Linking Leadership Styles to Corporate ESG Performance: A Novel Sierpinski Triangle Fuzzy Decision-Making Modelling

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Abstract*—Existing research generally addresses the factors affecting ESG performance at a general level, but fails to examine the relative impact of leadership approaches on this performance with a holistic decision-making model. This deficiency makes it difficult for businesses to align their sustainability strategies with the right leadership styles and creates uncertainty in achieving their ESG goals. In this context, the aim of this study is to determine the most appropriate leadership style for improving ESG performance and to prioritize the criteria influencing this selection with an integrated approach. To address this gap in the literature, the study proposes a new multi-criteria decision-making model. The model utilizes a combination of the Z-score-based normalized ideal distance method (z-NIDM), CIMAS, RAM, and the innovative Sierpinski triangle fuzzy sets. According to the analysis results, the most important criterion for improving ESG performance is promoting green innovation, with a weight of 0.108, followed by resource efficiency, with a weight of 0.105. The most appropriate leadership style was determined to be ethical leadership, with a weight of 1.4841. These findings suggest that, to achieve their sustainability goals, businesses must adopt ethical management approaches, increase investments in green innovation, and make resource efficiency a strategic priority. This study offers a unique contribution by introducing a new fuzzy set approach to the literature, analyzing the relationship between ESG and leadership with an integrated decision-making model, and proposing a methodologically robust framework.

***Keywords*—Leadership approaches; ESG performance; z-NIDM; CIMAS; RAM**

I. Introduction

The concept of ESG (environmental, social, and governance) is a sustainability approach that considers not only the financial performance of businesses but also their responsibilities to the environment, society, and corporate governance. ESG performance is a key indicator of companies' long-term success and stakeholder trust, as elements such as environmentally responsible production processes, respect for employee rights, ethical management, and transparency create both reputation and competitive advantage. Therefore, strong ESG performance increases investor interest, mitigates risks, and supports sustainable growth. However, achieving this performance depends largely on leadership [1]. Transformational Leadership motivates employees with its visionary approach, creates an organizational culture open to change, and inspires the achievement of sustainability goals. Servant leadership strengthens the social dimension by focusing on the needs of employees and society and emphasizes ethical values. Ethical leadership establishes a strong foundation in governance by integrating the principles of justice, honesty, and responsibility into corporate governance processes. Adaptive leadership, on the other hand, enhances the capacity to cope with environmental and social challenges by making flexible and innovative decisions in response to changing environmental conditions. Therefore, the conscious and balanced application of different leadership styles strengthens businesses' ESG performance, creates sustainable competitive advantage, and contributes to the formation of a credible corporate identity in the eyes of stakeholders.

Determining which leadership model is most effective in improving companies' ESG performance is critical to achieving sustainable performance, as each leadership model impacts the environmental, social, and governance dimensions differently. Environmentally, resource efficiency, optimizing energy, water, and raw material use, reducing carbon emissions, and encouraging green innovation enable businesses to develop environmentally responsible strategies [2]. In this process, visionary and innovative leadership approaches facilitate the adoption of environmentally friendly products and processes. Socially, employee engagement and motivation, effective implementation of diversity and inclusion policies, trust-based relationships with society, and stakeholder satisfaction contribute to the development of a strong corporate culture. In these areas, servant and transformational leadership styles strengthen social sustainability by centering the expectations of employees and society. In governance, ethical decision-making, transparency, risk management, accountability, and a long-term sustainability vision form the foundation of corporate trust. In this context, ethical and adaptive leadership support a flexible, reliable, and auditable organizational structure. In terms of overall performance, the integration of ESG strategies into corporate objectives, openness to change, and contribution to long-term financial sustainability enhance a company's competitiveness. Therefore, the choice of leadership model is shaped by the interaction of these multidimensional variables, and the right leadership approach strengthens businesses' capacity to achieve sustainable success and create social value by ensuring holistic development of ESG performance.

Identifying the leadership styles that should be considered most when improving companies' ESG performance is crucial, as leadership approaches directly impact all dynamics, from a company's strategic decision-making processes to its corporate culture. If the most appropriate leadership style is not determined, business policies cannot align with ESG objectives, leading to weakened environmental, social, and governance performance. Therefore, determining which leadership model most strongly supports ESG performance is critical for sustainable corporate success. However, this determination process depends not only on the general characteristics of leadership styles but also on the criteria that most influence this choice [3]. Factors such as environmental sensitivity, ethical decision-making capacity, ability to manage stakeholder expectations, level of employee engagement, and openness to innovation can all be decisive in choosing a leadership style. If these critical factors are not properly identified and prioritized, businesses may direct their resources in the wrong areas, struggle to achieve their sustainability goals, and lose stakeholder trust. However, the literature is quite limited in analyzing the criteria by which leadership styles that influence ESG performance should be prioritized. This deficiency creates a significant gap in the ESG and leadership literature. This gap creates both theoretical and practical misconceptions, measurement difficulties, and strategic uncertainties. Therefore, developing a new and comprehensive materiality analysis on this topic would make an original contribution to the literature and help businesses more effectively align their leadership strategies with their ESG objectives.

The aim of this study is to identify the leadership types that should be most considered when improving the ESG performance of businesses. To this end, the study aims to fill the existing gap in the sustainability and leadership literature and provide decision-makers with a scientifically based assessment model. The motivation for this research stems from the limited literature on how leadership approaches that influence ESG performance can be prioritized under different criteria. In this context, an extensive literature review was conducted, and twelve different assessment criteria affecting ESG performance were identified. Furthermore, five different leadership types that can be effective in ESG-focused management processes were selected as alternatives. In the study, evaluations of these criteria and alternatives were obtained from 10 different subject-matter experts. To account for demographic differences and evaluation consistency among the experts, importance weights were calculated using the Z-score-based normalized ideal distance method (z-NIDM). Additionally, the CIMAS technique was applied to determine the importance of the criteria. Furthermore, alternative leadership types were ranked using the RAM method. The newly developed Sierpinski triangle fuzzy settler approach was used in the analysis process to more precisely assess uncertainties. This comprehensive model enables the holistic evaluation of both quantitative and qualitative data in a multi-criteria decision-making process. The study addresses the following research questions: 1) Which leadership style has the most critical impact on improving ESG performance? 2) What are the most important criteria for determining leadership selection for ESG performance? 3) How do the weights of these criteria change under uncertainty? and 4) What innovation does the developed integrated model offer to existing analysis methods in the field of ESG and leadership? By addressing these questions, the study aims to make an original contribution to the ESG and leadership literature at both theoretical and applied levels.

This study provides a unique methodological and conceptual contribution to the literature by analyzing the most effective leadership type for improving ESG performance and the most critical criteria determining this choice using a new integrated multi-criteria decision-making model. The model proposed in this study offers significant advantages in several aspects compared to previously developed decision-making models in the literature: 1) First and foremost, the development of Sierpinski triangle fuzzy sets stands out as a unique innovation. This approach offers higher discrimination power and uncertainty sensitivity compared to existing uncertainty representation methods such as classical fuzzy sets, intuitionistic fuzzy sets, or type-2 fuzzy sets. The Sierpinski triangle structure can more accurately capture small differences in decision-makers' assessments, thus minimizing information loss. Thus, this study not only proposes a new decision model but also makes a methodological contribution by introducing a new type of fuzzy set to the literature. 2) The use of the z-NIDM technique in determining experts' importance weights is another significant advantage of the model. This method applies weighting by objectively considering the experts' demographic characteristics, knowledge levels, and evaluation consistency. In most studies in the literature, the assumption of equal weighting of experts increases the subjectivity and reduces the reliability of decision results. In contrast, the z-NIDM technique integrates expert opinions into the model in a more equitable, balanced, and statistically based manner. 3) Furthermore, the use of the CIMAS technique in calculating the importance weights of the criteria also increases the effectiveness of the model. Although many weighting methods, such as AHP, Entropy, CRITIC, and SWARA, are used in the literature, the CIMAS technique produces a more balanced result by integrating both objective and subjective information components. The CIMAS method is particularly suitable for multidimensional and uncertain issues such as ESG and leadership relationships, as it considers inter-criteria dependencies and adds flexibility to the decision process, compared to other techniques. Thanks to these three key innovations, the proposed model is superior to existing decision-making approaches in terms of both methodological robustness and practical applicability.

The following Section II explains the missing part in the literature. The proposed model is defined in Section III. The analysis results are demonstrated in Section IV. Moreover, Section V includes a discussion, and Section VI identifies the main concluding remarks.

II. Literature Review

In today's rapidly changing and transforming business environment, companies strive to maintain their operations and achieve a competitive advantage. In this process, focusing exclusively on financial operations is not sufficient to respond to varying stakeholder demands in a balanced manner. It is also necessary to demonstrate sensibility to environmental factors, social factors, and stakeholder expectations. The limited availability of resources in view of increasing consumption and demand makes environmental sustainability an ethical concern. In addition to environmental factors, being transparent and fulfilling responsibilities toward society, individuals and shareholders are becoming critical factors that determine the future of the business. Hence, companies share information about sustainability or corporate social responsibility activities in addition to financial reporting. Nevertheless, unstable conditions and diverse stakeholder demands necessitate more endeavors. As companies are accountable to all stakeholders, they need to share transparent information regarding environmental, social and governance activities for the sustainability of their operations. In this context, stakeholder theory proposes promoting innovation and sustainable development through actively communicating with all stakeholders [4]. Stakeholder orientation can significantly influence all aspects of an organization, from corporate governance to ethical practices and sustainability initiatives, from employee relations to customer and community engagement [5].

Environmental performance indicates the influence of a company on the natural environment. This ecological impact comprises resource protection, waste management, emissions reduction, energy efficiency and biodiversity conservation [6]. Growing environmental and ecological concerns, particularly climate change, impact corporate operations in different aspects. These rising concerns lead international communities and global leaders to initiate various reforms and agreements to protect the natural environment. In this context, companies incline to place greater emphasis on environmental sustainability practices such as recycling, resource reduction, product and service redesign to establish a trustworthy image, enhance their reputation and protect the planet [7]. Dohrmann et al. [8] found that environmental performance has a positive influence on firm performance and board independence strengthens this relationship. According to Tong et al. [9], reducing emissions, within the scope of environmental performance, is one of the crucial ways to engage the attention of stakeholders. Companies can effectively address their stakeholders' needs by creating, implementing and publicly disclosing the strategies of carbon emission reduction. These effective strategies enable companies to improve their reputation and attract more investors. In this process, companies can convey new business processes and their benefits to relevant stakeholders by establishing open and transparent communication. Innovation, one of the important business processes, plays a central role in company growth. Wang and Ahmad [10] conducted a study on green process, green product innovation and financial performance. In this study, green innovation impacts financial performance positively. Companies that invest in green process and product innovation may provide advantages in terms of mitigating environmental concerns and potential penalties, creating new market niches, developing nature-friendly products, having a green image and enhancing financial performance. By integrating a strong ethical approach and environmental awareness, companies may adopt sustainable practices, reduce ecological effects and advance environmental performance [11].

Another notable aspect for companies is social factors. Social performance involves corporate endeavors to improve and manage relationships with stakeholders such as employees, community, customers and suppliers [12]. According to Covington et al. [13], diversity and inclusion, one of the social factors, refers to an environment that values differences among employees and encourages both individuality and a sense of belonging. Hence, this social factor may have a significant impact on corporate performance. As a matter of fact, in the study conducted by the same authors, it was observed that companies with higher diversity and inclusion ratings exhibited stronger innovation performance in terms of parameters such as number of patents, number of citations and the economic value of patents. Within the scope of social factors, product responsibility may influence consumer behavior and corporate image. According to Mensah et al. [14], companies that focus on product responsibility can strengthen brand image and achieve greater consumer loyalty. To lower transaction costs, reduce waste and minimize customer complaints and returns, companies can use environmentally sustainable materials and prioritize product robustness.

Sustainable development requires the protection of resources and the minimization of transaction costs. Hence, companies need to meticulously consider factors such as board diversity and board size to achieve sustainable development goals [15]. At this point, governance is another critical factor in terms of sustainable operations and corporate reputation. Companies can create a mutual trust in the relations with stakeholders and enhance company value through effective governance practices. Companies need to center upon ameliorating governance practices such as transparency and accountability and align their governance-related activities with strategic objectives [16]. As key stakeholders of a company, senior management personnel have critical roles in the governance practices and decision-making process. Moreover, their attitudes and behaviors toward sustainable development goals impact the efficiency of corporate social responsibility activities. The purposeful development of corporate social responsibility strategies can yield positive results for the company. In fact, it has been observed in the literature that corporate social responsibility practices have significant and positive effects on financial performance, innovation, reputation and firm sustainability [17]. Herewith, corporate governance becomes a strategic obligation for organizations aiming to lead change, create sustainable value and enhance performance. In a dynamic and complex business environment, companies can provide a basis for long-term achievement and resilience by balancing interests, encouraging innovation, managing risks and involving stakeholders in the processes [18].

Environmental, social and governance-related activities encompass aspects that companies need to prioritize. The concept of ESG, which considers these factors together, becomes a focal point of research since it has significant effects on corporate reputation and investor preferences. ESG encompasses a company's environmental influence, social responsibilities and governance implementations at the heart of its actions [19]. ESG criteria become the main indicators of risk management, management competence and non-financial performance. ESG consists of a wide range of environmental concerns such as carbon emissions, climate change and energy use; social issues such as employee well-being, product safety and human rights; and governance-related issues such as corruption, board independence and protection of shareholder rights. Bai et al. [20] stated that ethical constraints and public pressure can encourage companies to prioritize environmental and social factors and adopt more active ESG practices, thereby improving their ESG performance. Increasing ESG performance enables companies to enhance their corporate reputation and reduce certain risks by minimizing environmental penalties and financial restrictions. According to Chen et al. [21], companies that operate their activities ethically and responsibly to advance the society's welfare can contribute to increased company value. ESG disclosure enables a company to gain competitive advantages, strengthen its reputation from the perspective of stakeholders and enhance long-term performance.

The literature review reveals that environmental, social and governance activities have significant effects on financial performance, sustainability and corporate reputation of companies. Transparently sharing information regarding these activities enables companies to attract strategic investors, gain stakeholder trust and increase financial performance. ESG practices, which consider environmental, social and governance activities together, have become a prominent concept in the literature and the business world in recent years. The presence of effective leaders may be crucial for the adoption and successful implementation of ESG practices by employees at all levels within a company. In this regard, it has been observed that studies examining the effect of leadership types on ESG performance are limited. However, no comparative study has been found that examines which leadership type has the greatest impact on ESG performance on a sectoral basis. Hence, this study may fill a research gap in the relevant literature and provide guidance to practitioners to improve ESG performance in business.

III. Methodology

This section includes the definitions and formulations of z-NIDM, STFSs, CIMAS and RAM, respectively. In expert-based solutions, assuming the same importance of evaluations is criticized. To address this criticism objectively, the z-NIDM approach is integrated into the model. This approach generates expert-weighted values, aiming to yield more realistic results. In the optimal analysis process, the CIMAS method is used to prioritize decision-making criteria. RAM finds the optimal solution by considering the importance of these criteria. The process of methodology is presented in Fig. 1.

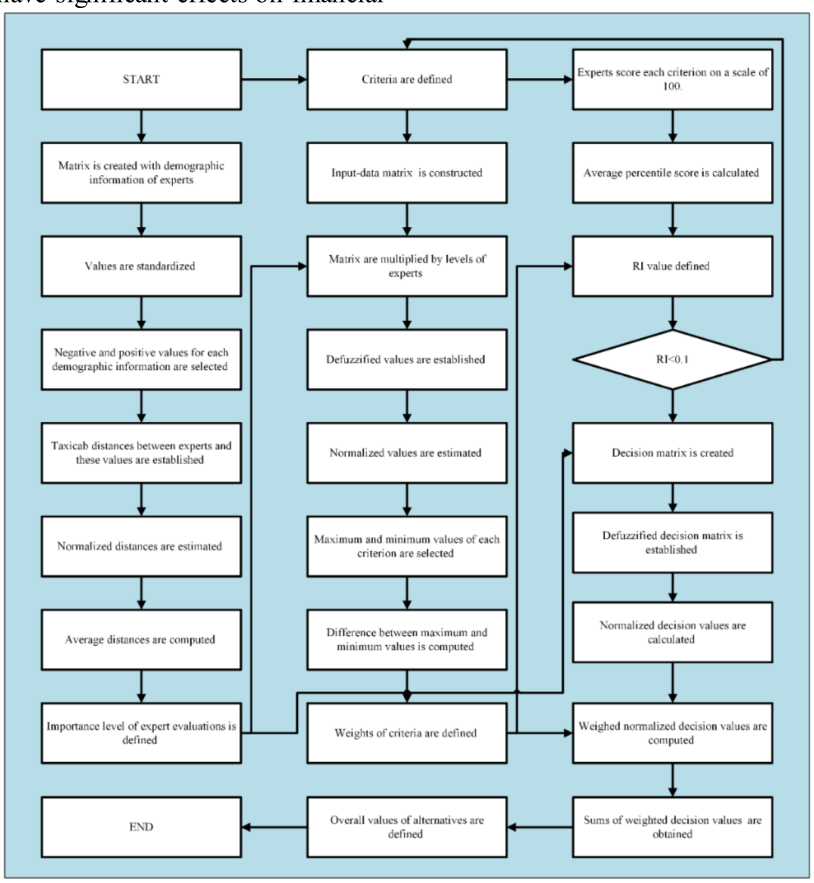

Fig. 1. Process of methodology.

A. z-NIDM

This approach allows the importance value of expert evaluations to be calculated objectively using demographic information. This approach is based on the average distance normalized to negative and positive values [22]. The calculation steps are as follows.

Firstly, the matrix formed in Eq. (1) is created with demographic information of experts.

$$Y = \left[y_{ij}\right]_{e\times d} \tag{1}$$

where, *e* and *d* are the numbers of experts and demographic information. Thus, y_{ij} means the value of i^{th} demographic information of j^{th} expert. Since the value ranges of the information are different from each other, the values need to be standardized with the help of Eq. (2) to Eq. (4).

$$\bar{y}_j = \frac{1}{e}\sum_{i=1}^{e} y_{ij} \tag{2}$$

$$\sigma_j = \sqrt{\frac{1}{e}\sum_{i=1}^{e}(y_{ij}-\bar{y}_j)^2} \tag{3}$$

$$z_{ij} = \frac{y_{ij}-\bar{y}_j}{\sigma_j} \tag{4}$$

Afterwards, the negative and positive values for each demographic information are selected via Eq. (5) and Eq. (6), respectively.

$$neg_j = \min_i z_{ij} \tag{5}$$

$$pos_j = \max_i z_{ij} \tag{6}$$

After determining the negative and positive values, the Taxicab distances between experts and these values are established by Eq. (7) and Eq. (8), respectively.

$$negD_i = \sum_{j=1}^{d}\left|z_{ij}-neg_j\right| \tag{7}$$

$$posD_i = \sum_{j=1}^{d}\left|z_{ij}-pos_j\right| \tag{8}$$

Next, the normalized distances are estimated with the help of Eq. (9) and Eq. (10).

$$negN_i = \frac{negD_i}{\max negD_i} \tag{9}$$

$$posN_i = \frac{\min posD_i}{posD_i} \tag{10}$$

Then, the average distances are computed using Eq. (11).

$$A_i = \frac{1}{2}(negN_i + posN_i) \tag{11}$$

Finally, the importance level of expert evaluations is defined as Eq. (12):

$$E_i = \frac{A_i}{\sum_{i=1}^{e} A_i} \tag{12}$$

B. STFSs

Fuzzy sets are a theory used in uncertainty measurement and are defined by degrees of membership and non-membership of an object. STFSs are a set inspired by the Sierpinski Triangle fractal shapes. This fractal shape has a structure with an infinitely sided main field that converges to zero [23]. This feature makes it useful for studying chaotic systems. It is recommended to use this fractal dimension $\left(\frac{\log 3}{\log 2} \approx 1.585\right)$, for optimal modelling of chaotic structure in linguistic structures. A STFS $\left(\tilde{F}\right)$ is described with Eq. (13).

$$\tilde{F} = \{x, (\alpha_{\tilde{F}}(x), \beta_{\tilde{F}}(x)) : x \in D\} \tag{13}$$

wherein, α and β are between zero and one and named as membership and non-membership degrees. These degrees satisfy the condition in Eq. (14).

$$0 \le \alpha_{\tilde{F}}^{1.585}(x) + \beta_{\tilde{F}}^{1.585}(x) \le 1 \tag{14}$$

The indeterminacy degree is computed with Eq. (15).

$$\pi_{\tilde{F}}(x) = \sqrt[1.585]{1-\alpha_{\tilde{F}}^{1.585}(x)-\beta_{\tilde{F}}^{1.585}(x)} \tag{15}$$

Consider that $\tilde{X}$ and $\tilde{Y}$ are two fuzzy numbers. Then general operations are calculated by Eq. (16) to Eq. (21). $(s, \lambda > 0)$

$$\tilde{X} \cup \tilde{Y} = (\max\{\alpha_{\tilde{X}}, \alpha_{\tilde{Y}}\}, \min\{\beta_{\tilde{X}}, \beta_{\tilde{Y}}\}) \tag{16}$$

$$\tilde{X} \cap \tilde{Y} = (\min\{\alpha_{\tilde{X}}, \alpha_{\tilde{Y}}\}, \max\{\beta_{\tilde{X}}, \beta_{\tilde{Y}}\}) \tag{17}$$

$$\tilde{X}\oplus\tilde{Y} = \left(\begin{array}{c}\sqrt[1.585]{\dfrac{\alpha_{\tilde{X}}^{1.585}+\alpha_{\tilde{Y}}^{1.585}-\alpha_{\tilde{X}}^{1.585}\alpha_{\tilde{Y}}^{1.585}-(1-s)\alpha_{\tilde{X}}^{1.585}\alpha_{\tilde{Y}}^{1.585}}{1-(1-s)\alpha_{\tilde{X}}^{1.585}\alpha_{\tilde{Y}}^{1.585}}},\\ \dfrac{\beta_{\tilde{X}}\beta_{\tilde{Y}}}{\sqrt[1.585]{s+(1-s)\left(\beta_{\tilde{X}}^{1.585}+\beta_{\tilde{Y}}^{1.585}-\beta_{\tilde{X}}^{1.585}\beta_{\tilde{Y}}^{1.585}\right)}}\end{array}\right) \tag{18}$$

$$\tilde{X}\otimes\tilde{Y} = \left(\begin{array}{c}\sqrt[1.585]{\dfrac{\alpha_{\tilde{X}}\alpha_{\tilde{Y}}}{\sqrt[1.585]{s+(1-s)\left(\alpha_{\tilde{X}}^{1.585}+\alpha_{\tilde{Y}}^{1.585}-\alpha_{\tilde{X}}^{1.585}\alpha_{\tilde{Y}}^{1.585}\right)}}},\\ \sqrt[1.585]{\dfrac{\beta_{\tilde{X}}^{1.585}+\beta_{\tilde{Y}}^{1.585}-\beta_{\tilde{X}}^{1.585}\beta_{\tilde{Y}}^{1.585}-(1-s)\beta_{\tilde{X}}^{1.585}\beta_{\tilde{Y}}^{1.585}}{1-(1-s)\beta_{\tilde{X}}^{1.585}\beta_{\tilde{Y}}^{1.585}}}\end{array}\right) \tag{19}$$

$$\lambda\odot\tilde{X} = \left(\begin{array}{c}\sqrt[1.585]{\dfrac{\left[1+(s-1)\alpha_{\tilde{X}}^{1.585}\right]^{\lambda}-\left(1-\alpha_{\tilde{X}}^{1.585}\right)^{\lambda}}{\left[1+(s-1)\alpha_{\tilde{X}}^{1.585}\right]^{\lambda}-(s-1)\left(1-\alpha_{\tilde{X}}^{1.585}\right)^{\lambda}}},\\ \dfrac{\sqrt[1.585]{s}\,\beta_{\tilde{X}}^{\lambda}}{\sqrt[1.585]{\left[1+(s-1)\left(1-\beta_{\tilde{X}}^{1.585}\right)\right]^{\lambda}+(s-1)\beta_{\tilde{X}}^{1.585\lambda}}}\end{array}\right) \tag{20}$$

$$\tilde{X}^{\lambda} = \left(\begin{array}{c}\dfrac{\sqrt[1.585]{s}\,\alpha_{\tilde{X}}^{\lambda}}{\sqrt[1.585]{\left[1+(s-1)\left(1-\alpha_{\tilde{X}}^{1.585}\right)\right]^{\lambda}+(s-1)\alpha_{\tilde{X}}^{1.585\lambda}}},\\ \sqrt[1.585]{\dfrac{\left[1+(s-1)\beta_{\tilde{X}}^{1.585}\right]^{\lambda}-\left(1-\beta_{\tilde{X}}^{1.585}\right)^{\lambda}}{\left[1+(s-1)\beta_{\tilde{X}}^{1.585}\right]^{\lambda}-(s-1)\left(1-\beta_{\tilde{X}}^{1.585}\right)^{\lambda}}}\end{array}\right) \tag{21}$$

Suppose that $\tilde{F}$ is ST fuzzy number. Score and accuracy function are established using Eq. (22) and Eq. (23), respectively.

$$SF\left(\tilde{F}\right) = \frac{\alpha_{\tilde{F}}^{1.585}(x)-\beta_{\tilde{F}}^{1.585}(x)+1}{2} \tag{22}$$

$$AF\left(\tilde{F}\right) = \alpha_{\tilde{F}}^{1.585}(x)+\beta_{\tilde{F}}^{1.585}(x) \tag{23}$$

C. STF-CIMAS

The CIMAS approach, which integrates the level of experts in the process of determining the criterion importance, has the advantage over other methods in terms of calculating the RI value for the reliability of the results. The steps in which ST fuzzy numbers are integrated into CIMAS are as follows [24]:

In the traditional CIMAS method, the expert level is obtained by normalizing the years of experience. However, since this approach is too soft, in this manuscript, the expert-level values obtained from z-NIDM are used. After determining the level of experts, experts express the importance of *n* criteria with linguistic scale. These linguistic scales of the experts are converted into ST fuzzy numbers and the input-data matrix in Eq. (24) is constructed.

$$\tilde{H} = \begin{bmatrix} \tilde{h}_{11} & \cdots & \tilde{h}_{1n} \\ \vdots & \ddots & \vdots \\ \tilde{h}_{e1} & \cdots & \tilde{h}_{en} \end{bmatrix} \tag{24}$$

where, $\tilde{h}_{ij} = \left(\alpha_{\tilde{h}_{ij}}, \beta_{\tilde{h}_{ij}}\right)$ represents the value of j^{th} criterion of i^{th} expert. Next, the values of this matrix are multiplied by the levels of experts using Eq. (25).

$$\tilde{K} = E_i \odot \tilde{H} = \begin{bmatrix} \tilde{k}_{11} & \cdots & \tilde{k}_{1n} \\ \vdots & \ddots & \vdots \\ \tilde{k}_{e1} & \cdots & \tilde{k}_{en} \end{bmatrix} = \begin{bmatrix} E_1 \odot \tilde{h}_{11} & \cdots & E_1 \odot \tilde{h}_{1n} \\ \vdots & \ddots & \vdots \\ E_e \odot \tilde{h}_{e1} & \cdots & E_e \odot \tilde{h}_{en} \end{bmatrix} \tag{25}$$

Afterwards, the defuzzified values are established with the help of Eq. (26).

$$F = SF(\tilde{K}) = \begin{bmatrix} f_{11} & \cdots & f_{1n} \\ \vdots & \ddots & \vdots \\ f_{e1} & \cdots & f_{en} \end{bmatrix} = \begin{bmatrix} SF(\tilde{k}_{11}) & \cdots & SF(\tilde{k}_{1n}) \\ \vdots & \ddots & \vdots \\ SF(\tilde{k}_{e1}) & \cdots & SF(\tilde{k}_{en}) \end{bmatrix} \tag{26}$$

After creating the defuzzified matrix, the normalized values are estimated via Eq. (27).

$$\mathfrak{y}_{ij} = \frac{f_{ij}}{\sum_{i=1}^{e} f_{ij}} \tag{27}$$

Next, the maximum and minimum values of each criterion for normalized matrix are selected by Eq. (28) and Eq. (29), respectively.

$$mx_j = \max_i \mathfrak{y}_{ij} \tag{28}$$

$$mn_j = \min_i \mathfrak{y}_{ij} \tag{29}$$

Then, difference between maximum and minimum values for each criterion is computed with Eq. (30).

$$diff_j = mx_j - mn_j \tag{30}$$

The weights of criteria are defined as Eq. (31):

$$w_j = \frac{diff_j}{\sum_{j=1}^{n} diff_j} \tag{31}$$

Finally, the reliability index is estimated. This time, experts score each criterion on a scale of 100. The sum of the scales assigned by each expert to the criteria should be 100. Then, the average percentile score is calculated using Eq. (32), where g_{ij} is the percentile score given by the i^{th} expert for the j^{th} criterion.

$$APS_j = \frac{1}{e} \sum_{i=1}^{e} g_{ij} \tag{32}$$

Afterwards, the RI value defined in Eq. (33) is obtained between the criteria weights obtained from CIMAS and the average percentage scores.

$$RI = \frac{\sum_{j=1}^{n} |100 w_j - APS_j|}{100} \tag{33}$$

If the RI value is less than 0.1, the results are reliable. Otherwise, the analysis process is repeated.

D. STF-RAM

The RAM method ranks alternatives by using the differences in compensation levels across benefit and utility criteria. Like other methods, this method ranks alternatives without converting cost criteria into benefit criteria. The steps in which ST fuzzy numbers are integrated into RAM are as follows [25]:

Firstly, *m* alternatives are evaluated by experts with linguistic scales. These linguistic scales are transformed into ST fuzzy numbers. Thus, the matrix in Eq. (34) is created for the t^{th} expert.

$$\tilde{R}^{(t)} = \begin{bmatrix} \tilde{r}_{11}^{(t)} & \cdots & \tilde{r}_{1n}^{(t)} \\ \vdots & \ddots & \vdots \\ \tilde{r}_{m1}^{(t)} & \cdots & \tilde{r}_{mn}^{(t)} \end{bmatrix} \tag{34}$$

where, $\tilde{r}_{ij}^{(t)} = \left(\alpha_{\tilde{r}_{ij}^{(t)}}, \beta_{\tilde{r}_{ij}^{(t)}}\right)$. Next, these values are multiplied by levels of experts with the help of Eq. (35).

$$\tilde{U}^{(t)} = E_{(t)} \odot \tilde{R}^{(t)} = \begin{bmatrix} E_{(t)} \odot \tilde{r}_{11}^{(t)} & \cdots & E_{(t)} \odot \tilde{r}_{1n}^{(t)} \\ \vdots & \ddots & \vdots \\ E_{(t)} \odot \tilde{r}_{m1}^{(t)} & \cdots & E_{(t)} \odot \tilde{r}_{mn}^{(t)} \end{bmatrix} = \begin{bmatrix} \tilde{u}_{11}^{(t)} & \cdots & \tilde{u}_{1n}^{(t)} \\ \vdots & \ddots & \vdots \\ \tilde{u}_{m1}^{(t)} & \cdots & \tilde{u}_{mn}^{(t)} \end{bmatrix} \tag{35}$$

Then, matrices are summed by Eq. (36).

$$\tilde{A} = \sum_{t=1}^{e} \tilde{U}^{(t)} = \begin{bmatrix} \sum_{t=1}^{e} \tilde{u}_{11}^{(t)} & \cdots & \sum_{t=1}^{e} \tilde{u}_{1n}^{(t)} \\ \vdots & \ddots & \vdots \\ \sum_{t=1}^{e} \tilde{u}_{m1}^{(t)} & \cdots & \sum_{t=1}^{e} \tilde{u}_{mn}^{(t)} \end{bmatrix} = \begin{bmatrix} \tilde{a}_{11} & \cdots & \tilde{a}_{1n} \\ \vdots & \ddots & \vdots \\ \tilde{a}_{m1} & \cdots & \tilde{a}_{mn} \end{bmatrix} \tag{36}$$

Afterwards, the defuzzified decision matrix is established using Eq. (37).

$$A = SF(\tilde{A}) = \begin{bmatrix} SF(\tilde{a}_{11}) & \cdots & SF(\tilde{a}_{1n}) \\ \vdots & \ddots & \vdots \\ SF(\tilde{a}_{m1}) & \cdots & SF(\tilde{a}_{mn}) \end{bmatrix} = \begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{m1} & \cdots & a_{mn} \end{bmatrix} \tag{37}$$

After constructing the defuzzified decision matrix, the normalized decision values are calculated with Eq. (38).

$$\xi_{ij} = \frac{a_{ij}}{\sum_{i=1}^{m} a_{ij}} \tag{38}$$

The weighed normalized decision values are computed using Eq. (39).

$$b_{ij} = \xi_{ij} w_j \tag{39}$$

Finally, the sums of weighted decision values of benefit and cost criteria of alternatives are obtained by Eq. (40) and Eq. (41). Then, overall values of alternatives are defined as Eq. (42).

$$S_{+i} = \sum_{j=1}^{n} b_{+ij} \tag{40}$$

$$S_{-i} = \sum_{j=1}^{n} b_{-ij} \tag{41}$$

$$\theta_i = \sqrt[2+S_{-i}]{2 + S_{+i}} \tag{42}$$

IV. Analysis

This section includes the results of methodology. All tables are given in the Appendix section (Table I to Table XXI).

A. Establishing the Levels of Experts

Within the z-NIDM framework, demographic information about experts is needed for analysis. Experts' age, total experience, industry experience, management experience, teaching experience, and number of projects are collected regarding expertise. This information is shown in Table I. The values' statistics are estimated with Eq. (2) and Eq. (3). The arithmetic mean and standard deviation of each information are given in Table II. Using these statistics, the values are standardized with the help of Eq. (4). The standardized information matrix is shared in Table III. Afterwards, the negative and positive values for each demographic information are selected via Eq. (5) and Eq. (6), respectively. The negative and positive values for each standardized information are summarized in Table IV. After determining the negative and positive values, the Taxicab distances between experts and these values are established by Eq. (7) and Eq. (8), respectively. Next, the normalized distances are estimated with the help of Eq. (9) and Eq. (10). The results are summarized in Table V. Then, the average distances are computed using Eq. (11). Finally, the importance value of expert evaluations is defined as Eq. (12). The results are illustrated in Fig. 2.

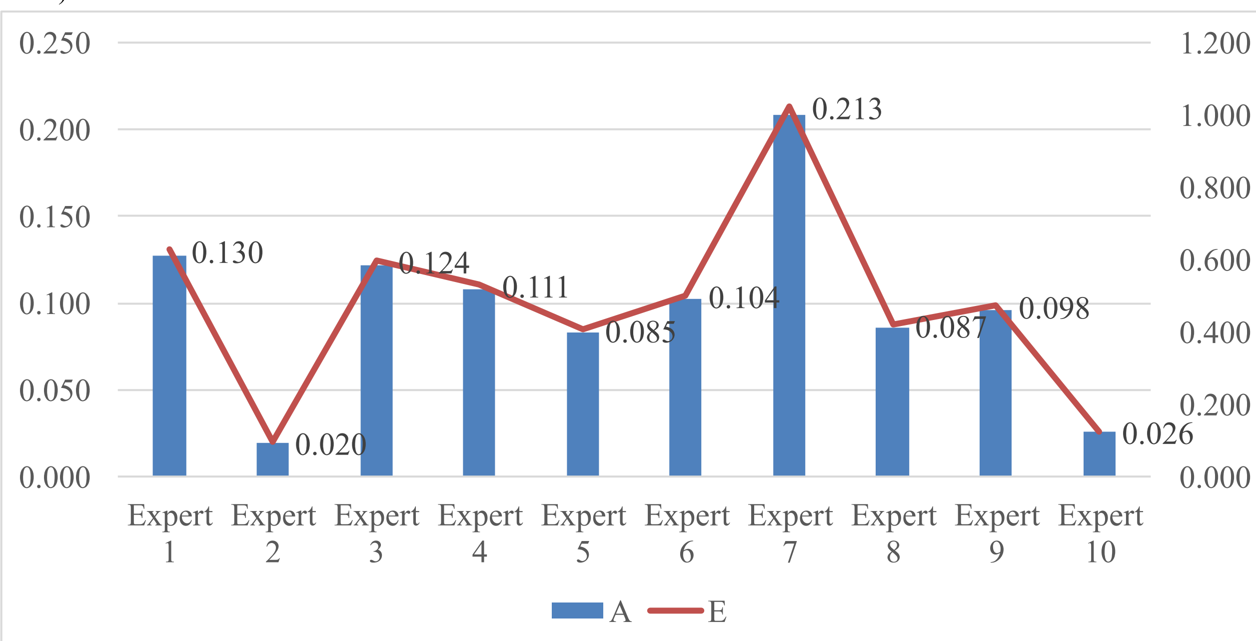

Fig. 2. Levels of experts.

As can be seen, E values in Fig. 2, the highest level is Expert 7 with .213. Expert 7 has the maximum age, total experience, industry experience, manager experience, and teaching experience. The second level is Expert 1 with .130.

B. Weighting of the Criteria

Twelve criteria across four dimensions are determined to improve the ESG performance of companies. This list of criteria and the short codes created for use in the analysis are presented in Table VI. Two of these criteria, ethical problems and difficulty of integrating ESG strategies into corporate objectives, are of the cost type, while the other ten criteria are constructed as benefit type and introduced to the experts as such. Ten experts express the importance of 12 criteria with linguistic scale. The results are displayed in Table VII. These linguistic scales of the experts are converted into ST fuzzy numbers and the input-data matrix in Eq. (24) is constructed. The input-data matrix is exhibited in Table VIII. Next, the values of this matrix are multiplied by the levels of experts using Eq. (25). The levels of experts are defined in Fig. 2. The expert-weighted values are expressed in Table IX. Afterwards, the defuzzified values are established with the help of Eq. (26). In other words, the score functions of fuzzy numbers in Table IX are estimated. The defuzzified matrix is shown in

Table X. After creating the defuzzified matrix, the normalized values are estimated via Eq. (27). That is, the columns are summed, and the values are divided by this total. The normalized matrix is illustrated in Table XI. Next, the maximum and minimum values of each criterion for normalized matrix are selected by Eq. (28) and Eq. (29), respectively. Then, the difference between maximum and minimum values for each criterion is computed with Eq. (30). The results are summarized in Table XII. The weights of the criteria are defined as Eq. (31). The weights of criteria are visualized in Fig. 3.

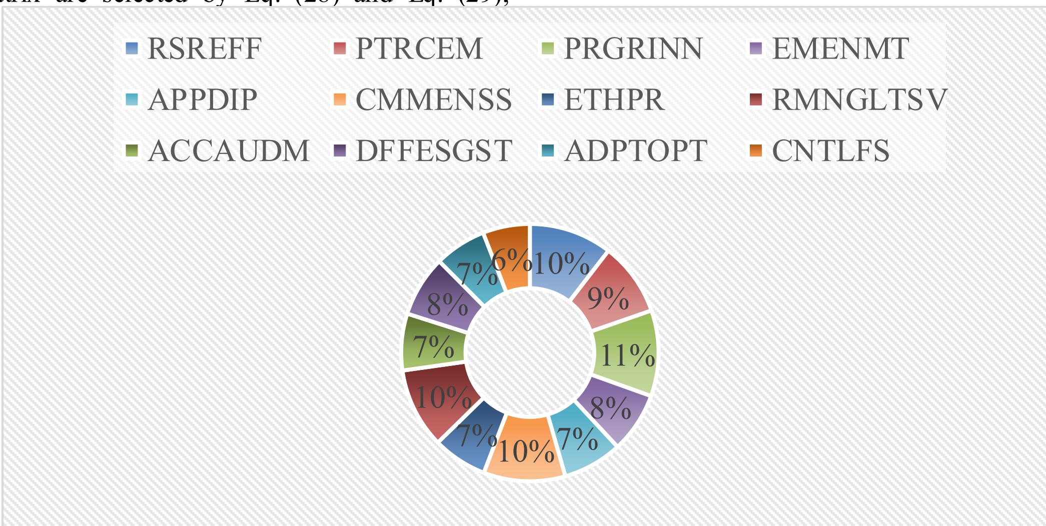

Fig. 3. Weights of the criteria

When Fig. 3 is examined, the most important criterion to improve the ESG performance of companies is promoting green innovation with .108. The second important criterion is resource efficiency with .105. Finally, the reliability index is estimated. This time, experts score each criterion on a scale of 100. The percentile scores are shown in Table XIII. Then, the average percentile score is calculated using Eq. (32). The average percentile scores are shared in Table XIV. Afterwards, the RI value defined in Eq. (33) is obtained between the criteria weights obtained from CIMAS in Fig. 3 and the average percentage scores in Table XIV. RI equals to .078. This value is smaller than 0.1. That is, the results are reliable.

C. Ranking Leadership Styles

The general leadership styles are transformational leadership (TR), servant leadership (SR), ethical leadership (ET), adaptive leadership (AD), and authentic leadership (AU). These 5 leadership styles are evaluated by experts with linguistic scales. The results are displayed in Table XV. These linguistic scales are transformed into ST fuzzy numbers. Thus, the matrix in Eq. (34) is created. Next, these values are multiplied by the levels of experts with the help of Eq. (35). Then, matrices are summed by Eq. (36). The decision matrix is shared in Table XVI. Afterwards, the defuzzified decision matrix is established using Eq. (37). The defuzzified decision matrix is illustrated in Table XVII. After constructing the defuzzified decision matrix, the normalized decision values are calculated with Eq. (38). The normalized decision matrix is summarized in Table XVIII. The weighted normalized decision values are computed using Eq. (39). The values in Fig. 3 are used as weight of the criteria. The weighted normalized decision matrix is displayed in Table XIX. Finally, the sums of weighted decision values of benefit and cost criteria of alternatives are obtained by Eq. (40) and Eq. (41). Then, overall values of alternatives are defined as Eq. (42). The results are shared in Table XX. As can be understood from the overall values in Table XX, the most suitable leadership style to improve the ESG performance of companies is the ethical leadership style, with 1.4841.

A sensitivity analysis is conducted to test the sensitivity and robustness of the results. For this purpose, scenarios are created and the analyses are rerun. In this context, different scenarios are constructed by increasing the weight of each criterion by 10%. The value of the first criterion in Fig. 3 for the first scenario is increased by 10%, and then criteria weights are normalized. The RAM analysis is repeated with the new weights. In other words, twelve scenarios are created for twelve criteria, and twelve RAM analyses are run. The results are summarized in Table XXI. As can be seen from the ranks in Table XXI, the results are the same across scenarios. This shows that the methodology is robust.

V. Discussion

The results of the study indicate that the most important criterion for improving companies' ESG performance is encouraging green innovation, with a weighting of 0.108, followed by resource efficiency, with a weighting of 0.105. This finding demonstrates the critical importance of investing in innovative and environmentally friendly technologies to enhance their sustainability performance [26]. The importance of green innovation is frequently emphasized in the literature. The primary reason for this is that developing environmentally friendly products and processes not only reduces environmental impacts but also significantly contributes to businesses' competitive advantage, brand reputation, and long-term financial sustainability. Resource efficiency, in turn, reduces costs and environmental burden by optimizing the use of energy, water, and raw materials. In light of these findings, policymakers should create tax incentives, sustainable production funds, and environmentally responsible investment programs to support businesses' green R&D activities [27]. At the corporate level, companies should establish sustainable innovation units, adopt circular economy principles in their supply chains, and train their employees in an organizational culture with a high environmental awareness. Furthermore, green innovation and resource efficiency indicators should be clearly defined in performance measurement systems and integrated into management decision-making processes. This will ensure both institutional sustainability at the micro level and create a development model that supports environmental and economic balance at the macro level.

According to the study results, ethical leadership, with a weighting of 1.4841, is the most suitable leadership style for improving companies' ESG performance. This finding demonstrates that a management approach based on ethical values plays a decisive role in companies achieving their sustainability goals. By centering the principles of fairness, honesty, responsibility, and transparency in decision-making processes, ethical leadership both improves the quality of corporate governance and strengthens stakeholder trust. The literature frequently emphasizes that ethical leadership is one of the most critical factors supporting ESG performance [28]. Ethics-based management approaches increase employee motivation and a sense of corporate belonging, while also embedding social responsibility and environmental awareness in the corporate culture. In this context, it is recommended that ethical leadership training be expanded at the policy level for business managers, corporate codes of ethics are established, and independent units are established to monitor their implementation [29]. Furthermore, public authorities and regulatory bodies should develop reward mechanisms and sustainable management standards that encourage ethical leadership practices in businesses. From a corporate strategy perspective, it's crucial to prioritize executives with a high sensitivity to ethical values in leadership selection and promotion processes, to assess stakeholder expectations from an ethical perspective in decision-making, and to strengthen accountability mechanisms [30]. Thus, an ethical leadership approach will not only enhance the quality of governance but also lay the foundation for sustainable corporate transformation in environmental and social dimensions.

VI. Conclusion

This study aims to determine the most effective leadership style in improving the ESG performance of businesses and to identify the most important criteria influencing this choice. In this context, an extensive literature review is conducted, 12 criteria affecting ESG performance are identified, and five different leadership styles are evaluated as alternatives. Expert opinions are utilized throughout the analysis process, and their importance weights are objectively calculated using the z-NIDM. Criteria importance levels are determined using the CIMAS method, and alternative leadership styles are ranked using the RAM technique. Furthermore, to more accurately model uncertainties, the Sierpinski triangle fuzzy sets developed in this study are used, thus introducing a new fuzzy set approach to the literature. The analysis results indicate that ethical and transformational leadership styles are the most effective approaches in improving ESG performance, while criteria related to environmental and governance dimensions most strongly shape leadership impact. These findings demonstrate that leadership style is a determinant not only of organizational success but also of sustainability performance. The study provides original and significant contributions to the literature by proposing a new integrated multi-criteria decision-making model from a methodological perspective, introducing Sierpinski triangle fuzzy sets to the literature, and presenting an empirical analysis of the ESG-leadership relationship.

This study has some theoretical and methodological limitations. First, the scope of the research is based on a general assessment across sectors, and no sector-specific analysis is conducted. However, different sectors may exhibit differences in ESG dynamics, environmental sensitivity levels, and leadership structures. Therefore, future studies applying the model to specific sectors such as energy, finance, healthcare, or manufacturing could provide a more in-depth understanding of the impact of leadership types on ESG performance within the context of sectoral differences. Furthermore, while the integrated decision-making model proposed in this study, the z-NIDM–CIMAS–RAM–Sierpinski fuzzy approach, offers a robust methodological framework, it does have certain limitations. Because the applicability of the model relies heavily on expert opinion, the results obtained may vary depending on the participant profile. Furthermore, because Sierpinski triangle fuzzy sets are a novel structure, they need to be tested on different problem types and samples. Comparing this method with other fuzzy logic approaches in future research will increase the generalizability and reliability of the model. However, evaluating the adaptability of the model in different decision environments, especially dynamic and uncertain data structures, is also suggested as an important research area for future studies.

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APPENDIX

TABLE I. INFORMATION ABOUT EXPERTS

	Age	Total Experience	Industry Experience	Manager Experience	Teaching Experience	Number of Projects
Expert 1	51	30	28	11	3	3
Expert 2	35	13	11	4	2	2
Expert 3	54	32	28	11	3	2
Expert 4	52	31	26	10	3	2
Expert 5	46	27	25	10	2	2
Expert 6	51	28	23	9	4	2
Expert 7	54	35	33	13	5	2
Expert 8	45	24	20	8	2	4
Expert 9	47	25	22	9	2	4
Expert 10	37	18	13	5	1	2

TABLE II. ARITHMETIC MEAN AND STANDARD DEVIATION OF INFORMATION

	Age	Total Experience	Industry Experience	Manager Experience	Teaching Experience	Number of Projects
Arithmetic	47.2	26.3	22.9	9.0	2.7	2.5
Stand. Dev.	6.353	6.325	6.457	2.608	1.100	.806

TABLE III. STANDARDIZED INFORMATION MATRIX

	Age	Total Experience	Industry Experience	Manager Experience	Teaching Experience	Number of Projects
Expert 1	.598	.585	.790	.767	.273	.620
Expert 2	-1.920	-2.103	-1.843	-1.917	-.636	-.620
Expert 3	1.070	.901	.790	.767	.273	-.620
Expert 4	.756	.743	.480	.383	.273	-.620
Expert 5	-.189	.111	.325	.383	-.636	-.620
Expert 6	.598	.269	.015	.000	1.182	-.620
Expert 7	1.070	1.375	1.564	1.534	2.091	-.620
Expert 8	-.346	-.364	-.449	-.383	-.636	1.861
Expert 9	-.031	-.206	-.139	.000	-.636	1.861
Expert 10	-1.606	-1.312	-1.533	-1.534	-1.545	-.620

TABLE IV. NEGATIVE AND POSITIVE VALUES OF EACH STANDARDIZED INFORMATION

	Age	Total Experience	Industry Experience	Manager Experience	Teaching Experience	Number of Projects
Neg	-1.920	-2.103	-1.843	-1.917	-1.545	-.620
Pos	1.070	1.375	1.564	1.534	2.091	1.861

TABLE V. DISTANCES AND NORMALIZED DISTANCES

	negD	posD	negN	posN
Expert 1	13.582	5.863	.801	.423
Expert 2	.909	18.535	.054	.134
Expert 3	13.130	6.315	.774	.393
Expert 4	11.964	7.481	.705	.332
Expert 5	9.323	10.121	.550	.245
Expert 6	11.393	8.051	.672	.308
Expert 7	16.964	2.481	1.000	1.000
Expert 8	9.631	9.814	.568	.253
Expert 9	10.797	8.648	.636	.287
Expert 10	1.799	17.646	.106	.141

TABLE VI. LIST OF CRITERIA

Dimensions	Criteria	Short Codes
Environmental Dimension	Resource efficiency	RSREFF
	Potential for reducing carbon emissions	PTRCEM
	Promoting green innovation	PRGRINN
Social Dimension	Employee engagement and motivation	EMENMT
	Applicability of diversity and inclusion policies	APPDIP
	Community engagement and stakeholder satisfaction	CMMENSS
Governance Dimension	Ethical problems	ETHPR
	Risk management and long-term sustainability vision	RMNGLTSV
	Accountability and audit mechanisms	ACCAUDM
General / Performance Dimension	The difficulty of integrating ESG strategies into corporate objectives	DFFESGST
	Adaptation and openness to change	ADPTOPT
	Contribution to long-term financial sustainability	CNTLFS

TABLE VII. LINGUISTICS OF CRITERIA

	RSREFF	PTRCEM	PRGRINN	EMENMT	APPDIP	CMMENSS	ETHPR	RMNGLTSV	ACCAUDM	DFFESGST	ADPTOPT	CNTLFS
Expert 1	ML	MH	L	L	MH	ML	M	L	M	ML	M	M
Expert 2	Vl	M	L	ML	L	L	MH	Vl	Vl	Vl	Vl	ML
Expert 3	MH	L	Vl	MH	MH	L	ML	Vl	ML	L	M	MH
Expert 4	M	Vl	MH	M	Vl	MH	M	ML	L	MH	ML	MH
Expert 5	M	Vl	ML	M	M	ML	ML	MH	L	L	Vl	L
Expert 6	ML	M	L	MH	L	ML	L	M	L	M	MH	MH
Expert 7	MH	L	Vl	Vl	M	MH	ML	MH	ML	Vl	L	ML
Expert 8	Vl	MH	Vl	ML	M	ML	Vl	MH	MH	ML	MH	M
Expert 9	L	L	Vl	Vl	MH	ML	Vl	MH	MH	M	M	Vl
Expert 10	M	Vl	L	L	L	L	M	ML	Vl	MH	Vl	ML

TABLE VIII. INPUT-DATA MATRIX

	RSREFF	PTRCEM	PRGRINN	EMENMT	APPDIP	CMMENSS	ETHPR	RMNGLTSV	ACCAUDM	DFFESGST	ADPTOPT	CNTLFS
Expert 1	(.4,.5)	(.6,.3)	(.25,.6)	(.25,.6)	(.6,.3)	(.4,.5)	(.5,.4)	(.25,.6)	(.5,.4)	(.4,.5)	(.5,.4)	(.5,.4)
Expert 2	(.1,.75)	(.5,.4)	(.25,.6)	(.4,.5)	(.25,.6)	(.25,.6)	(.6,.3)	(.1,.75)	(.1,.75)	(.1,.75)	(.1,.75)	(.4,.5)
Expert 3	(.6,.3)	(.25,.6)	(.1,.75)	(.6,.3)	(.6,.3)	(.25,.6)	(.4,.5)	(.1,.75)	(.4,.5)	(.25,.6)	(.5,.4)	(.6,.3)
Expert 4	(.5,.4)	(.1,.75)	(.6,.3)	(.5,.4)	(.1,.75)	(.6,.3)	(.5,.4)	(.4,.5)	(.25,.6)	(.6,.3)	(.4,.5)	(.6,.3)
Expert 5	(.5,.4)	(.1,.75)	(.4,.5)	(.5,.4)	(.5,.4)	(.4,.5)	(.4,.5)	(.6,.3)	(.25,.6)	(.25,.6)	(.1,.75)	(.25,.6)
Expert 6	(.4,.5)	(.5,.4)	(.25,.6)	(.6,.3)	(.25,.6)	(.4,.5)	(.25,.6)	(.5,.4)	(.25,.6)	(.5,.4)	(.6,.3)	(.6,.3)
Expert 7	(.6,.3)	(.25,.6)	(.1,.75)	(.1,.75)	(.5,.4)	(.6,.3)	(.4,.5)	(.6,.3)	(.4,.5)	(.1,.75)	(.25,.6)	(.4,.5)
Expert 8	(.1,.75)	(.6,.3)	(.1,.75)	(.4,.5)	(.5,.4)	(.4,.5)	(.1,.75)	(.6,.3)	(.6,.3)	(.4,.5)	(.6,.3)	(.5,.4)
Expert 9	(.25,.6)	(.25,.6)	(.1,.75)	(.1,.75)	(.6,.3)	(.4,.5)	(.1,.75)	(.6,.3)	(.6,.3)	(.5,.4)	(.5,.4)	(.1,.75)
Expert 10	(.5,.4)	(.1,.75)	(.25,.6)	(.25,.6)	(.25,.6)	(.25,.6)	(.5,.4)	(.4,.5)	(.1,.75)	(.6,.3)	(.1,.75)	(.4,.5)

TABLE IX. EXPERT-WEIGHTED VALUES

	RSREFF	PTRCEM	PRGRINN	EMENMT	APPDIP	CMMENSS	ETHPR	RMNGLTSV	ACCAUDM	DFFESGST	ADPTOPT	CNTLFS
Expert 1	(.12,.91)	(.19,.85)	(.07,.94)	(.07,.94)	(.19,.85)	(.12,.91)	(.15,.89)	(.07,.94)	(.15,.89)	(.12,.91)	(.15,.89)	(.15,.89)
Expert 2	(.01,.99)	(.05,.98)	(.02,.99)	(.04,.99)	(.02,.99)	(.02,.99)	(.06,.98)	(.01,.99)	(.01,.99)	(.01,.99)	(.01,.99)	(.04,.99)
Expert 3	(.19,.86)	(.07,.94)	(.03,.96)	(.19,.86)	(.19,.86)	(.07,.94)	(.12,.92)	(.03,.96)	(.12,.92)	(.07,.94)	(.15,.89)	(.19,.86)
Expert 4	(.14,.9)	(.03,.97)	(.17,.88)	(.14,.9)	(.03,.97)	(.17,.88)	(.14,.9)	(.11,.93)	(.06,.95)	(.17,.88)	(.11,.93)	(.17,.88)
Expert 5	(.12,.93)	(.02,.98)	(.09,.94)	(.12,.93)	(.12,.93)	(.09,.94)	(.09,.94)	(.15,.9)	(.05,.96)	(.05,.96)	(.02,.98)	(.05,.96)
Expert 6	(.1,.93)	(.13,.91)	(.06,.95)	(.17,.88)	(.06,.95)	(.1,.93)	(.06,.95)	(.13,.91)	(.06,.95)	(.13,.91)	(.17,.88)	(.17,.88)
Expert 7	(.26,.77)	(.1,.9)	(.04,.94)	(.04,.94)	(.21,.82)	(.26,.77)	(.16,.86)	(.26,.77)	(.16,.86)	(.04,.94)	(.1,.9)	(.16,.86)
Expert 8	(.02,.98)	(.15,.9)	(.02,.98)	(.09,.94)	(.12,.92)	(.09,.94)	(.02,.98)	(.15,.9)	(.15,.9)	(.09,.94)	(.15,.9)	(.12,.92)
Expert 9	(.06,.95)	(.06,.95)	(.02,.97)	(.02,.97)	(.16,.89)	(.1,.93)	(.02,.97)	(.16,.89)	(.16,.89)	(.13,.91)	(.13,.91)	(.02,.97)
Expert 10	(.06,.98)	(.01,.99)	(.03,.99)	(.03,.99)	(.03,.99)	(.03,.99)	(.06,.98)	(.04,.98)	(.01,.99)	(.07,.97)	(.01,.99)	(.04,.98)

TABLE X. DEFUZZIFIED MATRIX

	RSREFF	PTRCEM	PRGRINN	EMENMT	APPDIP	CMMENSS	ETHPR	RMNGLTSV	ACCAUDM	DFFESGST	ADPTOPT	CNTLFS
Expert 1	.103	.169	.068	.068	.169	.103	.133	.068	.133	.103	.133	.133
Expert 2	.007	.033	.016	.025	.016	.016	.042	.007	.007	.007	.007	.025
Expert 3	.163	.065	.031	.163	.163	.065	.099	.031	.099	.065	.129	.163
Expert 4	.118	.028	.150	.118	.028	.150	.118	.090	.060	.150	.090	.150
Expert 5	.096	.023	.074	.096	.096	.074	.074	.123	.048	.048	.023	.048
Expert 6	.087	.113	.057	.144	.057	.087	.057	.113	.057	.113	.144	.144
Expert 7	.243	.100	.049	.049	.193	.243	.149	.243	.149	.049	.100	.149
Expert 8	.023	.126	.023	.076	.099	.076	.023	.126	.126	.076	.126	.099
Expert 9	.054	.054	.026	.026	.137	.083	.026	.137	.137	.108	.108	.026
Expert 10	.040	.009	.020	.020	.020	.020	.040	.031	.009	.051	.009	.031

TABLE XI. NORMALIZED MATRIX

Experts	RSREFF	PTRCEM	PRGRINN	EMENMT	APPDIP	CMMENSS
Expert 1	.110	.235	.132	.087	.173	.112
Expert 2	.008	.046	.031	.032	.016	.018
Expert 3	.175	.091	.061	.209	.167	.071
Expert 4	.126	.039	.292	.150	.029	.163
Expert 5	.103	.031	.144	.123	.098	.081
Expert 6	.093	.156	.111	.183	.058	.095
Expert 7	.260	.139	.095	.062	.197	.265
Expert 8	.025	.174	.045	.097	.101	.083
Expert 9	.058	.076	.050	.033	.140	.090
Expert 10	.043	.012	.038	.025	.020	.022

Experts	ETHPR	RMNGLTSV	ACCAUDM	DFFESGST	ADPTOPT	CNTLFS
Expert 1	.175	.070	.161	.133	.154	.138
Expert 2	.055	.007	.009	.009	.008	.026
Expert 3	.130	.032	.120	.085	.148	.169
Expert 4	.155	.093	.072	.194	.104	.155
Expert 5	.097	.127	.059	.063	.026	.050
Expert 6	.075	.116	.069	.146	.165	.148
Expert 7	.196	.251	.181	.063	.115	.154
Expert 8	.031	.130	.152	.098	.145	.102
Expert 9	.034	.142	.166	.140	.124	.026
Expert 10	.053	.032	.011	.067	.010	.032

TABLE XII. MAXIMUM, MINIMUM, AND DIFFERENCE

	RSREFF	PTRCEM	PRGRINN	EMENMT	APPDIP	CMMENSS	ETHPR	RMNGLTSV	ACCAUDM	DFFESGST	ADPTOPT	CNTLFS
Max	.260	.235	.292	.209	.197	.265	.196	.251	.181	.194	.165	.169
Min	.008	.012	.031	.025	.016	.018	.031	.007	.009	.009	.008	.026
Diff	.252	.223	.260	.183	.180	.248	.165	.243	.172	.185	.157	.143

TABLE XIII. PERCENTILE SCORES

	RSREFF	PTRCEM	PRGRINN	EMENMT	APPDIP	CMMENSS
Expert 1	10	9	10	5	10	10
Expert 2	11	10	10	5	10	10
Expert 3	15	10	10	5	5	15
Expert 4	5	10	15	10	5	15
Expert 5	10	9	5	10	10	5
Expert 6	10	11	5	5	15	10
Expert 7	10	15	5	5	5	15
Expert 8	15	10	15	15	5	5
Expert 9	10	7	10	10	9	10
Expert 10	10	5	10	10	4	5
	ETHPR	**RMNGLTSV**	**ACCAUDM**	**DFFESGST**	**ADPTOPT**	**CNTLFS**
Expert 1	5	10	5	6	10	10
Expert 2	5	10	5	6	9	9
Expert 3	5	5	5	6	9	10
Expert 4	5	5	5	6	9	10
Expert 5	10	5	7	15	6	8
Expert 6	5	7	7	5	9	11
Expert 7	10	7	7	5	7	9
Expert 8	10	8	10	3	2	2
Expert 9	5	15	10	4	5	5
Expert 10	5	20	10	10	6	5

TABLE XIV. AVERAGE PERCENTILE SCORES

	RSREFF	PTRCEM	PRGRINN	EMENMT	APPDIP	CMMENSS	ETHPR	RMNGLTSV	ACCAUDM	DFFESGST	ADPTOPT	CNTLFS
APS	10.6	9.6	9.5	8	7.8	10	6.5	9.2	7.1	6.6	7.2	7.9

TABLE XV. LINGUISTICS OF LEADERSHIP STYLES

	RSREFF	PTRCEM	PRGRINN	EMENMT	APPDIP	CMMENSS	ETHPR	RMNGLTSV	ACCAUDM	DFFESGST	ADPTOPT	CNTLFS
TR	M	M	H	MH	M	M	ML	M	MH	L	M	M
SR	M	H	M	M	MH	MH	L	H	MH	ML	MH	MH
ET	VVH	H	VVH	VH	VH	VH	VVL	H	VH	Vl	VH	VVH
AD	H	MH	M	M	H	H	L	MH	M	M	H	MH
AU	MH	M	MH	H	MH	H	M	H	H	L	M	MH
	RSREFF	**PTRCEM**	**PRGRINN**	**EMENMT**	**APPDIP**	**CMMENSS**	**ETHPR**	**RMNGLTSV**	**ACCAUDM**	**DFFESGST**	**ADPTOPT**	**CNTLFS**
TR	MH	M	MH	MH	H	M	L	H	H	L	MH	MH
SR	H	H	H	M	H	M	L	H	H	M	H	H
ET	VVH	VVH	VVH	VVH	VVH	VVH	VVL	VH	VVH	Vl	VH	H
AD	M	H	MH	MH	MH	M	ML	MH	H	ML	MH	H
AU	M	H	MH	H	M	M	ML	MH	MH	ML	MH	H
	RSREFF	**PTRCEM**	**PRGRINN**	**EMENMT**	**APPDIP**	**CMMENSS**	**ETHPR**	**RMNGLTSV**	**ACCAUDM**	**DFFESGST**	**ADPTOPT**	**CNTLFS**
TR	M	MH	H	MH	M	MH	M	M	H	ML	MH	MH
SR	MH	M	H	H	M	MH	ML	MH	MH	ML	MH	M
ET	VVH	VH	VH	H	VH	VH	VVL	VVH	VVH	Vl	H	VH
AD	M	MH	MH	MH	H	M	ML	MH	MH	M	M	H
AU	M	M	MH	MH	M	M	M	H	MH	ML	M	M
	RSREFF	**PTRCEM**	**PRGRINN**	**EMENMT**	**APPDIP**	**CMMENSS**	**ETHPR**	**RMNGLTSV**	**ACCAUDM**	**DFFESGST**	**ADPTOPT**	**CNTLFS**
TR	MH	MH	H	H	MH	H	M	MH	MH	L	H	M
SR	H	MH	M	MH	M	M	ML	M	M	M	M	H
ET	VH	VH	VH	VH	VVH	VVH	Vl	VH	H	Vl	H	VVH
AD	MH	H	M	MH	M	M	M	H	H	M	M	H
AU	MH	M	MH	H	MH	H	L	MH	MH	L	MH	M
	RSREFF	**PTRCEM**	**PRGRINN**	**EMENMT**	**APPDIP**	**CMMENSS**	**ETHPR**	**RMNGLTSV**	**ACCAUDM**	**DFFESGST**	**ADPTOPT**	**CNTLFS**
TR	H	M	H	MH	MH	M	M	MH	MH	M	M	H
SR	H	M	H	H	M	MH	M	H	MH	ML	M	MH
ET	H	H	VVH	VVH	H	VVH	Vl	H	VVH	VVL	VVH	VVH
AD	MH	H	MH	MH	MH	MH	ML	H	M	ML	M	H
AU	M	MH	MH	H	M	MH	ML	H	H	L	M	MH
	RSREFF	**PTRCEM**	**PRGRINN**	**EMENMT**	**APPDIP**	**CMMENSS**	**ETHPR**	**RMNGLTSV**	**ACCAUDM**	**DFFESGST**	**ADPTOPT**	**CNTLFS**
TR	M	M	H	H	H	H	L	M	MH	L	MH	M
SR	H	H	MH	MH	MH	M	ML	H	MH	L	H	M

ET	VVH	VH	VVH	VH	VH	VH	VVL	H	VH	VVL	VVH	VVH
AD	H	H	H	M	M	H	ML	M	M	ML	M	H
AU	M	H	MH	M	MH	M	M	H	M	L	H	M
	RSREFF	**PTRCEM**	**PRGRINN**	**EMENMT**	**APPDIP**	**CMMENSS**	**ETHPR**	**RMNGLTSV**	**ACCAUDM**	**DFFESGST**	**ADPTOPT**	**CNTLFS**
TR	H	MH	H	MH	H	MH	M	M	MH	ML	M	MH
SR	MH	MH	H	M	M	H	L	H	M	ML	M	MH
ET	VVH	VVH	VVH	VVH	H	VVH	VVL	VH	H	VVL	VH	VH
AD	MH	MH	MH	MH	M	MH	L	M	MH	ML	MH	M
AU	H	M	MH	H	MH	MH	ML	H	H	M	MH	MH
	RSREFF	**PTRCEM**	**PRGRINN**	**EMENMT**	**APPDIP**	**CMMENSS**	**ETHPR**	**RMNGLTSV**	**ACCAUDM**	**DFFESGST**	**ADPTOPT**	**CNTLFS**
TR	MH	M	M	M	MH	H	ML	MH	H	ML	MH	M
SR	MH	MH	MH	M	M	MH	L	H	H	ML	MH	M
ET	VH	H	VH	VVH	VH	VVH	Vl	VVH	VH	VVL	VH	H
AD	M	MH	M	M	H	H	L	MH	H	L	MH	H
AU	M	M	MH	H	H	H	L	M	MH	ML	M	H
	RSREFF	**PTRCEM**	**PRGRINN**	**EMENMT**	**APPDIP**	**CMMENSS**	**ETHPR**	**RMNGLTSV**	**ACCAUDM**	**DFFESGST**	**ADPTOPT**	**CNTLFS**
TR	M	H	H	H	MH	M	ML	MH	M	ML	H	H
SR	H	MH	H	M	MH	H	L	H	M	L	H	M
ET	VH	VVH	H	H	VH	VVH	Vl	VVH	H	Vl	VVH	VVH
AD	M	M	M	MH	MH	MH	L	MH	M	ML	M	H
AU	MH	H	H	MH	M	M	L	M	M	M	MH	MH
	RSREFF	**PTRCEM**	**PRGRINN**	**EMENMT**	**APPDIP**	**CMMENSS**	**ETHPR**	**RMNGLTSV**	**ACCAUDM**	**DFFESGST**	**ADPTOPT**	**CNTLFS**
TR	MH	M	M	M	MH	MH	ML	MH	H	M	H	MH
SR	MH	MH	M	H	H	H	M	M	MH	M	H	M
ET	VVH	VVH	VVH	VVH	VVH	VVH	Vl	VVH	VVH	VVL	H	VH
AD	H	M	M	MH	H	MH	M	MH	M	L	M	M
AU	H	M	H	H	H	MH	L	M	MH	L	M	MH

TABLE XVI. DECISION MATRIX

	RSREFF	PTRCEM	PRGRINN	EMENMT	APPDIP	CMMENSS	ETHPR	RMNGLTSV	ACCAUDM	DFFESGST	ADPTOPT	CNTLFS
TR	(.6,.3)	(.57,.33)	(.68,.22)	(.63,.27)	(.62,.28)	(.61,.29)	(.44,.45)	(.55,.35)	(.62,.28)	(.37,.52)	(.59,.31)	(.58,.32)
SR	(.64,.26)	(.61,.29)	(.64,.26)	(.58,.32)	(.55,.35)	(.62,.28)	(.34,.54)	(.67,.23)	(.58,.32)	(.39,.5)	(.59,.3)	(.58,.32)
ET	(.87,.11)	(.82,.12)	(.86,.11)	(.84,.12)	(.8,.12)	(.87,.1)	(.1,.84)	(.82,.12)	(.8,.13)	(.1,.82)	(.82,.12)	(.86,.11)
AD	(.6,.3)	(.63,.27)	(.57,.33)	(.57,.33)	(.61,.29)	(.62,.28)	(.35,.53)	(.6,.3)	(.59,.31)	(.43,.47)	(.57,.33)	(.65,.25)
AU	(.59,.31)	(.56,.33)	(.61,.29)	(.66,.24)	(.58,.31)	(.61,.29)	(.4,.49)	(.65,.24)	(.63,.27)	(.38,.51)	(.57,.33)	(.58,.32)

TABLE XVII. DEFUZZIFIED DECISION MATRIX

	RSREFF	PTRCEM	PRGRINN	EMENMT	APPDIP	CMMENSS	ETHPR	RMNGLTSV	ACCAUDM	DFFESGST	ADPTOPT	CNTLFS
TR	.644	.620	.727	.674	.666	.655	.495	.598	.669	.424	.640	.633
SR	.684	.660	.686	.629	.597	.667	.403	.714	.624	.447	.643	.625
ET	.884	.850	.880	.862	.832	.889	.137	.847	.832	.145	.847	.876
AD	.651	.674	.621	.620	.655	.664	.408	.644	.636	.478	.615	.697
AU	.641	.614	.663	.711	.634	.657	.457	.702	.680	.437	.621	.632

TABLE XVIII. NORMALIZED DECISION MATRIX

	RSREFF	PTRCEM	PRGRINN	EMENMT	APPDIP	CMMENSS	ETHPR	RMNGLTSV	ACCAUDM	DFFESGST	ADPTOPT	CNTLFS
TR	.184	.181	.203	.193	.197	.185	.260	.171	.195	.219	.190	.183
SR	.195	.193	.192	.180	.176	.189	.212	.204	.181	.231	.191	.181
ET	.252	.249	.246	.247	.246	.252	.072	.242	.242	.075	.252	.253
AD	.186	.197	.174	.177	.194	.188	.215	.184	.185	.248	.183	.201
AU	.183	.180	.185	.203	.187	.186	.240	.200	.197	.226	.184	.182

TABLE XIX. WEIGHTED DECISION MATRIX

	RSREFF	PTRCEM	PRGRINN	EMENMT	APPDIP	CMMENSS	ETHPR	RMNGLTSV	ACCAUDM	DFFESGST	ADPTOPT	CNTLFS
TR	.019	.017	.022	.015	.015	.019	.018	.017	.014	.017	.012	.011
SR	.020	.018	.021	.014	.013	.019	.015	.021	.013	.018	.012	.011
ET	.026	.023	.027	.019	.018	.026	.005	.024	.017	.006	.016	.015
AD	.019	.018	.019	.013	.014	.019	.015	.019	.013	.019	.012	.012
AU	.019	.017	.020	.015	.014	.019	.016	.020	.014	.017	.012	.011

TABLE XX. SUMS AND OVERALL VALUES

	S+	S-	Overall
TR	.161	.035	1.4603
SR	.162	.032	1.4613
ET	.212	.011	1.4841
AD	.159	.034	1.4601
AU	.161	.034	1.4607

TABLE XXI. SENSITIVITY ANALYSIS

	TR	SR	ET	AD	AU
Senario_1	4	2	1	5	3
Senario_2	4	2	1	5	3
Senario_3	4	2	1	5	3
Senario_4	4	2	1	5	3
Senario_5	4	2	1	5	3
Senario_6	4	2	1	5	3
Senario_7	4	2	1	5	3
Senario_8	4	2	1	5	3
Senario_9	4	2	1	5	3
Senario_10	4	2	1	5	3
Senario_11	4	2	1	5	3
Senario_12	4	2	1	5	3