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# Evaluationof Global Goals Promoting Sustainability: A Study of Selected Sixty-Eight Countries

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**Abstract-** The purpose of this study is to evaluate the performance of countries atpromoting sustainability.The study follows a positivist approach with data from World Development Indicators (WDI).Grey system theory is employed to calculate the level of performance of 68 countries.The performance ofcountries is classified into seven levels: *exceptionally high, excellent, above average, average, below average, poor* and *very poor.* Results show that member countries of the Organization for Economic Cooperation and Development (OECD)have *exceptionally high*performance,whereas, Arabian Countries (AC) have*very poor*performance. This research study investigatesthe important issue of global goals on sustainability using an original data set that provides value able new insight.It is useful for the international community, political governments,policymakers, researchers and international institutions.

**Key Words: Global goals, GRA, Grey system theory, Pakistan, sustainability, SDGs.**

## I. INTRODUCTION

Global goals promoting sustainability are aimed to "end poverty, protect the planet, and ensure prosperity for all" (United Nations, 2018a), therefore, countries are expected to deliverbest on the goals. The roots of the concept of sustainability can be traced back to the early 1700 A. D. in literal writings of German researchers however in recent times it was first used in the Brundtland Report of 1987(Kuhlman & Farrington 2010). A wide array of definitions of sustainability can be found inliterature like: 'sustainability means endurance', 'Sustainability is the ability to exist constantly', 'Sustainability focuses on meeting the needs of the present without compromising the ability of future generations to meet their needs' etc. but this study follows the definition as given by WDI (2020). There are numerous methods used in literature to evaluate the progress of countries on global goals on sustainability viz graphical feedback loops (Cernev and Fenner, 2020),qualitative content analysis (Ordonez-Ponce and Khare, 2021),semantic network(García, et al. 2020)statistical methods (e.g. Kolmogorov–Smirnov test, other non-parametric tests and Bonferroni test &Kruskal-Wallis test) and data visualizations (Yang, 2020). However, there is a lack of systematic methods for quantitative assessment of the progress of achieving SDGs at country and regional levels (Huan, et al. 2021).It happens to be a well-investigated area for an instance:Cerf (2019) uncovered multiple complex challenges and revealed that environment-health-economic nexus if aligned effectively are the major determinants of successful implementation of Sustainable Development Goals (SDGs). Dalampira and Nastis (2020) emphasized the need to change the description of SDGs to measure three pillars (i.e. seventeen goals, one hundred sixty-nine targets, three hundred thirty indicators) of multidirectional sustainable goals.Hickel (2019) proclaimed the change in SDGs target and suggested the improvement in human development objectives by reducing inequality within and between the nations to achieve SDGs. Valencia et al. (2020) gathered data from seven cities of four continents (Gothenburg & Malmo-Sweden, Buenos Aires-Argentina, Kisumu-Kenya, Sheffield-UK, Shimla-India and Cape Town-South Africa) and documented five aspects (integrated governance, indicators, urban boundary delimitation, trade-offs & synergies) and actors that need to be considered to embark on agenda of SDGs at city levels. Van Zanten and van Tulder (2020) claimed that service activities predominantly have positive but industrial, agricultural and manufacturing activities harm SDGs.The problem under study is the evaluation of countries performance to embark on the regime of sustainability. For measurements of sustainable development goals, it is inevitable to compare different possible outcomes with certain standards (Kuhlman & Farrington 2010). Grey systems theory is the most appropriate to address the issue. The contribution of the study is to evaluate the performance of

countries on global goals on sustainability which envisages on sixty-eight countries and ten variables on which the data is available on the website of WDI (2020). The agenda of research on sustainability is hot and current because sustainability is considered vital for securing a safe future. The question of sustainability is intimately but directly concerned with the continuation of civilization. There is a lot of research work done on sustainability and global goals are also determined but the clarity could not be struck. It has become fundamentally important, therefore, understanding and implementation of sustainability demands rather clear and deeper insight that could only be provided through determining dimensions of the phenomenon via evolving new variety of research methodologies. Objectives of the study include i) to analyze the country level position of selected sixty-eight countries as against global goals on sustainability, ii) to rank them on basis of Grey Rational Grades and iii) to classify them to discuss the position of economic bloc wise performance to form some informed opinion.An array of methodological choiceswas considered to achieve the objectives and found Grey Relational Analysis to be the most appropriate methodology. Grey Relational Analysis is an integral part of Grey Systems Theory having the capability of investigating a multitude of alternatives based on multiple criteria instantaneously. The paper is arranged as follows: *Section 2* - literature survey, *Section 3* -methodology, *Section 4* -analysis/results/discussion and*Section 5* -concluding remarks.

## II. LITERATURE SURVEY

Avalanche of published research is evident across the globe in the area of promoting Sustainable Development Goals (SDGs). It is hot and important research worth topic fundamentals of its importance have been iterated by (Cernev&Fenner 2020). United Nations (2015a), Zhang, et al. (2016), ESCAP (2017), United Nations (2018b). Stafford-Smith et al. (2016) have also highlighted the importance of global goals promoting sustainability and the inter-relationships and dependencies between various goals.The contemporary literature is rich on this topicincluding but not limited to: environmental governance and sustainable development in Bangladesh (Ahmed, 2019), advancing SDGs in leading European banks and institutions (Avrampou et al., 2019; Holden, 2019), role of academic libraries of Ghana in promoting SDGs (Atta-Obeng&Dadzie, 2020), pig production and its impact on SDGs in China (Bai et al., 2019), compact city planning and development in Sweden for attaining SDGs (Bibri et al., 2019), SDGs localization in tourism sector of South Africa (Dube&Nhamo, 2020), establishing a baseline model to evaluate the UN-SDGs in Australian building sector (Illankoon et al., 2020), Indian corporate approaches toward SDGs (Jha&Rangarajan (2020), localization of SDGs within UK (Jones & Comfort, 2020), economy and social role in localizing SDGs in South Korea (Lee, 2020), Brazilian food policy and SDGs (Ribeiro et al., 2020), development of geoparks in Caribbean and Latin America by UNESCO and their contribution in attainment of UN-SDGs agenda 2030 (Rosado-González et al., 2020), foreign ownership and its impact on corporate sustainability disclosure in Pakistan (Rustam et al., 2019), tourism governance and accomplishment of SDGs in Africa (Siakwah et al., 2020), role of international trade in attainment of SDGs in Thailand (Sudsawasd et al., 2020). A lot of research has surpassed on the issues of the role of gender & migration (Gammage&Stevanovic, 2019; Hennebry et al., 2019; Holliday et al., 2019) and nursing particularly during the COVID-19 pandemic (Osingada& Porta, 2020; Tremblay et al., 2020; Upvall&Luzincourt, 2019). A systematic review of literature has been done on SDGs (Mio et al., 2020). Martí-Ballester (2020) analyzed the pension funds' financial performance of different sectors (including technology and energy) relevant to sustainable development goals.Poddar et al. (2019) buttressed that companies that are more inclined/taking initiative to have a higher environmental footprint and/or having high corporate social responsibility are more aligned with SDGs. Tsalis et al. (2020) proposed a methodological framework for assessing the firms' level of alignment of corporate sustainability practices with the UN-SDGs (United Nations' 2030 Agenda and its 17 Sustainable Development Goals).

***Theoretical Framework:*** Theory provides an understanding of the phenomenon and theoretical framework fixes limits of the research. United Nations has listed the key seventeen SDGs namely: no poverty, zero hunger, good health and well-being, quality education, gender equality, clean water and sanitation, affordable and clean energy, decent work and economic growth, industry, innovation and infrastructure, reduced inequality, sustainable cities and communities, responsible consumption and production, climate action, life below water, life on land, peace and justice strong institutions and partnerships to achieve the goal (United Nations 2021).In addition to the specification of theoretical by United Nations, World Bank Group on its website WDI 2020 also has provided the framework of global goals on sustainability along with observationlevel metadata. This study follows the schema of WDI 2020 with minor adjustments based on the availability of complete data on variables that have been adopted.Theoretical foundations of research, however, are also espousedin the existing literature.

Halisçelik and Soytas (2019) examined the success levels of Millennium Development Goals (MDGs) of 187 countries to classify their achievement. MDGs index provides a method for comparing countries' performance level over the period.Moya-Clemente et al. (2020) argued that protecting terrestrial ecosystems and their sustainable usage hasa significant positive effect on affordable and ecological clean water that promote sustainable entrepreneurship development goals. Durugbo and AmankwahAmoah (2019) affirmed that multinational companies craft policies to address the concern of pollution and renewable sources of energy. McElwee et al. (2020) carried a study to investigate the impact of interventions in agro-food sectors and global land on Nature's Contribution to People (NCP) and UN-SDGs. It found that bioenergy carbon capture & storage has a significant negative impact on both NCP and SDG. Hinz et al. (2020) stated that agricultural lands are needed to be intensified to preserve the fertility of the land. to meet the food requirement that results in biodiversity losses and.Lorenz et al. (2019) bolstered that decrease in soil organic carbon has a positive impact on the mitigation of land and soil degradation that achieves SDGs.Singh et al. (2019) identified the impact of climate change on the marine ecosystem and stress that timely action is the need of the day to mitigate this impact to achieve SDGs. Bouma (2019) asserted that the internet and social media has raised the awareness of information and knowledge sharing that is very much aligned with achieving SDGs. Ordonez-Ponce and Khare (2021) concluded that emissions and energy have major concerns with SDGs.Thus in the context of the current problem this study evaluates the alternativesbased onten different criteriaindicating achievements on global goals leading to sustainability.

## III. METHODOLOGY

The study follows positivism as research philosophy, deduction as a research approach, archival research as a strategy, mono method of analysis espoused in grey systems theory as methodological choice usinga cross-sectional type of secondary data.There are five parts of grey system theory i.e. grey prediction, grey relational analysis, grey decision, grey programming and grey control (Julong, 1989; Wei, 2011). This study uses grey relational analysis which is a mathematical approach having the capability of using limited data and comparing it with reference series. It transforms the data set of different scales of measurement into a standardized form of 0 to 1 (Lin, Lin &Ko, 2002). It interplays with differences of comparable sequences with reference sequences and calculates hierarchical grades for each alternative(Wei, 2010; Kung & Wen, 2007). The data set for the investigation has been extracted from the website of World Development Indicators (WDI, 2020). Sixty-eight countries have been included in the analysis. Selection of countries has been made based onthe availability of data on variables. The variables have been adopted from WDI. The classical procedure of GRA has been applied to secondary data for analysis(Hamzacebi et al., 2011; Kuo et al., 2008; Tayyar et al., 2014; Wu, 2002; Zhang et al., 2011). However, analysis has been augmented with the classificationof the countries and to interpret the results in a more effective and informed manner (Qazi et al., 2020). A shaded graph has also been added to visually present the results of GRA.

***Grey Relational Analysis:*** Usingthe same notations and procedure as used byErtuğrul, et al. (2016)andQazi et al. (2020) GRA proceeds as follows,whereas,the variable specification has been adopted from WDI (2020). Origin, quality, and characteristics of the dataset used are also specified by WDI (2020). The description, unit of measurement and acceptability characteristic are appended therefrom in Table 1.

**Table 1:** Descriptions of Variables

| Code | Variable of Achieving Sustainability Goals | Measure | Criteria |
|---|---|---|---|
| **1** | People using safely managed drinking water services | % of population | Larger is the best |
| **2** | Access to electricity | % of population | Larger is the best |
| **3** | Renewable energy consumption | % of total final energy consumption | Larger is the best |
| **4** | Expenditures for R&D | % of GDP | Larger is the best |
| **5** | Ambient PM 2.5 air pollution | micrograms per cubic meter | Smaller is the best |
| **6** | Adjusted net savings | % of GNI | Larger is the best |
| **7** | Carbon dioxide emissions | metric tons | Smaller is the best |

| | | | |
|---|---|---|---|
| **8** | Nationally protected terrestrial and marine areas | % of total territorial area | Larger is the best |
| **9** | Combined source estimates | per 100,000 people | Larger is the best |
| **10** | Individuals using the Internet | % of population | Larger is the best |

Out of the ten criteria two (i.e. ambient PM 2.5 air pollution and carbon dioxide emissions) possess the characteristic *"smaller the best acceptable"*, whereas the other eightcriteria possess the characteristic "*larger the best acceptable*".

***Step 1:***An extracted data set and established decision matrix.

$$x_i(k) = \begin{bmatrix} x_1(1)x_1(2) & \cdots & x_1(m) \\ \vdots & \ddots & \vdots \\ x_n(1)x_n(2) & \cdots & x_n(m) \end{bmatrix} Eq.\ (1)$$

**Table 2:**Country Level Dataset on Global Goals Promoting Sustainability

| Sr. | Country | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** | Armenia | 86.5 | 100 | 15.8 | 0.3 | 32.2 | 1.5 | 1.9 | 23.1 | 2.6 | 65 |
| **2** | Austria | 98.9 | 100 | 34.4 | 3 | 12.6 | 14.1 | 6.9 | 28.4 | 0.5 | 88 |
| **…** | ……. | … | … | … | … | … | … | … | … | … | … |
| **…** | ……. | … | … | … | … | … | … | … | … | … | … |
| **48** | Pakistan | 35.3 | 71 | 46.5 | 0.2 | 58.6 | 12.7 | 0.9 | 9.8 | 5 | 16 |
| **49** | Paraguay | 63.9 | 99 | 61.7 | 0.1 | 11.6 | 14.5 | 0.9 | 14.3 | 9.3 | 61 |
| **…** | ……. | … | … | … | … | … | … | … | … | … | … |
| **…** | ……. | … | … | … | … | … | … | … | … | … | … |
| **67** | United Kingdom | 100 | 100 | 8.7 | 1.7 | 10.5 | 5.5 | 6.5 | 28.8 | 1 | 95 |
| **68** | United States | 99 | 100 | 8.7 | 2.7 | 7.4 | 6.1 | 16.5 | 26.3 | 5 | 87 |

Source of Data: (World Development Indicators (WDI), 2020)

***Step 2:*** Created reference series and comparison matrix.

$$x_0 = [x_0(k) \dots \dots \dots \dots \dots x_0(n)] \qquad Eq.\ (2)$$

**Table 3:** Reference Sequence and Comparable Sequences

| Sr. | Country | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **0** | Reference Sequence | 100 | 100 | 89.1 | 4.3 | 5.9 | 36.8 | 0.1 | 55.1 | 29.4 | 100 |
| **1** | Armenia | 86.5 | 100 | 15.8 | 0.3 | 32.2 | 1.5 | 1.9 | 23.1 | 2.6 | 65 |
| **2** | Austria | 98.9 | 100 | 34.4 | 3 | 12.6 | 14.1 | 6.9 | 28.4 | 0.5 | 88 |
| **…** | ……. | … | … | … | … | … | … | … | … | … | … |
| **…** | ……. | … | … | … | … | … | … | … | … | … | … |
| **48** | Pakistan | 35.3 | 71 | 46.5 | 0.2 | 58.6 | 12.7 | 0.9 | 9.8 | 5 | 16 |
| **49** | Paraguay | 63.9 | 99 | 61.7 | 0.1 | 11.6 | 14.5 | 0.9 | 14.3 | 9.3 | 61 |
| **…** | ……. | … | … | … | … | … | … | … | … | … | … |
| **…** | ……. | … | … | … | … | … | … | … | … | … | … |
| **67** | United Kingdom | 100 | 100 | 8.7 | 1.7 | 10.5 | 5.5 | 6.5 | 28.8 | 1 | 95 |
| **68** | United States | 99 | 100 | 8.7 | 2.7 | 7.4 | 6.1 | 16.5 | 26.3 | 5 | 87 |

***Step 3:*** Created a normalized matrix using the following formulas:

For normalization of the variables having characteristic*larger the best*

$$x_i^*(k) = \frac{x_i^{(0)}(k) - min\ x_i^{(0)}(k)}{max\ x_i^{(o)}(k) - min\ x_i^{(o)}(k)} Eq.\ (3)$$

Fornormalization of the variables having characteristic*smaller the best*

$$x_i(k) = \frac{max\ x_i^{(o)}(k) - x_i^{(0)}(k)}{max\ x_i^{(0)}(k) - min\ x_i^{(0)}(k)} Eq.\ (4)$$

**Table 4:** Normalized Comparable Sequences

| Sr. | Country | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **0** | Reference Sequence | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| **1** | Armenia | 0.8547 | 1.0000 | 0.1773 | 0.0698 | 0.6804 | 0.2661 | 0.9589 | 0.4085 | 0.0790 | 0.5833 |
| **2** | Austria | 0.9882 | 1.0000 | 0.3861 | 0.6977 | 0.9186 | 0.5281 | 0.8447 | 0.5065 | 0.0069 | 0.8571 |
| **…** | ……. | … | … | … | … | … | … | … | … | … | … |
| **…** | ……. | … | … | … | … | … | … | … | … | … | … |
| **48** | Pakistan | 0.3036 | 0.6282 | 0.5219 | 0.0465 | 0.3597 | 0.4990 | 0.9817 | 0.1627 | 0.1615 | 0.0000 |
| **49** | Paraguay | 0.6114 | 0.9872 | 0.6925 | 0.0233 | 0.9307 | 0.5364 | 0.9817 | 0.2458 | 0.3093 | 0.5357 |
| **…** | ……. | … | … | … | … | … | … | … | … | … | … |
| **…** | ……. | … | … | … | … | … | … | … | … | … | … |
| **67** | United Kingdom | 1.0000 | 1.0000 | 0.0976 | 0.3953 | 0.9441 | 0.3493 | 0.8539 | 0.5139 | 0.0241 | 0.9405 |
| **68** | United States | 0.9892 | 1.0000 | 0.0976 | 0.6279 | 0.9818 | 0.3617 | 0.6256 | 0.4677 | 0.1615 | 0.8452 |

For example, calculation of cell America; People using safely managed drinking water services.

$$x_1^*(1) = \frac{x_1^0(1) - min\ x_1^0(1)}{max\ x_1^0(1) - min\, x_1^o(1)} = \frac{86.5 - 7.10}{100 - 7.10} = 0.8547$$

***Step 4:*** Obtained absolute values by calculating deviation sequence.

$\Delta_0(\gamma) = |x_0(\gamma) - x_1(\gamma)| Eq.(5)$

**Table 5:** Deviation Sequences

| Sr. | Country | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **0** | Reference Sequence | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| **1** | Armenia | 0.1453 | 0.0000 | 0.8227 | 0.9302 | 0.3196 | 0.7339 | 0.0411 | 0.5915 | 0.9210 | 0.4167 |
| **2** | Austria | 0.0118 | 0.0000 | 0.6139 | 0.3023 | 0.0814 | 0.4719 | 0.1553 | 0.4935 | 0.9931 | 0.1429 |
| **…** | ……. | … | … | … | … | … | … | … | … | … | … |
| **…** | ……. | … | … | … | … | … | … | … | … | … | … |
| **48** | Pakistan | 0.6964 | 0.3718 | 0.4781 | 0.9535 | 0.6403 | 0.5010 | 0.0183 | 0.8373 | 0.8385 | 1.0000 |
| **49** | Paraguay | 0.3886 | 0.0128 | 0.3075 | 0.9767 | 0.0693 | 0.4636 | 0.0183 | 0.7542 | 0.6907 | 0.4643 |
| **…** | ……. | … | … | … | … | … | … | … | … | … | … |
| **…** | ……. | … | … | … | … | … | … | … | … | … | … |
| **67** | United Kingdom | 0.0000 | 0.0000 | 0.9024 | 0.6047 | 0.0559 | 0.6507 | 0.1461 | 0.4861 | 0.9759 | 0.0595 |
| **68** | United States | 0.0108 | 0.0000 | 0.9024 | 0.3721 | 0.0182 | 0.6383 | 0.3744 | 0.5323 | 0.8385 | 0.1548 |

For example, calculation of deviation for "People using safely managed drinking water services" (1) To Armenia is calculated as follows

$$\triangle_{01}(1) = |x_0^*(1) - x_1^*(1)| = |1 - 0.8547| = 0.1453$$

***Step 5:***Calculated grey relational co-efficient based on values of the normalized sequence. Term $\xi$is distinguishing co-efficient between 0 and 1 the usual value of which is 0.5 in literature.

$\gamma[x_0^*(k), x_i^*(k)] = \frac{\Delta_{min} + \xi \Delta_{max}}{x_{0i}(k) + \xi \Delta_{max}}$ , $0 < \gamma[x_o^*(k), x_i^*(k)] \leq 1 Eq.\ (6)$

**Table 6:** Grey Relational Co-efficient

| Sr. | Country | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **0** | Reference | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sequence | | | | | | | | | | |
| **1** | Armenia | 0.7748 | 1.0000 | 0.3780 | 0.3496 | 0.6101 | 0.4052 | 0.9241 | 0.4581 | 0.3519 | 0.5455 |
| **2** | Austria | 0.9769 | 1.0000 | 0.4489 | 0.6232 | 0.8600 | 0.5144 | 0.7631 | 0.5033 | 0.3349 | 0.7778 |
| **…** | **……** | **…** | **…** | **…** | **…** | **…** | **…** | **…** | **…** | **…** | **…** |
| **…** | **……** | **…** | **…** | **…** | **…** | **…** | **…** | **…** | **…** | **…** | **…** |
| **48** | Pakistan | 0.4179 | 0.5735 | 0.5112 | 0.3440 | 0.4385 | 0.4995 | 0.9648 | 0.3739 | 0.3736 | 0.3333 |
| **49** | Paraguay | 0.5627 | 0.9750 | 0.6192 | 0.3386 | 0.8783 | 0.5189 | 0.9648 | 0.3987 | 0.4199 | 0.5185 |
| **…** | **……** | **…** | **…** | **…** | **…** | **…** | **…** | **…** | **…** | **…** | **…** |
| **…** | **……** | **…** | **…** | **…** | **…** | **…** | **…** | **…** | **…** | **…** | **…** |
| **67** | United Kingdom | 1.0000 | 1.0000 | 0.3565 | 0.4526 | 0.8995 | 0.4345 | 0.7739 | 0.5070 | 0.3388 | 0.8936 |
| **68** | United States | 0.9789 | 1.0000 | 0.3565 | 0.5733 | 0.9648 | 0.4393 | 0.5718 | 0.4843 | 0.3736 | 0.7636 |

For example, calculation of grey relational co-efficient for "people using safely managed drinking water services" (1) To Armenia is calculated as follows

$$\gamma[x_0^*(1), x_1^*(1)] = \frac{\Delta_{min} + \xi\Delta_{max}}{\Delta_1(1) + \xi\Delta_{max}} = \frac{0 + (0.5) \times 1}{0.1453 + (0.5) \times 1} = 0.7748$$

***Step 6:***Calculated grey relational grade

$\gamma(x_0^*, x_i^*) = \sum_{k=1}^{n} \beta_k \gamma\ [x_0^*(k), x_i^*(k)] Eq.\ (7)$

$\sum_{k=1}^{n} \beta_k = 1 Eq.\ (8)$

**Table 7:** Grey Relational Grades

| Sr. | Country | Grades |
|---|---|---|
| **0** | Reference Sequence | 1.0000 |
| **1** | Armenia | 0.5797 |
| **2** | Austria | 0.6802 |
| **…** | **……** | **…** |
| **…** | **……** | **…** |
| **48** | Pakistan | 0.4830 |
| **49** | Paraguay | 0.6195 |
| **…** | **……** | **…** |
| **…** | **……** | **…** |
| **67** | United Kingdom | 0.6656 |
| **68** | United States | 0.6506 |

For example, the grey relational grade for Armenia is calculated as under

$$\gamma(x_0^*, x_1^*) = \sum_{k=1}^{n} \beta_k\ \gamma[x_0^*(1), x_1^*(k)]$$

$$= 0.10 \times (0.7748 + 1.0000 + 0.3780 + 0.3496 + 0.6101 + 0.4052 + 0.9241 + 0.4581 + 0.3519 + 0.5455) = 0.5797$$

## IV. RESULTS & DISCUSSION

This section contains the results of the study and the discussion accordingly.

***Results:***Based on Grey Relational Analysis performed in the preceding section,the following results have been generated (Table 8). Using the grey relational analysis (i.e. mathematical technique of data analysis with the capability of handling a multitude of variables, cases and periods), the study has categorized 68 countries of the world into seven different categories. Approximately ten countries have been classified into each category.

**Table 8:**Results of Grey Relational Analysis

| Country | Grey Relational Grades | Rank | Country | Grey Relational Grades | Rank | Country | Grey Relational Grades | Rank |
|---|---|---|---|---|---|---|---|---|
| Reference Sequence | 1.0000 | 0 | Estonia | 0.6400 | 23 | Philippines | 0.5824 | 47 |
| ***Exceptionally High*** | | | Canada | 0.6374 | 24 | Kuwait | 0.5806 | 48 |
| Sweden | 0.7293 | 1 | Costa Rica | 0.6368 | 25 | Georgia | 0.5805 | 49 |
| Iceland | 0.7225 | 2 | Ireland | 0.6353 | 26 | Armenia | 0.5797 | 50 |
| Denmark | 0.6976 | 3 | Latvia | 0.6345 | 27 | ***Poor*** | | |
| Slovenia | 0.6928 | 4 | Portugal | 0.6314 | 28 | Ukraine | 0.5775 | 51 |
| Norway | 0.6849 | 5 | Guatemala | 0.6309 | 29 | Russian Federation | 0.5757 | 52 |
| Switzerland | 0.6829 | 6 | Colombia | 0.6290 | 30 | Azerbaijan | 0.5752 | 53 |
| Austria | 0.6802 | 7 | ***Average*** | | | Jordan | 0.5748 | 54 |
| Finland | 0.6801 | 8 | Poland | 0.6289 | 31 | Kazakhstan | 0.5741 | 55 |
| New Zealand | 0.6781 | 9 | Chile | 0.6268 | 32 | Bahrain | 0.5704 | 56 |
| Korea, Rep. | 0.6762 | 10 | Czech Republic | 0.6243 | 33 | Mexico | 0.5701 | 57 |
| ***Excellent*** | | | Hungary | 0.6218 | 34 | Tunisia | 0.5642 | 58 |
| Germany | 0.6760 | 11 | Paraguay | 0.6195 | 35 | Kyrgyz Republic | 0.5615 | 59 |
| Luxembourg | 0.6760 | 12 | Bulgaria | 0.6163 | 36 | Qatar | 0.5609 | 60 |
| Israel | 0.6743 | 13 | Croatia | 0.6111 | 37 | ***Very Poor*** | | |
| Singapore | 0.6694 | 14 | Belarus | 0.6092 | 38 | Serbia | 0.5575 | 61 |
| United Kingdom | 0.6656 | 15 | Cyprus | 0.6092 | 39 | Nicaragua | 0.5549 | 62 |
| France | 0.6599 | 16 | Malaysia | 0.6045 | 40 | Peru | 0.5421 | 63 |
| Netherlands | 0.6597 | 17 | ***Below Average*** | | | Oman | 0.5309 | 64 |
| Belgium | 0.6563 | 18 | Greece | 0.6042 | 41 | Uganda | 0.5029 | 65 |
| United States | 0.6506 | 19 | Italy | 0.6005 | 42 | Iraq | 0.5002 | 66 |
| Japan | 0.6473 | 20 | Moldova | 0.5957 | 43 | Pakistan | 0.4830 | 67 |
| ***Above Average*** | | | Romania | 0.5946 | 44 | Mongolia | 0.4617 | 68 |
| Slovak Republic | 0.6433 | 21 | Ecuador | 0.5859 | 45 | | | |
| Spain | 0.6429 | 22 | North Macedonia | 0.5839 | 46 | | | |

By employing classification of the countries on a scale of 7 items (i.e. *exceptionally high, excellent, above average, average, below average, poor* and *very poor)* the results can be viewed as; i)countries having grey relational grade between0.7293 to 0.6762 have exceptional performance, ii) countries having grey relational grade ranging between 0.6760 to 0.6473 are considered having excellent performance, iii) countries having grey relational grade ranging between 0.6433 to0.6290 are considered having above-average performance*, iv)* countries having grey relational grade ranging between 0.6289 to 0.6045 are considered having average performance*, v)* countries having grey relational grade ranging between 0.6042 to 0.5797 are considered having below-average performance, vi) countries having grey relational grade ranging between 0.5775 to 0.5609 are considered having poor performance and *vii)* countries having grey relational grade ranging between 0.5575 to 0.4617 are considered to havevery poor performance concerning global goals promoting sustainability.

The results provide rather deeper insights to form informed opinion about the performance of subject countries on SDGs. Sweden, Iceland, Denmark, Slovenia, Norway, Switzerland, Austria, Finland, New Zealand and Korea, Rep. (mostly European countries) have *exceptionally high* performance on SGDs.Luxembourg, Israel, Singapore, United Kingdom, France, Netherlands, Belgium, United States and Japan have *excellent* performance.Slovak Republic, Spain, Estonia, Canada, Costa Rica, Ireland, Latvia, Portugal, Guatemala and Colombia have *above-average* performance.Poland, Chile, Czech Republic,

Hungary, Paraguay, Bulgaria, Croatia, Belarus, Cyprus and Malaysia have *average* performance.Greece, Italy, Moldova, Romania, Ecuador, North Macedonia, Philippines, Kuwait, Georgia and Armenia have *below-average* performance. Ukraine, Russian Federation, Azerbaijan, Jordan, Kazakhstan, Bahrain, Mexico, Tunisia, Kyrgyz Republic and Qatar have *poor* performance. Serbia, Nicaragua, Peru, Oman, Uganda, Iraq, Pakistan and Mongolia have *very poor* performance on SDGs. It is evident from results that educationally and technologically advanced countries have better performance on SDGs as compared to the developing and less developed countries.

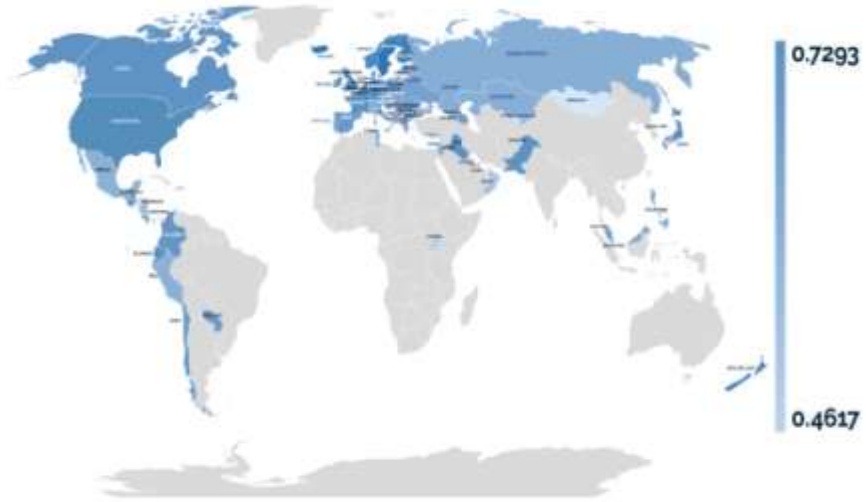


***Figure 1: Shaded Graph of Countries' Performance on Global Goals Promoting Sustainability***

**A shaded graph (Figure 1) has been added to present the results of GRA in visual form fora better understanding of the readers. The variation of GRG has been captured into the colour as presented on a scale given alongside the figure. Countries having better performance are depicted in dark bluecolour and vice versa.**

***Discussion:*** Keeping in mind the aim of the study i.e. to evaluate country-level performance on global goals promoting sustainability the authors extracted the data from WDI on the variables considered as indicators of achievement of SDGs and applied GRA for ranking the countries based on their grey relational grade. The countries are also classified on a continuum of exceptionally high to very poor performance. This study is different from contemporary studies as the dimension of SDGs under investigation has been less studied, the authors could not find the study that has applied the GRA procedure on the data, alternatives and variables like the subject matter of this study. Presentation of the results of the study in form of logical classification on a continuum of performance is also different from contemporary literature. Graphical visualization of results on a shaded graph is the uniqueness of this study. Contemporary literature witnesses investigations of one or two variables concerning mostly about some single country and dealing multitude of alternate countries.A composite criterion in one mathematical model is a rare phenomenon in contemporary literature (Table 9).

**Table9:** Comparison of Results

| Studies | Focus | Variables | Methodology | Results |
|---|---|---|---|---|
| Current | Evaluation of global goals promoting sustainability | Drinking water, electricity, renewable energy, air pollution, R & D, carbon dioxide emissions, terrestrial & marine areas, internet | Grey relational analysis | Educationally and technologically advanced countries have better performance on SDGs as compared to the developing and less developed countries |
| Halisçelik and Soytas (2019 | Measure the level and compare the | Health, poverty reduction, gender | Development of index creation | It is pertinent to measure the |

| | | | | |
|---|---|---|---|---|
| | performance of countries of achieving SDGs | equality, education, environment | method | performance of countries in both dimensions (economic and human development). |
| Durugbo and AmankwahAmoah (2019) | How do MNCs craft regulatory policies to attain SDGs under uncertainty | Climate, pollution, waste disposal, renewable sources of energy | Inductive methodology (analytical induction and grounded theory) | Multinational companies craft the policies to address the concern of pollution and renewable sources of energy |
| Lorenz et al. (2019) | Monitoring of land and soil degradation in relation to UN-SDGs | Soil organic carbon, ecosystem services, soil degradation | Sampling and laboratory test | Decrease in soil organic carbon has a significant positive impact on the mitigation of land and soil degradation that achieves in SDGs |
| Bouma (2019) | Sharing soil expertise across the stakeholders | Soil expertise, information | Exploratory research | Internet and social media are prerequisites for sharing soil information to stakeholders for the attainment of SDGs. |
| Ordonez-Ponce and Khare (2021) | Contribution of the industry to environmental sustainability | Energy, emission, water &effluent, biodiversity | Qualitative content analysis | Energy and emission are the most reported contributor and water & affluent and biodiversity are the least reported contributors of attainment of SDGs |

Halisçelik and Soytas (2019 measuredthe level and compare the performance of countries of achieving SDGs using variables health, poverty reduction, gender equality, education and environment. Durugbo and AmankwahAmoah (2019) evaluated that how do MNCs craft regulatory policies to attain SDGs under uncertainty used variables like climate, pollution, waste disposal and renewable sources of energy**.** Lorenz et al. (2019) conducteda study on a different dimension of the SDGs e.g.monitoring of land and soil degradation. Bouma (2019) conducted exploratory research by taking an expert opinion on soil-related variablesconcerning UN-SDGs included variables like soil organic carbon, ecosystem services, soil degradation and used lab testing methodologies. Ordonez-Ponce and Khare (2021) evaluated the contribution of industry towards environmental sustainability and concentrated on energy, emission, water &effluent and biodiversity using qualitative content analysis. In this way the current study is different in scope, dataset, methodology, results inpresentation and contribution.

## V. CONCLUSION

Evaluating country-level performance on global goals promoting sustainability has gained fundamental importance. Though global goals are defined, yet clarity is needed for understanding and implementation of sustainabilityvia evolving new variety of research methodologies. Therefore this research has investigated the phenomenon using real-time country-level secondary data of WDI and applied classical GRA espoused in grey system theory. Results of the study reveal that: Sweden, Iceland, Denmark, Slovenia, Norway, Switzerland, Austria, Finland, New Zealand and Korea, Rep. (mostly European countries) have *exceptionally high* performance on SGDs.Luxembourg, Israel, Singapore, United Kingdom, France, Netherlands, Belgium, United States and Japan have *excellent* performance. Slovak Republic, Spain, Estonia, Canada, Costa Rica, Ireland, Latvia, Portugal, Guatemala and Colombia have *above-average* performance.Poland, Chile, Czech Republic, Hungary, Paraguay, Bulgaria, Croatia, Belarus, Cyprus and

Malaysia have *average* performance.Greece, Italy, Moldova, Romania, Ecuador, North Macedonia, Philippines, Kuwait, Georgia and Armenia have *below-average* performance. Ukraine, Russian Federation, Azerbaijan, Jordan, Kazakhstan, Bahrain, Mexico, Tunisia, Kyrgyz Republic and Qatar have *poor* performance. Serbia, Nicaragua, Peru, Oman, Uganda, Iraq, Pakistan and Mongolia have *very poor* performance on SDGs.This study contributes to the existing literature by way ofthe hierarchy of countries based on the relative performance of global goals promoting sustainability. It further contributes in form of classification and grouping of countries on a continuum of SDG performance on a ranking scale. It also contributed a shaded graph to visualize the results at a glance and a discussion that provides a contrast of current study with contemporary studies. Besides, it provides deeper insights and understanding about the performance of different economic blocs on promoting global goal on sustainability.This study has profound implications for the international community, political governments, policymakers, researchers and international institutions. It provides a rather detailed framework for future studies on the phenomenon.This study has few limitations as well.

1. It is a cross-sectional study.Longitudinal research is recommended in future.
2. This study uses GRA as a technique of hierarchicalization. In future, techniques like RIDIT, TOPSIS, SWARA, VIKOR, ISM etc. may be used for enhancing the understanding.
3. The study has given equal weight to all variables but in future, this scheme may be changed based on AHP and/or Entropy method.

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