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Study of Environmental Performance Index of Mines Using a Balanced Scorecard Approach and Fuzzy Network Analysis

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ABSTRACT

Background: Environmental performance indexes are numerical values that provide insights into the condition of the environment and human health. This study focuses on the use of the Sustainability Balanced Scorecard (SBSC) as a multidimensional tool for measuring environmental performance and health in mining companies. The application of SBSC is crucial in guiding mining companies towards sustainable development and human health objectives.
Methods: Based on the literature and research background, 75 initial indicators were examined. Subsequently, 28 indicators were selected as final indicators. The Fuzzy Analytical Network Process (FANP) method was used for weighting and ranking the perspectives of the SBSC. Additionally, a pairwise comparison questionnaire was designed and distributed among the experts.
Results: The research findings demonstrated that among various perspectives of the SBSC, the "growth and learning" perspective had the highest average weight of 0.48, indicating its superiority over other perspectives. The "society" perspective ranked second, with an average weight of 0.24, while the "environment and health" perspective ranked third, with an average weight of 0.22. Finally, the "economy" perspective ranked fourth with an average weight of 0.16 compared with the other perspectives.
Conclusion: The primary objective of the present study was to identify, prioritise, and assess the aspects that influence sustainability, and after that provide a complete framework for evaluating sustainability performance in the mining industry. To achieve this, a sophisticated theoretical framework called SBSC was introduced. This framework provides a strong means of measuring and evaluating sustainable performance in mining and related sectors.

1. Introduction

The mining industry is often criticised for its frequent fatalities, resource depletion, and unsustainable practises. It is impossible to completely ban the mining industry because it is such a major player in the global economy, but it is possible to perform mining activities in a sustainable manner. With environmental laws becoming more stringent

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across the world, the mining industry is under pressure to adopt sustainability in its industrial activities. Realising the need to integrate sustainability into all industrial activities, stakeholders in the mining industry emphasise adopting sustainability (Marimuthu et al., 2021). Sustainable development is one of the most important topics of our century, driven by social changes, environmental degradation, and threats to human health. Currently, the comparison criterion for sustainable development among countries is their environmental performance index, as evaluated by the International Environmental Performance Index (EPI) (Mohammadi et al., 2022). During the 1970s and 1980s, companies primarily focussed on complying with environmental management regulations, observing a weak relationship between sustainability reporting and organisational performance. Later, in the 1990s, sustainability reporting expanded to include occupational health and safety (OHS), with a paradigm shift towards reporting on societal-based activities, leading to institutionalisation (Ikram et al., 2020). Scientific research on sustainable development can help industries, particularly the mining sector, in adopting strategies that address the current expectations of stakeholders in a broader sense and simultaneously support the preservation of social assets, natural resources, and human health for the future (Mohammadi et al., 2022). sustainability is defined as achieving economic, environmental, and social dimensions that support an organisation for long-term competition, green development and a low-carbon economy play an important role in achieving a sustainable society (Afarin et al., 2022). A tool that have recently been considered by experts to align sustainable actions with organisational strategies is the Balanced Scorecard. Since this tool recognizes the strategic role of non-financial factors in the economic success of an organisation, it serves as a suitable starting point for integrating sustainability aspects within an organization. Nowadays, the traditional Balanced Scorecard has been developed and integrated with environmental, economic, and social dimensions, resulting in an adapted tool known as the SBSC (Fukardi & Mohtat, 2016). Considering that the concept of sustainable development is recognised as a guide and goal for developing organisational strategies and policies towards dynamic and sustainable progress, the SBSC can serve as a reliable framework for the development, implementation, and evaluation of organisational strategies. The SBSC will be presented as a new practical tool for assessing sustainable development (Fukardi & Mohtat, 2016). This research aims explain the indicators of environmental performance and sustainable development in the mining industry using the SBSC method and fuzzy network analysis. It also provide a comprehensive picture of the SBSC

1.1 Different Definitions of Sustainable Development

Various definitions of sustainable development have been proposed, with one of the most well-known and comprehensive definitions originating from the Brundtland Report titled "Our Common Future." According to this definition, sustainable development is the development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs, and it encompasses the relationship between humans and nature worldwide (Shafii et al., 2018).

2. Materials and Methods

The research methodology is considered a mixed or hybrid approach, that combines a set of quantitative and qualitative methods. Generally, the research is defined into eight main stages:

2.1 Determining the Perspectives of the SBSC

Companies integrate their social, human health, and environmental goals with the four main perspectives of BSC in the initial stages of sustainability implementation. Companies may simultaneously integrate both approaches by adding one or two sustainability perspectives. The model of the sustainable performance evaluation network in mining and a comparison of these two is indicated in Table 1.

Table 1. How to replace the SBSC perspective with the BSC perspective

Row	BSC perspectives	Operation performed	SBSC perspectives
1	Financial	Replace	Economy
2	Internal processes	Replace	Environment
3	Growth and learning	No change	Growth and learning
4	Customer	Replace	Social

2.2 Determining the perspective of the SBSC through global reporting initiatives and environmental performance indicators

To enhance the evaluation and monitoring of any subject, specific indicators are determined. In this regard, the SBSC model has incorporated sustainability performance indicators in the form of indicators that have been considered and are categorised into four perspectives: economic, environmental, social, and growth and learning. When considering the sustainability performance indicators of firms, several globally accepted measures of evaluation exist. The Global Reporting Initiative (GRI) was initiated to measure the economic, social, and environmental performance of firms. This framework uses over 100 indicators relevant to the three major areas of sustainability performance (Rajash, 2020). Environmental performance assessment is a management process that enables organisations to measure and evaluate environmental performance using key performance indicators and provide reliable and credible information to stakeholders. The ISO14031 standard aims to provide a model for defining specific indicators, periodic measurement of indicators, as well as presentation of environmental performance reports to society and stakeholders with a common expression. This standard helps organisations to make a more accurate and comprehensive assessment of their environmental performance by setting goals and criteria that continuously improve their performance and demonstrating performance trends.

2.3 Sampling and expert selection

The sampling method used in this research is purposive sampling. In qualitative studies, sampling aims to identify special groups of people who possess certain characteristics or live in similar social phenomena. Participants are selected on the basis their capability to provide insights into research-related behaviours from particular perspectives. Purposive sampling, also known as non-probability, targeted, or qualitative sampling, refers to the purposeful or qualitative selection of research units to acquire knowledge or information (Jalali, 2013). In this research, managers and senior experts with more than 10 years of work experience were targeted to distribute, questionnaires for indicator screening.

2.4 Screening and Selecting Key Sustainability Performance Indicators Using Expert Opinions

Information serves as a crucial decision-making resource, and interviews and questionnaires are the primary data collection tools in research, providing researchers with detailed quantitative and qualitative information. In this study, to identify the most suitable indicators among the selected indicators in the research literature, a closed-ended questionnaire was designed and administered in a graded manner. Competency-based scales were developed (graded and competency questions are a type of question where the respondent ranks the desired cases based on their preference). A five-option Likert scale (Table 2) and a triangular fuzzy manner were used to evaluate individuals' attitudes towards the selection of the most suitable indicators for assessing sustainability performance. The questionnaires were completed through personal visits. The fuzzy Delphi technique was used to analyse the data, both to establish experts' consensus on the indicators as a basis for decision making and to analyse experts' verbal opinions more accurately in a fuzzy space.

Table 2. Linguistic Expression Triangular Fuzzy Numbers

Language expression	Triangular fuzzy numbers
Not important at all	(0,0,0.25)
Slightly important	(0,0.25,0.5)
Neutral	(0.25,0.5,0.75)
Moderately important	(0.5,0.75,1)
Extremely important	(0.75,1,1)

2.5 Fuzzy Defuzzification

Fuzzy defuzzification is an important stage in fuzzy systems. In fuzzy systems, the results of approximate reasoning usually come in the form of one or more fuzzy sets. However, fuzzy results are not easily interpretable, necessitating the conversion of fuzzy outputs into crisp (non-fuzzy) numbers. There are various methods for fuzzy defuzzification, including the center of gravity method, surface center method, maximum method, sum center method, and weighted average center method (Radfar et al., 2010). In this study, the fuzzy defuzzification method of fuzzy average was used to rank the fuzzy numbers. fuzzy defuzzification refers to the process of converting fuzzy numbers into crisp numbers, aiming to facilitate improved decision-making under uncertain conditions.

2.6 Using FANP for Weighting and Ranking of the SBSC Perspectives

2.6.1 Designing Fuzzy Linguistic Criteria

The utilisation of fuzzy methodology necessitates the representation of all values in pairwise comparison matrices in the form of fuzzy numbers. In this study, triangular fuzzy numbers were employed. After identifying the final factors influencing the assessment of sustainability performance in the mining and mining industries through the second questionnaire, which was used to evaluate the relative impact of the identified factors, the opinions of seven respondents were considered. The assessment was based on a five-point Likert scale (Table 3). The numbers were converted to triangular fuzzy numbers according to the following table. The pairwise comparison matrix employed a scale of 1 to 9 to determine the relative importance of each element compared with other elements concerning a particular characteristic. A score of 1 indicates equal importance between two factors, whereas a score of 9 indicates complete dominance of one factor (row element) over another factor (column element).

Table 3. Linguistic Comparative Variables for Evaluating the Importance of Perspectives

Definition	Number is definite	Triangular fuzzy numbers
Equally preferred	1	(0,0,0.25)
Moderately preferred	3	(0,0.25,0.5)
Strongly preferred	5	(0.25,0.5,0.75)
Very strongly preferred	7	(0.5,0.75,1)
Extremely preferred	9	(0.75,1,1)

2.6.2 Preparation of Pairwise Comparison Questionnaire

In a decision-making process involving multiple decision-makers, it is crucial to consider the opinions of all decision-makers in the pairwise comparison matrix, thereby avoiding biased perspectives. Deir and Forman (1992) suggested several methods for incorporating the perspectives and judgments of group members in pairwise comparison matrices, including consensus, voting, or bargaining, the geometric mean of individual judgments, and separate models. In this study, the geometric mean of individual judgments was used (Mirsenjari & Mohammadyari, 2018).

2.7 Validity and reliability of the measurement tool and determination of the inconsistency rate using the Gogus and Boucher method

To examine the validity and reliability of the questionnaire, the opinions of experts and specialists were used. Reliability, or consistency is concerned with the measurement tool produces consistent results under similar conditions. The validity of the questionnaire helps us determine to what extent the main question of the questionnaire is closely related and similar to the topics for which it is prepared for measurement. Because the questionnaire in this research was based on pairwise comparisons, the concept of inconsistency rate was used to measure reliability and validity. Therefore, the Gogus and Boucher inconsistency rate method was used (Gogus & Boucher, 1998). This means that for pairwise comparison questionnaires, reliability or validity indices such as Cronbach's alpha are not applicable. Instead, the completed pairwise comparison questionnaires provided by the decision-makers were evaluated, and any questionnaire exhibiting an inappropriate inconsistency rate (greater than 0.1) was excluded. Furthermore, before calculating the weights of the criteria, the consensus of individual's opinions must be ensured. It is better to include the opinions of different decision makers in group calculations when the inconsistency rate of each decision maker's opinions is less than 0.1. If the inconsistency rate is less than or equal to 0.1, there is consistency in pairwise comparisons, and the process can continue. Otherwise, the decision makers needs to review the pairwise comparisons. The consistency of the matrix indicates the extent to which we can rely on the priorities determined in the matrix. In other words, the satisfaction of the relationship aik * akj = aij for one of the i, j, and k, was necessary to maintain consistency within the matrix.

2.8 Determining the Final Weights

The final weights were determined by multiplying the weights of the perspectives from the SBSC by the weights of the determined indicators.

3. Results and Discussion

From the beginning, the main focus of incorporating the concept of sustainable development into mining strategies has been on identifying which indicators to use and how to weigh them. Therefore, it can be concluded that this research provides appropriate answers to these issues. By developing a Balanced Scorecard for sustainable development determining the indicators for each perspective, and ultimately assigning weights to them, it can pave the way for moving towards sustainable development in the mining sector. The results of this study are as follows:

3.1 Identification of indicators

To identify the initial indicators, the sustainability reports of three mining companies, SSR Mining's 2018 sustainability report (Benson, 2018), FORTUNA Silver Mines INC's 2018 sustainability report (Ganoza, 2018) and Endeavour Mining's 2017 sustainability report (De Montessus, 2017) along with the Bank Ayande 's 2017 sustainability performance report (Ayandeh Bank, 2017) were examined on the GRI website. In Addition, the Environmental Performance Indicator Guidelines developed by the Ministry of the Environment, Japan Government, were used to guide the identification of key environmental performance indicators in organizations (Ministry of the Environment (Japan Government), 2002). This resulted in the identification of 75 initial indicators.

3.1.1 Extracted Initial Indicators from the Literature

The Extracted initial indicators from the literature mentioned in the text above are shown in Table 4.

3.2 Expert Judgement for Screening and Selecting of Indicators

To validate and screen the indicators, expert judgments were solicited. At this stage, 15 experts familiar with the company's internal and external environment, processes, and operations participated. The required data were obtained by combining questionnaire tools in the employee's questionnaires, which included 75 indicators. These indicators were derived from the existing research literature, and categorised into four perspectives: learning and growth, social, economic, and environmental aspects of the organization. The data were organised (learning and growth perspective with 4 indicators, social perspective with 18 indicators, economic perspective with 11 indicators, and environmental perspective with 42 indicators). The indicators were then presented to the expert group, who were asked to provide their opinions on each indicator using the linguistic variables provided in the questionnaire. expert opinions, including any additional relevant indicators not covered in the questionnaire, were compiled in the expert opinion section. In this method, fuzzy logic and numbers derived from the fuzzy Delphi technique were used to reach a consensus among experts regarding the indicators and to analyze their opinions more precisely. The statistical population of this research consisted of 15 experts and professionals who were familiar with the operation internal and external environment. All information was collected through consensus of expert judgments. Of the 15 distributed questionnaires among the experts, one was found to be invalid. Finally, 14 valid questionnaires were collected. To screen the indicators from the fuzzy average column, the arithmetic mean was taken and its fuzzy number (4.45, 3.84, 2.56) was obtained, with a non-fuzzy number of 3.6. Therefore, indicators with an average score below 3.6, which means that they did not achieve the minimum score, were excluded. Based on this criterion, the following indicators were removed: E1, E2, E3, E6, E8 and E9 from the economic perspective; G1 and G2 from the learning and growth perspective; S1, S4, S8, S9, S10, S11, S12, S14, S15, S16 and S18 from the social perspective; and EN2, EN3, EN4, EN5, EN9, EN10, EN11, EN14, EN16, EN17, EN18, EN21, EN22, EN25, EN28, EN29, EN30, EN31, EN32, EN33, EN34, EN35, EN36, EN37, EN38, EN40, EN42 from the environmental perspective. In total, 47 indicators were excluded from the original set.

Table 4. Extracted Initial Indicators from the Literature

SBSC indicators							
Economic		Social		Learning and Growth		Environment	
Indicator Code	Indicator	Indicator Code	Indicator	Indicator Code	Indicator	Indicator Code	Indicator
E1	The amount of net profit on sales	S1	Customer Satisfaction	G1	Average Training Hours per Employee	EN1	Air Quality Improvement and Dust Control
E2	Return on Sales	S2	Identification and Selection of Stakeholders	G2	Knowledge Management	EN2	Noise Control
E3	Cost-to-Income Ratio	S3	Employee Turnover	G3	Skill Development	EN3	Greenhouse Gas Emissions (CO_2 equivalent)
E4	Sales and Revenue	S4	Women's Involvement in Business	G4	Education Level of Employees	EN4	Waste Management
E5	Social Investment and Active Community Engagement	S5	Local Workforce Employment	-	-	EN5	Hazardous Material Management
E6	Total Production and Sales Volume	S6	Training for Local Personnel	-	-	EN6	Waste Disposal Management
E7	Total equity to total assets ratio	S7	Bribery and Corruption Risk	-	-	EN7	Percentage Reduction in Hazardous Waste Generation
E8	Sales of Goods and Services	S8	ISO45001 Certification	-	-	EN8	Total Production Waste Generated
E9	Net profit to total assets ratio	S9	Zero Fatality	-	-	EN9	Chemical Release
E10	Sales to total fixed assets ratio	S10	Number of Industrial Accidents	-	-	EN10	Total Input Material Quantity (volume or weight of consumed raw materials)
E11	Current assets to current liabilities ratio	S11	Incident Frequency Rate	-	-	EN11	Prominent Zero Spillage
-	-	S12	Incident Severity Rate	-	-	EN12	Energy Consumption Reduction
-	-	S13	Lost Time Injury Frequency	-	-	EN13	Energy Intensity per Ton of Output
-	-	S14	Number of Employees	-	-	EN14	Percentage Reduction in Electricity Consumption in a Year
-	-	S15	Customer Growth Rate	-	-	EN15	Energy Consumption Intensity Ratio KW/t of Production
-	-	S16	Number of consistent customers in both years under review	-	-	EN16	Total Input Energy Quantity
-	-	S17	Number of Customers	-	-	EN17	Fuel Consumption
-	-	S18	New Customer Acquisition Rate	-	-	EN18	Number of Low Carbon Emission Vehicles
-	-	-	-	-	-	EN19	Biodiversity Management and Environmental Restoration
-	-	-	-	-	-	EN20	Efforts towards Mine Rehabilitation
-	-	-	-	-	-	EN21	Total Land Disturbed and Damaged
-	-	-	-	-	-	EN22	Total Rehabilitated Land
-	-	-	-	-	-	EN23	Amount of Water Recycled per Cubic Metre (recycle)
-	-	-	-	-	-	EN24	Amount of Water Reused per Cubic Meter (reuse)
-	-	-	-	-	-	EN25	Surface Water Consumption
-	-	-	-	-	-	EN26	Groundwater Consumption
-	-	-	-	-	-	EN27	Percentage of Water Recycled as a Portion of Total Consumption
-	-	-	-	-	-	EN28	Total Input Water Resources Quantity
-	-	-	-	-	-	EN29	Total Water Discharged
-	-	-	-	-	-	EN30	Number of Environmental Reports
-	-	-	-	-	-	EN31	Number of Participations in Environmental Exhibitions
-	-	-	-	-	-	EN32	Number of Advertisements Related to the Environment
-	-	-	-	-	-	EN33	Number of Environmental Meetings with Stakeholders
-	-	-	-	-	-	EN34	Number of Environmental Education Programmes and Participants in Local Communities
-	-	-	-	-	-	EN35	Number of Employees Participating in Voluntary Activities Organized by the Company
-	-	-	-	-	-	EN36	Recognition of Environmental Conservation Activities
-	-	-	-	-	-	EN37	Number of Environmental Certifications
-	-	-	-	-	-	EN38	Number of Internal and External Audits
-	-	-	-	-	-	EN39	Financial Resources for Environmental Research and Development
-	-	-	-	-	-	EN40	Percentage of Purchases that Consider Environmental Considerations in Productions and Services
-	-	-	-	-	-	EN41	Total Expenditure for Environmental Protection Activities
-	-	-	-	-	-	EN42	Number of Green Teams

3.3 Ranking of Perspectives

According to the identification of sustainable performance evaluation indicators in mining and mining industries, the ranking of the identified perspective in SBSC is performed using the fuzzy FANP method. To achieve the research objective, paired comparison questionnaires were designed and distributed among the experts. The fuzzy approach, employing verbal expressions and fuzzy numbers listed in Table 3, was used. This facilitated the final identification of the factors influencing the evaluation of sustainability performance in the mining and mining industries. The second questionnaire was employed to evaluate the relative impact of the identified factors using a five-point Likert scale.

3.4 Determining validity and reliability and calculating the inconsistency rate

After collecting the data, the fuzzy equivalents of the experts' opinions were calculated. After preparing the single matrix (average of experts' opinions), the inconsistency rate for the collected data was calculated using the Gogos and Butcher inconsistency rate method. The results showed that the inconsistency rate for all obtained matrices was less than 0.1, affirming the consistency of pairwise comparisons of the perspectives (Stemler, 2019).

3.5 Making pairwise comparisons

To avoid bias attitude, a group decision was used to form the matrix of paired comparisons. The attitudes and judgments of the group members were incorporated into the matrix of paired comparisons using the geometric mean method of individual judgments (due to the large number of tables of paired comparisons, it is not refused) (Kou et al., 2016). By calculating the geometric mean for each matrix array, pairwise comparisons of the criteria were obtained, as presented in Table 5.

Table 5. The geometric mean of paired comparisons

	Economy	Society	Environment	Growth and Learning
Economy	(0, 0, 0.25)	(0, 0.52, 0.75)	(0, 0.57, 0.84)	(0, 0.38, 0.64)
Society	(0.6, 0.8, 1)	(0, 0, 0.25)	(0, 0.42, 0.68)	(0, 0.56, 0.8)
Environment	(0, 0.56, 0.78)	(0.5, 0.16, 0.95)	(0, 0, 0.25)	(0, 0.4, 0.66)
Growth and Learning	(0, 0.59, 0.83)	(0.64, 0.89, 1)	(0, 0.5, 0.65)	(0, 0, 0.25)

3.6 Normalising paired comparisons

After normalising the pairwise comparison matrix and calculating the arithmetic mean of each column, the weights of the perspectives were obtained. Table 6 shows the normalisation of pairwise comparisons.

Table 6. Normalization of pairwise comparisons

	The first normalized column	The second normalized column	The third normalized column	Fourth normalized column
Economy	(0.42, 0, 0)	(0.66, 0.34, 0)	(0, 0.39, 0)	(0, 0, 0)
Society	(1.67, 0.42, 0.23)	(0.22, 0, 0)	(0, 0.29, 0)	(0, 0, 0)
Environment	(1.3, 0.29, 0)	(0.84, 0.1, 0.17)	(0, 0, 0)	(0, 0, 0)
Growth and Learning	(1.39, 0.3, 0)	(0.88, 0.57, 0.22)	(0, 0.34, 0)	(0, 0, 0)

3.7 Determining the weight of perspective and the weight of a stable balanced scorecard

After normalising the matrix of pairwise comparisons and calculating the arithmetic mean of each row, the weight of the views was obtained. The matrix of pairwise comparisons of the four main aspects of the balanced scorecard and Table 7 are the weights of the four main perspective caculated by the FANP method. The relative weight of the views of the stable balanced scorecard, which is equal to the arithmetic mean of each row, is shown in fuzzy form. The final weight of each landscape is determined from the product of the fuzzy weight of the balanced scorecard of sustainability, as well as the scores of the indicators. Ranking ultimate perspectives weights are shown in figure1.

Stable weight = weight of indicators * weight of perspective

Table 7. Perspective Fuzzy Final Weight Final Deterministic Weight

Perspective	Average fuzzy final weight	The final weight is finalized	Rank
Economy	(0.27, 0.19, 0)	0.16	4
Society	(0.48, 0.18, 0.6)	0.24	2
Environment	(0.6, 0, 1.04)	0.22	3
Growth and Learning	(0, 0.57, 3.55)	0.48	1

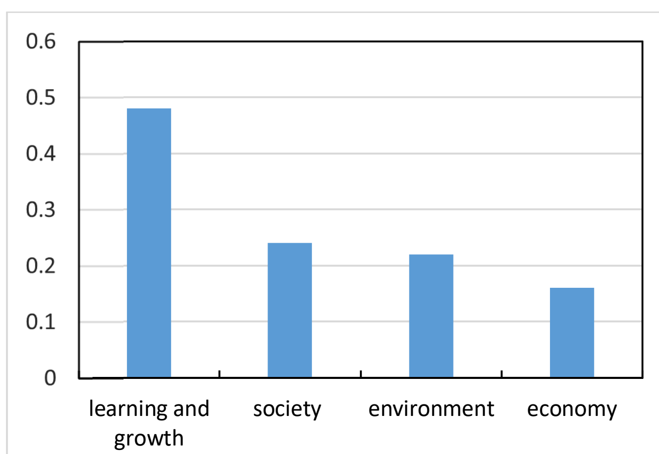

Figure1. Ranking ultimate perspective weight

To evaluate the importance of the indicators in the perspectives, a Balanced Scorecard tool was used, which included items in the questionnaire. The mentioned questionnaires consisted of 75 indicators, which were measured on a five-point Likert scale. The variables in the questionnaire were defined as triangular fuzzy numbers. Table 2 shows the linguistic variables for evaluating the importance of the indicators.

3.8 Main Findings

The main objective of the present research was to identify, rank, and score the factors affecting sustainable development and the environmental performance index, and ultimately develop a comprehensive model for evaluating the performance of sustainable development in the mining and mining industries in Iran. In addition, this research aims to address the challenges faced by companies in sustainability rating, including the lack of standards, credibility of information, directionality, transparency, independence. The current study has contributed by presenting an advanced theoretical model for measuring environmental performance using the SBSC with four perspectives: economic, social, environmental, and growth and learning. In this study, fuzzy sets, which have better compatibility with linguistic descriptions and sometimes capture human importance, were used. The numbers used in this study were triangular fuzzy numbers. Additionally, FANP was employed for rank the factors affecting sustainability. By reviewing various articles and examining the research literature, the operationalisation of indicators related to each of the four perspectives of the Balanced Scorecard, including social, environmental, economic, and growth and learning perspectives, was performed, resulting in the identification of 75 initial indicators. After consulting with experts, the identified factors influencing sustainable performance in the mining and mining industries were analysed using a questionnaire. The indicators were evaluated on the basis of their suitability and relevance to the research. In this analysis, indicators with an average weight greater than 0.3 were considered suitable indicators, resulting in the selection of 28 final indicators. The weights of each perspective in evaluating the sustainability performance of the mining industry were determined using the FANP method and pairwise comparison questionnaires. Because the research questionnaire was based on pairwise comparisons, the concept of inconsistency ratio was used to measure its reliability or validity. The inconsistency ratio was estimated using the Gogos and Butcher method, and all values were less than 0.1, indicating consistency. The evaluation of the sustainability performance indicators in the mining and mining industries showed that the identified SBSC indicators ranked "number of lost days" with an average weight of 0.10 first, followed by "Total Waste Production" with an average weight of 0.73 in the second place, and "waste management" and "mining rehabilitation efforts" with a weight of 0.59 third. The results of the research showed that among the perspectives of the Balanced Scorecard, the "growth and learning" perspective had a superiority with an average weight of 0.48 compared with the other perspectives. The "Social" perspective ranked second with an average weight of 0.24, followed by the "environmental" perspective with an average weight of 0.22, and finally, the "Economic" perspective with an average weight of 0.16 compared to the other perspectives. This issue confirms that it will not be possible to create a value-creating process unless we provide a suitable working environment for the learning and growth of the company's employees (learning and growth perspective), and this is possible by meeting human needs and improving the quality of life of employees. social view and to improve the quality of life of employees, we must try to manage the environment and prevent pollution and waste of resources (environmental view) to ultimately create economic efficiency and economic growth (economic view). In previous foreign research, the theoretical aspects of sustainability scorecard were mostly discussed, and there was no research on this subject in the industry and mining sector. In domestic research, we can refer to the research (Alam Tabriz et al., 2013), that the sources of extracting sustainability indicators are almost the same, and most of them in both types of research are from the GRI, but the approach used in this research is different. In another study (Mohammadi et al., 2022), a performance evaluation study based on a sustainable balanced scorecard was used in five economic, environmental, social, internal process, and growth and learning areas. For the main dimensions and criteria of evaluating the sustainability performance of the investigated industry, it was determined that environmental and social factors are the most influential factors and internal and economic processes factors are the most influential factors. Also, economic criteria (0.239), internal processes (0.21), social (0.188), growth and learning (0.183), and environmental (0.178) are the most important detergent industry strategies. In this study, it agrees with the study done. In a study by Nikbakht and Rahimipour (2022), the conceptual model of sustainability performance evaluation from financial perspectives, growth and learning, internal process, customer, environment, social, and foresight was used, and the results indicate that all dimensions of the scorecard the stable balance had a positive and significant effect on performance evaluation in private banks (Nikbakht & Rahimipour, 2022). The landscapes used in this study are largely aligned with the landscapes used in the study.

4. Conclusion

The primary objective of the present study was to investigate, prioritize, and assess the aspects that influence sustainability, and thereafter provide a complete framework for evaluating sustainability performance in the mining and mining industries. To achieve this objective, a comprehensive framework called SBSC was introduced. The SBSC encompasses four perspectives: economics, society, environment, and growth and learning. The assessment of sustainability performance indicators revealed that the "number of lost days" index ranked first, followed by the "total number of production waste" index. The third place was occupied by the indicators of "waste management" and "efforts for mine rehabilitation". Moreover, the research findings indicated that the "growth and learning" dimension exhibited the highest level of sustainability, followed by the "society" dimension in second place, the "environment" dimension in third place, and lastly, the "economy" dimension in fourth place. However, the research is limited in terms of sustainable development indicators and a lack of comprehensive research in the mining sector. Additionally, the data collected for this research was based on the opinions of company managers and experts, which is a significant limitation in terms of comprehensiveness. To address these limitations, it is recommended to replicate the study procedure in organizations operating in comparable industries. This replication would enable meaningful comparisons between different companies and sectors.

Authors' Contributions

Hasan Karimzadegan, Farzam Babaei: Writing-original draft; Writing-review and editing; Investigation; Resources. Saeed Azimizadeh, Hooman Bahmanpour, Mohamad Reza Tabesh: Writing-review and editing; Visualization; Methodology; Investigation.

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All ethical principles are considered in this article.

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