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Evaluating the Progress of the EU Countries Towards Implementation of the European Green Deal: A Multiple Criteria Approach

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Abstract: The European Green Deal (EGD) is a package of policy initiatives launched by the European Commission in December 2019, which aims to set the European Union (EU) on the path to a green transition with the final goal of achieving climate neutrality by 2050. The package includes interlinked initiatives covering the climate, the environment, energy, transport, industry, agriculture, and sustainable finance. It is thus evident that holistic and scientifically sound decision support systems are crucial to help EU policymakers and stakeholders in monitoring the progress of countries towards the implementation of the EGD. Indeed, the multidimensionality of this policy initiative lends itself well to its integration into a Multiple Criteria Decision Aiding (MCDA) approach to the identification of priorities for action. Therefore, this research aims to evaluate the progress of the EU countries towards the implementation of the European Green Deal, using MCDA. The PROMETHEE II method was applied to the data for EU countries, using 26 key indicators collected from the Eurostat database and organized into three thematic clusters. The results enabled us to calculate overall scores measuring the degree of implementation of the EGD by the EU countries, and their profiles with respect to the key indicators and thematic clusters. By analyzing these profiles, strengths and weaknesses were identified. Thus, the fundamental novelty of this research consists of the first concrete application of a holistic and 'ready-to-use' decision-making tool that can be adopted by EU policymakers and stakeholders to draw up a roadmap towards climate neutrality.

Keywords: climate impact; land protection; green transition; environmental assessment; policy evaluation; policy making; decision aiding

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1. Introduction

The European Green Deal (EGD) is an ambitious strategy set up by the European Commission with the twofold objective of developing a fair and prosperous society based on a competitive low-carbon economy [1,2]. The EGD represents the most recent initiative on sustainable development, as well as the main tool for implementing the UN 2030 Agenda for Sustainable Development and the Sustainable Development Goals (SDGs) [3]. For the first time, climate and environmental policies are the basis of an organic plan leading to wider sustainability, industrial, innovation, and societal ambitions [4]. To achieve this, the EGD includes eight key areas, which involve all the main sectors of the EU economy; specifically as follows:

1. to enhance the EU's climate ambitions for the 2030 and 2050 targets.
2. to provide clean, affordable, and secure energy.
3. to mobilize the industry in order to facilitate the transition towards a clean and circular economy.
4. to build and renovate in an energy- and resource-efficient way.
5. to achieve zero pollution for a toxic-free environment.
6. to preserve and restore ecosystems and biodiversity.
7. to promote a fair, healthy, and environmentally friendly food system.
8. to accelerate the shift to sustainable and smart mobility.

However, some authors have pointed out that not all the policy areas included in the EGD are characterized by the same level of ambition, nor are there sufficient legislative instruments to be effective, and these discrepancies may jeopardize the full achievement of EGD objectives. When considering these two aspects, the central role of climate and energy policies becomes clear [5]. This can be explained by public concern about climate issues before the launching of EGD, the so-called 'Greta effect' [6]. Indeed, the main objectives are the reduction of EU net domestic production of greenhouse gas (GHG) emissions by 2030 (at least 55% compared with 1990 levels) and the achievement of climate neutrality by 2050 [7]. At the same time, the EGD pursues the decoupling of economic growth from resource use and net zero emissions by ensuring social justice (the 'Leave No One Behind' objective) and dealing with the distributional issues linked to decarbonization [4]. Thus, the challenge is not merely environmental but also social and economic [3,4,8,9].

The scientific world's interest in the EGD has been high since its introduction. In 2022, quite early after its launch, Ejdys and Szpilko [3] dedicated a review to the EGD, identifying a corpus of 641 records in Scopus and WoS directly or indirectly connected to it. Their analysis revealed eight thematic clusters, linked to the eight thematic areas of the EGD. Considering the most frequent keyword analysis they provided, "Energy and Climate change" was prominent, confirming the dominance of some themes over the others also described by some authors in the literature [10]. Moreover, Ejdys and Szpilko [3] underlined that it is time to measure the effectiveness and efficiency of the initiatives undertaken and that this should be a new research direction. Schoenefeld et al. [11] highlighted that policy monitoring and evaluation are key for good implementation, but real-world applications have been rare, including in relation to EU climate policy. Indeed, policies and strategies can impact differently on the EU member states; thus, monitoring and evaluating their achievement in an integrated way is crucial in order to ensure the implementation of EU policies [10,11].

The present work aims to contribute to filling this gap in the literature, analyzing the first effects of the implementation of EGD by the EU member states, using a multi-perspective approach. Because of the multi-dimensional nature of the policy initiative, the Multiple Criteria Decision Aiding (MCDA) approach was chosen to build a comprehensive index, which included 26 criteria collected from the Eurostat database, divided into three main thematic areas in order to deepen the analysis. The choice to operate within the official framework provided by Eurostat is crucial to avoid issues of ambiguity that may be present when operating outside a clear conceptual framework and context [12]. The potential of MCDA's application to climate-related policy assessment has already been widely proven [13], demonstrating the robustness of the approach. To our knowledge, there has been just one previous attempt to measure the effect of EGD [10], although with a limited number of criteria, no distinction among thematic dimensions, and not considering all the EU member states.

2. Literature Review

After the launch of the EGD by the European Commission in 2019, some EU countries took action to achieve the EGD objectives under its eight key areas, while others had made previous significant efforts. There are several international studies on the initiatives carried out by the member states, as well as European Commission policy documents that model the implementation of the EGD objectives.

EU member states are called on to develop climate plans to reduce GHG emissions by at least 55% by 2030 compared with 1990 levels; however, little progress towards this target has been made [14,15]. Countries like Sweden, Finland, and Latvia shared the highest proportion of renewable energy in gross final energy consumption among the EU member states in 2020 [16], while other countries as Poland and Hungary are struggling in leaving coal and other fossil fuel energy sources [17]. This disparity in the achievement of this target is often guided by financial constraints and political disagreement [18,19]. In recent years, the European Commission has tried to reduce the disparity among the member states through the European Climate Law [20], which includes regulations for making the achievement of the climate neutrality legally binding by 2050 [21], and has implemented initiatives for monitoring the progress of the member states [22].

The shift towards a clean, affordable, and secure energy system is promoted by the EGD, although the significant reliance on fossil fuels by some member states as well as political events can threaten the achievement of this objective [23]. For instance, the energy crisis caused by the invasion of Ukraine arose from weaknesses in the EU's energy supply chain [24], especially in countries which depend on Russian gas [25]. The commitment of the EU to promoting renewable energy supply and energy diversification is evident [26], especially in some countries such as Sweden, Finland, and Latvia, which have increased their share of renewable energy consumption [16]. Moreover, the European Commission supports the most carbon-dependent countries through the Just Transition Fund [27]. In order to plan energy transition activity, the EU relies on the Energy System Integration Strategy and the Clean Energy for All Europeans package to estimate the impacts of renewable energy supply.

The transition towards a sustainable and circular economy is another key area in the EGD for encouraging industries to lower their environmental impacts [28]. However, the success has been undermined by the lack of preparation of the member states in adopting regulations and providing incentives [29], or the challenges that industries have to cope with when adopting circular economy practices [30]. Indeed, countries such as the Netherlands and Germany have already made significant steps towards the adoption of circular economy practices, while others, like Spain and Italy, still struggle in dealing with effective waste management and recycling systems [31]. To this effect, financial investments to provide industries with innovative and sustainable technologies can be the keystone for the achievement of this transition [32]. Moreover, to foster the achievement of this goal, the EU has developed initiatives like the European Circular Economy Stakeholder Platform [33] and can benefit from the adoption of input–output models in combination with Life Cycle Assessment (LCA) tools.

The EGD also focuses on building and renovating the EU in an energy- and resource-efficient way [34]. Indeed, the EU has set strong goals to improve energy efficiency in buildings, promoting the refurbishment of existing buildings to nearly zero-energy standards [35], although the achievement of these standards is often hindered by the financial and labor skills constraints [14]. The action plans set out for the Renovation Wave intend to renovate about 35 million buildings by 2030, with a focus on improving their energy efficiency while reducing air emissions [21], and member states have to adopt strict energy performances in order to meet the EU climate goals [36]. Countries like Sweden and Finland have made strong progress in energy-efficient construction practices [37], while Greece faces issues such as financial constraints, lack of technical expertise, and low public awareness [38]. Energy- and resource-efficient building and renovation is reinforced through financial provision and technical assistance to facilitate the retrofit of public and private buildings [39], and the primary policy tools adopted by the European Commission are the Energy Performance of Buildings Directive [40] together with the Renovation Wave [34].

Through the achievement of zero pollution for a toxin-free environment, the EU seeks to minimize levels of contaminants with the aim of protecting public health and natural ecosystems [41]. This aim is threatened by weak implementation of existing regulations and ineffective monitoring systems in member states [42]. Member states must monitor and report the levels of pollutants dangerous for public health and the environment [43]. Countries such as Denmark and Sweden have already reduced the use of pesticides and promoted the adoption of organic farming principles [44], while many Eastern countries are still dependent on agrochemical inputs [45], and Malta shared the highest percentage of groundwater monitoring stations with a nitrate concentration higher than 50 mg/L [46]. Moreover, Sweden, Finland, and Latvia have reduced their GHG emissions by relying more on renewable energy sources [16]; on the other hand, Bulgaria and Romania have slowed down progress because of industrial dependence on fossil fuel [25]. Also, Spain and Italy have ineffective waste management [31]. In this regard, the Zero Pollution Action Plan is the key EU policy initiative for the achievement of decontamination and subsequent reductions in healthcare and environmental remediation costs [47].

The EU set out their Biodiversity Strategy [48] for protecting and restoring the natural ecosystems and promoting sustainable land use practices [49], supporting cooperation between member states and local actors, ensuring adequate financial resources [41], or integrating the concept of biodiversity into their national strategies and engaging in collaborative efforts [21]. Among the member states, single countries like Croatia and Portugal or countries in partnership such as Netherlands and Belgium or Romania and Germany have already established initiatives in the conservation of biodiversity by putting the rewilding principles into practice [50]. Yet, countries with economies largely based on agriculture, such as Spain, Poland, and France, can suffer heavy losses in terms of farmland biodiversity if food production increases [51]. The European Commission proposed the Nature Restoration Law to introduce binding targets for ecosystem restoration across the EU [36] and applied ecosystem models coupled with biophysical simulation models to predict potential outcomes of restoration activity on biodiversity and ecosystem services.

Another key priority of the EGD is advocacy for a fair, healthy, and environmentally friendly food system. In this regard, the European Commission released the Farm to Fork Strategy [52] for developing a sustainable food system while reducing environmental impacts, ensuring food security and promoting healthy nutrition [49]. For this purpose, the European Commission have provided financial resources and policy tools that foster the adoption of sustainable ways of agriculture [43]. Progressive agricultural policies in Denmark and Sweden have already been adopted to reduce the use of pesticides, promoting organic farming [44]. On the other hand, Eastern countries such as Poland face the challenges of adopting sustainable agricultural practices and are still highly dependent on chemical inputs [45]. To reduce the ecological footprint of agriculture, huge financial investments in research and development are needed; thus, the European Commission has implemented analytical tools for modelling economic and environmental impacts related to changes in food systems [49].

Finally, the EGD aims at the transition towards sustainable and intelligent mobility, and pursuing this target via the Sustainable and Smart Mobility Strategy [53]. Therefore, the European Commission has proposed initiatives to promote sustainable transport models for reducing dependence on fossil fuels and consequent emissions [14,15]. For achieving this target, huge financial investments in infrastructure and technologies are required [14], including cycling and public transit systems [39]. For instance, Norway, Sweden, and the Netherlands have an upward growth trend for electric vehicle uptake [54]. On the contrary, Eastern European countries have accounted for low transport sustainability, mainly caused by a carbon-intensive vehicle fleet, ineffective public transport, lack of innovation, and few low-carbon alternatives [55].

3. Materials and Methods

3.1. Dataset Structure and Data Collection

The implementation of an analysis framework such as the MCDA-based approach requires a well-structured dataset organized into thematic clusters and evaluation criteria (i.e., indicators) [56–58]. At the end of March 2022, the statistical office of the European Union (Eurostat) released a new interactive dashboard to show relevant statistics related to the EGD. Particularly, this dashboard enables monitoring of the achievement of the EGD's objectives through 75 key indicators, organized into the following thematic clusters: (i) reducing our climate impact; (ii) protecting our planet and health; (iii) enabling a green and just transition. Thus, using such a database allows one to follow the recommendations to base policy monitoring and assessment on unambiguous variables that allow comparisons of countries and tracking over time [11].

The recent scientific literature shows that a large number of indicators can have several shortcomings when they are used in an MCDA framework, including difficulties in data accessibility; excessive consumption of economic resources for data collection and updating; incomplete, redundant, and/or ambiguous description of the phenomenon to be measured; and difficulties in interpreting the results and policy implications [58–61]. Thus, the original dataset set was analyzed to reduce their incorrect use. In particular, the indicators with missing data for all the EU countries (i.e., data are collected only at EU level) and with the same information (i.e., overlapping indicators) were discarded; when missing data concerned only a few countries, they were replaced by the average value of that indicator or by the most recent data for the country before 2022. This analysis resulted in 26 indicators, which were checked further according to the following selection criteria [62,63]: (a) adequately relevant to the main objective and results-oriented; (b) reflecting the wellbeing of the people living in the country/region; (c) measuring the effects of policy interventions; (d) sensitiveness to policy change; (e) ensuring that the distinctions and comparability between provinces/areas are reflected; (f) clear identification of the contribution's direction (positive/negative); (g) coherence, robustness, and accurateness; (h) accessibility and periodical updatability. The final dataset of 26 indicators and related parameters is shown in Appendix A (Table A1); these were used as input data for MCDA application using PROMETHEE II (see Section 3.2).

3.2. PROMETHEE II

The Preference Ranking Organization Method for Enrichment of Evaluations (PROMETHEE) is a family of MCDA outranking methods developed by Brans [64] that ranks a set of alternatives by performing pairwise comparisons between them for each evaluation criterion [65]. There are several PROMETHEE methods [64,66–68]: (1) PROMETHEE I provides the partial ranking of alternatives by computing the positive and negative outranking flows; (2) PROMETHEE II provides the complete ranking, i.e., the net outranking flow as the difference between the positive and negative flows for each alternative; (3) PROMETHEE III is suitable for ranking the alternatives based on intervals; (4) PROMETHEE IV generates a complete or partial ranking of alternatives when the set of feasible solutions is continuous; (5) PROMETHEE V is used for problems with segmentation constraints; (6) PROMETHEE VI is applied for representations of the human brain; (7) PROMETHEE GDSS performs group decision-making when the group of decision-makers (or stakeholders) is not homogeneous and has different points of view.

In this research, PROMETHEE II was applied due to its several advantages. Firstly, it organizes the evaluation criteria (i.e., the indicators) into thematic clusters or dimensions in such a way that the EU countries could be ranked on an overall score (net outranking flow, φ) and evaluated on a score related to each indicator and cluster separately (unicriterion net flow, φ_j) [69,70]. PROMETHEE II has a simple and clear structure for different users (e.g., researchers, policy makers, and stakeholders), it enables re-evaluation of the results when updates information is available (e.g., new indicator data), it manages uncertainty through the use of thresholds, and software is available to implement the procedure, manage the information quickly, and present the results clearly from multiple perspectives [70,71]. Additionally, PROMETHEE II can deal with small amounts of missing data (both quantitative and qualitative) at the pairwise comparison level [70,72] and it is suitable for making decisions in the frame of public policy [58,72,73]. Finally, PROMETHEE is a non-compensatory method, meaning it avoids trade-offs among dimensions; thus, it is not possible that a disadvantage in some criteria can be compensated by a large advantage in another criterion [74]. The application of PROMETHEE II was carried out with the software "Visual PROMETHEE" Academic Edition (version 1.4.0.0) [70].

Let us consider the multicriteria problem $max\ \{g_1(a), g_2(a), \ldots, g_j(a), \ldots, g_k(a) | a \in A\}$, where A is a finite set of n alternatives $\{a_1, a_2, \ldots, a_i, \ldots, a_n\}$ and $\{g_1(\cdot), g_2(\cdot), \ldots, g_j(\cdot), \ldots, g_k(\cdot)\}$ is a set of k evaluation criteria that can be maximized and/or minimized. These data are inserted into a table containing $n \times k$ evaluations, where the rows are the alternatives and the columns are the criteria [64]. In this research, the alternatives were the EU countries (including the EU), with the indicator values as of 2019, while the evaluation criteria were the indicators, organized into the three thematic clusters mentioned in Section 3.1. Regarding the maximization and minimization of criteria, a criterion that is minimized represents a situation in which a higher value results in a less favorable outcome in relation to the implementation of EGD. Conversely, a criterion that is maximized indicates that a higher value will yield a more favorable outcome [59,60].

In PROMETHEE II, two further types of information are required, that is, the criteria weights and the preference function [75]. The weights provide information about the criteria; a weight is a positive score reflecting the criterion's relative importance, and the higher the weight, the greater the criterion's importance. The weights are normalized to sum to 1 (i.e., 100%) and defined independently of the criterion's unit of measurement. Since the EGD includes policy packages that have to equally contribute to the EGD's implementation and these are strictly interconnected, assigning equal weights to the thematic clusters (33.3%) is possible. This choice is also supported by the consideration that political action is not always comparable; thus, assigning equal weights may help in highlighting distortions due to an unequal distribution of funding [5].

The preference function associated with each criterion explains the deviations between the pairwise evaluation of two alternatives into degrees of preference [65]. A degree of preference ranges from 0 to 1 and defines the extent to which one alternative is preferred over another, based on the point of view of the analyst or decision-maker [69]. There are six different preference functions: (1) Usual, (2) U-shape, (3) V-shape, (4) Level, (5) Linear, and (6) Gaussian. For qualitative criteria, the Usual and Level functions are generally suitable, whereas the Linear function is the most applied for quantitative criteria. For a comprehensive explanation of the preference functions, see Brans and De Smet [64]. Since all the indicators in this study were quantitative, it was necessary to set p and q thresholds and to choose a Linear preference function. The threshold p is the smallest deviation that generates a complete preference for a particular alternative, while the threshold q is the largest deviation considered negligible in the preference for a particular alternative on each criterion [64]. The values of these thresholds are strongly dependent on the preferences of the the analyst or decision-maker and their level of knowledge of the criteria [76]. The assignment of the thresholds' values requires particular attention to avoid analytic mistakes leading to controversial results. Therefore, this assignment was conducted by means of the "Preference Function Assistant" tool implemented in "Visual PROMETHEE" software, which identified the most appropriate value of the thresholds for each indicator according to the statistical analysis and a few simple questions about the pairwise comparisons for a given indicator. After obtaining the above information, the application of PROMETHEE II was carried out according to the following step-by-step procedure:

1. Determination of the deviation between alternatives (i.e., the EU Countries including the EU with the indicators' values as of 2019) based on pairwise comparisons, which is the deviation between alternatives a and b on each criterion (i.e., indicator);
2. Application of the preference function, namely, the preference of alternative a to alternative b for each criterion;
3. Calculation of the aggregated preference index indicating with which degree alternative a is preferred to alternative b across all criteria, and how far b is preferred to a, given the criteria weights. At the pairwise comparison level, the preference index is calculated from the values taken by the preference functions associated with the criteria: if for criterion g_j, either $g_j(a)$ or $g_j(b)$ are missing or not applicable, the pairwise substitution approach is applied. In this way, both the preference degrees are equal to zero and no assumption is made that either alternative a or b performs better on criterion g_j;
4. Calculation of the positive and negative outranking flows. The positive outranking flow $\varphi^+(a)$ measures how much alternative a outranks all the other n−1 alternatives. This flow is a global measure of the strength of alternative a; so, the higher $\varphi^+(a)$, the better the alternative. By contrast, the negative outranking flow $\varphi^-(a)$ measures how much the alternative a is outranked by all other n−1 alternatives. This flow is a global measure of the weakness of alternative a; so, the lower $\varphi^-(a)$ the better the alternative;

Calculation of the net outranking flow of alternative a $\varphi(a)$; as the balance between the positive and the negative outranking flows; $\varphi(a)$ ranges between -1 (worst possible value) and +1 (best possible value); so, the higher $\varphi(a)$, the better the alternative. The net outranking flow was computed to determine both the overall ranking of the EU countries and the ranking for each thematic cluster. Furthermore, this flow was also calculated separately for each criterion. In accordance with the definitions of the aggregated preference index and of the positive and the negative outranking flows, φ_j is the unicriterion net flow obtained when only the criterion $g_j(\cdot)$ is considered. This flow indicates the extent to which the alternative a outranks ($\varphi_j(a) > 0$) or is outranked ($\varphi_j(a) < 0$) by all the other alternatives for only the criterion $g_j(\cdot)$. The unicriterion net flow value ranges between -1 and +1. This disaggregated view of an alternative's strengths and weaknesses is useful for defining its profile, which is the set of all the single-criterion net flows. This enabled the investigation of the performance of the EU countries for any indicator and each thematic cluster, suggesting strengths and weaknesses.

For a more detailed description of the stepwise procedure of PROMETHEE II, see [64,72,75].

4. Results and Discussion

4.1. Overall and Thematic Clusters Analyses

4.1.1. The Countries Overall and Cluster Rankings: Net Outranking Flow

The primary outcomes from PROMETHEE II were the overall scores for the EU countries and their specific scores for the three thematic clusters (net outranking flow, φ) (Table 1). The EU score for 2019 (shown between dashed lines) was considered as the baseline; thus, the countries with higher overall scores than the baseline made more progress towards the achievement of the EGD objectives, while countries with lower overall scores made less progress than the EU average.

Table 1. The EU countries' overall and thematic cluster scores (net outranking flow, φ).

Rank	Country	Overall Score	Ranking Class	Thematic Clusters Score		
				CI	PH	GJ
1	Sweden (SE)	0.15	High	0.32	−0.02	0.16
2	Austria (AT)	0.13	High	0.14	0.05	0.20
3	Netherlands (NL)	0.12	High	0.15	−0.05	0.25
4	Belgium (BE)	0.07	High	−0.07	−0.02	0.32
5	Slovenia (SI)	0.07	High	−0.01	0.15	0.06
6	Latvia (LV)	0.06	Medium	0.11	0.10	−0.03
7	France (FR)	0.06	Medium	−0.06	0.12	0.12
8	Germany (DE)	0.05	Medium	−0.12	0.14	0.13
9	Slovakia (SK)	0.05	Medium	0.07	0.07	0.00
10	Portugal (PT)	0.03	Medium	0.06	0.11	−0.08
11	Croatia (HR)	0.03	Medium	0.01	0.06	0.02
12	Romania (RO)	0.01	Medium	0.15	−0.08	−0.04
13	Denmark (DK)	0.01	Medium	0.22	−0.17	−0.02
14	Malta (MT)	0.00	Medium	0.08	−0.25	0.17
15	Estonia (EE)	0.00	Medium	−0.05	0.11	−0.06
16	Finland (FI)	−0.02	Low	−0.05	0.09	−0.10
17	EU (2019)	−0.03	Low	0.04	−0.07	−0.06
18	Czechia (CZ)	−0.04	Low	−0.12	0.01	0.00
19	Spain (ES)	−0.04	Low	−0.06	0.01	−0.06
20	Italy (IT)	−0.04	Low	−0.23	0.04	0.07
21	Greece (EL)	−0.04	Low	−0.04	0.08	−0.17
22	Hungary (HU)	−0.05	Low	−0.01	−0.13	0.00
23	Poland (PL)	−0.07	Low	−0.12	−0.05	−0.05
24	Bulgaria (BG)	−0.08	Low	0.03	−0.23	−0.04
25	Lithuania (LT)	−0.09	Low	0.01	−0.10	−0.17
26	Cyprus (CY)	−0.10	Low	−0.09	0.05	−0.25
27	Luxembourg (LU)	−0.11	Low	−0.22	0.09	−0.19
28	Ireland (IE)	−0.12	Low	−0.11	−0.08	−0.16

Note: CI = reducing our climate impact; PH = protecting our planet and health; GJ = enabling a green and just transition.

Additionally, Table 1 shows the division of EU countries into three ranking classes (High–Medium–Low). The classes should be considered as homogeneous groups in terms of achieving the EGD objectives. The classes were determined using the equal interval approach, considering the overall score. Specifically, Sweden achieved the best overall score (0.15), confirming the good performance of this country in terms of sustainable development as well as climate actions, as reported by several authors. Ozdemir et al. [10], in their attempt at EGD assessment, found that Sweden has been the best performer according to the TOPSIS and COPRAS methods, while it ranks second using the MAIRCA framework. Thus, although they applied a shorter list of criteria (15) and MCDA methods, allowing different compensation approaches, there is convergence among the results. Broadening the analysis to Sweden's energy and environmental performance, Tutak et al. [77] found that this country is the leader among the EU-27 countries in implementing sustainable energy solutions and climate neutrality activity. The authors underlined that Sweden started a process of energy transition in the 1970s and has a long tradition in the development of ambitious environmental policies. Moreover, looking at the implementation of the 2030 Agenda by Sweden, several authors have identified its leading role in reaching a good sustainable development level [12,78–81]. Meanwhile, Ireland's low overall score (−0.12) is in line with the research by Slevin and Berrin [82], who highlighted that this country is facing several challenges, such as significant fossil fuel dependency; increasing GHG emissions from agriculture, transport, and energy sectors; a decline in biodiversity; and moderate quality conditions in about 25% of surface water and groundwater. In this regard, the authors emphasized the need to foster an innovative transition process across all levels of Ireland's economy and society. Ireland has had the largest delay in achieving the EGD objectives, according to the evaluation by Ozdemir et al. [10].

To better understand the distribution of performance across EU countries, we analyzed the range of values of the overall scores and the three thematic clusters (Figure 1). The overall scores provided the shortest set of values, having a 0.27 score difference between the best (Sweden) and the worst country (Ireland), with a median value of zero. Moreover, considering the positive domain, the difference between Sweden and Estonia was 0.15, while the difference between Finland and Ireland was −0.10 in the negative domain. Thus, the underperforming countries had relatively closer outcomes in comparison to the others. The analysis of ranges of values in the three clusters provides more detailed information. The GJ scoring range was the largest among the three groups (0.57), indicating that there is considerable variability in the implementation of the green and just transition across EU countries. Again, the range in the positive domain was larger (0.32) than in the negative one (0.23). In addition, in this thematic cluster, the median value was below zero, meaning that half of the EU countries underscored in this dimension. The distribution of the thematic CI scores was comparable to that of GJ, showing similar values (range 0.55, divided between 0.32 in the positive domain and −0.23 in the negative one). The two thematic clusters CI and GJ were numerically closer than PH and are conceptually alike, as the green and just transition and the reduction of climate impact are linked areas of action [83]. Thus, their similar distribution may indicate the need for distinct strategies across the EU.

It should be noted that in this case, the median is negative while the EU (2019) (average) is positive. On the other hand, the range of values of PH is narrower compared with the other two clusters (0.40), meaning that the performances of countries have been quite close to each other with respect to the protecting health and the planet. However, the distribution in the positive and the negative domains is not the same, the range in the former being rather narrow (0.15) compared with the latter (0.25). The median value in this case is over zero. This wide range of differences in the distribution of results between countries has been highlighted by some authors who have studied sustainable development issues in EU member states, noting that even when distances do close, it is not always to the same extent [78].

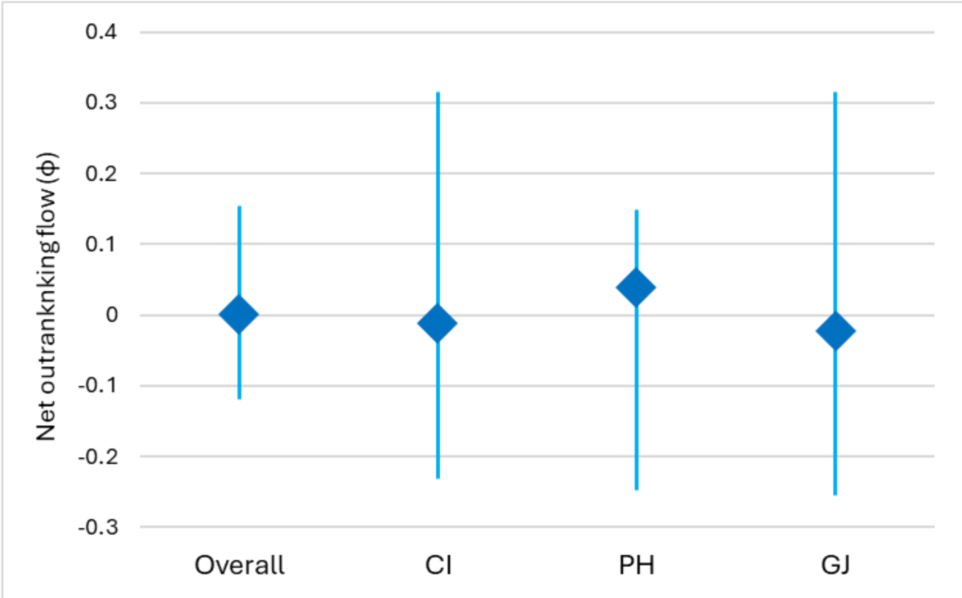

Figure 1. The range of values and median of the overall and cluster scores (net outranking flow, φ).

4.1.2. Sensitivity Analysis

To assess the stability and strengthen the overall scores of the EU countries and of the three thematic clusters (net outranking flow, φ), two sensitivity analyses were performed. The first one considered the presence of outliers, while the second considered a different distribution of weights across the three thematic clusters.

Outliers were identified applying the interquartile range method (IQR) [84], which is suitable for PROMETHEE [85]. Using the IQR test, it is possible to detect two different kinds of outliers: mild and extreme outliers. After calculating IQR ($Q_3 - Q_1$), mild outlier threshold results can be calculated using $Q_1 - (1.5 * IQR)$ (lower) and $Q_3 + (1.5 * IQR)$ (upper), while extreme thresholds use $Q_1 - (3 * IQR)$ (lower) and $Q_3 + (3 * IQR)$ (upper). In this analysis, mild outliers were not considered. Instead, extreme outliers were considered and assigned for the corresponding result function to the minimum or maximum value (depending on relative position) of the scale. We found out the following outliers, divided according to the subdimensions: CI: CI2 (France, Germany, Italy); PH: PH5 (Malta, Spain) and PH6 (Denmark, Lithuania, Sweden); GJ: GJ8 (Austria). Table 2 reports the rankings and classes produced by fixing the outliers.

The first six positions and the last eight remained the same, while there were some changes in the intermediate ranks. Classes were quite stable, although positions from 4 to 6 were classified as Medium, while Spain was classified as Medium instead of Low. Thus, the elimination of outliers confirmed in general terms the ranking, except for countries in the middle of the ranking with very close net outranking flow (φ) values.

Another sensitivity analysis was performed, modifying the weights of the three thematic clusters. Specifically, we considered a set of weights equal to 60-20-20, varying the distribution among the three clusters. Table 3 reports the modification of the classes according to the three sets of weights used.

Table 2. Comparison between the original overall ranking and class and the overall ranking and class after removing the outliers.

Countries	Original Ranking	Ranking Without Outliers	Original Class	Class Without Outliers
Sweden	1	1	High	High
Austria	2	2	High	High
Netherlands	3	3	High	High
Belgium	4	4	High	Medium
Slovenia	5	5	High	Medium
Latvia	6	6	Medium	Medium
Germany	8	7	Medium	Medium
France	7	8	Medium	Medium
Slovakia	9	9	Medium	Medium
Denmark	13	10	Medium	Medium
Malta	14	11	Medium	Medium
Portugal	10	12	Medium	Medium
Croatia	11	13	Medium	Medium
Romania	12	14	Medium	Medium
Estonia	15	15	Medium	Medium
Spain	19	16	Low	Medium
EU (2019)	17	17	Low	Low
Finland	16	18	Low	Low
Italy	20	19	Low	Low
Czechia	18	20	Low	Low
Greece	21	21	Low	Low
Hungary	22	22	Low	Low
Poland	23	23	Low	Low
Lithuania	25	24	Low	Low
Bulgaria	24	25	Low	Low
Cyprus	26	26	Low	Low
Luxembourg	27	27	Low	Low
Ireland	28	28	Low	Low

Table 3. Sensitivity analysis with the alternative sets of weights for the three thematic clusters: 60-20-20 for CI-PH-GJ (Sensitivity W1), 20-60-20 for CI-PH-GJ (Sensitivity W2), and 20-20-60 for CI-PH-GJ (Sensitivity W3). Arrow ↔ means no class change, arrow ↑ means upper class shift and arrow ↓ means lower class shift.

Country	Original Rank	Original Achievement Class	Sensitivity W1	Sensitivity W2	Sensitivity W3
Sweden	1	High	↔	↔	↔
Austria	2	High	↔	↔	↔
Netherlands	3	High	↔	↔	↔
Belgium	4	High	↓	↔	↔
Slovenia	5	High	↓	↔	↔
Latvia	6	Medium	↔	↑	↔
France	7	Medium	↔	↑	↑
Germany	8	Medium	↔	↑	↑
Slovakia	9	Medium	↔	↑	↔
Portugal	10	Medium	↔	↑	↔
Croatia	11	Medium	↔	↑	↔
Romania	12	Medium	↔	↑	↔
Denmark	13	Medium	↔	↑	↔
Malta	14	Medium	↔	↑	↑
Estonia	15	Medium	↔	↑	↔
Finland	16	Low	↔	↑↑	↔
EU (2019)	17	Low	↔	↑	↔
Czechia	18	Low	↔	↑	↑
Spain	19	Low	↔	↑	↑
Italy	20	Low	↔	↑	↑
Greece	21	Low	↔	↑	↔
Hungary	22	Low	↔	↑	↑
Poland	23	Low	↔	↑	↔
Bulgaria	24	Low	↔	↑	↔
Lithuania	25	Low	↔	↑	↔
Cyprus	26	Low	↔	↔	↔
Luxembourg	27	Low	↔	↔	↔
Ireland	28	Low	↔	↔	↔

Using the three alternative sets of weights, the first three top positions as well as the three last ones remained unchanged. However, the set W2, where the greatest weight was assigned to PH experienced a higher level of change. In particular, there was an increase in number in the Medium class. Indeed, with this weight set, the distribution range of the overall score was shorter than in the original one, as it also was in both the W1 and W3 sets. However, in this case, the EU members that ranked at the top or at the bottom remained unchanged, meaning that those positions were stable. On the other hand, the intermediate positions were less stable, because of the quite similar performance the countries showed.

4.1.3. Thematic Cluster Analysis

To understand the differences highlighted in the singular performance aspects and also their distribution, it is necessary to analyze in depth the relationship between the thematic clusters and how they contribute to the overall scoring. Although Sweden was the best ranked considering the overall score, it was the best performing only for the thematic cluster “Reducing our climate impact” (CI) (0.32), confirming its leading role in the climate neutrality initiative [77]. Slovenia was the best in the cluster “Protecting our planet and health” (PH) (0.15), while Belgium received the highest score for the cluster “Enabling a green and just transition (GJ) (0.32), confirming some of the literature outcomes [86,87]. Even though Ireland achieved the worst overall score, it was not the worst considering all the cluster scores. Italy was the worst within the cluster “Reducing our climate impact” (CI), with a score equal to −0.23; Malta contributed the worst performance in the cluster “Protecting our planet and health” (PH) (−0.25); and Cyprus was the worst country considering the cluster “Enabling a green and just transition” (GJ), with a score of −0.25. The bad results for Cyprus are probably linked to the large share of oil in the country’s energy use and the high share of imports in its total energy consumption [88], while for Malta, a mix of elements are involved. For instance, Malta has one of the lowest surface areas under organic farming among the EU countries [89]. In addition, it has the highest excess mortality rates in the EU due to changes in emissions and rising PM2.5 concentrations [90].

To better highlight such different performances according to the three thematic clusters and the global scores, two charts have been created: one with positive values for the overall score (Figure 2A) and one with negative values (Figure 2B). In both graphs, the x-axis reports the PH score, the y-axis reports the CI score, and the colors of the bubbles represent the GJ score divided into five equal interval classes (in Figure 2A, the darker the color, the better the score; in Figure 2B, the lighter the color, the better the score). The size of the bubble represents the absolute value of the overall score. In Figure 2A, 15 EU countries are shown. Only three countries had positive performances for all the scores (Austria, Croatia, and Slovakia), and four countries have two negative values in the thematic cluster scoring. When countries had negative scores for two thematic clusters, one of them was the PH or GJ score. Moreover, in cases of two negative values, the overall score was only slightly above 0; thus, the countries are not even clearly shown in the graph. Belgium (third quadrant) was the only exception, ranked fourth considering the overall score. The distribution of the negative values (Figure 2A) was quite similar across the three thematic clusters, showing six countries with negative PH (third and fourth quadrants), five with negative CI (second and third quadrants), and five with negative GJ scores (dark red). Figure 2B includes 12 countries, 11 of which have negative values for at least two thematic cluster scores; Ireland and Poland have all negative scores. Italy is the only country with just one negative thematic cluster score (CI); however, the overall score is negative because of its poor positive performances in the clusters PH and GJ and the very negative result for cluster CI. The countries with negative overall scores generally have a PH cluster a high score (positive for 7 out of 12 countries); thus the majority of these countries are positioned in the first and second quadrants. The CI cluster score is positive only for Lithuania and Bulgaria, and the GJ score for only Italy and Hungary.

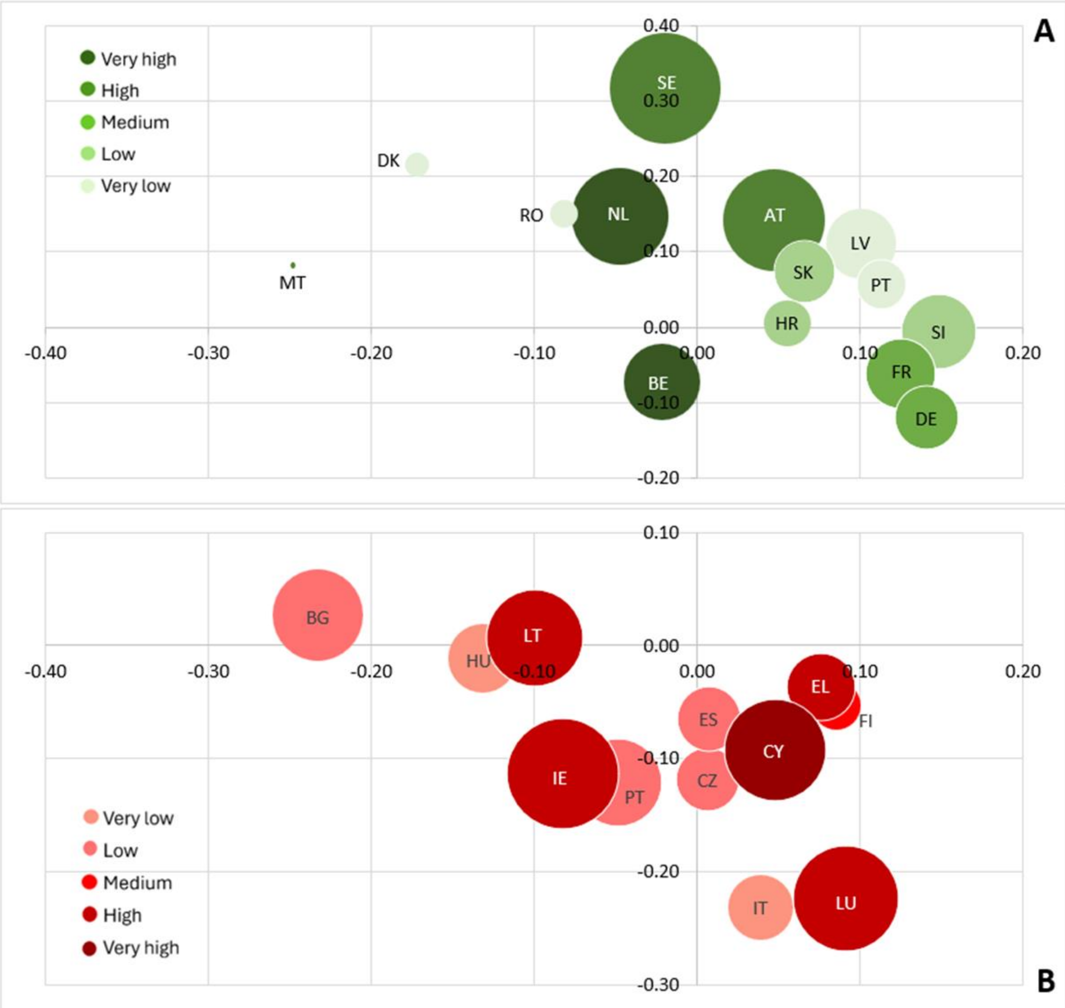

Figure 2. Joint analysis of the thematic cluster scores (CI, PH, GJ) and the overall score (net outranking flow, φ). (**A**) EU countries with positive values of the overall score, (**B**) those with negative values. In both figures, the *x*-axis reports the PH score, the *y*-axis reports the CI score, and the colors of the bubbles represent the GJ score. The overall score is represented by the dimensions of the bubbles.

4.2. Countries' Profiles: Unicriterion Net Flow

The second outcome generated by PROMETHEE II was the profile (unicriterion net flow, φ_j) separately showing the specific performances of the EU countries with respect to the thematic clusters and indicators (Table A2). This outcome enabled in-depth analysis determining the best and worst performances within each thematic cluster and the related indicators.

Regarding the best performances, the highest score of Sweden in the thematic cluster CI was mainly due to the indicators CI1: "Net GHG emissions" (0.86) and CI4: "Renewable energy by sector (transport, electricity, heating and cooling)" (0.97). The score for the first indicator (CI1) highlighted the progress of this country towards achievement of SDG 13 on climate action [91], which is embedded in the European Commission's Priorities under the EGD. SDG 13 attempts to accomplish the goal of limiting global warming to well below 2 °C and aiming at 1.5 °C (compared to pre-industrial times) up to the mid-century, through achieving climate neutrality [92]. This SDG also seeks to boost countries' resilience and adaptive capacity when facing climate-related natural hazards and consequent disasters [93]. The current result is strengthened by the briefing document "Sweden's climate action strategy" [94], which reported that Sweden accounted for 0.16% of the EU's net GHG emissions in 2023 and achieved a net emissions reduction of 72.6% from 2005 to 2023, well above the EU average reduction of 30.5%. In the same period, the country reduced emissions covered by the EU emissions trading system by 26.5%. In addition, Sweden's land use, land-use change, and forestry (LULUCF) sector contributes greatly to carbon storage. In this respect, Donatti et al. [95] pointed out that interventions aimed at nature conservation, restoration, and management can help society adapt to climate change, both in low-density human settlements and where extreme weather events are very frequent. The score for the second indicator (CI4) reflects progress towards the achievement of SDG 7 in Sweden, regarding affordable and clean energy [96], which is also incorporated in the European Commission's Priorities under the EGD. This SDG seeks to ensure universal access to modern energy services, improve energy efficiency, and increase the share of renewable energy. Countries are called on to promote clean energy research and related investment in infrastructures and technologies, in order to accelerate the transition to an affordable and reliable energy system [97,98]. The indicator CI4 is also relevant for achieving SDG 13, categorized under the key area "Energy Decarbonization and Sustainable Industry" by Sachs et al. [99]. Koundouri et al. [100] highlighted a considerable overlap of this goal with the EU Energy Integration Strategy and the EU Hydrogen Strategy. The high score achieved by Sweden for this indicator is also confirmed by the briefing "Sweden's climate action strategy" [94] and by Rădulescu et al. (2022) [16], which highlighted that Sweden achieved a 64% share of renewable energy sources (RESs) in final energy consumption, and exceeded its 2020 target for the RES share by about 11 percentage points. Furthermore, Sweden expects to reach 78% fossil-free energy by 2030. From 2005 to 2022, the amount of RES used in Sweden increased by 59%, mostly due to the development of wind and hydropower power, heat pumps, and biofuels.

The leading performance of Slovenia in the PH cluster resulted mainly from high scores for the indicators PH1: "Forest and other wooded land" (0.51) and PH2: "Terrestrial protected areas" (0.48). The score for the indicator PH1 underlined the progress towards SDG 15, which is incorporated into the European Commission's Priorities under the EGD. SDG 15 outlines the importance of sustainable management of forests and halting deforestation, combatting desertification, restoring degraded land and soil, halting biodiversity loss, and protecting threatened species [101]. This result is confirmed by reports from the Slovenia Forest Service [102] that more than half of the country's surface (58%) is covered by forest; about 91% of forests are classified as productive, while the rest are protected and special purpose forests. Slovenia pays great attention to forest management, based on the following three principles: (i) sustainability, ensuring the sustainability of forests' economic, ecological, and social functions, and conservation of forests for future generations; (ii) proximity to nature, including natural and holistic processes in management of forests to preserve their ecological balance; (iii) multifunctionality, managing forests in a way that preserves and provides permanent forest ecosystem services for society, while at the same time provides income for forest owners. The score for the indicator PH2 emphasized the achievement of good conservation, maintenance, or restoration status for habitat types and species of EU interest, in accordance with the EU Habitats and Birds Directives [103]. This result is in line with Alberdi et al. [86], who reported that Slovenia reached the third-highest ratio in the EU (19.10%) of forest habitat area in Sites of Community Importance (SCI) to overall national forest area. Moreover, the Slovenia Forest Service [102] reported that forests represent over 70% of national Natura 2000 sites, and that the conservation of 43 animal species, five plant species, and 11 forest habitat types within the Slovenian Natura 2000 sites are at the core of European forest heritage. In this respect, Ferreira et al. [104] and D'Odorico et al. [105] emphasized that, especially in Europe, appropriate management practices can reduce pressures on the natural capital of forests and soils, caused by increasing population, land-use changes, loss of biodiversity, desertification, and climate change.

Within the cluster GJ, Belgium showed the best performance thanks to the indicators GJ2: "Circular material use rate" (0.75) and GJ8: "Expenditure on environmental protection by institutional sector (total economy) (0.82). The score for the indicator GJ2 highlighted the progress of this country in using resources from recycled waste materials. This result is confirmed by the analysis carried out by the European Environmental Agency (EEA) on circular material use rates in Europe [106], which listed Belgium among the countries with the largest absolute increases in circular material use since 2010 (more than five percentage points), thus contributing to meeting the target of doubling the EU rate by 2030. An optimal performance for the indicator GJ2 means achieving several goals under policies and initiatives strongly linked to the EGD. Firstly, it is connected to the UN agenda for Sustainable Development, particularly to SDG 12 that seeks to achieve sustainable production and consumption based on advanced technological capacity, resource efficiency, and reducing global waste. This indicator is relevant to monitoring the circularity of the European economy under the Circular Economy Action Plan (CEAP) launched in 2020 [33]. Indeed, the EU's transition to a closed-loop circular economy will reduce the stress on natural resources and trigger sustainable growth and jobs through tailored initiatives to prevent waste and to keep the resources used in the EU economy as long as possible, simultaneously enhancing the resilience of the social–ecological European system [107,108]. Additionally, this indicator is relevant under the Sustainable Consumption and Production and Sustainable Industrial Policy (SCP/SIP) Action Plan [109], which aims at improving the environmental performance of products and increasing the demand for more sustainable goods and production technologies. Finally, this indicator is linked to the 8th Environment Action Programme (EAP) adopted in March 2022 [110], which aims to accelerate the transition to a climate-neutral, resource-efficient, and regenerative economy, recognizing that human wellbeing depends on healthy ecosystems, according to the One Health approach [111]. Moving the focus to the indicator GJ8, it is to be noted that the score demonstrates the efforts made by Belgian corporations, general governments, non-profit institutions serving households, and households, towards reducing and preventing pollution and any other degradation of the environment. As highlighted by Basoglu and Uzar [112], Belgium had already registered a higher level of environmental expenditure (1.67% of the total public expenditures) than northern European countries on average (1.47%) since the early 2000s. This expenditure contributes directly or indirectly to the EU's policy priorities on environmental protection, resource management, and green growth [113]. This outcome is in line with previous analysis of the environmental protection expenditure accounts [114], which highlighted that the average expenditure on environmental protection across the EU countries was about 2% of GDP, while Belgian national expenditure accounted for about 3.4% of its GDP, ranking it among the only 8 countries above the average EU expenditure.

Regarding the worst countries' performances, the lowest score for Italy in the CI cluster was mainly due to the indicators CI2: "Greenhouse gas emissions by sector (energy, industrial processes, agriculture, LULUCF, water management)" with a score of −0.74, and: CI3 "Climate related economic losses" (−0.93). The score for the indicator CI2 suggests that Italy should put in place further initiatives for combating climate change in accordance with achieving SDG 13 on climate action, as already highlighted previously by D'Adamo et al. [115]. This score is confirmed by *The Climate Action Monitor 2023* [116], which revealed how Italian GHG emissions were higher than other EU countries in 2021 for two out of seven sectors (waste production and management, and residential). In this regard, Laureti et al. [31] also reported that Italy is struggling with ineffective waste management and recycling systems. In addition, the OECD [116] reported that Italian emissions for three out of seven sectors (industrial processes and product use, transport, and manufacturing industries and constructions) were similar to the EU average, while GHG emissions from energy industries and agriculture were lower than other EU countries. However, Boix-Fayos and De Vente [117] underlined that agriculture is the second largest sector for GHG emissions in the EU (11%); thus, transforming European agriculture to become more sustainable and climate-friendly can contribute significantly to achieving EGD objectives in line with the Farm to Fork Strategy [52]. The score for the indicator CI3 indicates the urgent need to improve commitment to achieving SDG 1 of ending poverty in all its forms everywhere and SDG 11 of making cities and human settlements inclusive, safe, resilient, and sustainable, with specific reference to Targets 1.5 and 11.5. In line with this result, the EAA calculated that the total economic losses caused by weather and climate-related extreme events in Italy over 43 years accounted for EUR 133,934 million, while the average equal value for EU countries was about EUR 27,344 million [118]. The EU considers disaster and climate resilience as key objectives of humanitarian assistance; for instance, the EU Resilience Marker is used in all humanitarian projects to define ways to reduce disaster risks and to strengthen people's capacities to cope with disasters and crises [119]. It is to be noted that disaster risk management in the EU is also closely connected to global initiatives, such as the Action Plan for the Sendai Framework for Disaster Risk Reduction 2015–2030 [120], linking climate change adaptation to disaster risk reduction strategies and their coherent implementation in EU partner countries [121]. However, Zuccaro et al. [122] emphasized that these actions can be pursued through a comprehensive approach based on policies and measures including science and evidence-based disaster risk reduction and climate change adaptation. Also, Cappelli et al. [123] pointed out that countries should devote great attention to tackling climate-related disasters, possibly with affordable preventive measures or timely technological solutions ensuring resilience.

The worst performance by Malta in the PH cluster resulted mainly from the low scores for indicators PH1: "Forest and other wooded land" (−0.73) and PH5: "Nitrate in groundwater" (−0.99). The score for the indicator PH1 highlighted that Malta should implement suitable actions in accordance with SDG 15, for protecting, restoring, and promoting sustainable use of land, avoiding inappropriate practices that threaten the natural capital of European forests and soils [104]. This result is valid by the Eurostat's annual data collection "European Forest Accounts" (EFA) [124], which reported that Malta has only 1.46% share of forest on its total land area. The low performance in indicator PH5 suggests a need for action to achieve SDG 2, relating to ending hunger and malnutrition, and SDG 6, on clean water and sanitation, which are incorporated into the EGD. SDG 2 aims to end hunger and malnutrition and ensure access to safe, nutritious, and sufficient food, while SDG 6 calls for ensuring universal access to safe and affordable drinking water, sanitation, and hygiene, and also aims to improve water quality and its efficient use by encouraging sustainable abstractions and freshwater supply. This result is supported by the Nitrate Directive report published by the EAA [46], which highlighted that Malta shared the highest percentage of groundwater monitoring stations with a nitrate concentration higher than 50 mg/L. Worldwide, nitrate pollution of water mainly derives from agriculture, specifically, from the use of fertilizers and pesticides. In addition to contamination by fertilizers, in Europe, landfills, industrial activities, and sewage make a remarkable contribution to nitrate presence in groundwater [125]. For these reasons, groundwater nitrate contamination should be addressed from a surface-to-groundwater profile perspective, through the adoption of nitrate management practices and policies that include and support source reduction, in situ groundwater remediation, and polluted groundwater reutilization [126]. The protection of water resources, water ecosystems, and drinking and bathing water is at the cornerstone of several EU environmental policies. In particular, EU water policy provides a comprehensive framework to address water protection and achieve good status for inland surface waters, transitional waters, coastal waters, and groundwater. According to the Drinking Water Directive [127], a nitrate concentration of 50 mg/L in groundwater used as drinking water is the maximum amount allowed. Also, the Nitrates Directive [128] defines vulnerable homogeneous zones for nitrate concentrations in waters (including groundwater), while the Water Framework Directive is the main European legislation aiming at preventing water pollution. The EU Biodiversity Strategy for 2030 [48] corroborates the implementation of the Water Framework Directive's goals by requiring member states to restore freshwater ecosystems. Additionally, the eighth Environment Action Programme [110] fixes the environmental policy agenda for the years 2021–2030 and mentions water-related issues in two out of its six priority objectives: (1) pursuing an ambition of zero pollution for a toxin-free environment, including for air, water, and soil, and protecting the health and wellbeing of citizens from environment-related risks and impacts; and (2) protecting, preserving, and restoring biodiversity and enhancing natural capital, notably air, water, soil, and forest, freshwater, wetland, and marine ecosystems.

The worst performance by Cyprus in the GJ cluster depended on the low scores for the indicators GJ4: "Population unable to keep their homes adequately warm" (−0.57) and GJ8: "Expenditure on environmental protection by institutional sector (total economy)" (−0.43). The score for the indicator GJ4 highlighted that this country should implement strategies to make progress towards achievement of SDG 7, fostering the transition to an affordable and reliable energy system through clean energy research and related investment in infrastructures and technologies [97]. This result is corroborated by the report "9% of EU population unable to keep home warm in 2022" [129], which stated that 9.3% of the EU population were unable to keep their homes adequately warm during 2022, and the highest shares were recorded for Bulgaria (22.5%) and Cyprus (19.2%). In this respect, the European Pillar of Social Rights [130] lists energy among the essential services that everyone should have access to. With its EU Energy Poverty Observatory [131], the EU seeks to help Member States in their efforts to decrease energy poverty and ensure access to affordable energy. The European Commission also issued recommendations about energy poverty as part of the Renovation Wave, proposing actions for Member States to alleviate energy poverty and a Council Recommendation to ensure a fair transition towards climate neutrality to complement the package on delivering the EGD presented in July 2021. The Commission has already adopted a Communication on tackling rising energy prices [132], which highlights key elements to mitigate energy poverty and address the immediate impact of recent price increases. Finally, the score for the indicator GJ8 highlights the need to increase expenditure on environmental protection expenditure to prevent, reduce, and eliminate pollution and other drivers of environmental degradation, as well as to set up policy initiatives fostering the green economy and green jobs [133]. This result is supported by the analysis of the environmental protection expenditure accounts [114], which reported that Cyprus' national expenditure on environmental protection was 1.2% of GDP, corresponding to about one percentage point below the EU average expenditure.

5. Conclusions

The new challenges to humanity posed by the current international context are being addressed by the EU in a structural manner with the EGD. With the main objective of combating climate change, the EGD provides a comprehensive set of policy initiatives at every institutional level, covering a wide range of areas and sectors. The model of society that it intends to realize is sustainable, resource-efficient, and climate-resilient. However, the challenge is not the same across the EU countries, and each one faces specific issues.

Thus, understanding how the different countries are moving towards achieving EGD objectives is fundamental for its success.

In this research, the EU countries' progress towards the implementation of the EGD was investigated by the application of PROMETHEE II. The results enabled measurement of the degree of implementation of the EGD by EU countries, with a focus on three thematic clusters and 26 key indicators. The fundamental novelty of this research consists of the concrete application of a holistic and 'ready-to-use' decision-making tool that can be adopted by policy makers and stakeholders drawing up the EU roadmap towards climate neutrality. It is to be noted that this research does not intend to criticize the countries that currently have a low degree of EGD implementation, but rather it aims to identify key hotspots to prioritize. In the same way, virtuous countries may be considered as positive role models. In this regard, the ranking of the EU countries and the analysis of thematic clusters and related indicators can facilitate the identification of country-specific policy actions, considering the overall policy framework at the same time. However, the feasibility and implementation of such actions should be further explored together with a wide range of actors who are constantly involved in combatting climate change, protecting the environment and public health, and fostering green transition in the main economic sectors.

The proposed methodology provided reliable results, despite some issues such as missing indicators for a few countries, which were replaced by the average value of that indicator or by the most recent data for the country before 2022. Likewise, non-applicable indicators were addressed using the pairwise substitution approach.

The short range of time analyzed should be considered as one limitation of the study, and at the same time, a suggestion for future research. Temporal analysis will provide indications about the path undertaken by each EU Member to reach the EGD goals. In light of the above considerations, the proposed research should be interpreted as a first step of an assessment effort to be improved in the future, particularly monitoring the effects of the EGD implementation over time up to the milestone of climate neutrality by 2050. The quality of such research could be enhanced by the inclusion of EU opinion leaders and/or relevant stakeholders in the decision-making process, particularly with regard to the attribution of weights to the thematic dimensions and/or indicators. Moreover, the set of indicators could be increased following the enhancement of the Eurostat database and of the interactive visualization tool "Statistics for the European Green Deal".

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Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Table A1. The list of indicators with collected data and PROMETHEE II parameters (N/A = indicator not applicable).

THEMATIC CLUSTER		REDUCING OUR CLIMATE IMPACT (Weight = 33.3%)										PROTECTING OUR PLANET AND HEALTH (Weight = 33.3%)								PROTECTING OUR PLANET AND HEALTH (Weight = 33.3%)							
INDICATOR CODE		CI1	CI2	CI3	CI4	CI5	CI6	CI7	CI8	CI9	CI10	PH1	PH2	PH3	PH4	PH5	PH6	PH7	PH8	GJ1	GJ2	GJ3	GJ4	GJ5	GJ6	GJ7	GJ8
MIN/MAX		MIN	MIN	MIN	MAX	MIN	MIN	MAX	MAX	MIN	MIN	MAX	MAX	MAX	MAX	MIN	MIN	MIN	MIN	MIN	MAX	MAX	MIN	MIN	MAX	MAX	MAX
THRESHOLDS	q	2.52	190.6	79.12	11.9	0.9	6.28	9.77	1.16	2.97	12.4	12.96	8.92	10.79	5.38	11.35	16.41	33.7	5054.54	7.47	5.91	0.73	5.49	3.63	14.65	2.75	0.56
	p	5.85	352.12	153.78	25.03	1.92	14.61	21.9	2.32	6.55	29.98	31.14	20.9	23.94	12.94	22.1	35.28	80.19	10,392.5	16.38	13.42	1.74	11.94	8.38	34.03	5.57	1.26
EU (2019)		8.4	137.7	35.1	22.4	3.2	23.2	1.8	2.3	82.0	72.9	40.4	27.5	17.0	9.4	22.6	92.0	51.0	6562.7	19.0	9.1	1.7	8.2	15.6	57.3	7.3	2.0
EU COUNTRIES (2022)	AT	7.8	74.8	22.0	33.8	3.3	31.4	19.9	1.8	77.3	68.1	46.4	29.2	N/A	25.7	22.3	108	36	8079.0	20.4	13.8	3.2	3.9	11.7	54.8	4.4	3.6
	BE	9.3	108.9	69.0	13.8	3.9	28.6	19.3	0.5	82.5	76.5	24.3	14.7	37.8	7.6	28.6	66	44	5363.0	17.3	22.2	3.4	6.0	15.6	78.3	5.1	3.3
	BG	7.7	59.1	6.0	19.1	2.9	13.0	4.7	0.0	86.9	60.5	48.0	41.0	8.0	2.2	30.5	78	158	14,603.0	20.7	4.8	0.8	20.7	15.9	85.6	15.3	2
	HR	5.5	26.3	84.0	29.4	2.2	23.2	2.6	0.0	85.5	69.8	58.0	38.1	9.5	8.9	20.2	59	96	1838.0	15.3	5.8	1.4	6.2	10.2	61.5	9.0	2
	CY	10.2	9.6	0.0	19.4	2.7	17.0	5.4	0.0	84.4	100.0	43.2	37.7	8.6	6.3	7.8	66	70	3294.0	20.3	3.2	0.8	16.9	14.9	60.0	6.0	1.2
	CZ	11.4	118.5	7.0	18.2	3.6	27.4	3.1	0.0	81.2	77.8	37.9	21.9	N/A	16.0	18.5	66	81	3672.0	17.3	11.9	1.9	6.1	17.8	53.2	4.2	3
	DK	7.4	44.2	1.0	41.6	2.7	31.4	36.1	4.2	80.8	90.4	16.4	14.9	18.7	11.4	18.3	109	21	3333.0	25.9	7.4	2.9	6.9	23.1	96.3	5.8	2.1
	EE	10.7	14.1	0.0	38.5	3.5	30.0	6.3	0.4	85.6	72.7	58.3	20.9	18.7	23.4	5.2	66	7	16,752.0	29.6	16	1.8	4.1	20.7	79.2	7.0	2
	FI	9.3	47.3	0.0	47.9	5.4	42.6	33.8	0.4	84.2	77.0	69.9	13.3	11.0	15.0	0.2	66	3	19,950.0	44.4	0.6	3.0	2.6	15.7	70.8	5.7	1.9
	FR	5.7	409.7	122.0	20.3	3.0	24.8	16.7	2.8	84.3	87.4	32.8	28.0	45.4	9.9	19.3	65	30	5076.0	13.1	19.3	2.2	12.1	11.0	73.3	4.5	2
	DE	9.3	777.4	123.0	20.8	3.1	29.1	18.4	2.2	84.7	73.4	32.4	37.4	45.4	9.8	24.2	69	39	4604.0	13.7	13	3.1	8.2	13.6	70.1	4.0	2.3
	EL	7.4	82.2	2.0	22.7	2.0	16.1	4.7	0.0	84.6	97.7	47.5	34.9	19.8	17.2	20.2	66	95	2858.0	12.0	3.1	1.5	19.2	16.2	27.8	13.6	1.4
	HU	5.6	60.3	214.0	15.2	2.5	24.4	5.9	0.2	76.2	69.8	26.1	22.2	N/A	6.3	20.2	66	107	2838.0	15.9	7.9	1.4	7.2	10.3	80.3	5.4	1.4
	IE	13.0	63.7	0.0	13.1	2.8	24.2	19.2	0.6	81.6	99.3	19.0	13.9	2.3	2.2	13.3	45	9	2971.0	13.4	1.8	2.2	7.2	23.8	83.8	4.2	0.9
	IT	6.7	419.5	284.0	19.1	2.4	21.9	4.2	0.0	81.7	87.6	37.0	21.4	9.7	18.1	17.8	47	79	3212.0	11.1	18.7	1.4	9.5	12.5	53.7	5.2	2.6
	LV	8.3	10.6	0.0	43.3	2.3	26.2	8.8	0.0	84.7	46.8	56.2	18.2	15.8	15.9	3.4	66	75	1330.0	19.8	5.4	0.8	6.6	10.6	91.5	7.4	1.2
	LT	4.6	19.2	0.0	29.6	2.2	21.7	8.2	0.3	92.9	53.6	39.6	17.1	22.8	9.3	20.2	87	77	2003.0	22.7	4.1	1.1	20.0	13.6	78.0	4.8	1.9
	LU	14.5	10.1	0.0	14.4	5.8	30.6	22.5	0.0	83.1	86.3	35.5	55.8	N/A	6.2	20.2	38	12	15,169.0	32.1	5.2	1.1	2.1	15.7	93.3	3.2	0.9
	MT	5.0	2.6	0.0	13.4	1.7	8.2	20.3	0.0	82.9	100.0	10.4	29.0	5.5	0.6	59.0	66	37	5004.0	11.0	15.1	0.6	6.8	6.8	100.0	5.8	2.1
	NL	9.5	163.0	41.0	15.0	3.2	22.3	30.8	2.4	85.5	52.4	10.9	26.5	26.1	4.4	20.2	55	32	6921.0	7.5	27.5	2.2	7.1	14.5	97.8	6.2	1.9
	PL	9.4	383.4	0.0	16.9	2.7	20.1	3.6	0.1	82.7	76.8	36.4	39.6	21.9	3.9	20.2	66	125	4739.0	17.0	8.4	1.5	4.7	20.2	70.7	8.1	2.4
	PT	5.2	60.6	73.0	34.7	2.0	11.8	18.2	0.2	88.4	87.7	49.9	22.4	4.5	19.3	22.6	60	20	1878.0	16.7	2.6	1.7	20.8	10.1	93.0	5.3	1.8
	RO	3.3	110.0	54.0	24.1	1.6	16.9	10.6	0.0	82.4	54.0	35.5	23.4	21.4	5.1	20.2	44	103	8410.0	32.7	1.4	0.5	12.5	10.6	95.6	10.1	2.4
	SK	5.5	37.2	14.0	17.5	2.9	20.3	2.9	0.5	79.0	66.9	48.6	37.4	N/A	13.7	17.9	66	98	2462.0	11.8	9.1	1.0	8.1	12.7	71.3	7.1	1.9
	SI	7.3	15.7	72.0	25.0	2.9	21.1	8.9	0.0	86.1	67.3	62.5	40.4	5.0	11.1	14.1	59	56	5397.0	23.1	9.4	2.1	3.6	11.4	75.5	7.6	2.4
	ES	5.5	309.3	221.0	22.1	2.4	13.0	5.6	2.2	84.0	95.6	41.2	28.0	12.4	10.8	40.7	40	30	2480.0	7.7	7.1	1.4	20.8	11.5	93.3	4.1	1.8
	SE	0.6	47.1	0.0	66.0	4.1	29.8	38.6	2.2	81.0	71.1	67.0	15.0	16.0	19.9	20.2	90	6	15,627.0	21.0	6.1	3.5	5.9	8.0	84.6	4.6	2.1

CI1: Net GHG emissions (t of CO_2 equivalent per capita); CI2: Greenhouse gas emissions by sector (all sectors: energy, industrial processes, agriculture, LULUCF, water management) (million t); CI3: Climate-related economic losses (EUR per capita); CI4: Renewable energy by sector (all sectors: transport, electricity, heating and cooling) (% of gross final energy consumption); CI5: Primary energy consumption (toe per capita); CI6: Final energy consumption in households by use (all uses: space heating, space cooling, water heating, cooking, lighting and other electrical appliances, other end uses) (GJ per capita); CI7: Zero-emission vehicles (passenger cars) (% of new vehicles registered in the year); CI8: Zero-emission vehicles (good vehicles $\geq$ 3.5 t) (% of new vehicles registered in the year); CI9: Passenger transport by passenger cars (% in inland passenger-km): CI10: Freight transport by road (% in inland freight ton–km); PH1: Forest and other wooded land (% of total land area); PH2: Terrestrial protected areas (% ot total area); PH3: Marine protected areas (% of exclusive economic zone); PH4: Area under organic farming (% of UAA): PH5: Nitrate in groundwater (mg/L); PH6: Use and risk of chemical pesticides (index, average 2015–2017 = 100); PH7: Premature deaths due to exposure to fine particulate matter (PM2.5) (rate); PH8: Generation of hazardous and non-hazardous waste (kg per capita); GJ1; Raw material consumption by main material category (total) (t per capita); GJ2: Circular material use rate (% of material input for domestic use); GJ3: Gross domestic expenditure on R&D (all sectors: business enterprise, government, higher education, private non-profit) (% of GDP); GJ4: Population unable to keep their home adequately warm (% of population); GJ5: GHG emissions by intensity of employment (t GHG/employed person); GJ6: High-speed internet coverage (% of households); GJ7: Environmental tax revenues (% of total tax revenue); GJ8: Expenditure on environmental protection by institutional sector (total economy) (% of GDP).

Table A2. The unicriterion net flow (φ_j) showing the performances of the EU countries for each indicator and thematic cluster. The baseline (i.e., the EU score for 2019) is shown between dashed lines.

Rank	Country	REDUCING OUR CLIMATE IMPACT (CI)									
		CI1	CI2	CI3	CI4	CI5	CI6	CI7	CI8	CI9	CI10
1	Sweden	0.86	0.16	0.16	0.97	−0.41	−0.27	0.83	0.54	0.18	0.15
2	Austria	0.01	0.14	0.13	0.16	−0.03	−0.37	0.17	0.27	0.71	0.22
3	Netherlands	−0.19	0.07	0.11	−0.24	0.00	0.00	0.63	0.64	−0.15	0.58
4	Belgium	−0.16	0.11	0.11	−0.25	−0.28	−0.22	0.13	−0.17	0.03	−0.01
5	Slovenia	0.05	0.17	0.10	−0.10	0.06	0.06	−0.17	−0.27	−0.20	0.24
6	Latvia	−0.04	0.17	0.16	0.59	0.16	−0.14	−0.17	−0.27	−0.08	0.73
7	France	0.20	−0.72	−0.27	−0.16	0.04	−0.10	0.00	0.73	−0.06	−0.27
8	Germany	−0.16	−1.00	−0.28	−0.15	0.02	−0.24	0.08	0.54	−0.08	0.08
9	Slovakia	0.22	0.17	0.14	−0.20	0.06	0.11	−0.31	−0.17	0.47	0.25
10	Portugal	0.25	0.15	0.10	0.20	0.24	0.58	0.07	−0.23	−0.53	−0.28
11	Croatia	0.22	0.17	0.06	0.00	0.19	−0.04	−0.32	−0.27	−0.15	0.18
12	Romania	0.53	0.11	0.11	−0.11	0.42	0.29	−0.15	−0.27	0.04	0.53
13	Denmark	0.04	0.16	0.16	0.52	0.09	−0.37	0.76	0.91	0.21	−0.34
14	Malta	0.28	0.17	0.16	−0.26	0.37	0.76	0.19	−0.27	0.00	−0.59
15	Estonia	−0.36	0.17	0.16	0.39	−0.10	−0.29	−0.23	−0.19	−0.16	0.10
16	Finland	−0.16	0.16	0.16	0.72	−0.92	−0.93	0.71	−0.19	−0.05	−0.02
17	EU (2019)	−0.05	0.09	0.12	−0.13	0.00	−0.04	−0.34	0.60	0.07	0.09
18	Czechia	−0.47	0.10	0.15	−0.19	−0.13	−0.18	−0.31	−0.27	0.15	−0.04
19	Spain	0.22	−0.30	−0.86	−0.14	0.14	0.52	−0.24	0.54	−0.05	−0.48
20	Italy	0.09	−0.74	−0.93	−0.18	0.14	0.02	−0.28	−0.27	0.10	−0.27
21	Greece	0.04	0.14	0.15	−0.13	0.24	0.34	−0.27	−0.27	−0.08	−0.54
22	Hungary	0.21	0.15	−0.84	−0.23	0.13	−0.09	−0.24	−0.23	0.83	0.18
23	Poland	−0.17	−0.64	0.16	−0.21	0.09	0.12	−0.29	−0.25	0.01	−0.01
24	Bulgaria	0.02	0.16	0.15	−0.18	0.06	0.52	−0.27	−0.27	−0.30	0.38
25	Lithuania	0.34	0.17	0.16	0.00	0.19	0.03	−0.18	−0.21	−0.97	0.54
26	Cyprus	−0.28	0.17	0.16	−0.17	0.09	0.29	−0.25	−0.27	−0.06	−0.59
27	Luxembourg	−0.85	0.17	0.16	−0.25	−0.95	−0.32	0.32	−0.27	−0.01	−0.24
28	Ireland	−0.68	0.15	0.16	−0.26	0.08	−0.08	0.13	−0.15	0.11	−0.57

Rank	Country	PROTECTING OUR PLANET AND HEALTH (PH)							
		PH1	PH2	PH3	PH4	PH5	PH6	PH7	PH8
1	Sweden	0.64	−0.41	−0.09	0.54	0.00	−0.49	0.43	−0.79
2	Austria	0.13	0.05	0.00	0.80	−0.03	−0.85	0.22	0.06
3	Netherlands	−0.71	−0.06	0.17	−0.35	0.00	0.19	0.25	0.13
4	Belgium	−0.36	−0.41	0.57	−0.22	−0.13	0.05	0.15	0.17
5	Slovenia	0.51	0.48	−0.22	−0.04	0.09	0.15	0.04	0.17
6	Latvia	0.35	−0.32	−0.10	0.27	0.49	0.05	−0.15	0.22
7	France	−0.16	0.00	0.72	−0.10	0.02	0.07	0.27	0.18
8	Germany	−0.17	0.35	0.72	−0.11	−0.06	0.00	0.20	0.18
9	Slovakia	0.17	0.35	0.00	0.13	0.04	0.05	−0.41	0.20
10	Portugal	0.20	−0.21	−0.24	0.51	−0.04	0.14	0.34	0.20
11	Croatia	0.39	0.38	−0.14	−0.15	0.00	0.15	−0.39	0.20
12	Romania	−0.09	−0.18	0.00	−0.32	0.00	0.37	−0.46	0.03
13	Denmark	−0.59	−0.41	−0.06	−0.02	0.04	−0.86	0.34	0.19
14	Malta	−0.73	0.04	−0.21	−0.54	−0.99	0.05	0.21	0.18
15	Estonia	0.40	−0.25	−0.06	0.72	0.38	0.05	0.42	−0.82
16	Finland	0.70	−0.45	−0.13	0.21	0.70	0.05	0.45	−0.85
17	EU (2019)	0.01	−0.02	−0.08	−0.13	−0.04	−0.56	0.09	0.14
18	Czechia	−0.05	−0.22	0.00	0.28	0.03	0.05	−0.23	0.19
19	Spain	0.03	0.00	−0.12	−0.05	−0.76	0.49	0.27	0.20
20	Italy	−0.06	−0.23	−0.14	0.43	0.04	0.28	−0.20	0.19
21	Greece	0.15	0.26	−0.04	0.37	0.00	0.05	−0.38	0.19
22	Hungary	−0.32	−0.21	0.00	−0.27	0.00	0.05	−0.49	0.19
23	Poland	−0.08	0.45	0.02	−0.37	0.00	0.05	−0.64	0.18

Table A2. *Cont.*

Rank	Country								
24	Bulgaria	0.16	0.50	−0.16	−0.46	−0.16	−0.14	−0.87	−0.72
25	Lithuania	−0.01	−0.36	0.05	−0.13	0.00	−0.38	−0.18	0.20
26	Cyprus	0.07	0.37	−0.15	−0.27	0.23	0.05	−0.10	0.19
27	Luxembourg	−0.09	0.92	0.00	−0.28	0.00	0.55	0.39	−0.76
28	Ireland	−0.51	−0.43	−0.30	−0.46	0.10	0.34	0.41	0.19
Rank	**Country**	**ENABLING A GREEN AND JUST TRANSITION (GJ)**							
		GJ1	**GJ2**	**GJ3**	**GJ4**	**GJ5**	**GJ6**	**GJ7**	**GJ8**
1	Sweden	−0.01	−0.19	0.75	0.23	0.47	0.19	−0.15	0.03
2	Austria	0.01	0.21	0.66	0.26	0.18	−0.46	−0.16	0.90
3	Netherlands	0.42	0.90	0.14	0.21	0.04	0.42	−0.09	−0.05
4	Belgium	0.11	0.75	0.72	0.23	−0.06	0.08	−0.12	0.82
5	Slovenia	−0.11	−0.07	0.08	0.26	0.20	0.01	0.00	0.14
6	Latvia	0.04	−0.21	−0.35	0.22	0.25	0.30	−0.02	−0.43
7	France	0.19	0.62	0.14	−0.04	0.22	−0.04	−0.15	−0.01
8	Germany	0.18	0.15	0.62	0.19	0.09	−0.11	−0.19	0.10
9	Slovakia	0.23	−0.09	−0.30	0.20	0.12	−0.09	−0.05	−0.05
10	Portugal	0.12	−0.29	−0.11	−0.77	0.29	0.33	−0.11	−0.09
11	Croatia	0.15	−0.20	−0.21	0.22	0.28	−0.31	0.25	−0.01
12	Romania	−0.67	−0.34	−0.49	−0.08	0.25	0.38	0.50	0.14
13	Denmark	−0.26	−0.15	0.52	0.21	−0.81	0.39	−0.10	0.03
14	Malta	0.26	0.31	−0.43	0.21	0.59	0.47	−0.10	0.03
15	Estonia	−0.49	0.39	−0.07	0.25	−0.63	0.10	−0.06	−0.01
16	Finland	−0.96	−0.38	0.57	0.28	−0.07	−0.10	−0.10	−0.05
17	EU (2019)	0.06	−0.09	−0.11	0.19	−0.06	−0.40	−0.03	−0.01
18	Czechia	0.11	0.07	−0.02	0.22	−0.31	−0.50	−0.17	0.59
19	Spain	0.41	−0.16	−0.21	−0.77	0.19	0.33	−0.18	−0.09
20	Italy	0.26	0.58	−0.21	0.14	0.13	−0.49	−0.12	0.25
21	Greece	0.22	−0.27	−0.18	−0.73	−0.13	−0.94	0.92	−0.27
22	Hungary	0.14	−0.13	−0.21	0.21	0.28	0.12	−0.11	−0.27
23	Poland	0.11	−0.11	−0.18	0.25	−0.58	−0.10	0.07	0.14
24	Bulgaria	0.00	−0.23	−0.35	−0.77	−0.10	0.20	0.96	−0.01
25	Lithuania	−0.09	−0.25	−0.28	−0.76	0.09	0.07	−0.13	−0.05
26	Cyprus	0.02	−0.27	−0.35	−0.57	0.00	−0.35	−0.09	−0.43
27	Luxembourg	−0.64	−0.22	−0.28	0.30	−0.07	0.33	−0.27	−0.67
28	Ireland	0.19	−0.32	0.14	0.21	−0.85	0.18	−0.17	−0.67

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