Developing Weighted Triple-Bottom Line Indicators for Pakistani Steel Sustainability: A Delphi Consensus Study

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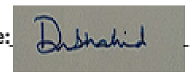
Signature: 

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No part of this thesis has been submitted anywhere else for any other degree. This thesis is submitted to the Department of Design and Manufacturing Engineering in partial fulfillment of the requirements for the degree of Master of Science in Field of Department of Design and Manufacturing Engineering by Department of Department of Design and Manufacturing Engineering, National University of Sciences and Technology, Islamabad.

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DEDICATION

Dedicated to my exceptional parents and Teachers, whose tremendous support and cooperation led me to this wonderful accomplishment.

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I am profusely thankful to my beloved parents who raised me when I was not capable of walking and continued to support me throughout every department of my life.

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ABSTRACT

This research proposes a set of weighted Triple Bottom Line (TBL) indicators that are adapted to the specific issues faced by the Pakistani steel sector. This study tackles the crucial gap in complete sustainability evaluation that exists within the Pakistani steel industry. There is a lack of a standardized framework within the sector for analyzing its environmental, social, and economic policies, even though there are efforts being made to promote sustainability. The Delphi approach is used in this study, which involves the participation of specialists from a wide range of fields to generate a comprehensive set of indicators. The Delphi technique, which is well-known for its capacity to deal with difficult problems, works to ease the formation of agreement among various stakeholders. The research highlights significant indicators, such as the amount of electricity used and the working conditions, so drawing attention to areas that may be improved and providing direction for decision-making. The study throws light on top priority indicators and aspect categories by means of expert consensus and analysis. It also provides significant insights for the purpose of improving sustainable practices in the Pakistani steel sector. This all-encompassing approach helps to develop informed decision-making among stakeholders and policymakers, and it adds to a more thorough knowledge of the performance of sustainability.

Keywords: Sustainability Indicators, Triple Bottom Line, Steel Industry, Delphi Method

INTRODUCTION

1.1. Background

The steel industry plays a crucial role in global economic development due to its significant impact on various sectors and economies worldwide. Steel is widely used in engineering applications, including construction, transportation, industrial equipment, and infrastructure development [1]. The industry's importance is further highlighted by its strong interdependence with consumer markets, making it a key player in driving economic growth and stability [2]. Moreover, the steel industry is a major energy consumer, accounting for 8% of global energy demand and contributing to 9% of global greenhouse gas emissions [3]. Efforts to enhance energy efficiency and reduce environmental impacts within the steel sector are essential for sustainable industrial practices and mitigating climate change [4]. Additionally, the industry's reliance on raw materials like iron ore and coal underscores its significance in global resource utilization and trade dynamics [4] . The steel industry also serves as a key employer and contributor to national economies. Steel production facilities provide employment opportunities and contribute to local and regional economic development. The industry's resilience and adaptability are crucial for maintaining economic stability and competitiveness, especially in regions where steel production forms a significant part of the economic base [5].

In terms of technological advancements, the steel industry is transitioning towards Industry 4.0, integrating digital technologies and automation to enhance productivity and quality [2], [6]. This transformation not only drives innovation within the sector but also positions steel producers to meet evolving market demands and remain competitive in a rapidly changing industrial landscape [6].

Sustainability has become a crucial consideration in the steel industry due to its significant implications for environmental stewardship, resource efficiency, and long-term viability. The steel sector, known for its substantial energy consumption and greenhouse gas emissions, is under mounting pressure to embrace sustainable practices to mitigate its environmental impact [3]. The industry's shift towards sustainability is vital not only for reducing carbon footprints but also for enhancing operational efficiency and competitiveness in a rapidly evolving global market [7] .

Efforts to enhance energy efficiency and decrease emissions in steel production are fundamental aspects of sustainability initiatives within the industry. Through the implementation of energy-efficient technologies and the optimization of production processes, steel manufacturers can reduce their environmental footprint and contribute to global endeavors to address climate change [7], [8]. Moreover, the incorporation of renewable energy sources, such as green hydrogen, offers an opportunity for the steel industry to lessen its dependence on fossil fuels and transition towards cleaner production methods [3].

Furthermore, sustainability in the steel industry goes beyond environmental concerns to encompass social and economic dimensions. The concept of sustainability underscores the significance of fostering positive social impacts, including establishing safe working environments, supporting local communities, and promoting ethical labor practices [2]. By prioritizing social responsibility, steel companies can bolster their reputation, attract top talent, and cultivate stronger relationships with stakeholders [9].

In terms of economic sustainability, the adoption of sustainable practices in the steel industry can result in cost savings, improved resource management, and enhanced market competitiveness [10]. Investments in energy efficiency, waste reduction, and circular economy initiatives not only benefit the environment but also contribute to long-term financial stability and resilience [10], [11]. Additionally, sustainable practices in steel production can create new market opportunities, attract environmentally conscious consumers, and drive innovation within the industry [12].

The utilization of by-products like steel slag in various applications, such as soil improvement and road construction, exemplifies the industry's commitment to sustainability through waste valorization and resource optimization [13],[14]. By repurposing industrial waste streams, steel manufacturers can minimize landfill waste, conserve natural resources, and promote a more circular approach to materials management [15].

The steel industry in Pakistan has been a significant contributor to the country's economic development, infrastructure growth, and industrial progress since the early 1950s. This sector encompasses various activities such as steel production, manufacturing, and supply chain operations, supporting sectors like construction, automotive, and machinery manufacturing. It is able to capitalize on the country's substantial iron ore deposits, which are the primary source of its production. This essential industry not only contributes to the growth of the economy but also serves as a significant source of employment opportunities for a sizeable portion of the target population. Over the last several years, the Pakistani steel sector, which encompasses the production of iron and steel, metallurgical engineering, and construction, has seen substantial expansion because of robust demand on both the local and international levels. There are over 600 mills of varied sizes that make up Pakistan's steel industry, which is an important industrial sector [16]. In 2019, the industry had a production capacity of 3.3 million tons, which accounted for 0.18 percent of the total steel output worldwide. A production capacity that is more than 5 million tons per year has been achieved by the industry, which has flourished[17]. There are around twenty notable firms that have been instrumental in this rise. These companies jointly have eighty percent of the market share. Furthermore, the sector generated a total revenue of PKR 150 billion in the fiscal year 2020, which is a notable indication of the substantial influence it has on the economy of the country[18]. The contribution that Pakistan makes to the overall production of the world is 0.18 percent, which places it in the 39th position out of fifty nations. According to the aggregated Logistic Performance Index (LPI) for the year 2018, Pakistan was ranked 122nd out of 160 countries [19]. The boost in domestic demand has led to significant increases in both the local production of steel and the imports of steel. Both expansions have occurred simultaneously.

1.2. Current Sustainability State in Steel Industry

Arena and Azzone emphasize the lack of specific laws and guidelines on sustainability indicators in the steel industry. However, they provide a set of sustainability indicators that can be used globally and can be tailored to various industries [20]. Several studies have highlighted this issue and emphasized the need of creating comprehensive and unified frameworks to evaluate sustainability in the steel sector. Rajak and Vinodh developed customized measures specifically designed for the steel industry and highlighted the challenge of evaluating performance using a wide range of sustainability indicators. They emphasized the need of including crucial sustainability indicators to improve decision-making [21]. Ahmad et al. said that sustainability indicators for various sectors, including the steel industry, have not yet achieved a completely matured state. They highlighted that the absence of defined indicators poses a challenge in correctly evaluating the progress of a specific industrial sector in its efforts towards achieving sustainable development [22]. Tolettini & Maria investigated the challenges encountered by energy-intensive industries, such as the steel sector, in achieving environmental sustainability objectives. Their primary argument was the lack of a well defined and globally recognized approach to assess environmental sustainability performance, leading to a lack of clarity and ability to monitor progress [23]. One of the primary reasons for the absence of robust sustainability indicators in the steel sector is the complexity involved in defining and measuring sustainability across various operational aspects. The multifaceted nature of steel production, which includes resource utilization, energy consumption, emissions, waste management, and social impacts, necessitates a holistic approach to indicator development [24]. Without a unified framework for sustainability assessment, steel companies may find it challenging to align their practices with global sustainability goals and benchmarks. Furthermore, the lack of standardized sustainability indicators impedes the industry's ability to monitor progress, establish targets, and compare performance across different steel companies and regions. A comprehensive set of indicators is crucial for benchmarking sustainability performance, identifying areas for enhancement, and promoting transparency and accountability within the industry [25]. Without tangible metrics to showcase environmental stewardship, social responsibility, and economic resilience, steel companies may encounter obstacles in building trust, attracting investment, and meeting stakeholder expectations [26].

To achieve effective sustainability assessment and decision-making in the steel business, it is necessary to develop comprehensive frameworks and include key indicators. Additional research and engagement are required to tackle these difficulties and encourage the use of standardized and robust sustainability indicators in the industry. According to Valente et al., the current research on sustainability indicators in sectors lacks sufficient coverage of all elements of sustainability with equal emphasis. Based on the given data, 44% of the identified indicators pertain to the environment, 28% pertain to the economy, and 27% pertain to social aspects. The analysis of conversations indicates that the environmental component is more prominently discussed in comparison to the other aspects [27].

1.3. Sustainability in Pakistan’s Steel Industry

The sustainability landscape in Pakistan's steel industry presents a complex scenario characterized by a mix of progress and challenges. While some studies have delved into specific aspects of sustainability, such as reducing CO2 emissions and evaluating emission effects, there remains a notable gap in the availability of a comprehensive set of sustainability indicators that can effectively capture the industry's overall sustainability performance [28]. The existing research highlights the difficulty that industries face in establishing a uniform framework for defining and reporting sustainability indicators. This lack of a standardized approach hinders the industry's ability to comprehensively address all facets of sustainability, including environmental stewardship, social responsibility, and economic viability [29].

One of the key challenges facing the sustainability efforts in Pakistan's steel industry is the need for a more holistic and integrated approach to sustainability assessment. The industry must move beyond isolated sustainability initiatives and adopt a systemic view that considers the interconnectedness of environmental, social, and economic factors [30]. This shift towards a more comprehensive sustainability strategy requires collaboration among industry stakeholders, policymakers, and researchers to develop a unified framework for measuring and monitoring sustainability performance. Moreover, the steel industry in Pakistan is increasingly facing environmental challenges as it continues to develop and expand. Issues such as atmospheric corrosion, resource utilization, and waste management pose significant sustainability concerns that need to be addressed through innovative solutions and sustainable practices [31]. Additionally, the industry's integration of green supply chain management practices, such as those related to the China-Pakistan Economic Corridor (CPEC), underscores the importance of aligning sustainability goals with economic development initiatives. Balancing economic growth with environmental protection and social responsibility remains a critical challenge for the steel industry in Pakistan [32]. Furthermore, the quality of effluents from industrial estates, including those in the steel sector, raises concerns about water pollution and its impact on public health. Efforts to address water quality issues and enforce regulations are essential to mitigate the environmental and health risks associated with industrial activities [33].

1.4. Problem Statement

The current literature on sustainability indicators in the steel industry lacks a comprehensive framework specifically designed for the Pakistani context. Existing studies often focus on a limited range of sustainability aspects or lack a standardized approach. This gap hinders an accurate and holistic assessment of the Pakistani steel industry's sustainability performance. This study aims to address this gap by developing a set of weighted Triple Bottom Line (TBL) indicators specifically tailored to the Pakistani steel sector. These indicators will consider environmental, social, and economic aspects to provide a more comprehensive evaluation of the industry's sustainability practices. By employing the Delphi method, this study will leverage the expertise of key stakeholders to create a set of credible and well-informed indicators. This approach will ensure the indicators accurately reflect the unique challenges and characteristics of the Pakistani steel industry, enabling a more effective measurement and monitoring framework for sustainable development.

1.5. Research Objectives

- Develop a weighted Triple Bottom Line (TBL) framework of sustainability indicators to assess the environmental impact of the Pakistani steel industry.
- Evaluate the social sustainability of the Pakistani steel industry using TBL indicators.
- Analyze the economic sustainability of the Pakistani steel industry using TBL indicators with a focus on cost management strategies.

LITERATURE REVIEW

2.1. Triple Bottom Line Approach:

The Triple Bottom Line (TBL) is a sustainability concept that evaluates an organization's efficiency in terms of financial, environmental, and social sustainability [34]. By focusing on these three pillars, the TBL method helps companies establish a connection between their business strategy and sustainability, leading to long-term prosperity and adaptability for both the businesses and the communities they operate in [35], [36]. Implementing a TBL strategy signifies that companies prioritize not only financial gains but also their impact on society and the environment, considering all these aspects collectively [36]. This holistic approach is crucial for firms to achieve sustainability and success [37].

The TBL framework emphasizes managing and integrating the environmental, social, and economic impacts of an organization efficiently and effectively [35]. It goes beyond the traditional dimensions of sustainability and recognizes that tensions in corporate sustainability can arise at different levels, during change processes, and within various temporal and spatial contexts [38]. Companies adopting a TBL approach must develop internal capabilities and collaborate with stakeholders to achieve sustainability at both the organizational and systemic levels [38]. Additionally, green purchasing strategies have been found to have positive associations with the triple bottom line performance, further highlighting the importance of considering environmental factors in business decisions [39].

The TBL strategy encourages businesses to balance profit-making with social responsibility and environmental stewardship, promoting sustainable development goals [40]. It is essential for companies to not only pursue profit and social service but also prioritize sustainability and environmental conservation [34]. By considering economic, environmental, and social values simultaneously, the TBL contributes to the concept of sustainable development, which requires the promotion of economic growth, environmental sustainability, and social justice [34].

2.1.1 Environmental Pillar

The steel industry is known for its significant environmental footprint due to energy-intensive production processes and emissions of greenhouse gases. Environmental sustainability in the steel industry involves reducing carbon emissions, minimizing waste generation, and conserving natural resources. To improve environmental performance, steel companies can implement cleaner production technologies, increase energy efficiency, and invest in recycling and waste management initiatives. By adhering to stringent environmental regulations and adopting sustainable practices, the steel industry can mitigate its environmental impact and contribute to a greener future [41].

2.1.2 Social Pillar

Social sustainability in the steel industry pertains to the well-being of employees, communities, and other stakeholders affected by steel production activities. This pillar encompasses aspects such as labor rights, health and safety standards, community engagement, and corporate social responsibility initiatives. Steel companies need to prioritize the welfare of their workforce, ensure safe working conditions, and engage with local communities to build trust and foster positive relationships. By supporting social development programs, promoting diversity and inclusion, and upholding ethical business practices, steel companies can enhance their social sustainability and contribute to the overall well-being of society [42].

2.1.3 Economic Pillar

In the steel industry, economic sustainability involves ensuring the profitability and long-term viability of steel companies. This pillar encompasses aspects such as financial performance, cost efficiency, and innovation in production processes. Companies in the steel industry need to adopt sustainable business models that not only focus on short-term gains but also consider the long-term economic impact of their operations. By investing in research and development, adopting efficient technologies, and optimizing supply chain management practices, steel companies can enhance their economic sustainability [43].

2.2. Sustainability Indicators

Sustainability indicators are essential for evaluating and monitoring the performance of the steel industry in terms of social, economic, and environmental sustainability. A sustainability indicator is a numerical metric that transmits information or specifies a certain condition, with the aim of accurately capturing the observed issue and enabling its monitoring. These indicators offer valuable insights into the industry's progress towards sustainable development and help pinpoint areas for enhancement. The World Steel Association has devised sustainability indicators for the steel industry to gauge performance across social, economic, and environmental dimensions [44]. These indicators empower companies to assess their sustainability practices and outcomes, assisting them in aligning their operations with sustainable development goals. Furthermore, a composite sustainability performance index has been suggested for the steel industry, underscoring the importance of measuring and monitoring sustainability performance [45]. Energy management practices and sustainability indicators have been recognized as pivotal areas of focus for steel companies to elevate their sustainability performance [46]. By giving precedence to energy conservation measures and promoting awareness of sustainability indicators within organizations, steel companies can enhance their energy efficiency and diminish their environmental impact. Additionally, a sustainable assessment system has been established for Chinese iron and steel firms, underscoring the significance of utilizing sustainability indicators to bolster sustainable development initiatives [47]. The utilization of sustainability indicators in the steel industry extends to domains such as water consumption, wastewater discharge, and integration of renewable energy [48][49]. These indicators aid companies in monitoring their environmental impact, optimizing resource utilization, and transitioning towards more sustainable practices. Moreover, sustainability indicators are crucial for evaluating the economic and qualitative determinants of steel production, considering factors like carbon emissions reduction and sustainable development regulations [50].

2.2 Challenges in the Pakistani Steel Industry

While research conducted in Pakistan provides valuable insights into sustainability concerns in several sectors, it does not specifically examine the present status of sustainability indicators in the steel industry of Pakistan. The research conducted by Bux et al. aimed to enhance sustainability in Pakistan's manufacturing industry via the use of corporate social responsibility (CSR) principles. The authors discovered that Pakistan's manufacturing industry does not include sustainable practices, even if firms strive to comply with international norms [51]. A study conducted by Azeem et al. examined the obstacles that hinder the use of environmentally friendly construction methods in Pakistan. The study highlighted further obstacles, such as limited public knowledge of the need and benefits of using environmentally friendly construction methods, insufficient government incentives, and a dearth of defined norms and standards for green building [52]. Khokhar et al. emphasizes the importance of social sustainability in supply chain management in the Pakistani business. It is advisable to include sustainable social development practices into the supply chain, especially in the steel industry [53]. This highlights the need of using customized measurements to evaluate social sustainability aspects that are specific to the steel industry in Pakistan.

2.3 Delphi Approach

The Delphi technique refers to a method that involves obtaining input and feedback from a group of experts to make informed decisions or predictions. The Delphi procedure has been selected as the optimal research approach for creating the weighted Triple Bottom Line (TBL) sustainability indicators in the steel industry of Pakistan. The Delphi method is a systematic and collaborative qualitative research procedure that involves collecting and analyzing input from a panel of experts via many rounds of standardized questionnaires or surveys [54]. This method is particularly well-suited for complex and unexpected situations, such as the development of comprehensive sustainability indicators, since it allows for the integration of several perspectives and experience from professionals in the area [55].

In a Delphi study, an expert is defined as an individual who possesses exceptional abilities or expertise. This is demonstrated through their leadership positions in professional organizations, authoritative roles within these groups, presentations at national conferences, or contributions to esteemed publications. Moreover, an individual's competency may be assessed based on their possession of specialized or advanced education, as well as their ability, willingness, sufficient time, and exceptional communication skills required for active participation [56], [57]. Goodarzi et al. conducted a scientific assessment to determine the reliability of the Delphi approach. The suggested optimal number of panel experts ranged from 10 to 20 individuals. Furthermore, they proposed using mean and standard deviation indices to facilitate the transition from one round to the next in the Delphi process [58]. Amr Sourani and Sohail have said that a minimum of seven or eight experts is necessary for the Delphi survey. Moreover, Geist, Ahmad, and Wong suggested that an optimal quantity of experts would be within the spectrum of 20 to 60 [22], [59], [60]. Alternatively, some scholars argue that a cohort including 9 to 13 experts is better suitable for expeditiously and effectively arriving at a decisive outcome in Delphi research, particularly in the context of formulating indicators. Hsu et al. used a panel of nine experts[61], whereas Sánchez-

Lezama et al. utilized a panel of 13 experts to identify significant sustainability criteria and performance measures [62], as well as to comprehend the socio-ecological factors that influence compliance with mammography screening. Ahmad and Wong and Barzekar et al. each used a group of 10 experts to create sustainability indicators for the Malaysian food manufacturing sector and establish standards for monitoring the sustainability of ecotourism, respectively [22], [63].

This study aims to use the Delphi approach to access the combined expertise of key stakeholders, including industrial professionals, academicians, environmentalists, social activists, and economists. The Delphi technique facilitates the open expression of different perspectives, mitigates the impact of influential individuals, and strives to achieve a consensus or the most dependable set of indicators via several rounds of anonymous feedback and controlled communication. Implementing the Delphi technique will provide a methodical and comprehensive approach to creating a customized set of TBL sustainability indicators with assigned weights that are specifically designed for the unique difficulties and features of the steel sector in Pakistan. This participatory process ensures that the final indicators are well-informed, reliable, and appropriately represent the sustainability performance of the sector, hence providing a more effective system for measuring and monitoring.

2.4 Research Gap

The existing literature on sustainability in the Pakistani steel industry lacks comprehensive research on weighted Triple Bottom Line (TBL) indicators. This research gap hinders a comprehensive assessment of the industry's sustainability performance. Therefore, this study's main goal is to close this gap by creating a set of weighted TBL indicators that are especially suited to the steel sector in Pakistan. These indicators will enable a more accurate and holistic evaluation of the industry's sustainability practices, considering environmental, social, and economic aspects. The proposed indicators aim to provide valuable insights to stakeholders, policymakers, and industry players, facilitating better decision-making processes and fostering sustainable practices within the Pakistani steel sector.

METHODOLOGY

3.1. Questionnaire Development

This study employed the Delphi method to develop a comprehensive set of sustainability indicators tailored specifically for the steel industry in Pakistan. Prior to commencing the study, an extensive review of existing literature on sustainability indicators in manufacturing industries, with a particular focus on steel manufacturing, was conducted. This literature review served as a foundation for identifying and selecting relevant indicators for inclusion in the study. The initial questionnaire was constructed based on insights gleaned from the literature review, encompassing indicators and their respective units of measurement. To ensure the reliability of the questionnaire, collaboration with a seasoned researcher in the field was sought, resulting in the refinement and finalization of the questionnaire.

3.2. Expert Panel Selection

A meticulous approach was taken in the selection of the panel of experts for the study, employing multiple methods. Recommendations from esteemed researchers, referrals from industry professionals, and experts cited in published works were all taken into consideration. In instances where certain experts were unavailable, alternative experts were approached to ensure a diverse and knowledgeable panel. The selected experts demonstrated a keen understanding of the study objectives and were divided into two groups: those with substantial experience (at least two years) in the steel industry, and academic scholars holding doctoral degrees with relevant experience. Despite initially inviting over 100 experts, a total of 22 experts ultimately participated in the study, a typical number for Delphi studies.

3.3. Delphi Method Rounds

The research proceeded through two rounds of the Delphi method. In the first round, experts were tasked with evaluating the proposed indicators and providing feedback for refinement, particularly regarding their measurement units. The second round aimed to achieve consensus among the experts, with flexibility afforded in their participation. In summary, the research spanned approximately six months and culminated in the development of a comprehensive set of sustainability indicators tailored specifically for the Pakistani steel industry.

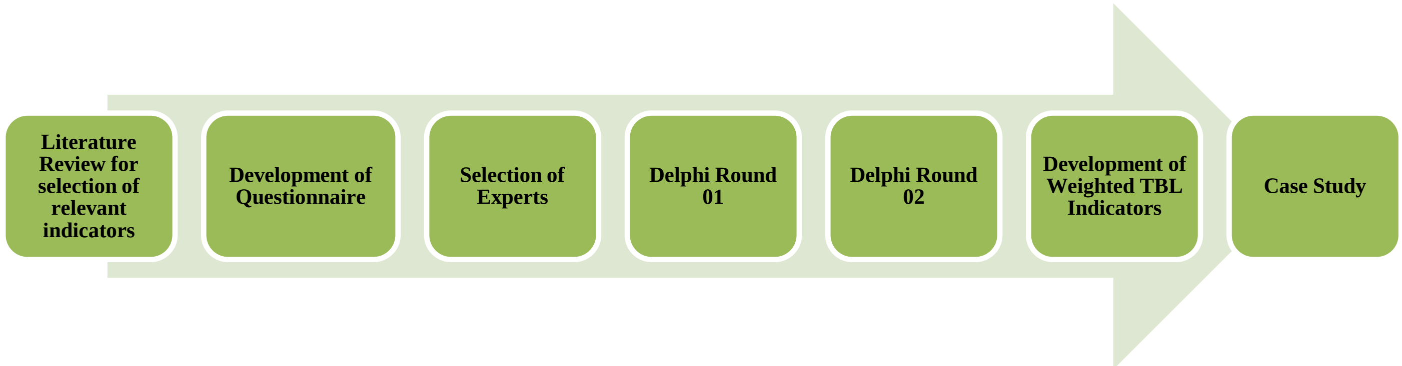

Figure 3.1: Methodology Overview

DEVELOPMENT OF SUSTAINABILITY INDICATORS

4.1. Characteristics of experts:

Only fifteen of the twenty-two experts who were originally asked to take part in the Delphi research that was dedicated to the steel sector in Pakistan gave their ideas during the first round of the questionnaire. Table 1 provides information on the characteristics of the individuals who took part in the first round of competition. These individuals included nine academics and six professionals from industry. The number of years of experience was determined by considering the first publication that was associated with sustainability (for academic experts) and the beginning of their work in research centers and industry (for industry-based experts). When examining the publishing histories of academic specialists, only works that had been subjected to peer review were considered, with a particular emphasis on journals that were indexed in Scopus. There is a summary of the material provided by the experts in Table 1.

Table 1: Experts and their characteristics

No.	Expert Qualification	Expert experience (years)	Publications	Affiliation	Gender
1	PhD	more than 2	More than 10	Academia	Male
2	PhD	more than 2	More than 20	Academia	Female
3	PhD	more than 5	More than 15	Academia	Male
4	PhD	more than 10	More than 20	Academia	Male
5	PhD	more than 2	More than 10	Academia	Male
6	PhD	more than 10	More than 100	Academia	Male
7	PhD	more than 5	More than 30	Academia	Female
8	PhD	more than 10	More than 250	Academia	Male
9	PhD	more than 10	More than 70	Academia	Male
10	Bachelor	more than 2	-	Industry	Male
11	Bachelor	more than 2	-	Industry	Male
12	Bachelor	more than 2	-	Industry	Male
13	Bachelor	more than 2	-	Industry	Male
14	Bachelor	more than 2	-	Industry	Male
15	Bachelor	more than 2	-	Industry	Male

An examination of the table indicates that every individual who is participating in round 1 has a minimum of two years of experience, with fifty percent of them having five years of experience.

Sixty percent of these specialists have an academic background, and each of them has more than ten research articles to their name. One-fourth of the members are female, while the remaining 86% are male. In addition, every single industry expert has a minimum of a bachelor's degree and has more than two years of experience in the field.

4.2. Data Collection:

The instrument that was used for the purpose of gathering information on the Pakistani steel sector was developed because of recognized sustainability indicators that are often seen in manufacturing literature, particularly from the perspective of steel manufacture. The indicators, which have also been referenced in previous research publications, include both scientific characteristics that are involved with the production of knowledge and policy-based features that are associated with social and political norms. Indicators that are associated with the environment, such as those that pertain to the use of resources and energy, are examples of indicators that come under the category of science-based. The other side of the coin is that policy-based indicators include things like a reasonable income, job stability, and the level of happiness experienced by consumers.

In the beginning, the basic sets of science-based and policy-based indicators were obtained from literature. Subsequently, these sets were adjusted to correspond with the viewpoint of the Pakistani steel sector. Although Table 2 only provides a concise presentation of the environmental indicators that were derived from the round-01 questionnaire, later changes and the results for all aspects of sustainability are examined in depth.

Experts were charged with assessing the application of indicators on a Likert scale (ranging from 1 for least applicable to 5 for most relevant) and identifying the value of indicators using a simple YES/NO scale during the first round of the Delphi research. This was done in order to determine the significance of the indicators. In addition, experts were given the chance to offer feedback and make suggestions on modifications to components such as indicators, aspect categories, measurement units, and other aspects. As a result of the feedback received in round-01, the questionnaire for round-02 was designed with the primary objective of obtaining the consensus of the experts about the inclusion of indicators, in addition to collecting any additional remarks.

For the first time, the questionnaire was sent to a total of 22 specialists, which resulted in a response rate of 68% with 15 replies. We were able to accomplish this high response rate by delivering the questionnaire to just those individuals who were eager to take part in the study. We excluded those participants who were either unavailable or disinterested. In the first round, even after weekly reminders were sent out, it took more than three months for participants to submit their comments, even though they were given a window of three weeks to do so. During the second phase, the questionnaire was sent out to the fifteen experts, which resulted in a response rate of 67% with ten individuals taking part in the survey.

4.3. Round 01:

During this stage, the data collecting instrument for the steel sector in Pakistan consisted of a total of 134 indicators that were originally given to the specialists. Within this group, there were 59 indicators that were associated with the environmental element of sustainability, 31 indicators that were economic, and 44 indicators that were social. Following that, the applicability ratings that were supplied by the specialists were employed to compute the weight that was assigned to each indication, aspect category, and sustainability component.

When it came to the significance of the indicators, those that received a "NO" from the specialists were not included in the subsequent study. In addition, in response to the comments and suggestions given by specialists, modifications were implemented. For example, in the environmental aspect, the experts proposed that the exact raw materials that are utilized in the sector be included rather than general words. Therefore, the indication for "raw material" was deleted, and the indicators for "iron ore" and "scrap steel/iron" were added. In a similar manner, indications that had a score of less than three regarding their applicability were eliminated because of their poor agreement ratings. In addition, based on the comments made by specialists, several indications were eliminated, and the names of others were altered. For instance, the term "municipal waste" was eliminated from the category of "solid waste," and the term "hazardous waste" was replaced to "mill scale (surface oxides)."

In the economic category, the cost associated with durability and the materials used for packaging was eliminated, and a new indication was introduced: savings owing to material efficiency and recycling. In addition, the name of the aspect category was changed from "Profit" to "Profit/Revenue," and the name of the indication was changed from "Turnover ratio/Gross Margin" to "Gross Margin" in accordance with the recommendations made by qualified individuals.

Table 2: Environmental indicators in the round-01 questionnaire

Aspects	Indicators	Measuring Units	Likert scale				
			1	2	3	4	5
Material used	Raw materials	kg					
	Refractory materials	kg					
	Lubricants	kg					
	Limestone	kg					
	Refrigerant consumption	kg					
	Level of equipment used	Energy/ton					
	Chemicals for cleaning and washing	kg					
Energy used	Fuel (diesel, petrol,etc.)	kg					
	Natural gas	m3					
	LPG	m3					
	Non renewable energy usage	MJ					
	Renewable energy usage	MJ					
	Wood/coal	kg					
	Electricity	kWh					
	Coke	kg					
Water used	Overall water consumption	kg					
Air emissions	CO2	kg					
	CFC11	kg					
	CO	g					
	SO2	g					
	NOx	g					
	Volatile organic compounds (VOC)	g					
	Mercury	g					
	Hydrocarbons	g					
	Ammonia	g					
	Dust	g					
	Fumes	ppm					
	Lead (Pb)	g					
	Noise	db					
	Arsenic	g					
	Cadmium (Cd)	g					
	Nickel (Ni)	g					
	Chromium	g					
	Particulate matter	ppm					
Wastewater	Overall wastewater	L					
	Sb	mg/L					
	Heavy metals	mg/L					
	Lead (Pb)	mg/L					
	Nickel (Ni)	mg/L					

Aspects	Indicators	Measuring Units	Likert scale				
			1	2	3	4	5
	COD	mg/L					
	BOD	mg/L					
	Nitrogen compound	mg/L					
	Phosphorus	mg/L					
	Arsenic	mg/L					
	Benzene	mg/L					
	Chromium	mg/L					
	Suspended solids	mg/L					
	Oil	mg/L					
Solid waste	Hazardous waste	kg					
	Steel waste/scrap	kg					
	Non-hazardous waste	kg					
	Waste residue	kg					
	Municipal waste	kg					
	Slag	kg					
Land used	Percentage green cover of total plant area	ha					
	Land used for waste disposal	ha					
Waste management	Recycling of Solid Waste	kg					
	Recycling of fluid (cutting fluid)	kg					
	Recycling of water	L					

As a result of the input received during cycle 01, a number of social indicators were eliminated. These indicators were "Workload," "Health and Safety Practices," "Risk assessment," "Social innovation," and "Social contribution." In addition, a significant number of the names of the indicators were altered. An example of this would be the modification of the term "Lost Workdays" to "Absenteeism," as well as the modification of the term "Anti-Corruption Programs" to "Anti-Corruption Awareness." Numerous social indicators, such as "No. of allowable working hours per week" and "No. of workers under the age of 14" for the indicators "Working hours" and "Child Labor," respectively, have had their units of measurement altered, as was advised by the majority of the experts. In addition, a timeline of the number "a year" is added to the units of all the remaining and suitable indicators, such as the number of injuries that occur each year, the number of workers who leave their jobs in a year, and so on. Over the course of the second round, the total number of indications was cut down to 110, with 24 signs being eliminated from consideration.

4.4. Round 02:

There was a total of 110 indicators included in the tool for the Pakistani steel sector during the second phase. These indicators included 51 environmental indicators, 28 economic indicators, and 31 social indicators. The participants were given the job of stating their level of agreement (YES/NO) with each indication during this phase. Additionally, they were asked to rate the application of additional indicators that were suggested during the first round using a Likert scale that ranged from 1 to 5. In the second round, there was still the possibility of providing further information or comments. A score of 75% or higher on the agreement scale was used to create consensus on the inclusion of indicators. This score required at least seven out of ten experts to agree with an indicator. Consequently, certain indicators that did not fulfill this requirement were excluded from consideration. Examples include the term "Hydrochlorofluorocarbons (HCFC)," which received a score of 55.55% agreement from the air emissions aspect area, and the term "Biological Oxygen Demand (BOD)," which had a score of 66.66% agreement coming from the wastewater aspect category. It should be noted, however, that all indications that fulfilled the agreement level criterion were kept.

Further, some small adjustments were made to the document. As an example, the names of the indicators in the economic dimension were changed from "non-acceptance cost" to "non-acceptance cost (Rejection and Rework Costs)," and the word "Tax" was changed to "Tax (Carbon Taxes, Water Pollution Taxes)." To minimize misunderstanding in the social dimension, the names of the indicators, such as "Education" and "Inclusion of rights," were changed to "Education (Scholarship aid for students)" and "Inclusion of rights (Right to information, safety, etc.)," respectively, based on the comments received from experts.

4.5. Outcome of Delphi Method:

Following the completion of the examination of the application scores and the acquisition of expert consensus, a total of 106 sustainability indicators were finalized for the steel sector in Pakistan. There were 47 environmental indicators, 28 economic indicators, and 31 social indicators included in this. These indicators are broken down into their impact directions, verified measurement units, agreement scores, and weights, all of which are specified in the tables that are numbered three through five. Because of the influence that each indication has on sustainability, a positive (+) or negative (-) sign is assigned to each indicator. To put it another way, if the goal is to raise the score of an indicator, then the indicator is given a positive sign; otherwise, it is given a negative indication. The applicability scores, which are the mean scores of the indicators, were used in the calculation of the weights once they were determined.

4.6. Criteria for Weighting

$$Indicator\ Weight = \frac{Applicability\ Score\ of\ that\ indicator}{Sum\ of\ Applicability\ Scores\ of\ all\ Indicators\ in\ that\ Dimension}$$

$$Aspect\ Category\ Weight = \frac{Sum\ of\ Applicability\ Scores\ of\ All\ Indicators\ in\ that\ Category}{Sum\ of\ Applicability\ Scores\ of\ All\ Indicators\ in\ that\ Sustainability\ Dimension}$$

$$Dimension\ Weight = \frac{Sum\ of\ Applicability\ Scores\ of\ All\ Indicators\ in\ that\ Dimension}{Sum\ of\ Applicability\ Scores\ of\ All\ Indicators\ Across\ All\ Three\ Sustainability\ Dimensions}$$

The weight calculations for sustainability indicators, aspect categories, and sustainability aspects in the context of the Pakistani steel industry are represented by these formulae. These formulas are based on applicability scores.

Table 3: Final environmental indicators, agreement scores and weights

Aspects	**Indicators**	**Impact**	**Measuring Units**	**Agreement Score (%)**	**Applicability score**	**Indicator's weight**	**Aspect's weight**	**Dimension's weight**
Material used	Scrap Steel/Iron	-	kg	100	4.70	0.0282	0.089	0.4356
	Iron Ore	-	kg	80	3.70	0.0222		
	Refractory materials	-	kg	90	3.50	0.0210		
	Limestone	-	kg	90	2.90	0.0174		
Energy used	Fuel (diesel, petrol, etc.)	-	kg	90	3.40	0.0204	0.139	
	Natural gas	-	m3	90	4.40	0.0264		
	Renewable resource energy use	-	MJ	80	4.00	0.0240		
	Wood/coal	-	kg	90	3.50	0.0210		
	Electricity	-	kWh	100	4.78	0.0287		
	Coke	-	kg	90	3.10	0.0186		
Water used	Overall water consumption	-	kg	100	3.60	0.0216	0.022	
Air emissions	Carbon Dioxide (CO2)	-	kg	90	4.10	0.0246	0.310	
	Carbon Monoxide (CO)	-	g	77.77	3.22	0.0193		
	Sulphur Dioxide (SO2)	-	g	77.77	3.22	0.0193		
	Volatile organic compounds (VOC)	-	g	77.77	3.33	0.0200		
	Mercury (Hg)	-	g	77.77	3.44	0.0207		
	Hydrocarbons	-	g	77.77	3.44	0.0207		

Aspects	Indicators	Impact	Measuring Units	Agreement Score (%)	Applicability score	Indicator's weight	Aspect's weight	Dimension's weight
	Dust	-	g	77.77	3.78	0.0227		
	Fumes	-	ppm	88.88	3.75	0.0225		
	Lead (Pb)	-	g	77.77	3.11	0.0187		
	Noise	-	db	88.88	3.89	0.0233		
	Arsenic (As)	-	g	77.77	3.44	0.0207		
	Cadmium (Cd)	-	g	77.77	3.22	0.0193		
	Nickel (Ni)	-	g	77.77	3.33	0.0200		
	Chromium (Cr)	-	g	77.77	3.11	0.0187		
	Particulate matter (PM)	-	ppm	77.77	3.33	0.0200		
Wastewater	Overall wastewater	-	L	88.88	3.56	0.0213	0.207	
	Antimony (Sb)	-	mg/L	77.77	2.88	0.0173		
	Lead (Pb)	-	mg/L	75	3.13	0.0188		
	Nickel (Ni)	-	mg/L	75	2.75	0.0165		
	Chemical Oxygen Demand (COD)	-	mg/L	77.77	3.44	0.0207		
	Phosphorus (P)	-	mg/L	87.5	3.00	0.0180		
	Arsenic (As)	-	mg/L	75	3.25	0.0195		
	Benzene	-	mg/L	75	3.00	0.0180		
	Chromium (Cr)	-	mg/L	75	3.13	0.0188		
	Suspended solids	-	mg/L	87.5	3.13	0.0188		
	Oil	-	mg/L	87.5	3.25	0.0195		
Solid waste	Mill Scale (Surface Oxides)	-	kg	88.8	4.11	0.0247	0.129	
	Used Refractory materials	-	kg	100	4.22	0.0253		
	Steel waste/scrap	-	kg	100	4.60	0.0276		
	Non-hazardous waste	-	kg	100	4.11	0.0247		
	Slag	-	kg	100	4.40	0.0264		
Land used	Percentage green cover of total plant area	-	ha	100	3.67	0.0220	0.042	
	Land used for waste disposal	-	ha	93.3	3.25	0.0195		
Waste management	Recycling of Cutting Fluid	+	kg	75	3.25	0.0195	0.063	
	Recycling of Solid Waste	+	kg	87.5	3.67	0.0220		
	Recycling of Water	+	L	87.5	3.56	0.0213		

Table 4: Final social indicators, agreement scores, and weight

Aspects	Indicators	Impact	Measuring Units	Agreement Score (%)	Applicability score	Indicator's weight	Aspect's weight	Dimension's Weight
Worker/	Fair Wage or salary	+	VL to VH (1 to 5)	88.89	4.33	0.0396	0.0048	0.2863
	Work-related injuries	-	No. of injuries per year	100.00	4.00	0.0365		

Aspects	Indicators	Impact	Measuring Units	Agreement Score (%)	Applicability score	Indicator's weight	Aspect's weight	Dimension's Weight
Employee	Working hours	-	No. of allowable working hours per week	100.00	4.44	0.0406		
	No. of employees trained	+	No. of workers trained in a year	100.00	4.00	0.0365		
	Innovation potential	+	No. of new solutions proposed a year	77.78	3.25	0.0297		
	Equal opportunity or no discrimination	+	VL to VH (1 to 5)	100.00	3.33	0.0304		
	New Job Creation	+	No. of new jobs created in a year	77.78	3.63	0.0331		
	Social benefits (retirement benefits, etc)	+	VL to VH (1 to 5)	88.89	3.22	0.0294		
	Child labor	-	Percentage of workers underage of 14	88.89	3.75	0.0342		
	Forced labor	-	VL to VH (1 to 5)	77.78	4.00	0.0365		
	Absenteeism	-	No. of days in a year	100.00	3.25	0.0297		
	Employee' satisfaction	+	VL to VH (1 to 5)	100.00	3.13	0.0285		
	Freedom of association	+	VL to VH (1 to 5)	88.89	3.33	0.0304		
	Quality of life	+	VL to VH (1 to 5)	88.89	3.44	0.0314		
	Job security	+	VL to VH (1 to 5)	100.00	3.56	0.0325		
	Employee turnover	-	No. of employees leaving in a year	100.00	3.29	0.0300		
Local community	Anti-corruption awareness	+	No. of programs organized in a year	77.78	3.38	0.0308	0.0026	
	Local employment	+	Percentage of local employees	100.00	3.63	0.0331		
	Access to informational resources	+	VL to VH (1 to 5)	77.78	3.29	0.0300		
	Contributions to economic development	+	VL to VH (1 to 5)	100.00	3.38	0.0308		
	Community engagement (technology transfer)	+	No. of programs organized in a year	88.89	3.13	0.0285		
	Health and safety measures	+	VL to VH (1 to 5)	100.00	3.88	0.0354		
	Education	+	VL to VH (1 to 5)	100.00	3.63	0.0331		
	Preservation of culture and heritage	+	VL to VH (1 to 5)	100.00	2.86	0.0261		
	Sustainability Reporting	+	VL to VH (1 to 5)	88.89	3.63	0.0331		
Customers/ Consumers	Inclusion of rights	+	VL to VH (1 to 5)	87.50	3.43	0.0313	0.0011	
	Complaints or feedback	+	No. of complaints in a year	88.89	3.14	0.0287		
	Customer engagement for product development	+	No. of programs organized in a year	88.89	3.43	0.0313		

Aspects	Indicators	Impact	Measuring Units	Agreement Score (%)	Applicability score	Indicator's weight	Aspect's weight	Dimension's Weight
	Consumer satisfaction	+	Percentage of satisfied customers in a year	88.89	3.67	0.0335		
Suppliers/ Contractors	Suppliers' development	+	No. of suppliers trained in a year	88.89	3.71	0.0339	0.0006	
	Suppliers' management	+	No. of suppliers retained in a year	88.89	3.43	0.0313		

Table 5: Final Economic indicators, agreement scores and weights

Aspects	Indicators	Impact	Measuring Units	Agreement Score (%)	Applicability score	Indicator's weight	Aspect's weight	Dimension's Weight
Cost	Raw materials	-	PKR	100	4.14	0.039	0.0038163	0.278
	Waste disposal	-	PKR	87.50	3.67	0.034		
	Tax (Carbon Taxes, Water pollution taxes)	-	PKR	100	3.43	0.032		
	Transportation	-	PKR	100	3.14	0.030		
	Labor	-	PKR	87.50	3.50	0.033		
	Depreciation cost	-	PKR	100	4.00	0.038		
	Non acceptance cost (Rejection and Rework Costs)	-	PKR	83.33	3.20	0.030		
	Maintenance and repair	-	PKR	100	4.00	0.038		
	Utilities (electricity, water, etc.)	-	PKR	100	3.63	0.034		
	Environment and sustainability-related fines	-	PKR	100	3.63	0.034		
	Fines related to unfair labor practices	-	PKR	87.50	3.14	0.030		
	Inspection cost	-	PKR	100	3.71	0.035		
Profit/ Revenue	Total Revenue	+	PKR	100	4.14	0.039	0.0031496	
	Net Profit	+	PKR	100	4.29	0.040		
	Market value	+	PKR	100	3.86	0.036		
	Gross margin	+	dimensionless	100	4.00	0.038		
	Return on equity	+	PKR	100	4.00	0.038		
	Return on asset	+	PKR	100	3.86	0.036		
	Debt to assets ratio	-	dimensionless	100	3.83	0.036		
	Operating revenue growth rate	+	PKR	100	4.00	0.038		
	Turnover/Inventory ratio	+	dimensionless	85.71	3.67	0.034		
Investments	Investment in new process and products	+	PKR	100	4.00	0.038	0.0010493	
	Investment in environmental protection	+	PKR	100	3.88	0.036		

Aspects	Indicators	Impact	Measuring Units	Agreement Score (%)	Applicability score	Indicator's weight	Aspect's weight	Dimension's Weight
	External investments in company for environment and sustainability	+	PKR	87.50	4.00	0.038		
Savings	Savings due to energy efficiency	+	PKR	100	4.00	0.038	0.0013854	
	Savings due to material efficiency/recycling	+	PKR	88.89	4.57	0.043		
	Savings due to reduced water consumption	+	PKR	100	3.86	0.036		
	Incentives (tax relief, subsidies, etc.) provided by the government	+	PKR	88.89	3.25	0.031		

RESULTS AND DISCUSSION

Within the context of the Pakistani steel industry, the findings that are reported in Tables 3 to 5 offer insightful information that may be taken into consideration for analysis and conversations. The study was carried out on an individual level, consisting of the examination of indicators, facets, and dimensions, while taking into consideration the consensus among the specialists. This was done to guarantee its clarity.

5.1. Expert's consensus:

Within this part, the focus is centered on the agreement or consensus that the experts in the steel sector in Pakistan have provided to the indicators. For a particular indication, a score of one hundred percent consensus indicates that all the experts are in complete agreement with one another. The results of the Triple Bottom Line (TBL) viewpoint are shown in Table 6, which shows that around 39% (41/106) of the indicators received total agreement (100 percent consensus). There were about 19% (8/41) environmental indicators, approximately 49% (20/41) economic indicators, and approximately 32% (13/41) social indicators included in this. The economic component revealed an intriguing observation: while having a lower weight, there were more economic indicators with maximal agreement than environmental or social indicators in terms of quantity. This was the case even though economic indicators had a lower weight.

Additionally, in accordance with the screening criteria that were established previously, indicators that had a consensus of less than 75% were already discarded.

5.2. Indicator Level:

The relevance or importance of each indicator's applicability score offers insights into the sustainability performance of the Pakistani steel sector. This is referred to as the indicator level. For instance, when the environmental viewpoint is taken into consideration (Table 7), the most suitable indicators are electricity, scrap steel/iron, and steel waste/scrap. These three categories received scores of 4.78, 4.70, and 4.60, respectively. After conducting an analysis of the top 15 environmental indicators according to aspect category, it was discovered that solid waste (5/15),

Table 6: Global consensus on triple-bottom line sustainability indicators

No.	Indicators	Sustainability Dimension	Consensus Score (%)
1	Scrap Steel/Iron	Environmental	100.0
2	Electricity	Environmental	100.0
3	Overall water consumption	Environmental	100.0
4	Used Refractory materials	Environmental	100.0
5	Steel waste/scrap	Environmental	100.0
6	Non-hazardous waste	Environmental	100.0
7	Slag	Environmental	100.0
8	Percentage green cover of total plant area	Environmental	100.0
9	Work related injuries	Social	100.0
10	Working hours	Social	100.0
11	No. of employees trained	Social	100.0
12	Equal opportunity or no discrimination	Social	100.0
13	Absenteeism	Social	100.0
14	Employee' satisfaction	Social	100.0
15	Job security	Social	100.0
16	Employee turnover	Social	100.0
17	Local employment	Social	100.0
18	Contributions to economic development	Social	100.0
19	Health and safety measures	Social	100.0
20	Education	Social	100.0
21	Preservation of culture and heritage	Social	100.0
22	Raw materials	Economic	100.0
23	Tax (Carbon Taxes, Water pollution taxes)	Economic	100.0
24	Transportation	Economic	100.0
25	Depreciation cost	Economic	100.0
26	Maintenance and repair	Economic	100.0
27	Utilities (electricity, water, etc.)	Economic	100.0
28	Environment and sustainability-related fines	Economic	100.0
29	Inspection cost	Economic	100.0
30	Total Revenue	Economic	100.0
31	Net Profit	Economic	100.0

No.	Indicators	Sustainability Dimension	Consensus Score (%)
32	Market value	Economic	100.0
33	Gross margin	Economic	100.0
34	Return on equity	Economic	100.0
35	Return on asset	Economic	100.0
36	Debt to assets ratio	Economic	100.0
37	Operating revenue growth rate	Economic	100.0
38	Investment in new process and products	Economic	100.0
39	Investment in environmental protection	Economic	100.0
40	Savings due to energy efficiency	Economic	100.0
41	Savings due to reduced water consumption	Economic	100.0
42	Land used for waste disposal	Environmental	93.3
43	Refractory materials	Environmental	90.0
44	Limestone	Environmental	90.0
45	Fuel (diesel, petrol,etc.)	Environmental	90.0
46	Natural gas	Environmental	90.0
47	Wood/coal	Environmental	90.0
48	Coke	Environmental	90.0
49	Carbon Dioxide (CO2)	Environmental	90.0
50	Fair Wage or salary	Social	88.9
51	Social benefits (retirement benefits, etc)	Social	88.9
52	Child labor	Social	88.9
53	Freedom of association	Social	88.9
54	Quality of life	Social	88.9
55	Community engagement (technology transfer)	Social	88.9
56	Sustainability Reporting	Social	88.9
57	Complaints or feedback	Social	88.9
58	Customer engagement for product development	Social	88.9
59	Consumer satisfaction	Social	88.9
60	Suppliers development	Social	88.9
61	Suppliers management	Social	88.9

No.	Indicators	Sustainability Dimension	Consensus Score (%)
62	Savings due to material efficiency/recycling	Economic	88.9
63	Incentives (tax relief, subsidies, etc.) provided by the government	Economic	88.9
64	Fumes	Environmental	88.9
65	Noise	Environmental	88.9
66	Overall wastewater	Environmental	88.9
67	Mill Scale (Surface Oxides)	Environmental	88.8
68	Phosphorus (P)	Environmental	87.5
69	Suspended solids	Environmental	87.5
70	Oil	Environmental	87.5
71	Recycling of SolidWaste	Environmental	87.5
72	Recycling of Water	Environmental	87.5
73	Inclusion of rights	Social	87.5
74	Waste disposal	Economic	87.5
75	Labor	Economic	87.5
76	Fines related to unfair labor practices	Economic	87.5
77	External investments in company for environment and sustainability	Economic	87.5
78	Turnover/Inventory ratio	Economic	85.7
79	Non acceptance cost (Rejection and Rework Costs)	Economic	83.3
80	Iron Ore	Environmental	80.0
81	Renewable resource energy use	Environmental	80.0
82	Innovation potential	Social	77.8
83	New Job Creation	Social	77.8
84	Forced labor	Social	77.8
85	Anti-corruption awareness	Social	77.8
86	Access to informational resources	Social	77.8
87	Carbon Monoxide (CO)	Environmental	77.8
88	Sulphur Dioxide (SO2)	Environmental	77.8
89	Volatile organic compounds (VOC)	Environmental	77.8
90	Mercury (Hg)	Environmental	77.8
91	Hydrocarbons	Environmental	77.8

No.	Indicators	Sustainability Dimension	Consensus Score (%)
92	Dust	Environmental	77.8
93	Lead (Pb)	Environmental	77.8
94	Arsenic (As)	Environmental	77.8
95	Cadmium (Cd)	Environmental	77.8
96	Nickel (Ni)	Environmental	77.8
97	Chromium (Cr)	Environmental	77.8
98	Particulate matter (PM)	Environmental	77.8
99	Antimony (Sb)	Environmental	77.8
100	Chemical Oxygen Demand (COD)	Environmental	77.8
101	Lead (Pb)	Environmental	75.0
102	Nickel (Ni)	Environmental	75.0
103	Arsenic (As)	Environmental	75.0
104	Benzene	Environmental	75.0
105	Chromium (Cr)	Environmental	75.0
106	Recycling of Cutting Fluid	Environmental	75.0

air emissions (4/15), energy used (3/15), material used (2/15), and land utilized (1/15) are more relevant than other categories such as wastewater and waste management.

In developing nations like Pakistan, where environmental rules are still in the process of being developed, it is suggested that concentrating on these indicators may assist in the management of pollution and the mitigation of the adverse impacts that industrial operations have on the environment. As an example, the implementation of sustainability indicators for the purpose of addressing air emissions has become of the utmost importance in Pakistan, which is home to densely populated metropolitan regions and where air quality is particularly important.

Benzene, limestone, antimony, and nickel were the four indicators that received the lowest ranking in terms of their impact on the ecosystem overall. When a score of 3.5 or more is extremely relevant, forty-five percent (21 out of 47) of the indicators went into this group.

From an economic point of view, the three most appropriate indicators were found to be savings owing to material efficiency or recycling, net profit, raw materials, and total revenue. These three indicators received scores of 4.6, 4.3, 4.1, and 4.1, respectively. The profit and revenue category were the most dominant among the other categories, not only because it had a greater number of indicators but also because it received higher marks. There was just one indication that belonged to the area of savings and investments among the top ten indicators, while three indicators belonged to the category of costs. Considering that a score of 3.5 or more is considered extremely relevant, 82 percent (23/28) of indications that were highly appropriate. There is a full explanation of the local importance of economic indicators in Table 8.

Working hours, fair income or compensation, work-related injuries, the number of workers who have received training, forced labor, and health and safety measures were recognized as the most suitable indicators for the social dimension (see Table 9). Of the indicators that were highly appropriate, there were 45% (14/31) of them. When it came to the top ten social indicators, the indicators that were linked to employees, such as working hours, fair pay or salary, child labor, and the creation of new jobs, were more significant than the indicators that were related to the local community and about customers or consumers. It is possible that the difficulties that workers in the steel sector in Pakistan are experiencing are the reason for this focus on labor-related variables. The steel industry is typically the most labor-intensive sector, and the health and happiness of workers has a direct influence on the social sustainability of the business. For the purpose of ensuring that employment practices are both ethical and responsible, it is essential to place an emphasis on working hours, fair salaries, and also to address concerns such as child labor.

The utilization of power, the use of scrap steel or iron, and the utilization of steel waste or scrap were the top three sustainability indicators when viewed from the standpoint of the Triple Bottom Line (TBL). Indicators are ranked according to their worldwide priority, which is indicated in Table 10. When it comes to the top ten indicators based on worldwide priority, environmental indicators are ahead of the pack with a score of six out of ten. In all, nearly 55% (58/106) of the indicators were extremely relevant. This included 36% (21/58) environmental indicators, 40% (23/58) economic indicators, and 24% (14/58) social indicators.

5.3. Aspect and Dimension level:

It is also possible to undertake an examination at the levels of aspects and dimensions within the steel industry in Pakistan. When looking at the environmental viewpoint, which is illustrated in

Figure 1, it was discovered that the category of air emissions was more significant than other factors such as energy, water utilized, and land used. It is possible that this choice is a result of the fact that Pakistan struggles often with issues that are associated with poor air quality and air pollution. Although the use of energy, water, and land are all significant components of environmental sustainability, the direct effect that air emissions have on ecosystems is often more immediate and obvious.

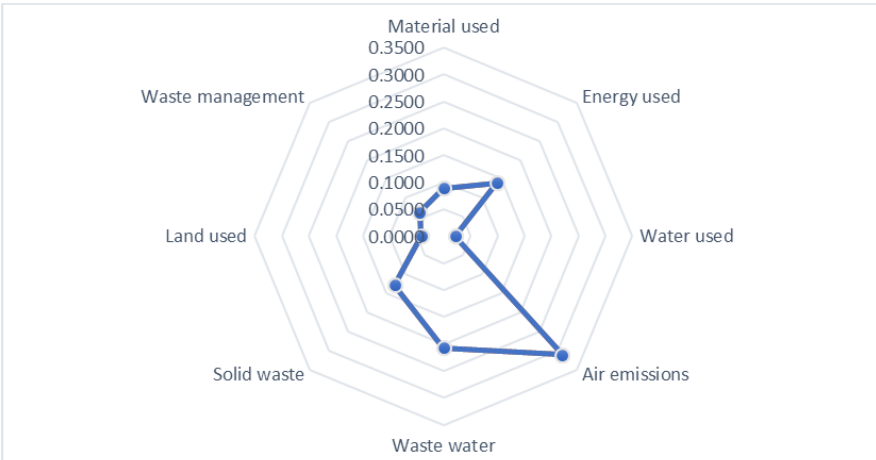

Figure 0.1: Aspect Weights of Environmental Category

Specifically, emissions from the atmosphere, especially those that contribute to emissions of greenhouse gases, have worldwide ramifications for climate change. As a result of the growing pressure placed on developing nations like Pakistan to reduce their carbon footprint, air emissions have emerged as a central topic of debate in the context of global sustainability studies. From an environmental point of view, wastewater came in second place since Pakistan is confronted with substantial difficulties relating to water shortages and water quality. It is essential to place a high priority on wastewater management in order to guarantee the effective use of the water resources that are available and to avoid the pollution of water bodies.

Table 7: Local priority of environmental indicators

No.	**Indicators**	**Aspect Category**	**Applicability Score**
1	Electricity	Energy used	4.78
2	Scrap Steel/Iron	Material used	4.70

No.	Indicators	Aspect Category	Applicability Score
3	Steel waste/scrap	Solid waste	4.60
4	Natural gas	Energy used	4.40
5	Slag	Solid waste	4.40
6	Used Refractory materials	Solid waste	4.22
7	Mill Scale (Surface Oxides)	Solid waste	4.11
8	Non-hazardous waste	Solid waste	4.11
9	Carbon Dioxide (CO_2)	Air emissions	4.10
10	Renewable resource energy use	Energy used	4.00
11	Noise	Air emissions	3.89
12	Dust	Air emissions	3.78
13	Fumes	Air emissions	3.75
14	Iron Ore	Material used	3.70
15	Percentage green cover of total plant area	Land used	3.67
16	Recycling of SolidWaste	Waste management	3.67
17	Overall water consumption	Water used	3.60
18	Overall wastewater	Waste water	3.56
19	Recycling of Water	Waste management	3.56
20	Refractory materials	Material used	3.50
21	Wood/coal	Energy used	3.50
22	Mercury (Hg)	Air emissions	3.44
23	Hydrocarbons	Air emissions	3.44
24	Arsenic (As)	Air emissions	3.44
25	Chemical Oxygen Demand (COD)	Waste water	3.44
26	Fuel (diesel, petrol,etc.)	Energy used	3.40
27	Volatile organic compounds (VOC)	Air emissions	3.33
28	Nickel (Ni)	Air emissions	3.33
29	Particulate matter (PM)	Air emissions	3.33
30	Arsenic (As)	Waste water	3.25
31	Oil	Waste water	3.25
32	Land used for waste disposal	Land used	3.25
33	Recycling of Cutting Fluid	Waste management	3.25
34	Carbon Monoxide (CO)	Air emissions	3.22
35	Sulphur Dioxide (SO_2)	Air emissions	3.22

No.	Indicators	Aspect Category	Applicability Score
36	Cadmium (Cd)	Air emissions	3.22
37	Lead (Pb)	Waste water	3.13
38	Chromium (Cr)	Waste water	3.13
39	Suspended solids	Waste water	3.13
40	Lead (Pb)	Air emissions	3.11
41	Chromium (Cr)	Air emissions	3.11
42	Coke	Energy used	3.10
43	Phosphorus (P)	Waste water	3.00
44	Benzene	Waste water	3.00
45	Limestone	Material used	2.90
46	Antimony (Sb)	Waste water	2.88
47	Nickel (Ni)	Waste water	2.75

The utilization of power, the use of scrap steel or iron, and the utilization of steel waste or scrap were the top three sustainability indicators when viewed from the standpoint of the Triple Bottom Line (TBL). Indicators are ranked according to their worldwide priority, which is indicated in Table 10. When it comes to the top ten indicators based on worldwide priority, environmental indicators are ahead of the pack with a score of six out of ten. In all, nearly 55% (58/106) of the indicators were extremely relevant. This included 36% (21/58) environmental indicators, 40% (23/58) economic indicators, and 24% (14/58) social indicators.

Table 8: Local priority of Economic Indicators

No.	Indicators	Aspect Category	Applicability score
1	Savings due to material efficiency/recycling	Savings	4.6
2	Net Profit	Profit/ Revenue	4.3
3	Raw materials	Cost	4.1
4	Total Revenue	Profit/ Revenue	4.1
5	Depreciation cost	Cost	4.0
6	Maintenance and repair	Cost	4.0
7	Gross margin	Profit/ Revenue	4.0

No.	Indicators	Aspect Category	Applicability score
8	Return on equity	Profit/ Revenue	4.0
9	Operating revenue growth rate	Profit/ Revenue	4.0
10	Investment in new process and products	Investments	4.0
11	External investments in company for environment and sustainability	Investments	4.0
12	Savings due to energy efficiency	Savings	4.0
13	Investment in environmental protection	Investments	3.9
14	Market value	Profit/ Revenue	3.9
15	Return on asset	Profit/ Revenue	3.9
16	Savings due to reduced water consumption	Savings	3.9
17	Debt to assets ratio	Profit/ Revenue	3.8
18	Inspection cost	Cost	3.7
19	Waste disposal	Cost	3.7
20	Turnover/Inventory ratio	Profit/ Revenue	3.7
21	Utilities (electricity, water, etc.)	Cost	3.6
22	Environment and sustainability-related fines	Cost	3.6
23	Labor	Cost	3.5
24	Tax (Carbon Taxes, Water pollution taxes)	Cost	3.4
25	Incentives (tax relief, subsidies, etc.) provided by the government	Savings	3.3
26	Non acceptance cost (Rejection and Rework Costs)	Cost	3.2
27	Transportation	Cost	3.1
28	Fines related to unfair labor practices	Cost	3.1

Working hours, fair income or compensation, work-related injuries, the number of workers who have received training, forced labor, and health and safety measures were recognized as the most suitable indicators for the social dimension (see Table 9).

Table 9: Local priority of Social Indicators

No.	Indicators	Aspects	Applicability score
1	Working hours	Worker/ Employee	4.4

No.	Indicators	Aspects	Applicability score
2	Fair Wage or salary	Worker/ Employee	4.3
3	Work related injuries	Worker/ Employee	4.0
4	No. of employees trained	Worker/ Employee	4.0
5	Forced labor	Worker/ Employee	4.0
6	Health and safety measures	Local community	3.9
7	Child labor	Worker/ Employee	3.8
8	Suppliers development	Suppliers/ Contractors	3.7
9	Consumer satisfaction	Customers/ Consumers	3.7
10	New Job Creation	Worker/ Employee	3.6
11	Local employment	Local community	3.6
12	Education	Local community	3.6
13	Sustainability Reporting	Local community	3.6
14	Job security	Worker/ Employee	3.6
15	Quality of life	Worker/ Employee	3.4
16	Inclusion of rights	Customers/ Consumers	3.4
17	Customer engagement for product development	Customers/ Consumers	3.4
18	Suppliers management	Suppliers/ Contractors	3.4
19	Anti-corruption awareness	Local community	3.4
20	Contributions to economic development	Local community	3.4
21	Equal opportunity or no discrimination	Worker/ Employee	3.3
22	Freedom of association	Worker/ Employee	3.3
23	Employee turnover	Worker/ Employee	3.3
24	Access to informational resources	Local community	3.3
25	Innovation potential	Worker/ Employee	3.3
26	Absenteeism	Worker/ Employee	3.3
27	Social benefits (retirement benefits, etc)	Worker/ Employee	3.2

No.	Indicators	Aspects	Applicability score
28	Complaints or feedback	Customers/ Consumers	3.1
29	Employee' satisfaction	Worker/ Employee	3.1
30	Community engagement (technology transfer)	Local community	3.1
31	Preservation of culture and heritage	Local community	2.9

The utilization of power, the use of scrap steel or iron, and the utilization of steel waste or scrap were the top three sustainability indicators when viewed from the standpoint of the Triple Bottom Line (TBL). Indicators are ranked according to their worldwide priority, which is indicated in Table 10.

When it comes to the top ten indicators based on worldwide priority, environmental indicators are ahead of the pack with a score of six out of ten. In all, nearly 55% (58/106) of the indicators were extremely relevant. This included 36% (21/58) environmental indicators, 40% (23/58) economic indicators, and 24% (14/58) social indicators.

Table 10: Global priority of triple-bottom line sustainability indicators

No.	Indicators	Sustainability Dimension	Applicability Score
1	Savings due to material efficiency/recycling	Economic	4.6
2	Net Profit	Economic	4.3
3	Raw materials	Economic	4.1
4	Total Revenue	Economic	4.1
5	Depreciation cost	Economic	4.0
6	Maintenance and repair	Economic	4.0
7	Gross margin	Economic	4.0
8	Return on equity	Economic	4.0
9	Operating revenue growth rate	Economic	4.0
10	Investment in new process and products	Economic	4.0
11	External investments in company for environment and sustainability	Economic	4.0
12	Savings due to energy efficiency	Economic	4.0
13	Investment in environmental protection	Economic	3.9
14	Market value	Economic	3.9
15	Return on asset	Economic	3.9
16	Savings due to reduced water consumption	Economic	3.9
17	Debt to assets ratio	Economic	3.8
18	Inspection cost	Economic	3.7
19	Waste disposal	Economic	3.7

No.	Indicators	Sustainability Dimension	Applicability Score
20	Turnover/Inventory ratio	Economic	3.7
21	Utilities (electricity, water, etc.)	Economic	3.6
22	Environment and sustainability-related fines	Economic	3.6
23	Labor	Economic	3.5
24	Electricity	Environmental	4.78
25	Scrap Steel/Iron	Environmental	4.70
26	Steel waste/scrap	Environmental	4.60
27	Working hours	Social	4.4
28	Natural gas	Environmental	4.40
29	Slag	Environmental	4.40
30	Fair Wage or salary	Social	4.3
31	Used Refractory materials	Environmental	4.22
32	Mill Scale (Surface Oxides)	Environmental	4.11
33	Non-hazardous waste	Environmental	4.11
34	Carbon Dioxide (CO_2)	Environmental	4.10
35	Renewable resource energy use	Environmental	4.00
36	Work related injuries	Social	4.0
37	No. of employees trained	Social	4.0
38	Forced labor	Social	4.0
39	Noise	Environmental	3.89
40	Health and safety measures	Social	3.9
41	Dust	Environmental	3.78
42	Fumes	Environmental	3.75
43	Child labor	Social	3.8
44	Suppliers development	Social	3.7
45	Iron Ore	Environmental	3.70
46	Percentage green cover of total plant area	Environmental	3.67
47	Recycling of SolidWaste	Environmental	3.67
48	Consumer satisfaction	Social	3.7
49	New Job Creation	Social	3.6
50	Local employment	Social	3.6
51	Education	Social	3.6
52	Sustainability Reporting	Social	3.6
53	Overall water consumption	Environmental	3.60
54	Overall wastewater	Environmental	3.56
55	Recycling of Water	Environmental	3.56
56	Job security	Social	3.6
57	Refractory materials	Environmental	3.50
58	Wood/coal	Environmental	3.50
59	Mercury (Hg)	Environmental	3.44
60	Hydrocarbons	Environmental	3.44

No.	Indicators	Sustainability Dimension	Applicability Score
61	Arsenic (As)	Environmental	3.44
62	Chemical Oxygen Demand (COD)	Environmental	3.44
63	Quality of life	Social	3.4
64	Inclusion of rights	Social	3.4
65	Customer engagement for product development	Social	3.4
66	Suppliers management	Social	3.4
67	Tax (Carbon Taxes, Water pollution taxes)	Economic	3.4
68	Fuel (diesel, petrol,etc.)	Environmental	3.40
69	Anti-corruption awareness	Social	3.4
70	Contributions to economic development	Social	3.4
71	Volatile organic compounds (VOC)	Environmental	3.33
72	Nickel (Ni)	Environmental	3.33
73	Particulate matter (PM)	Environmental	3.33
74	Equal opportunity or no discrimination	Social	3.3
75	Freedom of association	Social	3.3
76	Employee turnover	Social	3.3
77	Access to informational resources	Social	3.3
78	Arsenic (As)	Environmental	3.25
79	Oil	Environmental	3.25
80	Land used for waste disposal	Environmental	3.25
81	Recycling of Cutting Fluid	Environmental	3.25
82	Innovation potential	Social	3.3
83	Absenteeism	Social	3.3
84	Incentives (tax relief, subsidies, etc.) provided by the government	Economic	3.3
85	Carbon Monoxide (CO)	Environmental	3.22
86	Sulphur Dioxide (SO2)	Environmental	3.22
87	Cadmium (Cd)	Environmental	3.22
88	Social benefits (retirement benefits, etc)	Social	3.2
89	Non acceptance cost (Rejection and Rework Costs)	Economic	3.2
90	Complaints or feedback	Social	3.1
91	Transportation	Economic	3.1
92	Fines related to unfair labor practices	Economic	3.1
93	Lead (Pb)	Environmental	3.13
94	Chromium (Cr)	Environmental	3.13
95	Suspended solids	Environmental	3.13
96	Employee' satisfaction	Social	3.1
97	Community engagement (technology transfer)	Social	3.1
98	Lead (Pb)	Environmental	3.11
99	Chromium (Cr)	Environmental	3.11
100	Coke	Environmental	3.10

No.	Indicators	Sustainability Dimension	Applicability Score
101	Phosphorus (P)	Environmental	3.00
102	Benzene	Environmental	3.00
103	Limestone	Environmental	2.90
104	Antimony (Sb)	Environmental	2.88
105	Preservation of culture and heritage	Social	2.9
106	Nickel (Ni)	Environmental	2.75

Based on the economic perspective, as shown in Figure 2, the experts reached a consensus that the cost might have a more significant influence on the Pakistani steel sector than other categories. When considering the backdrop of Pakistan's economy, which is characterized by a middle-class economy, this may be explained by the idea that improving economic performance would be more successful if expenses were reduced rather than profits were increased. Controlling costs should be a top priority for firms and sectors since it will enable them to function more sustainably within their limited financial resources. There is the potential for cost management approaches to extend to environmental and social responsibilities, including the reduction of waste, the optimization of energy consumption, and the guarantee of fair labor standards. Taking into account these factors help to create a more comprehensive strategy for achieving economic sustainability. When viewed from a social perspective, several feature categories that are associated with workers and employees earned higher ratings (as shown in Figure 3). There is a possibility that this is a reference to the fact that the steel business is often labor-intensive, includes heavy equipment, and involves operations that might be potentially dangerous. The worker/employee category should be given priority since it has the potential to contribute to the professional development and progress of the workforce. It can also offer a stable and content workforce, which will ultimately lead to an increase in the total. productivity of the steel sector.

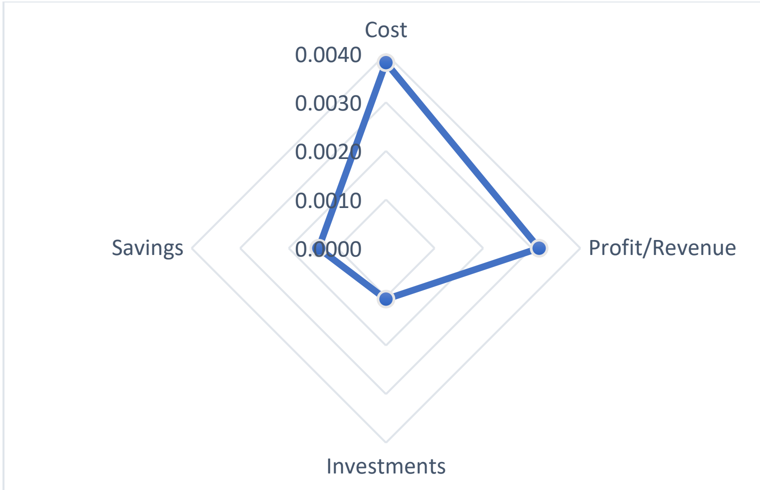

Figure 0.2: Aspect weights of economic category

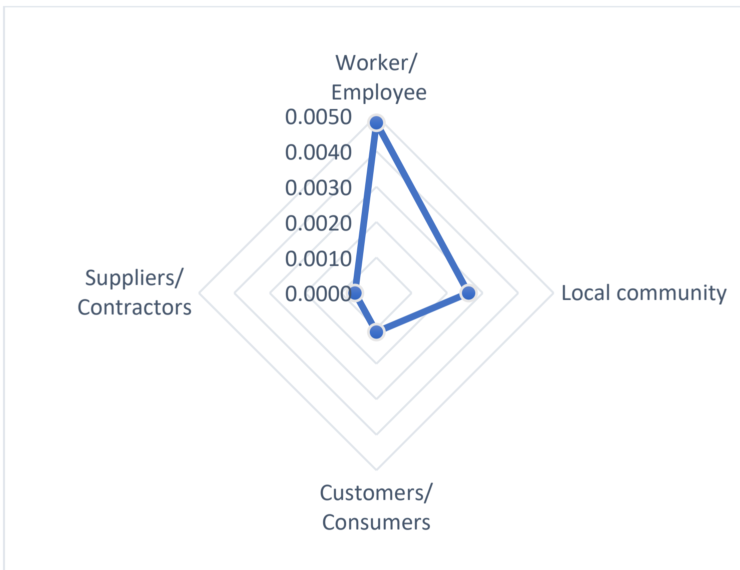

Figure 0.3: Aspect weights of social category

CASE STUDY

6.1. Company Introduction

To demonstrate the efficacy of the created indicators, they were subjected to thorough testing in a case study carried out inside a steel factory in Pakistan. To preserve anonymity, the firm in question is anonymized and identified as XYZ firm. XYZ Company, located in Islamabad, Pakistan, began operations in 2007 as a small-scale steel production factory with a staff of 180 employees. The main product of the company, steel rebar, is available in many grades that vary based on their composition.

6.2. Methodology: Sustainability Assessment Approach

The sustainability evaluation approach used for this case study defined the system boundary as gate-to-gate. This border includes the complete production process, starting with the collection of steel scrap to the manufacturing that takes place inside the plant grounds. Therefore, data collecting efforts were focused on capturing all relevant production and packaging processes inside the food manufacturing plant.

6.3. Data Collection and Normalization Process

Data was obtained by conducting on-site inspections and thorough interviews with important stakeholders, such as senior management and production people. In order to ease the comparison and assure clear understanding, the data obtained at different frequency, such as monthly, weekly, or daily, were converted into standardized metrics for each product. The quantitative data were accurately documented according to their specific units of measurement, while the qualitative observations were classified using a graded linguistic scale that spans from 1 to 5. In this scale, 1 represents 'Very Low' (VL) and 5 represents 'Very High' (VH).

To compensate for the lack of easily accessible data, a three-point estimate method was used for each indication. This method included determining the least, most probable, and maximum values. Due to the different units of measurement used by the indicators, it was not feasible to directly add them together. To overcome this obstacle, the gathered data was standardized to a consistent range of values between 0 and 1. The procedure of normalization, as described in Equation (1) for indicators with positive signs and Equation (2) for indications with negative signs, played a crucial role in making the data comparable. To get a combined actual value P(ň) from the standardized data, the graded mean integration representation technique was used, as described in Equation (3). Afterwards, the weighted score for each indication was calculated by multiplying its normalized value with the associated weight. Indicator scores were averaged at both the aspect category and dimension levels, taking into consideration their respective impact to determine the overall performance.

$$(\hat{y}_a, \hat{y}_b, \hat{y}_c) = \left(\frac{p1}{c^+}, \frac{p2}{c^+}, \frac{p3}{c^+}\right) \tag{1}$$

$$(\hat{y}_a, \hat{y}_b, \hat{y}_c) = \left(\frac{c^-}{p3}, \frac{c^-}{p2}, \frac{c^-}{p1}\right) \tag{2}$$

$$P(\check{n}) = \frac{1}{6}\left(\hat{y}_a + 4\hat{y}_b + \hat{y}_c\right) \tag{3}$$

Where $p1$,$p2$ and $p3$ are the three-point estimates, $c+$ and $c-$ are the maximum and minimum values respectively among the three-point estimates, and $\hat{y}_a$, $\hat{y}_b$, $\hat{y}_c$ represent the normalized values of the three-point estimates.

The collected data for all the dimensions as well as their scores calculated according to the above formulas are presented in table 11-13. This research yielded intriguing results by incorporating the relative weights and impact directions of the indicators. Based on the impact directions, a lower score for the environmental dimension and a higher score for social and economic dimension represent better performance. The dimension’s score showed that the company under consideration performed better in terms of social sustainability followed by environmental and economic sustainability. The hotspots for all sustainability dimensions can be found through the aspect categories as well as individual indicator level.

For environmental dimension, land used aspect category is performing the best in that dimension followed by overall water consumption and material used. The company needs to put more focus on improving its performance in terms of waste management, air emissions, wastewater, and solid waste, respectively. Recycling of water, cutting fluid and solid waste are the top environmental hotspots followed by steel waste/scrap and then electricity. It can be easily understood as the industry does not recycle much of its waste but rather disposes it off into the landfill. Also, industry mainly relies on electricity as it’s main source of energy.

Table 11: Evaluation of Environmental Dimension

			Three-point data			Normalized Data			Single Value				
Aspects	**Indicators**	**Impact**	**p1**	**p2**	**p3**	**xa**	**xb**	**xc**	**p(m)**	**Indicator's weight**	**Indicator's score**	**Aspect's score**	**Dimension's score**
Material used	Scrap Steel/Iron	-	0.84	1.05	1.27	0.66	0.80	1.00	0.81	0.0282	0.0229		0.7001
	Iron Ore	-	1.54	1.81	2.12	0.73	0.85	1.00	0.85	0.0222	0.0190		
	Refractory materials	-	4.57	5.1	5.63	0.81	0.90	1.00	0.90	0.0210	0.0189		
	Limestone	-	54	69	82	0.66	0.78	1.00	0.80	0.0174	0.0139	0.0746	
Energy used	Fuel (diesel, petrol,etc.)	-	4.2	4.8	5.6	0.75	0.88	1.00	0.88	0.0204	0.0179		
	Natural gas	-	1.86	2.1	2.33	0.80	0.89	1.00	0.89	0.0264	0.0235		
	Renewable resource energy use	-	0	0	0	0.00	0.00	0.00	0.00	0.0240	0.0000		
	Wood/coal	-	786	803	840	0.94	0.98	1.00	0.98	0.0210	0.0205		
	Electricity	-	790	810	836	0.94	0.98	1.00	0.97	0.0287	0.0279		
	Coke	-	562	670	705	0.80	0.84	1.00	0.86	0.0186	0.0160	0.1057	
Water used	Overall water consumption	-	3.55	3.87	4.12	0.86	0.92	1.00	0.92	0.0216	0.0199	0.0190	
Air emissions	Carbon Dioxide (CO_2)	-	1660	1779	1847	0.90	0.93	1.00	0.94	0.0246	0.0231		
	Carbon Monoxide (CO)	-	258	270	296	0.87	0.96	1.00	0.95	0.0193	0.0183		
	Sulphur Dioxide (SO_2)	-	12	14	17	0.71	0.86	1.00	0.86	0.0193	0.0165		
	Volatile organic compounds (VOC)	-	230	259	265	0.87	0.89	1.00	0.90	0.0200	0.0181		
	Mercury (Hg)	-	3.2	3.9	4.3	0.74	0.82	1.00	0.84	0.0207	0.0173		
	Hydrocarbons	-	0.77	0.81	0.86	0.90	0.95	1.00	0.95	0.0207	0.0196	0.2605	

			Three-point data			Normalized Data			Single Value				
Aspects	Indicators	Impact	p1	p2	p3	xa	xb	xc	p(m)	Indicator's weight	Indicator's score	Aspect's score	Dimension's score
	Dust	-	0.8	1.2	1.5	0.53	0.67	1.00	0.70	0.0227	0.0159		
	Fumes	-	65	68	72	0.90	0.96	1.00	0.95	0.0225	0.0215		
	Lead (Pb)	-	0.13	0.14	0.18	0.72	0.93	1.00	0.91	0.0187	0.0169		
	Noise	-	108	112	116	0.93	0.96	1.00	0.96	0.0233	0.0225		
	Arsenic (As)	-	14	16	18	0.78	0.88	1.00	0.88	0.0207	0.0182		
	Cadmium (Cd)	-	0	0	0	0.00	0.00	0.00	0.00	0.0193	0.0000		
	Nickel (Ni)	-	8.3	10	12	0.69	0.83	1.00	0.84	0.0200	0.0167		
	Chromium (Cr)	-	0.88	1	1.21	0.73	0.88	1.00	0.87	0.0187	0.0163		
	Particulate matter (PM)	-	294	300	311	0.95	0.98	1.00	0.98	0.0200	0.0196		
Waste water	Overall wastewater	-	22360	26000	29640	0.75	0.86	1.00	0.87	0.0213	0.0185		
	Antimony (Sb)	-	0.0088	0.01	0.0112	0.79	0.88	1.00	0.88	0.0173	0.0153		
	Lead (Pb)	-	6	8	10	0.60	0.75	1.00	0.77	0.0188	0.0144		
	Nickel (Ni)	-	35	41	46	0.76	0.85	1.00	0.86	0.0165	0.0142		
	Chemical Oxygen Demand (COD)	-	102	130	146	0.70	0.78	1.00	0.81	0.0207	0.0167		
	Phosphorus (P)	-	422	500	536	0.79	0.84	1.00	0.86	0.0180	0.0155		
	Arsenic (As)	-	0.084	0.1	0.116	0.72	0.84	1.00	0.85	0.0195	0.0165		
	Benzene	-	0	neg	0	0.00	0.00	0.00	0.00	0.0180	0.0000		
	Chromium (Cr)	-	22	26	30	0.73	0.85	1.00	0.85	0.0188	0.0160	0.1581	

Aspects	Indicators	Impact	Three-point data p1	p2	p3	Normalized Data xa	xb	xc	Single Value p(m)	Indicator's weight	Indicator's score	Aspect's score	Dimension's score
	Suspended solids	-	32	34	37	0.86	0.94	1.00	0.94	0.0188	0.0176		
	Oil	-	2	3	4	0.50	0.67	1.00	0.69	0.0195	0.0135		
Solid waste	Mill Scale (Surface Oxides)	-	26	35	46	0.57	0.74	1.00	0.76	0.0247	0.0187		
	Used Refractory materials	-	8	11	15	0.53	0.73	1.00	0.74	0.0253	0.0188		
	Steel waste/scrap	-	6	8	1	6.00	0.75	1.00	1.67	0.0276	0.0460		
	Non-hazardous waste	-	12	19	28	0.43	0.63	1.00	0.66	0.0247	0.0163		
	Slag	-	300	402	488	0.61	0.75	1.00	0.77	0.0264	0.0202	0.1199	
Land used	Percentage green cover of total plant area	-	0	0	0	0.00	0.00	0.00	0.00	0.0220	0.0000		
	Land used for waste disposal	-	0.00176	0.002	0.00224	0.79	0.88	1.00	0.88	0.0195	0.0172	0.0172	
Waste management	Recycling of Cutting Fluid	+	50	53	57	0.88	0.93	1.00	0.93	0.0195	0.0182		
	Recycling of SolidWaste	+	18	21	24	0.75	0.88	1.00	0.88	0.0220	0.0193		
	Recycling of Water	+	1.92	2.3	2.8	0.69	0.82	1.00	0.83	0.0213	0.0177	0.0551	

Table 12: Evaluation of Economic Dimension

Aspects	Indicators	Impact	Three-point data p1	p2	p3	Normalized Data xa	xb	xc	Single Value p(m)	Indicator's weight	Indicator's score	Aspect's score	Dimension's score
Cost	Raw materials	-	52000	55000	60000	0.867	0.945	1.000	0.941	0.039	0.037		0.020
	Waste disposal	-	500	780	1000	0.500	0.641	1.000	0.677	0.034	0.023		
	Tax (Carbon Taxes, Water pollution taxes)	-	0	0	0	0.000	0.000	0.000	0.000	0.032	0.000		
	Transportation	-	5000	9000	12000	0.417	0.556	1.000	0.606	0.030	0.018		
	Labor	-	3000	5500	8000	0.375	0.545	1.000	0.593	0.033	0.020	0.199	

Aspects	Indicators	Impact	Three-point data p1	Three-point data p2	Three-point data p3	Normalized Data xa	Normalized Data xb	Normalized Data xc	Single Value p(m)	Indicator's weight	Indicator's score	Aspect's score	Dimension's score
	Depreciation cost	-	1000	1600	2000	0.500	0.625	1.000	0.667	0.038	0.025		
	Non acceptance cost (Rejection and Rework Costs)	-	0	0	0	0.000	0.000	0.000	0.000	0.030	0.000		
	Maintenance and repair	-	2000	3000	4000	0.500	0.667	1.000	0.694	0.038	0.026		
	Utilities (electricity, water, etc.)	-	5000	6500	8000	0.625	0.769	1.000	0.784	0.034	0.027		
	Environment and sustainability-related fines	-	0	0	0	0.000	0.000	0.000	0.000	0.034	0.000		
	Fines related to unfair labor practices	-	0	0	0	0.000	0.000	0.000	0.000	0.030	0.000		
	Inspection cost	-	1000	1600	2000	0.500	0.625	1.000	0.667	0.035	0.023		
	Total Revenue	+	200000	259000	300000	0.667	0.863	1.000	0.853	0.039	0.033		
	Net Profit	+	19000	28000	35000	0.543	0.800	1.000	0.790	0.040	0.032		
	Market value	+	0	0	0	0.000	0.000	0.000	0.000	0.036	0.000		
	Gross margin	+	18	20	22	0.818	0.909	1.000	0.909	0.038	0.034		
	Return on equity	+	10	13	15	0.667	0.867	1.000	0.856	0.038	0.032		
	Return on asset	+	5	7	8	0.625	0.875	1.000	0.854	0.036	0.031		
	Debt to assets ratio	-	0.35	0.5	0.6	0.583	0.700	1.000	0.731	0.036	0.026		
	Operating revenue growth rate	+	1.9	1.95	2	0.950	0.975	1.000	0.975	0.038	0.037		
Profit/Revenue	Turnover/Inventory ratio	+	3.5	5	6.5	0.538	0.769	1.000	0.769	0.034	0.027	0.199	
	Investment in new process and products	+	0	0	0	0.000	0.000	0.000	0.000	0.038	0.000		
	Investment in environmental protection	+	0	0	0	0.000	0.000	0.000	0.000	0.036	0.000		
Investments	External investments in company for environment and sustainability	+	0	0	0	0.000	0.000	0.000	0.000	0.038	0.000	0.000	
	Savings due to energy efficiency	+	0	0	0	0.000	0.000	0.000	0.000	0.038	0.000		
	Savings due to material efficiency/recycling	+	0	0	0	0.000	0.000	0.000	0.000	0.043	0.000		
	Savings due to reduced water consumption	+	0	0	0	0.000	0.000	0.000	0.000	0.036	0.000		
Savings	Incentives (tax relief, subsidies, etc.) provided by the government	+	500	1200	2000	0.250	0.600	1.000	0.608	0.031	0.019	0.019	

Table 13: Evaluation of Social Dimension

			Three-point data			Normalized Data			Single Value				
Aspects	Indicators	Impact	p1	p2	p3	xa	xb	xc	p(m)	Indicator's weight	Indicator's score	Aspect's score	Dimension's score
	Fair Wage or salary	+	1	1	2	0.500	0.500	1.000	0.583	0.0396	0.02		0.476
	Work related injuries	-	1	1	2	0.500	1.000	1.000	0.917	0.0365	0.03		
	Working hours	-	3	3	4	0.750	1.000	1.000	0.958	0.0406	0.04		
	No. of employees trained	+	4	5	5	0.800	1.000	1.000	0.967	0.0365	0.04		
	Innovation potential	+	1	1	1	1.000	1.000	1.000	1.000	0.0297	0.03		
	Equal opportunity or no discrimination	+	4	4	5	0.800	0.800	1.000	0.833	0.0304	0.03		
	New Job Creation	+	1	1	2	0.500	0.500	1.000	0.583	0.0331	0.02		
	Social benefits (retirement benefits, etc)	+	1	1	2	0.500	0.500	1.000	0.583	0.0294	0.02		
	Child labor	-	0	0	1	0.000	0.000	0.000	0.000	0.0342	0.00		
	Forced labor	-	0	0	1	0.000	0.000	0.000	0.000	0.0365	0.00		
	Absenteeism	-	1	1	2	0.500	1.000	1.000	0.917	0.0297	0.03		
	Employee' satisfaction	+	2	3	4	0.500	0.750	1.000	0.750	0.0285	0.02		
	Freedom of association	+	2	2	3	0.667	0.667	1.000	0.722	0.0304	0.02		
	Quality of life	+	2	2	3	0.667	0.667	1.000	0.722	0.0314	0.02		
	Job security	+	3	3	4	0.750	0.750	1.000	0.792	0.0325	0.03		
Worker/ Employee	Employee turnover	-	1	1	2	0.500	1.000	1.000	0.917	0.0300	0.03	0.115	
	Anti-corruption awareness	+	0	1	1	0.000	1.000	1.000	0.833	0.0308	0.03		
	Local employment	+	35	40	50	0.700	0.800	1.000	0.817	0.0331	0.03		
Local community	Access to informati	+	2	2	3	0.667	0.667	1.000	0.722	0.0300	0.02	0.205	

			Three-point data			Normalized Data			Single Value	Indicator's weight	Indicator's score	Aspect's score	Dimension's score
Aspects	**Indicators**	**Impact**	**p1**	**p2**	**p3**	**xa**	**xb**	**xc**	**p(m)**				
	onal resources												
	Contributions to economic development	+	1	2	3	0.333	0.667	1.000	0.667	0.0308	0.02		
	Community engagement (technology transfer)	+	0	1	1	0.000	1.000	1.000	0.833	0.0285	0.02		
	Health and safety measures	+	1	2	3	0.333	0.667	1.000	0.667	0.0354	0.02		
	Education (Scholarship aid for students)	+	0	1	1	0.000	1.000	1.000	0.833	0.0331	0.03		
	Preservation of culture and heritage	+	0	0	1	0.000	0.000	1.000	0.167	0.0261	0.00		
	Sustainability Reporting	+	2	3	3	0.667	1.000	1.000	0.944	0.0331	0.03		
Customers/ Consumers	Inclusion of rights (Right to information, safety, etc)	+	1	2	3	0.333	0.667	1.000	0.667	0.0313	0.02		
	Complaints or feedback	+	1	2	2	0.500	1.000	1.000	0.917	0.0287	0.03		
	Customer engagement for product development	+	0	1	1	0.000	1.000	1.000	0.833	0.0313	0.03		
	Consumer satisfaction	+	2	3	3	0.667	1.000	1.000	0.944	0.0335	0.03	0.105	
Suppliers/ Contractors	Suppliers development	+	0	1	1	0.000	1.000	1.000	0.833	0.0339	0.03		
	Suppliers management	+	2	2	3	0.667	0.667	1.000	0.722	0.0313	0.02	0.051	

Moreover, it does not use any renewable source of energy and does not cover any land that includes plantation, hence their score was not considered. The figure highlights the top three environmental indicators that should be prioritized for improvement in the current study according to their impact direction.

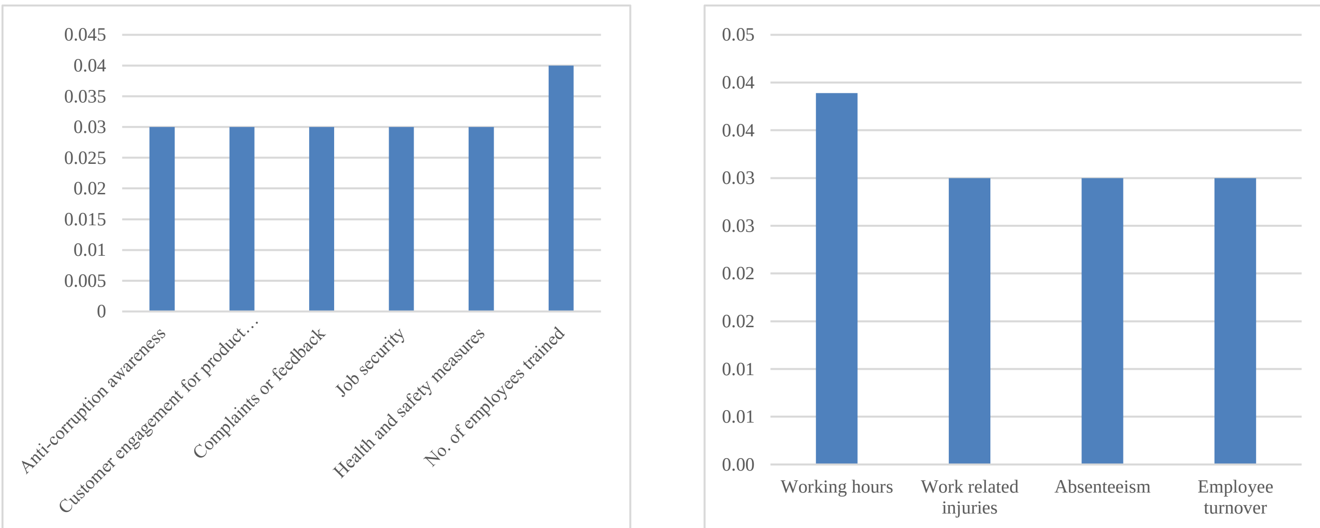

Figure 0.1: Top 10 social hotspots (Left) Positive Impact Direction (Right) Negative impact direction.

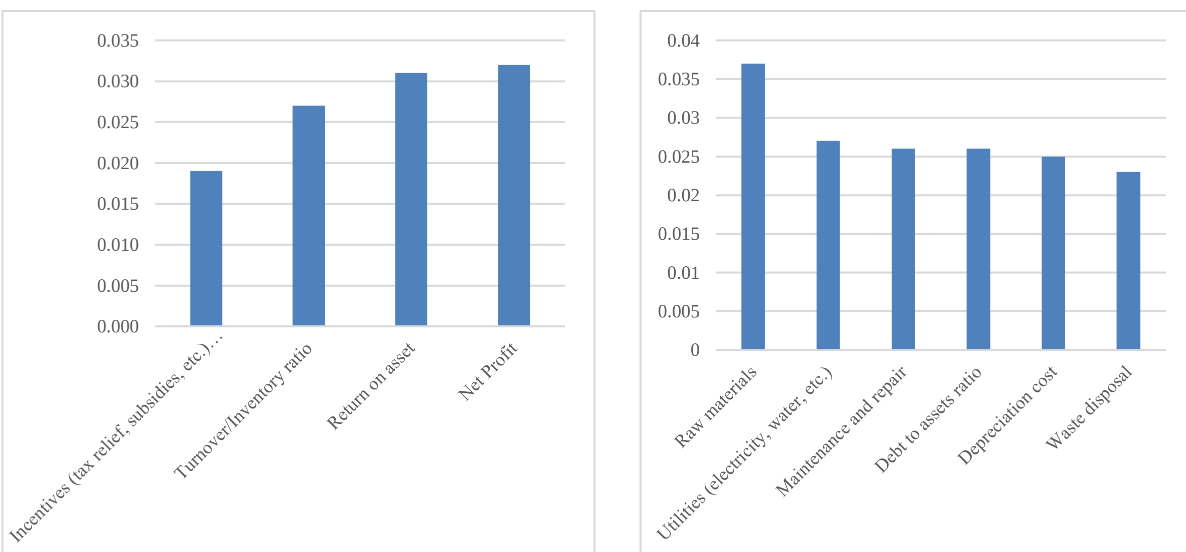

Figure 0.2: Top 10 economic hotspots (Left) Positive Impact Direction (Right) Negative impact direction.

IMPLICATIONS

This study enhances the theoretical comprehension of sustainability assessment by creating customized weighted Triple-Bottom Line (TBL) indicators for the Pakistani steel sector. This study addresses a vacuum in the existing literature by offering a complete collection of indicators that include the economic, environmental, and social dimensions of sustainability in this setting. The created TBL indicators may function as a framework for steel businesses to improve transparency in their sustainability reporting. Stakeholders, such as investors, regulators, and the public, may enhance their comprehension of a company's environmental, social, and economic effects. The study framework and methods are replicable and adaptable to other sectors or locations that have comparable sustainability concerns. By disseminating the findings and approach to pertinent stakeholders, it may actively contribute to wider endeavors aimed at advancing sustainable development and fostering ethical business practices on a worldwide scale. The study may provide a basis for the future establishment of industry-specific sustainability standards in Pakistan. The Delphi research approach may be used to several sectors, fostering a more extensive culture of sustainability across companies in Pakistan. The case study undertaken as part of the research provides useful insights into the actual implementation of the proposed indicators in a real-world setting. Through the examination of the use of these indicators within a particular steel firm, it is possible to discover obstacles in implementation, optimal methods, and possibilities for improvement, thus improving the efficiency and significance of the sustainability measuring framework.

CONCLUSION

During this research, the objective was to create a complete collection of weighted Triple Bottom Line (TBL) sustainability indicators that were especially customized to the steel sector in Pakistan. To collect ideas from a group of specialists, the Delphi technique was used. The findings of this approach were then examined to determine which indicators were the most pertinent across the environmental, social, and economic aspects of sustainability. The data indicates that the experts established a high degree of consensus on a major number of the measures, with roughly 39% of them reaching unanimous agreement on all the indicators. Economic indicators received the highest support, even though they carry less weight than environmental and social indicators. From an environmental point of view, the indicators that concentrate on the use of energy, the utilization of scrap steel and iron, and the effective management of steel waste emerged as the most important goals. The steel sector in Pakistan is becoming more concerned about resolving concerns related to air quality and reducing pollution, and this reflects that concern. Following the emphasis placed on the necessity of cost reduction initiatives by the economic component, profit and revenue indicators were also brought to light. The fact that this is the case implies that cost-control techniques within a constrained financial resource environment have a significant impact on the economic viability of the steel sector in Pakistan. Indicators of social sustainability gave priority to issues that were relevant to the well-being of employees, such as working hours, compensation that was equitable, and health and safety procedures. This focus may be linked to the labor-intensive nature of the steel industry as well as the significant role that workers play in the overall productivity of the business. In general, the research found a collection of TBL indicators that are highly relevant and may be used to effectively assess and monitor the sustainability performance of the steel sector in Pakistan. Stakeholders, policymakers, and industry participants can get useful insights from these indicators, which enables them to make choices that are informed and that support sustainable practices within the sector. It is advised that more study be conducted to evaluate the difficulties involved with the application of these indicators and to investigate the ways in which they may be incorporated into the management systems that are already in place within the Pakistani steel sector. This will contribute to a more thorough knowledge of how to attain sustainable development objectives in this essential industrial sector, which will be a result of this.

FUTURE RECOMMENDATIONS

The study revealed a need for further investigation into social sustainability metrics that are tailored to the Pakistani steel sector. This may include examining elements like community involvement, human rights, and product integrity. Collaboration among academics, industry stakeholders, and governmental authorities is crucial to advance the objective of sustainable development in the steel sector. To promote the broad implementation of sustainable practices and indicators in the industry, future efforts should give priority to information sharing, skill development, and lobbying for legislative changes. By promoting a culture of ongoing development and responsibility, these initiatives may help enhance the long-term durability and competitiveness of the steel industry while reducing its environmental and social effects.

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