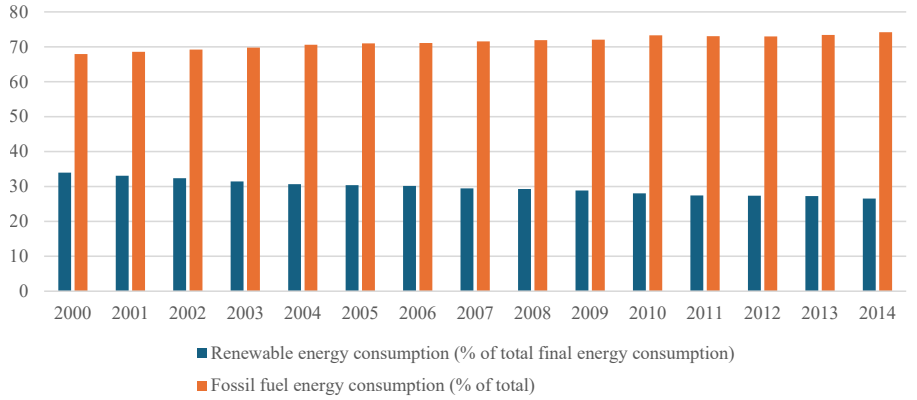
### 3.3 Market capitalisation

The market capitalisation values of the N-11 countries differ considerably. As can be seen in Table 3, Korea has the highest total market capitalisation of the listed companies, and Iran



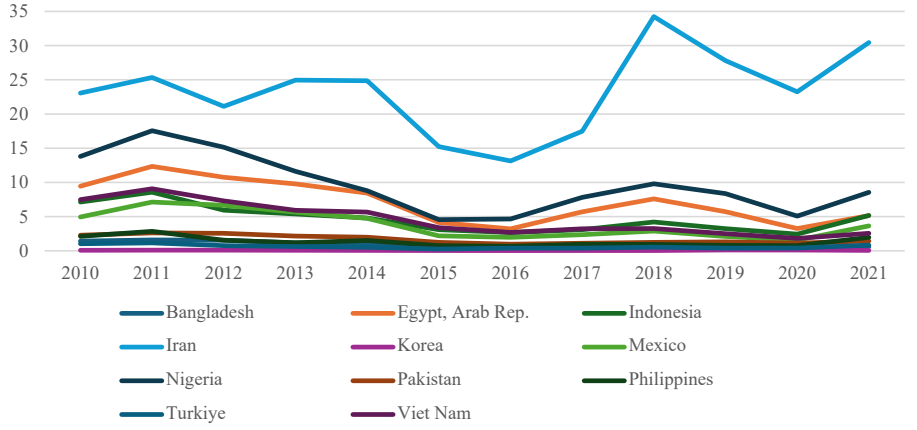

**Source(s):** WDI Database

**Figure 2.**
Total $CO_2$ emissions (kt) of the N-11 countries




**Source(s):** WDI Database

**Figure 3.**
Renewable energy and fossil fuel energy consumption in N-11 countries




**Source(s):** WDI Database

**Figure 4.**
Total natural resource rents (% of GDP) consumption in the N-11 countries

has the second highest value, whereas Pakistan has the lowest value. Korea, also, ranks first in terms of the number of listed companies.

In addition to this, Korea Exchange and Tehran Stock Exchange are placed in the largest stock exchanges across the world based on market capitalisation as of March 2024, and their values are 1.98 and 1.77 tri US dollars, respectively. Korea Exchange accounted for 1.4% total world equity market value (Statista, 2024a).

Among the N-11 countries, especially Korea, Indonesia, the Philippines, Mexico and Turkiye seem to be more attractive as emerging markets for investment (Alonaizi and Gadhoum, 2017).

## 4. Indicators and method used

### *4.1 Indicators*

To conduct performance analysis of the N-11 countries, the dataset used was obtained from the World Development Indicators database released by the World Bank (2024b). The

| Country | Name of the stock exchange | Number of listed companies | Domestic market capitalisation (million US$) |
|---|---|---|---|
| Bangladesh | Chittagong Stock Exchange (CSE) | 628 | 73,380 |
| Bangladesh | Dhaka Stock Exchange | 348 | 57,010 |
| Egypt | Egyptian Exchange | 242 | 35,111 |
| Indonesia | Indonesia Stock Exchange (IDX) | 852 | 604,638 |
| Iran | Iran Fara Bourse Securities Exchange | 148 | 48,495 |
| Iran | Tehran Stock Exchange | 380 | 1,160,181 |
| Korea | Korea Exchange (KRX) | 2,406 | 2,218,658 |
| Mexico | Bolsa Institucional de Valores (BIVA) | 64 | 17,300 |
| Mexico | Bolsa Mexicana de Valores (Mexican Stock Exchange) | 144 | 459,708 |
| Nigeria | Nigerian Exchange (NGX) | 174 | 86,163 |
| Pakistan | Pakistan Stock Exchange | 523 | 24,900 |
| The Philippines | Philippine Stock Exchange | 288 | 259,770 |
| Turkiye | Borsa Istanbul | 505 | 279,303 |
| Vietnam | Hanoi Stock Exchange | 345 | 22,399 |
| Vietnam | Ho Chi Minh Stock Exchange | 404 | 256,395 |

**Source(s):** Sustainable Stok Exchange Initiatives (2024)

**Table 3.** Market capitalisation values of the stock exchanges in N-11 countries

indicators were determined on the basis of the SDGs framework, mainly SDG7 and SDG13, which are considered to be energy use and climate change (United Nations, 2024b). The years 2010, 2015 and 2022 were selected in order to compare the situation before and after 2015, the year in which the SDGs were announced. The data for these years were analysed to gain insight into the performance of the countries and whether there is an improvement regarding climate change. The indicators used are given in Table 4 below.

### *4.2 Method*

It is aimed to minimise some variables and maximise some variables used in performance analysis. One of the multi-criteria decision-making methods can be used to analyse these conflicting variables at the same time. In this study, grey relational analysis (GRA) that is one

| SDGs | Indicators | Abbreviation |
|---|---|---|
| Goal 7. Ensure access to affordable, reliable, sustainable and modern energy for all | Access to clean fuels and technologies for cooking (% of population) | 7.1 |
| | Access to electricity (% of population) | 7.2 |
| | Energy intensity level of primary energy (MJ/$2017 PPP GDP) | 7.3 |
| | Renewable energy consumption (% of total final energy consumption) | 7.4 |
| Goal 13. Take urgent action to combat climate change and its impacts | Methane emissions in energy sector (thousand metric tons of $CO_2$ equivalent) | 13.1 |
| | Nitrous oxide emissions in energy sector (thousand metric tons of $CO_2$ equivalent) | 13.2 |
| | $CO_2$ emissions (metric tons per capita) | 13.3 |

**Source(s):** Author's own work

**Table 4.** Indicators used

of the most used multi criteria decision-making methods in the literature, was used to conduct performance analysis. Grey systems theory forms the basis of GRA. Grey systems theory that was developed by Deng (1982) in the early 1980s assumed that incomplete information or uncertainty is explained by greyness. The successive steps of the GRA are provided below Wu (2002).

Step 1: Collection data and construction of decision matrix

$x_i$ is the alternative, j is the criteria (indicator) and $x_i(j)$ is the value of the alternatives for each criteria

$$x_i = (x_i(1), x_i(2), ..., x_i(j), ..., x_i(n))$$

where $i = 1, 2, ..., m$ and $j = 1, 2, ..., n$

$$X_i = \begin{bmatrix} x_1(1) & x_1(2) & \cdots & x_1(n) \\ x_2(1) & x_2(2) & \cdots & x_2(n) \\ \vdots & \vdots & \ddots & \vdots \\ x_m(1) & x_m(2) & \cdots & x_m(n) \end{bmatrix} \quad (1)$$

The rows indicate alternatives and columns indicate the criteria.

Step 2: Normalisation of the decision matrix

Each $x_i(j)$ is transformed to $x_i^*(j)$ using one of the following formula

$$x_i^*(j) = \frac{x_i(j) - \min\limits_j x_i(j)}{\max\limits_j x_i(j) - \min\limits_j x_i(j)} \text{ if larger} - \text{is} - \text{better} \quad (2)$$

$\min x_i(j)_j$ is the minimum value of criteria j

$\max x_i(j)_j$ is the maximum value of criteria j

$$x_i^*(j) = \frac{\max\limits_j x_i(j) - x_i(j)}{\max\limits_j x_i(j) - \min\limits_j x_i(j)} \text{ if smaller} - \text{is} - \text{better} \quad (3)$$

$$x_i^*(j) = \frac{|x_i(j) - x_{0b}(j)|}{\max\limits_j x_i(j) - x_{0b}(j)} \text{ if nominal} - \text{is} - \text{best} \quad (4)$$

At the same time, the referential series of $x_0$ is normalised by using one of formulas 2, 3 or 4. Thus, $x_0(j)$ is used to replace $x_i(j)$. For example, if a larger is better transformation is used,

$$x_0^* = \frac{x_0(j) - \min\limits_j x_i(j)}{\max\limits_j x_i(j) - \min\limits_j x_i(j)} \quad (5)$$

After the decision matrix is normalised with the appropriate formulas, the following normalised matrix is obtained

$$X_i^* = \begin{bmatrix} x_1^*(1) & x_1^*(2) & \cdots & x_1^*(n) \\ x_2^*(1) & x_2^*(2) & \cdots & x_2^*(n) \\ \vdots & \vdots & \ddots & \vdots \\ x_n^*(1) & x_n^*(2) & \cdots & x_n^*(n) \end{bmatrix} \tag{6}$$

Step 3: Constructing of the absolute values matrix

The absolute value of difference between $x_0^*$ and $x_i^*$ at the $j^{th}$ point is denoted by $\Delta_{0i}(j)$ and this value is calculated as follows:

$$\Delta_{0i}(j) = \left| x_0^*(j) - x_i^*(j) \right| \tag{7}$$

$$\Delta_{0i}(j) = \begin{bmatrix} \Delta_{01}(1) & \Delta_{01}(2) & \cdots & \Delta_{01}(n) \\ \Delta_{02}(1) & \Delta_{02}(2) & \cdots & \Delta_{02}(n) \\ \vdots & \vdots & \ddots & \vdots \\ \Delta_{0m}(1) & \Delta_{0m}(2) & \cdots & \Delta_{0m}(n) \end{bmatrix} \tag{8}$$

Step 4: Calculation of the grey relational coefficients ($\gamma_{0i}(j)$)

$$\gamma_{0i}(j) = \frac{\Delta_{\min} + \zeta \Delta_{\max}}{\Delta_{0i}(j) + \zeta \Delta_{\max}} \tag{9}$$

where $\Delta_{\max} = \max_i \max_j \Delta_{0i}(j)$, $\Delta_{\min} = \min_i \min_j \Delta_{0i}(j)$, $\zeta \in [0, 1]$

Step 5: Calculation of the grey relational grade (grey relational grade takes value between 0 and 1)

If the weights of criteria are determined,

$$\Gamma_{0i} = \sum_{j=1}^{n} [W_i(j) \times \gamma_{0i}(j)] \; i = 1, 2, ..., m \tag{10}$$

At the end of the process, the alternative with the highest grey relational grade is considered the most similar to the reference country and it is determined as the best alternative.

In the last step of GRA, a weight is needed for each indicator to calculate the grey relational grade. These weights can either be determined as equal for all indicators or the entropy method can be used. The entropy method is employed to guarantee objectivity while deciding on the weights of the indicators. This method can be defined as a measure of observational variety and is also thought to be a nonparametric measure of diversity (Krippendorff, 1986).

Entropy method has four steps consecutively and these are as follows:

Step 1. Collection data and construction of decision matrix

Step 2. Normalisation of the decision matrix

Step 3. Determination of the entropies for each indicator

Step 4. Calculation of entropy weights

The higher value of the weight means that this indicator is more important than the others for the solution.

## 5. Results

After calculating the weights of the indicators for each year, the average value was calculated; thus, performance scores of the years would be compared using the average value of the weight.

The values determined based on the entropy method are given in the following table.

According to the entropy method, the renewable energy consumption indicator has the highest value; therefore, it is regarded as the most important indicator in determining performance score. $CO_2$ emissions and methane emissions in energy sector indicators are found to be almost equal and both have the second highest value, while access to electricity indicator has the lowest value. In addition to the weights obtained from the entropy method, equal weight values of the indicators are given in Table 5.

Based on the weights obtained from entropy method, performance scores of the countries calculated are given in Table 6.

According to the results obtained, it has been found that Bangladesh, the Philippines and Egypt have the three highest scores, while Mexico, Indonesia and Iran have the three lowest scores. In 2022, Nigeria is placed instead of Mexico in this group. It is observed that the performance scores of countries have either remained the same or increased slightly over the years. The largest increase between 2010 and 2022 has been observed in Mexico and Indonesia. Although the performance scores of the countries have changed in the same period, the change in Turkiye's performance score has remained almost at the same level. Average scores of the N-11 countries are 06,470, 06,595 and 06,672, respectively, and it has improved only by 3% between 2010 and 2022.

When the GRA is repeated with the equal weights for the year 2022, it is seen that the scores generally increase, and the rankings change by one or two places. Performance scores of the countries calculated based on the equal weights are stated in Table 7.

In addition to the performance analysis, whether there is a relationship between the performance scores of the countries and the total market capitalisation of the listed companies was investigated using the Spearman correlation coefficient in the last step of the research. However, the existence of such a relationship was not found.

## 6. Discussion and conclusion

Among the SDGs announced by the United Nations in 2015, the SDG7 and SDG13 cover the targets to be achieved by 2030 regarding global warming and climate change that is one of the most important environmental problems experienced in the world. The doubling of

| | Indicators | | | | | | |
|---|---|---|---|---|---|---|---|
| Years | 7.1 | 7.2 | 7.3 | 7.4 | 13.1 | 13.2 | 13.3 |
| 2010 | 0.1288 | 0.0807 | 0.0885 | 0.2028 | 0.1953 | 0.1135 | 0.1905 |
| 2015 | 0.1267 | 0.0790 | 0.0931 | 0.2010 | 0.2031 | 0.1062 | 0.1908 |
| 2022 | 0.1077 | 0.0755 | 0.1040 | 0.1961 | 0.2000 | 0.1179 | 0.1988 |
| *Average* | *0.1211* | *0.0784* | *0.0952* | *0.2000* | *0.1994* | *0.1126* | *0.1934* |
| *Equal weight* | *0.1429* | *0.1429* | *0.1429* | *0.1429* | *0.1429* | *0.1429* | *0.1429* |

**Source(s):** Author's own work

**Table 5.** Results of the entropy method

| | 2010 | | 2015 | | 2022 | | |
|---|---|---|---|---|---|---|---|
| | Score | Rank | Score | Rank | Score | Rank | Change % (2010–2022) |
| Bangladesh | 0.7563 | 1 | 0.7567 | 1 | 0.7811 | 1 | 0.0328 |
| Egypt, Arab Rep | 0.7199 | 3 | 0.7278 | 3 | 0.7422 | 3 | 0.0311 |
| Indonesia | 0.5375 | 10 | 0.5666 | 10 | 0.5729 | 10 | *0.0660* |
| Iran, Islamic Rep | 0.5040 | 11 | 0.5052 | 11 | 0.5111 | 11 | 0.0141 |
| Korea, Rep | 0.6223 | 7 | 0.6285 | 7 | 0.6400 | 7 | 0.0284 |
| Mexico | 0.5832 | 9 | 0.5992 | 9 | 0.6356 | 8 | *0.0899* |
| Nigeria | 0.6042 | 8 | 0.6171 | 8 | 0.6133 | 9 | 0.0152 |
| Pakistan | 0.6622 | 6 | 0.6732 | 6 | 0.6843 | 6 | 0.0334 |
| The Philippines | 0.7431 | 2 | 0.7445 | 2 | 0.7542 | 2 | 0.0150 |
| Turkiye | 0.7118 | 4 | 0.7245 | 4 | 0.7086 | 4 | *−0.0045* |
| Vietnam | 0.6725 | 5 | 0.7118 | 5 | 0.6963 | 5 | 0.0353 |
| N-11 (Average) | *0.6470* | | *0.6595* | | *0.6672* | | *0.0313* |

**Source(s):** Author's own work

**Table 6.** GRA scores of the N-11 countries

| Year 2022 | Scores based on entropy | Rank | Scores based on equal weighting | Rank |
|---|---|---|---|---|
| Bangladesh | 0.7811 | 1 | 0.7935 | 1 |
| Egypt, Arab Rep | 0.7422 | 3 | 0.7899 | 2 |
| Indonesia | 0.5729 | 10 | 0.6075 | 9 |
| Iran, Islamic Rep | 0.5111 | 11 | 0.5685 | 10 |
| Korea, Rep | 0.6400 | 7 | 0.6736 | 6 |
| Mexico | 0.6356 | 8 | 0.6734 | 7 |
| Nigeria | 0.6133 | 9 | 0.5446 | 11 |
| Pakistan | 0.6843 | 6 | 0.6715 | 8 |
| The Philippines | 0.7542 | 2 | 0.7567 | 3 |
| Turkiye | 0.7086 | 4 | 0.7534 | 4 |
| Vietnam | 0.6963 | 5 | 0.7269 | 5 |
| *Average* | *0.6672* | | *0.6872* | |

**Source(s):** Author's own work

**Table 7.** Comparison of the GRA scores based on two different weighting approach

greenhouse gas emissions over the last 50 years explains the reason for the rising temperature. The destructive consequences of this situation are emerging day by day. Almost 113 m hectares of tree cover were lost to wildfires across the world from 2001 to 2023, and 1 bn 715 m people were affected by drought worldwide from 1990 to 2023. According to the projections, sea level is expected to rise by 38 or 77 centimetres based on the very low and very high GHG emissions scenarios (Statista, 2024b). Today, it is well-known that GHG emissions have been revealed by economic growth and human activities.

On the other hand, the N-11 countries are the important emerging markets in the world and have the higher economic growth rate than the other countries, but this rapid economic growth steadily degrades environmental conditions due to excessive energy consumption. From this point of view, it is quite necessary today to measure the performance of the N-11 countries with respect to climate change and energy use as an output of the policies they follow regarding environmental sustainability. This study investigates the performance of the N-11 countries for the selected years. Thus, the tendencies of the countries on the subject are revealed.

When previous studies are examined, it is seen that advanced statistical analyses or econometric models are used to determine the environmental sustainability of N-11

countries, the variables affecting environmental degradation or the relationships between variables.

In our knowledge, this study is the first attempt to measure the performance of N-11 countries on climate change and energy use using multi-criteria decision-making, and it differs from the other studies with respect to indicators and method used. Indicators were determined based on SDG7 and SDG13 instead of the variables used in previous studies. However, the variables for GHG and renewable energy consumption are common. To conduct performance analysis of the N-11 countries, GRA was used, and the weights required for the analysis were determined by the entropy method to ensure objectivity.

According to the results obtained by the entropy method, renewable energy consumption is found to be the most important indicator in determining performance score. $CO_2$ emissions and methane emissions indicators are almost equal and seem to be second-important indicators. Regarding performance scores, the countries with the three highest scores are Bangladesh, the Philippines and Egypt, respectively, while Nigeria, Indonesia and Iran have the three lowest scores. During the analysis period, the countries with the highest increase in performance score were Mexico and Indonesia, followed by Bangladesh, Egypt, Pakistan and Vietnam. The countries with the least change in performance score were Iran, the Philippines and Nigeria and Turkiye's score remains the same. Another important finding is that the ranking has not changed in the course of years. The fact that the performance scores of the countries remain the same or change very little over time shows that the countries do not make sufficient efforts on this issue. When the GRA is repeated with the equal weighting approach for all indicators, it has been seen that the performance scores increased, but there is no important change in rankings.

If the common characteristics of the three countries with the highest scores are examined, it is seen that they are at lower middle income level, GDP per capita value is lower than other countries, TNRR value is not high except for Egypt and urbanisation rate is below 50%. On the contrary, when the common characteristics of the 3 countries with the lowest performance score are examined, it is realized that they are at the upper middle income level except Nigeria, the TNRR value is higher than other countries and the urbanisation rate is almost 50% and above. According to the findings in the literature, GDP level, urbanisation rate and TNRR negatively affect environmental sustainability. Regarding the N-11 countries, although the findings obtained in this study support the literature, no conclusive evidence has been obtained.

Since N-11 countries are emerging markets, they offer attractive opportunities for investors. Therefore, after the performance analysis, the Spearman correlation coefficient was used to investigate whether there is a relationship between the performance score of the countries and the total market value of the companies traded on the stock exchange. As a result, no statistically significant relationship was found.

South Korea is the most remarkable country among the N −11 countries. It is unique or ranks first in terms of some indicators. Korea is the only country in the group with high income levels and full democracy. In addition, it has the highest GDP per capita and urbanisation level. It also ranks first in terms of total market capitalisation of listed companies. Despite all these characteristics, the performance score is not high level and Korea is ranked seventh. The main reason for this situation is that Korea is not in the first place in indicators with higher weights, such as renewable energy use and $CO_2$ emissions.

Another country to be focused on is Iran as it has the lowest score among the N-11 countries. Iran is an authoritarian regime with a very low score in the democracy index. Its urbanisation rate is at a higher level compared to other countries. It is also one of the countries with the highest TNRR rate in the world. Accordingly, $CO_2$ emissions are the highest among the N-11 countries. Moreover, it is one of the three countries in the world that

did not sign the Paris Climate Agreement. However, Iran ranks the second in terms of total market capitalisation of the listed companies among the N-11 countries.

Various indices have been developed throughout the world to monitor and evaluate the performance of the countries in terms of environmental sustainability. The Climate Change Performance Index (CCPI), one of these indices, is released every year and it includes 63 countries as of 2023. GHG emissions, renewable energy, energy use and climate policy are the four sub-categories that make up the CCPI. Each country's overall score is determined using the information in these categories, and the results are used to rank the countries. Furthermore, based on the degree of the scores, the countries are split into five groups: very high, high, medium, low and very low (Burck *et al.*, 2023). According to the CCPI 2023, the Philippines receives a high while Nigeria, Pakistan Egypt and Vietnam earn a medium. Indonesia and Mexico are at the low whereas Turkiye, South Korea and Iran perform very low. Bangladesh is not included in the index. Despite the ranks changing from year to year, Iran and Korea are placed in the group called "very low" of this index continuously from 2018 to today. Also, according to the same index among N-11 countries, Mexico, Nigeria, Indonesia and Iran are the biggest producers of oil, gas and coal across the world. Considering that these countries have high values in terms of the NRR indicator, the reason for their low performance scores obtained in GRA can be explained.

This study has some limitations. When different multi-criteria decision-making methods and different weighting methods are applied or different indicators are used, it is clear that different rankings might be obtained.

As a further research, a comparison can be made by using other methods within the scope of multi-criteria decision-making by using a larger number of indicators for more countries.

It is very important that the N-11 countries, which are considered emerging markets and have an important place in world trade, should take measures to reduce the environmental degradation they cause. Especially, the countries having the lowest performance scores should review their climate change policies, and not only these countries but also all should implement preventative measures in order to meet the SDG targets by 2030. However, it would be optimistic to expect that N-11 countries, which have improved by only 3% in 12 years, will make a breakthrough by 2030.

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