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Article

Study of Social and Environmental Needs for the Selection of Sustainable Criteria in the Procurement of Public Works

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Abstract: Fostering sustainability in the construction industry has been claimed; however, important barriers are hindering its implementation in public procurement. The main reason is the lack of knowledge about what sustainability criteria should be included and the high level of subjectivity in the definition of their level of importance. Both aspects should be addressed depending on the specific context of each country. Therefore, the aim of this research focused on identifying the sustainability shortcomings that exist in each European Union country in order to determine the level of importance of each sustainability category. Five environmental categories and eight social categories were established, and, to assess the sustainability performance of the 28 European countries, 42 national indicators were selected and the Promethee method was undertaken to rank the countries. Finally, through a cluster analysis, two groups of countries were identified. The first group consisted of the most economically developed European Union countries. These countries need to focus mainly on the environmental performance. However, the second group needs to make an effort in social sustainability at the same time, which controls their environmental performance. This research provides guidance on the decision-making with regard to the inclusion of sustainability in public procurement of the construction industry.

Keywords: multicriteria analysis; public procurement; environmental criteria; social criteria; Promethee; sustainability

1. Introduction

Civil engineering projects are necessary for the development of society, especially for the economic development of countries [1]. However, construction is a critical industry with important effects on the environment, economy, and society [2,3]. For that reason, the need to ensure sustainable development in this industry has been demanded [4]. Developing new infrastructures and maintaining the existing ones is sustainable when the market demands in terms of social, environmental, and economic sustainability are satisfied [5].

Public procurement has been claimed as the best alternative to influence the market in terms of sustainable production and consumption since it represents large volumes of public spending each year [6]. In this regard, in the European Union (EU henceforth), the legal evolution from 2004 to 2014 has opened an opportunity to contribute to different social and environmental objectives [7]. Firstly, green public procurement was boosted as a key instrument to reduce the environmental impact of organizations [8,9]. The 2004 directives (Directive 2004/18/EC and Directive 2004/17/EC) explicitly stated that environmental criteria could be considered in procurement procedures as obligatory technical specifications for the product or service or as award criteria [9]. Subsequently, social considerations became relevant in public procurement [10]. The 2014 directives (Directive 2014/24/EU, Directive 2014/25/EU, and Directive 2014/23/EU) promoted a different approach in both the employment context and in supplier diversity. New and powerful terms were presented to go beyond and providing broader social benefits [11,12]. On the one hand, the directives increased the scope for contracting authorities to include social and environmental considerations in the design and execution of public tenders and, on the other hand, gave the member states some freedom to define national mechanisms to include social considerations in public procurement [10,12]. In this regard, Directive 2014/24/EU fosters contracting authorities to determine the most economically advantageous tender using social and environmental life cycle costing approach. Additionally, articles 67 and 68 of this directive set out a nonexhaustive list of possible award criteria, which includes environmental and social aspects. The aim of this list was to encourage contracting authorities to choose social and environmental award criteria in order to exploit the potential of public procurement to achieve the objectives of the Europe 2020 strategy [13].

In the construction industry, the design and construction of civil engineering projects are carried out mainly through public procurement procedures [2]. For that reason, the role of public procurement to promote the inclusion of sustainability has been proclaimed as a key element to favor the transformation of the construction sector towards sustainable construction [4]. However, currently, there are important barriers that prevent the effective inclusion of social and environmental criteria in procurement [8,14,15]. This mainly happens because of the lack of knowledge regarding the sustainability criteria that should be included in tenders and how these should be included to ensure their objective evaluation [16,17]. In addition, the level of importance assigned to these types of criteria in bidding processes is generally defined based on the intuition of public administration personnel and, thus, with a high level of subjectivity **[4,15]**. This is because there is an absence of a clear methodology that helps procurers to decide the criteria that should be considered in the bidding processes, as well as to assist in having an orientation regarding the weights that should be assigned to each one of them [15,18]. In this regard, a quantitative analysis of the sustainable development of different countries can help to understand the constraints and to propose specific measures to enhance sustainability [19]. In fact, Montalbán-Domingo et al. [14] highlighted the importance of taking into account the specific context of each country for both deciding the sustainable criteria to be included in public procurement and establishing the level of importance of these criteria in procurement procedures.

National indicators can be used to assess the sustainable performance of counties [20]. A large number of organizations have worked to define national indicators for different social and environmental topics [21]. The proof is that the World Bank's databank collects more than 1000 indicators defined by more than 70 different organizations, the United Nations established more than 200 indicators to assess the sustainable development goals, and the EU Sustainable Development Strategy defined more than 130 indicators to monitor and assess the progress towards the sustainable development [22]. Previous authors [14,16] have used national indicators to carry out comparative analyses of the sustainable performances of the EU Member States. Phillis et al. [23] evaluated the sustainable development of 106 cities in different countries and Widomski et al. [24] compared the sustainable development of Lublin and Poland with other EU countries. One of the main conclusions of these works was the importance of using multivariate data mining techniques for analysis of sustainable performance [19]. In this regard, the use of national indicators, joined with multicriteria decision (MCD) techniques, can be used for identifying the sustainable needs of each country [22]. In addition, this approach can assist procurers in their decision-making with respect to the sustainability criteria to be considered and the level of importance to be assigned to each of them [16].

Therefore, the aim of this paper was to identify the sustainable deficiencies of each European Union country (EU country henceforth) through a cross-country comparison. The use of Promethee was proposed for performing an objective measurement and assessment of sustainability performance. This way, the paper is organized as follows: Section 2 establishes the environmental and social criteria that should be included in public procurement of the construction industry; Section 3 details the method; Section 4 collects the results; a discussion of the research findings is comprised in Section 5; and, finally, Section 6 presents the concluding remarks, limitations, and future work.

2. Environmental and Social Criteria

In the construction industry, environmental sustainability can be understood as the protection of natural resources in order to reduce energy and water consumption, using renewable resources, and minimizing pollution [25]. Measuring environmental sustainability requires a careful evaluation of a wide range of criteria [26]. Initially, the inclusion of environmental criteria in public procurement focused only on controlling pollution. Subsequently, there was an evolution, and criteria such as recycling, reusing, waste disposal during production, energy use, the use of harmful substances, CO_2 emissions, work environment, noise control, and environmental management systems in the contractor's organization were included [27–30]. However, although environmental sustainability has emerged as an important field, this term has been misinterpreted in public procurement [8,30], and a limited number of environmental aspects has been considered in many instances [31].

Therefore, in order to clarify the environmental criteria that should be considered to assess the environmental performance in construction tendering documents, a deeper investigation into environmental sustainability was performed. This study reviewed guides, reports, books, sustainability certification systems, and scientific literature in order to determine the environmental categories that should be considered in public procurement of the construction industry. Environmental categories were grouped using the affinity diagram technique [32] into five categories: energy, emissions, waste, water, and flora and fauna. Fourteen subcategories were established to explain these five categories. Table 1 gathers a brief description of each environmental subcategory.

Table 1. Environmental categories and subcategories.

Category	Subcategory	Source	Justification and Explanation
Energy	Minimization and control of energy consumption	[33–38]	Improving energy efficiency is important to reduce the dependency on energy imports and to reduce pollution. To that end, the literature highlights the use of energy monitoring systems and getting energy performance certificates at the project level.
	Use of renewable energies	[18,26,38–40]	The generation of energy from fossil fuels produces greenhouse gas emissions, resource depletion, emissions of air pollutants, ocean acidification, and water pollution.
Emissions	Reducing and control the emissions of polluting gases	[33–35,38,40,41]	Emissions of greenhouse gases contribute to multiple global climate change impacts and exacerbate oceanic acidification.
	Minimizing the emissions of dust and other particles	[33,34,42,43]	Construction dust is one of the main sources of air emissions during an infrastructure's lifecycle.
Waste	Construction/demolition waste management and disposal	[26,33,34,44]	Proper waste management is essential to guarantee lower rates of sending waste to landfill, placing less strain on natural.
	Reduction of pollution caused by the spillage	[38,44–46]	In the construction industry, the reduction of spillage through conservation measures is demanded. An example is the creation of settlement lagoons intended to protect watercourses from pollution by containment of spillages.
	Recycling and reusing	[12,29,33,36,41]	Recycled and reused materials have been recognized as making an important contribution to reducing landfill and conserving nonrenewable resources.
	Minimizing waste generation	[35,37,44,47]	Waste has an important part to play in reducing carbon dioxide emissions.

Table 1. *Cont.*

Category	Subcategory	Source	Justification and Explanation
Water	Water quality protection and control	[18,36,39]	Water quality in streams can be affected by the construction. Having a hydro geological protection system and storm water management is essential during the construction works.
	Treatment and restoration measures	[38,48,49]	Pollutant removal can be an important component of protecting stream water quality.
	Minimizing water consumption	[38,45,50]	It is critical that infrastructure projects reduce overall water use, particularly potable water. One of the main impacts of civil engineering works on the water can be consumption during the contract period and subsequent operation of whatever facilities have been worked.
Flora and Fauna	Protection of vegetation and restoration of natural vegetation and damaged lands	[38,51–53]	In the construction industry, establishing measures to minimize the effect on natural vegetation is important as well as protecting nonhazardous trees and native plant communities and planting/replacing vegetation in a way that extends well beyond typical practices.
	Protection and control of fauna species	[38,47,51,53,54]	The extinction of threatened species needs to be prevented. In the construction industry, the safe passage of small fauna and amphibious or aquatic species across the infrastructures need to be ensured as well as during the construction.
	Erosion and sedimentation plan	[26,38,50,55]	Soil erosion decreasing agricultural productivity and carbon sequestration capacities. Additionally, reducing sedimentation during construction and in adjacent areas can help protect water quality.

On the other hand, regarding the social dimension of sustainability, this can be understood as the processes for improving health, safety, and well-being conditions of any person affected directly or indirectly by development efforts [56]. Montalbán-Domingo et al. [14] established eight social categories to be considered in public procurement of the construction industry. These eight categories are: cultural heritage, employment, health and safety, local, professional ethics, public participation, training, and users' impact. Based on these categories, a literature review was performed to establish the subcategories associated with each of them. Table 2 gathers a brief description of each social subcategory.

Table 2. Social categories and subcategories.

Category	Subcategory	Source	Justification and Explanation
Cultural Heritage	Cultural heritage appraisal and management plan	[38,41,57,58]	A historic environment management plan should be defined if there are historic–environment aspects to the site or its vicinity.
	Collaboration with historical or cultural preservationists	[38,57]	Including appropriate historical environment professionals (archaeologist, conservation architect, or historic buildings specialist) on the project team to manage and inspect the mitigation effort is recommended in construction projects.
Employment	Employment creation	[59,60]	The ratio of employee hires in an organization allows showing the effort made by the organization to enhance and revitalize the area where they operate.
	Job stability	[60–62]	Refers mainly to employee turnover. This allows assessing the levels of uncertainty and dissatisfaction among employees.
	Industry participation plan	[57,63,64]	In construction projects, the company needs to determine the expected degree to which the project will contribute to local firms' employment.

Table 2. *Cont.*

Category	Subcategory	Source	Justification and Explanation
Health and Safety	Work health and safety management officer	[63,65]	The contractor should hire a competent person authorized as a safety officer.
	Occupational health and safety performance	[63,65–67]	Occupational accidents lower employee productivity and could be symptomatic of poor management quality and lack of adequate internal management systems.
	Workplace health and safety management plan	[38,60]	The project team must define workplace health and safety plans and programs according to the characteristics and complexity of the project.
	Social benefits and social security	[63,65,68]	Occupational health and safety programs, services, and systems prevent harm and protect workers from work-related injuries and ill health.
Local Development	Local preference	[57]	The inclusion of local criteria in public procurement can protect local contractors and workers from foreign companies.
	Local employment through the use of local products and services	[57,63]	Encouraging the participation of local companies in construction projects can have direct and indirect benefits for the community. The employment of local people or the use of local products and services can reduce the distances traveled to and from work and decrease the inconveniences over local communities.
	Social value	[38,60,67,69,70]	Social value is based on promoting social responsibility on the contractors and subcontractors to commit to acting in a socially responsible way, and boosting the public commitments through training and raising community awareness in relation to the sustainable development.
Professional Ethics	Nondiscrimination and equal opportunities	[63,65,71]	Organization that actively promotes diversity and equality at work can directly generate significant benefits for both the workers and organization.
	Fair wages and fair income distributions	[63,65]	It focuses on ensuring that workers are capable to provide for their own needs and those of their families and guarantees a minimum wage to contribute to stability and prosperity in communities and attract more skilled, productive, and loyal employees.
	Child labor	[63,65]	Child labor results in underskilled and unhealthy workers for tomorrow and perpetuates poverty across generations.
	Forced labor	[63,65]	It is expected of an organization to prevent and combat all forms of forced or compulsory labor within its activities, being essential to avoid contributing to or becoming linked to the use of forced or compulsory labor through its relationships with suppliers, clients, etc.
	Freedom of association and collective bargaining	[63,65]	Freedom of association and collective bargaining are recognized as human rights by international conventions and agreements.
	Corruption	[63,65,72,73]	Corruption and bribery imply serious moral and political concerns, undermine good governance and economic development, and distort international competitive conditions.
	Respect of indigenous rights	[63]	The respect of indigenous rights must include their right to lands, resources, cultural integrity, self-determination, and self-government.
	Respect of intellectual property rights	[63]	Organizations must respect and safeguard the moral and economic rights of the creators of intellectual property.
Public Participation	Community relations program	[38,57,67,74–76]	The views of stakeholders can be actively considered in the construction stage of the project through an appropriate community relations program during the project.

Table 2. *Cont.*

Category	Subcategory	Source	Justification and Explanation
Training	Technical training	[38,40,65]	Training of employees reflects in their skills and capabilities, improving their performance and productivity.
	Sustainability training	[60,65,73,77–79]	To boost the organization's capacity to implement its human rights policies and procedures, specialized training has to be implemented in organizations to identify, prevent, and mitigate their negative human rights impacts.
Users' Impact	Effects on neighbors	[38,57,67]	A traffic management plan to limit the impact on users during the construction period is demanded, as well as the definition of control measures to put in place to minimize noise, dust, and pollution during the construction works.

3. Research Method

3.1. Overall Approach

This research characterized the social and environmental deficiencies that exist in the EU countries. Cook et al. [26] proposed the use of national indicators to evaluate and compare the sustainable performance of each country. Based on this, the methodology presented used national indicators to characterize these deficiencies. For that purpose, firstly, the databases that should be considered to extract the sustainability indicators of each country were selected. Indicators related to the proposed environmental and social categories were identified in each database. Subsequently, these indicators were evaluated and a statistical analysis was carried out in order to analyze the relationship between the selected indicators. Finally, the Promethee tool was applied to characterize the sustainable performance of the European countries and the results were assessed through a cluster analysis.

Out of the eight social categories, employment, health and safety, professional ethics, and training are addressed in this work. The categories of cultural heritage, local development, public participation, and users' impact depend on the specific context of each project and, therefore, could not be assessed through national indicators. On the other hand, the subcategories of child labor, forced labor, freedom of association and collective bargaining, corruption, respect of indigenous rights, and respect of intellectual property rights are fundamental human rights to be duly fulfilled by each member state.

3.2. Selection of National Indicators

Identifying the social weaknesses in a country is largely determined by the appropriateness of the national indicators used [19]. In this regard, a large number of organizations have contributed significantly to the development of sustainable development indicators at the national level [21]. Organizations such as Eurostat [80], the Organization for Economic Co-operation and Development (OECD) [81], the Sustainable Governance Indicators (SGI) [82], the International Labor Organization (ILO) [83], or the United Nations Conference on Sustainable Development (UNCSD) [84], among others, have a wide sample of national indicators in different fields. Therefore, in order to guarantee the appropriateness of the national indicators to use in this research, data sources possessing a quality assurance framework, such as those belonging to the Eurostat database [26], are preferred whenever possible.

A top-down approach was defined to evaluate, screen, and filter national indicators [85]. A 'theoretical' assessment was undertaken to evaluate the national indicators according to a set of quality criteria. Different quality criteria exist in the literature review to assess national indicators. Cook et al. [26] proposed the following quality criteria to select indicators to measure countries' environmental sustainability performance: policy relevance, utility, soundness, interpretability, and data availability and quality. Nardo et al. [86] highlighted that national indicators should be selected based on their analytical soundness, measurability, country coverage, and relevance to the phenomenon being measured. The International Monetary Fund uses the following criteria: assurance of integrity, methodological soundness, accuracy and reliability, serviceability, and accessibility [87]. Therefore, six quality criteria were defined to assess the national indicators: (1) relevance, to select the indicators related to some environmental or social category; (2) utility, to judge if the indicators were easily understandable; (3) measurable, to assess if the indicator was defined at the national scale; (4) countries coverage, to select the indicators which were available for all the EU countries; (5) time coverage, to screen indicators with data available for some of the years 2014, 2015, and 2016; and (6) soundness, to filter only those indicators with metadata available.

The databases of Eurostat [80], ILO [83], OECD [81], SGI [82], UNCSD [84], and the World Bank [88] were analyzed, and national indicators were selected only in case these satisfied the criteria relevance and utility. In this first filter, 186 environmental indicators and 153 social indicators were collected. These were subjected to a second screening based on the criteria measurable, time coverage, and soundness. This analysis resulted in 54 environmental indicators and 68 social indicators. After rejecting redundant indicators, 42 national indicators were selected (18 environmental and 24 social).

3.3. Discrimination Analysis

The coefficient of variation (CV) of each indicator was used to select only those indicators whose information is relevant to highlight the differences between countries in the sample [19]. This method has been widely used to simplify system analyses and obtain optimal subsets of national indicators [89]. When an indicator has similar values for all the countries, this represents that the discrimination of this indicator is too weak to recognize the differences among them [19]. CV can be calculated as the ratio between the standard deviation and the average value of each indicator (Equation (1)).

$$CV_i = \frac{\sqrt{\frac{1}{n-1}\sum\left(X_i - \overline{X}\right)^2}}{\overline{X}} \tag{1}$$

where $\overline{X}$ is the average value ($\frac{1}{n}\sum_{i=1}^{n} X_i$). The CV was calculated using SPSS 23.0 software. Low values of CV indicate that the indicator is too weak to discriminate the performance of the countries and the higher the CV, the more heterogeneous the sample is considered. Therefore, if it is lower than an established value, the indicator is removed from the analysis because it does not show diversified information. In this work, 0.10 was used as an acceptable reference level [90].

3.4. Correlation Analysis

To assess the suitability of the dataset, a correlation analysis was performed. A correlation analysis allows for identifying those indicators that provide identical information. Through this method, multicollinearity can be detected, and redundant indicators can be excluded [87]. Multicollinearity is identified through the correlation matrix. The multicollinearity corresponds to those indicators most highly correlated (coefficient correlation above 0.80).

According to Field [91], three types of correlation coefficients can be calculated to define the correlation matrix: (1) Pearson's correlation coefficient, which requires a normally distributed sample to assess the significance of the correlation; (2) Spearman's correlation coefficient, which is a nonparametric statistic and can be used when the data do not present a normal distribution; and, (3) Kendall's tau, which is another nonparametric correlation. The latter is recommended rather than Spearman's coefficient when the dataset is small, offering, in small samples, a better estimate of the correlation. These tests assume as null hypothesis that the correlation coefficient between variables is not significantly different from zero, being satisfied with this condition when the p-value is less than 0.5 [92]. Additionally, these correlation coefficients (r) represent the standardized covariance. The coefficients go from −1 to +1. A coefficient of +1 indicates that the two variables are perfectly positively correlated; a coefficient of −1 indicates a perfect negative relationship and a coefficient of zero indicates no linear relationship.

To measure the size of an effect, values of ±0.1 represent a small effect, ±0.3 a medium effect, and ±0.5 a large effect [91].

Thus, to select the correlation analysis to be performed, the normality of the sample was analyzed. Taking into account that the sample includes 28 countries, the Shapiro–Wilk test of normality was applied because the sample size was small (less than 50) [92]. This test compares the scores in the sample to a normally distributed set of scores with the same mean and standard deviation. If the test is nonsignificant ($p > 0.05$), the distribution of the sample is not significantly different from a normal distribution. However, if the test is significant ($p < 0.05$), the distribution in question is significantly different from a normal distribution [91]. Therefore, after analyzing the normality of the sample, the appropriate method of the correlation analysis was used to delete the highly correlated indicators (coefficient correlation above 0.80), resulting in the final list of national indicators.

3.5. Promethee

The Promethee method was developed by Jean-Pierre Brans in 1980s [93]. This method can provide a ranking of countries, from the best to the worst, based on their performances in a finite set of indicators [94]. This method is based on a pairwise comparison of countries along each indicator. Countries are evaluated according to different indicators, which have to be maximized or minimized. The Promethee includes both the Promethee I and the Promethee II. Promethee I performs a partial ranking in order to calculate the extent to which the performance of a country is better than the others (positive outranking flow—$\Phi^+(\mathrm{a})$), and the extent to which it is worse than the other countries (negative outranking flow$\Phi^-(\mathrm{a})$) [95]. Promethee II calculates a net outranking flow ($\Phi(\mathrm{a})$) for each country, determining its ranking based on Promethee I partial positive ($\Phi^+(\mathrm{a})$) and negative ($\Phi^-(\mathrm{a})$) flow rankings (Equation (2)) [95]:

$$(a) = \Phi^+(a) - \Phi^-(a) \quad (2)$$

The positive ($\Phi^+(\mathrm{a})$) and negative ($\Phi^-(\mathrm{a})$) flow rankings are evaluated based on the positive and negative differences between the evaluations of the alternatives on each indicator. For each indicator, a preference function must be computed to translate the difference between the evaluations obtained by two countries into a preference degree ranging from zero to one [96]. The preference function is the V-shaped function with the strict preference threshold (p); this is the maximum value of each indicator, if the indicators need to be maximized, while, in the case of indicators to be minimized, the value of this threshold will be the maximum as well, but with a negative sign [97]. In addition, this method requires the definition of weights and the selection of preference functions that convert the difference between alternatives into a ranging [22]. As defining weights in sustainability assessment is a highly subjective task [63], in this research, the weights were set to 1 for all the indicators, considering that every indicator had the same level of importance. Behzadian et al. [96] presented a detailed description of Promethee II. In this study, the analyzed sample was based on the 28 EU countries: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom.

3.6. Cluster Analysis

Finally, a cluster analysis was applied to analyze the results of Promethee. This method is the most appropriate hierarchical conglomerate analysis for small samples [98] and allows researchers to group the countries according to their performances in each criteria. The grouping method selected was the Ward method [99]. This method minimizes intergroup variance, while uniformity within the groups is maximized [91]. As the method is highly sensitive to outliers [98], the squared Euclidean distance was considered to assess the distance measures between observation units.

4. Results

4.1. Selected Indicators

A set of 41 indicators was obtained (see Table 3), of which the coefficient of variation (CV) was in all cases greater than 0.10. This last set was with the values recorded from 2014 to 2017, and an average was calculated between these four years, since not all countries presented data for all years.

Table 3. Environmental and social national indicators.

Categories	National Indicators	Unit	Source	CV
E1: Energy	Share of renewable energy in gross final energy consumption	%	Eurostat database	0.60
	Final energy consumption	Millions of tons of oil equivalent	Eurostat database	0.49
	Fossil fuel energy consumption	%	Eurostat database	0.27
E2: Emissions	CO_2 emissions	Metric tons per capita	Eurostat database	0.47
	CO_2 emissions from manufacturing industries and construction	% of total fuel combustion	Eurostat database	0.36
	PM2.5 air pollution, population exposed to levels exceeding WHO * guideline value	% of total	Eurostat database	0.45
	Greenhouse gas emissions	Metric tons per capita	Eurostat database	0.36
E3: Waste	Generation of waste excluding major mineral wastes by hazardousness	kg per capita	Eurostat database	0.80
	Waste in the construction sector	kg per capita	Eurostat database	1.43
E4: Water	Annual freshwater withdrawals	% of internal resources	World Bank **	1.16
	Percentage of anthropogenic wastewater that receives treatment	%	World Bank **	0.80
E5: Flora and Fauna	Adjusted savings: natural resources depletion	% of GNI	World Bank **	1.32
	Adjusted savings: net forest depletion	% of GNI	World Bank **	4.27
	Bird species, threatened	Number	World Bank **	0.33
	Fish species, threatened	Number	World Bank **	0.91
	Mammal species, threatened	Number	World Bank **	0.78
	Plant species, threatened	Number	World Bank **	1.70
S1: Employment	Temporary employment	%	Eurostat database	0.57
	Unemployment with advanced education	% of total labor force with advanced education	World Bank ***	0.72
	Unemployment with basic education	% of total labor force with basic education	World Bank ***	0.44
	Unemployment with intermediate education	% of total labor force with intermediate education	World Bank ***	0.62
	Unemployment, female	%	World Bank ***	0.60
	Unemployment, total	%	World Bank ***	0.51
	Youth unemployment rate	% of labor force ages 15–24	World Bank ***	0.50
	Job tenure	% of labor force	World Bank ***	0.24
	Long-term unemployment rate	% of unemployed	Eurostat database	0.80
	Unemployment rate of foreign-born	% of unemployed	Eurostat database	0.51

Table 3. *Cont.*

Categories	National Indicators	Unit	Source	CV
S2: Health and Safety	Death rate due to chronic disease	Number per 100,000 persons aged less than 65	Eurostat database	0.38
	Fatal accidents at work	Number of fatal accidents per 100,000 workers	Eurostat database	0.54
	Nonfatal accidents at work	Number of nonfatal accidents per 100,000 workers	Eurostat database	0.90
	Public health expenditure	% of GDP	Eurostat database	0.22
S3: Professional Ethics	Employed women being in managerial positions	% employed persons in managerial positions	Eurostat database	0.18
	Ratio of female to male labor force participation rate	%	World Bank ***	0.12
	Ratio of female to male salary	%	Eurostat database	0.13
	Human development index	Scale of 0 to 100	Eurostat database	0.11
	Employed persons at risk of poverty rate	% of labor force	Eurostat database	0.41
	Unemployment rate of disabled people	% of unemployed	World Bank ***	0.40
	Unemployment rate of foreign-born	% of unemployed	Eurostat database	0.51
	Corruption Perception Index	Scale of 0 to 100	Eurostat database	0.20
S4: Training	Employed persons participating in job-related nonformal education and training in the past 12 months	% of labor force	Eurostat database	0.33
	Patent applications	Number per million inhabitants	Eurostat database	1.17
	Research and development expenditure	% of GDP	Eurostat database	0.55

* WHO: World Health Organization; ** World Development Indicators database; ***; ILOSTAT database.

To determine the correlation analysis, the normality of the sample was analyzed. The results of the Shapiro–Wilk normality tests showed that only 13 indicators were normally distributed (p-value > 0.05). Therefore, the correlation matrix was calculated through Kendall's tau test. The correlation analysis was carried out using IBM SPSS Statistics 23.0. Table 4 shows the correlated indicators characterized by multicollinearity (Kendall's correlations > 0.8). As it can be observed, the indicator "unemployment total" was highly correlated with the indicators: "long-term unemployment rate" (0.801), "unemployment female" (0.887), "youth unemployment rate" (0.820), "unemployment rate by foreign-born" (0.802), "unemployment with advanced education" (0.836), "unemployment with intermediate education" (0.819), and "unemployment with basic education" (0.855). Similarly, the indicator "patent applications" was highly correlated with "research and development expenditure" (0.814). Consequently, the indicators "unemployment total" and "research and development expenditure" were considered, and the rest of the indicators characterized by multicollinearity were rejected.

4.2. Promethee Results

As a result of using Promethee, a ranking of countries for each category was obtained. Table 5 presents the net preference flows of each category for the 28 EU Countries. The best and the worst performances for each category are highlighted in bold. Regarding the environmental categories, Luxemburg was the country with the worst performances in energy (E1: −0.41), emissions (E2: −0.31), and waste (E3: −0.45); however, this country had the best performances in water (E4: 0.24) and flora and fauna (E5: 0.24). With regard to the social categories, the countries with the best performances were:

Romania in employment (S1: 0.31), Sweden in health and safety (S2: 0.25), and Finland in professional ethics and training. Spain showed the worst performances in the categories of employment (S1: −0.40) and professional ethics (S3: −0.13). Greece showed the worst performance in training (S4: −0.41).

Table 4. Main results of correlation analysis.

Correlated Indicators	Correlation Coefficient	Sig. (2-Tailed)	N
Long-term unemployment rate—Unemployment, total	0.801	0.000	28
Unemployment, female—Unemployment, total	0.887	0.000	28
Youth unemployment rate—Unemployment, total	0.820	0.000	28
Unemployment rate by foreign-born—Unemployment, total	0.802	0.000	28
Unemployment with advanced education—Unemployment, total	0.836	0.000	28
Unemployment with intermediate education—Unemployment, total	0.819	0.000	28
Unemployment with basic education—Unemployment, total	0.855	0.001	28
Patent applications—Research and development expenditure	0.814	0.000	28

Table 5. Net preference flow of each category.

Country	E1	E2	E3	E4	E5	S1	S2	S3	S4
Austria	0.02	−0.10	−0.14	0.05	0.08	0.07	0.07	0.07	0.25
Belgium	−0.16	−0.17	−0.07	−0.11	0.15	0.10	0.03	0.10	0.20
Bulgaria	0.06	0.02	0.04	−0.14	−0.19	0.17	−0.10	−0.06	−0.35
Croatia	0.12	0.01	0.14	−0.08	−0.15	−0.18	0.01	−0.05	−0.24
Cyprus	−0.04	−0.04	0.10	−0.35	0.08	−0.22	−0.01	−0.02	−0.32
Czech Republic	−0.06	−0.14	0.08	0.06	0.14	0.14	0.05	−0.03	0.19
Denmark	0.07	0.06	0.00	0.19	0.02	−0.07	0.08	0.10	0.22
Estonia	0.15	0.07	−0.36	0.07	0.15	0.11	0.00	−0.06	0.13
Finland	−0.02	0.12	−0.14	0.17	0.11	−0.10	0.02	0.13	0.43
France	0.02	0.00	−0.06	0.11	−0.10	−0.05	−0.11	0.03	0.13
Germany	−0.09	−0.10	−0.04	0.23	0.03	0.07	0.06	0.01	0.23
Greece	0.01	0.00	0.07	0.10	−0.22	−0.15	0.05	−0.12	−0.41
Hungary	0.03	0.00	0.10	−0.40	0.04	0.07	−0.12	−0.07	−0.16
Ireland	−0.08	0.10	0.07	0.12	0.07	0.06	0.07	0.03	0.12
Italy	0.01	0.02	0.05	0.06	−0.15	−0.02	0.05	−0.05	−0.12
Latvia	0.18	0.04	0.12	0.13	0.15	0.09	−0.02	−0.01	−0.18
Lithuania	0.08	0.03	0.12	−0.02	0.15	0.08	−0.16	−0.07	−0.14
Luxembourg	−0.41	−0.31	−0.45	0.24	0.24	0.09	−0.03	0.02	0.06
Malta	−0.05	0.13	−0.01	−0.44	0.16	0.16	−0.06	0.02	−0.12
Netherlands	−0.19	−0.15	−0.22	−0.24	0.02	−0.06	0.23	0.07	0.19
Poland	−0.04	−0.05	0.06	−0.04	−0.14	−0.11	0.04	0.02	−0.13
Portugal	0.10	0.22	0.11	−0.04	−0.21	−0.17	−0.30	−0.03	−0.15
Romania	0.12	−0.02	0.12	−0.25	−0.17	0.31	−0.16	−0.09	−0.36
Slovak Republic	0.00	−0.03	0.08	0.03	0.05	0.03	0.04	−0.06	−0.03
Slovenia	0.03	−0.15	0.10	0.03	0.08	−0.03	-0.05	0.07	0.20
Spain	0.03	0.17	0.09	0.07	−0.42	−0.40	−0.11	−0.13	−0.11
Sweden	0.17	0.24	0.03	0.23	0.11	−0.12	0.25	0.12	−0.02
UK	−0.06	0.03	0.01	0.24	−0.08	0.12	0.19	0.06	0.13

Note: E1: energy, E2: emissions, E3: waste, E4: water, E5: flora and fauna, S1: employment, S2: health and safety, S3: professional ethics, S4: training.

Figure 1 shows the performance of each category for each country according to their positions in the rankings. For example, Austria showed the worst performances, first, in the categories emissions and waste and, second, in water. However, this country was in the best position regarding training, health and safety, and professional ethics. Ireland presented a good performance for most of the categories except for energy. Denmark and Slovak's republic did not occupy positions over 21 for any category.

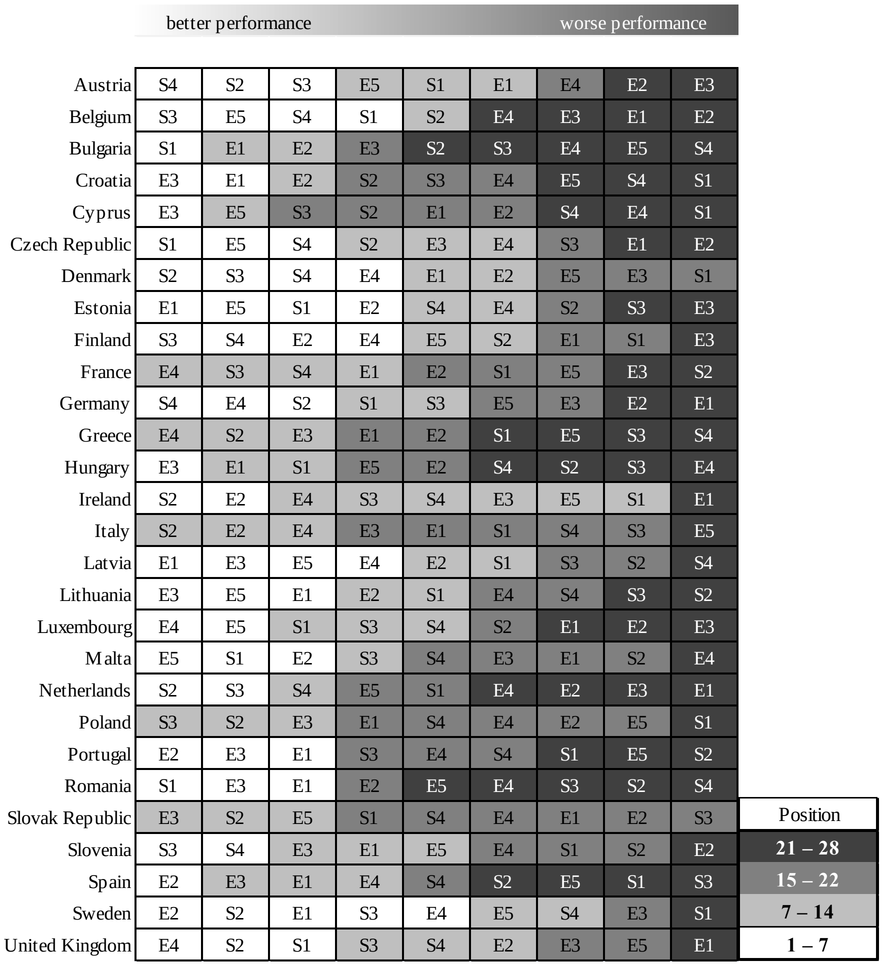

Figure 1. Performance of the EU countries. Note: E1: Energy; E2: Emissions; E3: Waste; E4: Water; E5: Flora and Fauna; S1: Employment; S2: Health and Safety; S3: Professional Ethics; S4: Training.

Finally, in order to understand the sustainable behavior of the EU countries, a cluster analysis was applied. Two groups of countries were identified. Figure 2 shows the results of the hierarchical agglomeration for the observed EU countries. On the basis of the results of the cluster analysis, it can be stated that two groups can be identified in terms of sustainable development. The first cluster consists of Germany, Austria, Czech Republic, Belgium, Netherlands, Luxembourg, Ireland, United Kingdom, Denmark, Sweden, and Finland. The second cluster is made up of Slovak Republic, Italy, Poland, Cyprus, Slovenia, France, Spain, Portugal, Croatia, Greece, Estonia, Malta, Hungary, Lithuania, Bulgaria, Romania, and Latvia.

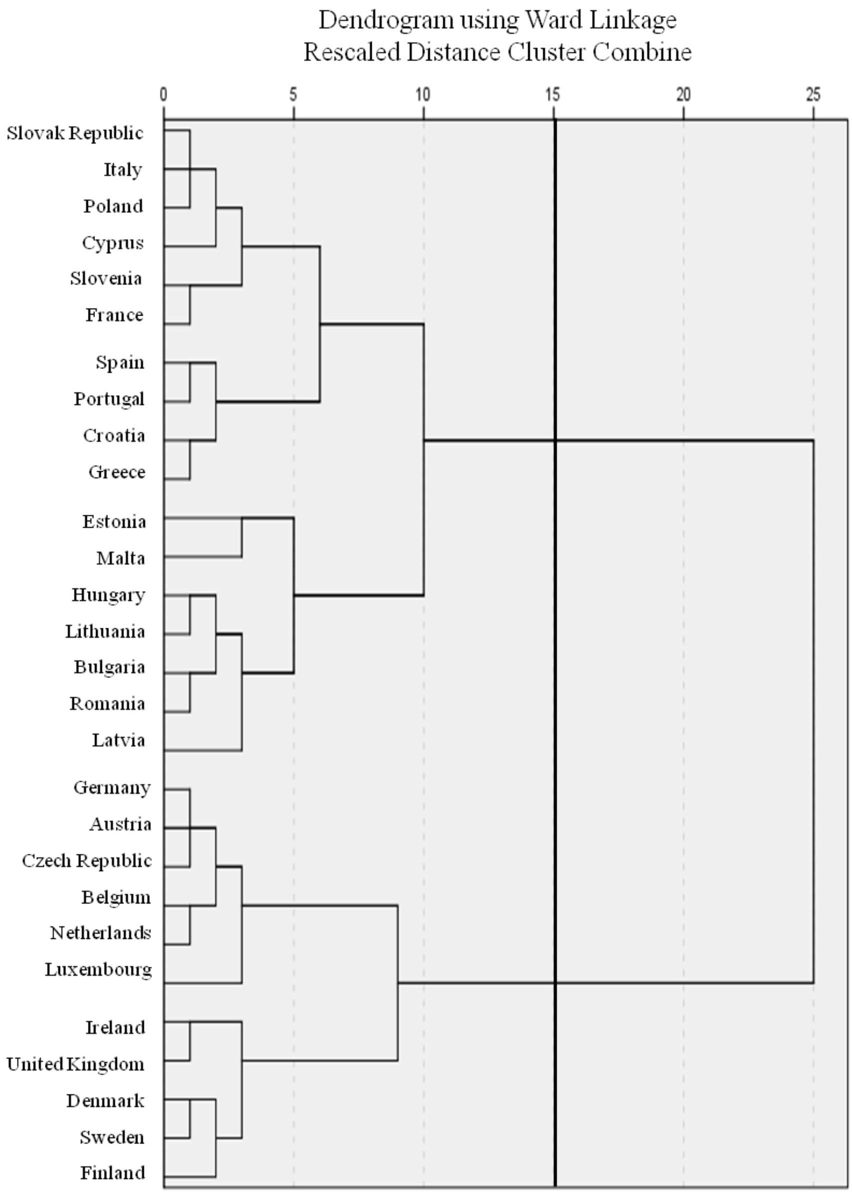

Figure 2. Dendrogram of cluster analysis.

5. Discussion

Most of the EU countries have implemented policies to improve their sustainable performance [100]. In this regard, two groups have been identified through the cluster analysis. The first one consists of the most economically developed EU countries (north–west axis): Germany, Austria, Czech Republic, Belgium, Netherlands, Luxembourg, Ireland, United Kingdom, Denmark, Sweden, and Finland. These countries have fostered strong strategies to improve their sustainability performance for years [22,95] and share a good performance in social sustainability, with a high level of human, and inclusive development [22]. However, as Szopik-Depczyńska et al. [20] stated, a greater volume of economic activities leads to worse results in the environmental indicators with respect to countries with less economic activities. For that reason, this group of countries needs to continue working on the improvement of their environmental performance. On the other hand, countries in the second cluster are the least successful in achieving their sustainable development goals. This set corresponds with the less developed economies in Europe (south–east axis). These countries are: Slovak Republic, Italy, Poland, Cyprus, Slovenia, France, Spain, Portugal, Croatia, Greece, Estonia, Malta, Hungary, Lithuania, Bulgaria, Romania, and Latvia. These countries share the need to make an effort mainly in social sustainability, with it being necessary to improve their performances in aspects such as full employment, professional ethics, and training, without ignoring their performance in the environmental aspects [22,95]. In order to achieve a deeper understanding, the main results for each environmental and social category are analyzed in-depth in the following sections.

5.1. Energy

Latvia, Sweden, Estonia, Romania, and Croatia were in the top five places; however, Germany, Belgium, Netherlands and Luxemburg showed the worst energy performance. Some authors [20,22] have indicated that more economically developed countries will score poorer more often than less developed countries [101], as a greater volume of economic activities leads to more energy consumption [102]. Although Sweden was one of the countries with the highest energy consumption, this country was by far the best performer in renewable energy, since the 54% of its energy came from renewable energy, followed by Latvia, Austria, and Denmark. However, Romania has a good position in the ranking because this country presented the lowest energy consumption. Regarding Latvia and Estonia, their energy consumptions were among the average values of EU countries; however, these countries had high percentages of renewable energy (37.8% Latvia and 27.9% Estonia).

Congestion can greatly influence vehicle fuel consumption due to queues and associated slowdown, both in the construction and in the maintenance phase of high traffic roads.

5.2. Emissions

For this criterion, Sweden, Portugal and Spain showed the best performances. Sweden was the country with the best values in population exposed to levels that exceed the World Health Organization reference value and emissions of greenhouse gases. Portugal and Spain obtained the second and third position thanks to their performances in CO_2 emissions and PM2.5 air pollution. On the other hand, Luxemburg, Belgium, and Netherlands showed the highest values in emissions generation, results which were in line with the energy results [22]. These results were expected as, according to the European Environmental Agency [103], the largest proportion of emissions come from energy production and consumption.

5.3. Waste

Croatia, Latvia, Romania, and Lithuania were the countries with the lowest values in waste generation. In this regard, it is important to highlight that waste generation directly depends on the population, the economic development of the country, and the main activities carried out [22]. Additionally, the indicator “waste generation excluding the main dangerous mineral waste” excludes the main mineral wastes such as dredging offal and contaminated soils. Large quantities of mineral waste are produced in some countries such as Romania [103], allowing the country to be among the first places.

5.4. Water

Luxembourg, the United Kingdom, and Sweden were in the top three positions as they presented the best values of “annual freshwater withdrawals” and “percentage of anthropogenic wastewater that receives treatment”. According to Kristensen et al. [104], the extraction of fresh water depends in part on several socioeconomic factors, mainly population, physiography, and climatic characteristics. Additionally, Antanasijević et al. [22] highlighted that countries such as Cyprus, Estonia, or the Netherlands have shown a negative trend in the overexploitation of natural resources. Although, in general, the EU countries perform well in terms of the extraction of fresh water in comparison with the rest of the world [105], there is a lack of adequate sanitation systems in countries such as Malta, Hungary, Cyprus, and Romania, which penalizes their water performance.

5.5. Flora and Fauna

As with the water category, Luxembourg had the best performance under the flora and fauna criterion, followed by Malta and Latvia. On the contrary, Spain, Greece, Portugal, and Bulgaria were in the last places. Despite the fact that Spain is the country with the greatest biological wealth in Europe thanks to its geographical location and climatic factors, it suffers a strong loss of biodiversity and it is the country with the highest number of threatened species. Aspects such as the pressure from disrespectful tourism with nature, the use of pesticides, and pollution contribute to the risk of the disappearance of some species [102].

5.6. Employment

Romania, Bulgaria, and Malta had the best situation regarding employment indicators. This was mainly because of the indicators "temporary employment" and "job tenure", where these countries had the best performances. The combination of high shares of temporary contracts and low transition rates towards permanent contracts is symptomatic of the EU labor market duality [106]. In this regard, Spain, Cyprus, Croatia, Portugal, and Greece were the bottom five countries in employment performance. Currently, their economic systems do not produce enough employment opportunities and these countries need to improve their performances in youth unemployment and foster the integration of the long-term unemployed in order to avoid negative consequences for social cohesion and potential growth [106].

5.7. Health and Safety

The first places were occupied by Sweden, Netherlands, the United Kingdom, Denmark, Austria, and Germany. On the other hand, the countries with the worst performance in health and safety were Portugal, Romania, Lithuania, Hungary, and Spain. Although the majority countries have made long-term progress regarding public health [22], countries such as Romania, Hungary, and Lithuania still show deficiencies in the death rate due to chronic diseases and high ratios in fatal and nonfatal accidents. Additionally, measures should be taken to improve working conditions of health workers in the construction industry of countries such as Romania, Portugal, Spain, and Lithuania [106], which is characterized by competitive processes with high participation of subcontractors and extended supply chains that along with ever-changing work environment and harsh working conditions, make it dangerous [77,107].

5.8. Professional Ethics

The most economically developed EU countries, such as Finland, Sweden, Belgium, Denmark, Netherlands, Austria, and the United Kingdom showed the best performance in professional ethics. In countries such as Lithuania, Spain, Hungary, and Slovakia, significant barriers exist for persons with disabilities in accessing the labor market growth [106]. The total number of people at risk of poverty or social exclusion has improved in comparison with the level around the start of the economic crisis [102]. However, countries such as Romania, Greece, Spain, Italy, and Poland showed percentages over the 11% of the population. Gender equality needs to be boosted in countries such as Malta, Italy, Romania, and Hungary in order to improve the ratio of female to male labor force participation. In addition, wage differences must be overcome in Estonia, Czech Republic, Germany, Austria, and the United Kingdom to achieve the gender equality. Finally, the most economically developed countries showed the best performance regarding the human development and the corruption perception.

5.9. Training

Countries such as Finland, Austria, Germany, Denmark, and Belgium showed the best performances in training criteria. On the opposite side, the worst positioned countries were Greece, Romania, Bulgaria, Cyprus, and Croatia. Training is essential to increase the knowledge, skills, and capacity of workers [38,40]. Members states, such as Greece, Bulgaria, Romania, Cyprus, Hungary, Portugal, and Croatia need to adapt their skills development systems to improve labor market growth [106]. On the other hand, one of the headline targets of Europe is to achieve research and development intensity [108]. For that reason, Finland, Sweden, Denmark, Austria, and Germany showed a research and development expenditure over the 3% of their GDP, while Romania, Cyprus, Latvia, and Bulgaria were under the 1% of their GDP.

6. Conclusions

The aim of this paper was to assess the sustainable performance of EU countries through a cross-country comparison. This result can help procurers to decide what sustainability categories to consider in the bidding processes, as well as to assist in having an orientation regarding their level of importance. Five environmental categories and eight social categories were established as the sustainability criteria to be included in public procurement of the construction industry. To analyze the sustainable performance of the 28 EU countries, national indicators were used. Eighteen environmental and 24 social indicators were selected from statistical databases. After a discrimination analysis and a correlation analysis to assess the suitability of the dataset, the Promethee method was performed to rank the countries. Finally, a cluster analysis was undertaken to extract conclusions about the overall performance of these countries. The results highlight differences in sustainability performance between the most economically developed EU countries with regard to the less well-off ones. In this sense, two groups of countries were identified to address sustainability. The first cluster consisted of the wealthiest countries (north–west axis): Germany, Austria, Czech Republic, Belgium, Netherlands, Luxembourg, Ireland, the United Kingdom, Denmark, Sweden, and Finland. These countries showed good performances on social aspects; however, they need to improve the results in terms of environmental sustainability. The second cluster was made up of the economically least developed countries (south–east axis): Slovak Republic, Italy, Poland, Cyprus, Slovenia, France, Spain, Portugal, Croatia, Greece, Estonia, Malta, Hungary, Lithuania, Bulgaria, Romania, and Latvia. These countries are characterized by being significantly behind in achieving the EU vision for sustainable European development, as these showed the lowest results in terms of social sustainability. Therefore, the results highlight the main categories to be addressed in each European country; however, due to the ongoing financial crisis, public authorities are faced with making challenging budgets. Thus, new innovative construction materials, technologies, and processes should be promoted to improve energy and environmental performance on a cost-effective manner. On the other hand, to promote the use of social and environmental considerations in public procurement procedures, the transposition of the EU directives into national legislation is not sufficient and legal frameworks must be complemented with actions to increase knowledge and improve capacity among public authorities and companies. In this respect, once the main environmental and social categories to be included in public procurement of each country have been identified, the indicators defined by the Joint Research Centre and the European Commission's Science and Knowledge Service in their procurement practice guidance documents can provide valuable assistance to procure sustainable infrastructures.

Regarding the limitations of this study, the assessment of the sustainability performance of EU countries depends on public datasets at the macro level. Thus, the availability and quality of national indicators can influence the results. In the case of the dataset collected, the indicators featured are characterized by very high availability and their quality is regularly monitored. On the other hand, the search for national indicators was consistent; however, it is possible that some indicators were not adequately identified and, therefore, were excluded from the search results. This fact is important since it can be expected that a different selection of social and environmental indicators could lead to a different cluster of countries.

Future research is needed to define quantitative indicators and weighting methodologies to assess environmental and social sustainability in public procurement, as well as developing industry-based national indicators for assessing sustainability performance in the construction industry.

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