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Original Article

Supply chain sustainability performance indicators - a content analysis based on published standards and guidelines

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ABSTRACT

The goal of this paper is to provide researchers and practitioners with the required guidance to achieve a better assessment of the sustainability-related performance of an organization and its supply chain (SC). In order to achieve this, standards and guidelines covering three sustainability dimensions (economic, social, and environmental) were analyzed for the identification of sustainability performance indicators (SPIs). A content analysis approach was applied for the data collection and analysis. Twelve international standards and guidelines were identified and selected for the purpose of conducting an analysis to integrate the latest findings on SPIs in sustainable supply chain management (SSCM). The findings of the content analysis revealed 232 original set of instances of sustainability-related information, of which 46% were related to the environmental dimension, 43% were related to the social dimension and 11% were related to the economic dimension of sustainability. In order to provide a better understanding and evaluation, each sustainability dimension was characterized using attribute categories. A descriptive evaluation of the academic literature, standards, and guidelines resulted in 18 attribute categories. Collected indicators were classified according to these attribute categories. In-depth analysis, restructuring, standardizing of attribute categories and indicators have led to 70 unique and coherent SPIs. Out of which 49% indicators were identified as environmental SPIs, 37% as social SPIs and 14% as economic SPIs. The results revealed a complete lack of agreement among the current standards on how to measure the sustainability-related performance of an organization and its SC.

KEYWORDS: Sustainable supply chain management · performance measurement · content analysis · sustainability performance indicators

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1. INTRODUCTION

In recent years, the term sustainability and its use in the context of supply chain management (SCM) have gained considerable importance. Measuring, improving and communicating the sustainability-related performance of an organization and its SC, has become essential for setting objectives and determining future courses of actions. Globalization, increasing uncertainty and scarcity of resources, higher pressure from regulatory bodies and NGOs, outsourcing as well as increasing consumer awareness, are some of the significant drivers behind the emerging focus on sustainability in SCs [14, 34, 66, 68]. Consumers are paying more attention to the environmental quality and social conditions associated with products and services they use. In fact, the rise in consumer awareness has translated into a 4% increase in consumer goods sales, for the brands committed to sustainability as compared to only 1% for the brands that are not committed to sustainability [54]. Further, in 2015, according to a survey conducted by Nielsen, 66% of consumers intend to pay more for sustainable products as compared to 55% in 2013 [54]. Organizations are increasingly asked by stakeholders to address and manage the social as well as the environmental issues caused by their operations [14, 33].

In spite of the increasing relevance of sustainability, there have been few attempts in the scientific literature to provide a quantitative framework for evaluating the sustainability-related performance of an organization [50, 72]. So far, there are no well-established standards developed to measure the sustainability-related performance of an organization; instead only a limited number of sustainability guidelines are being provided by few initiatives and governmental agencies [45, 64, 79]. In fact, the lack of an overarching standardized methodology as well as the absence of an SC perspective, are the main reasons behind the missing transparency and the conflicting information regarding the sustainability performance. There is an urgent and crucial need for a standardized framework for sustainability-related performance assessment of an organization's SC, that incorporates a set of recognized performance indicators [32, 34]. Selecting the right SPIs for each sustainability dimension, from the large but unstructured amount of existing indicators, remains a challenging task [11]. The aim of this paper is to address the following research question with a help of a multi-step approach of content analysis.

"What sustainability-related indicators for performance assessment are disclosed in published standards and guidelines regarding sustainability and its associated dimensions in SC."

It will provide a coherent and standardized set of SPIs for the assessment of the sustainability initiatives and their implementation. This research paper will also provide a better understanding of the current state of sustainability performance assessment in SCM, as well as how it can be measured using currently available standards and guidelines.

The remainder of the paper is structured as follows: Section 2 presents the research background and the state of the art in the field of SSCM and its performance measurement. Section 3 briefly presents the research methodology, while Section 4 provides a detailed analysis of the results and findings. Finally, the conclusions, strengths, and weaknesses of the adopted research method as well as suggested future research directions are presented in Section 5.

2. BASIC TERMINOLOGY

The basic terminologies related to the topic of SSCM, primary terms associated with sustainability-related performance measurement, and clear definition of SPIs are described below in detail.

2.1 Sustainable supply chain management

In the last few decades, both researchers and practitioners have been continuously making efforts to incorporate issues like green, social responsibility, human rights, health and safety, etc. in the field of SCM. The term SSCM has been discussed extensively and includes research across the areas of responsible SCM, ethical SCM, green SCM, as well as the research dealing with social or environmental impacts [22, 27, 59, 78]. Organizations are considered to be responsible for their business activities that affect the environment, society, and economy of their own business as well as their SC participants [71]. Therefore, any problem related to the environmental or social dimension of sustainability at any level in the SC could harm the focal organization and may result in a bad reputation. On the one hand, globalization caused SCs to expand. On the other hand, it has raised the question of managing sustainability issues within the conventional SC network. Organizations from different geographic regions of the world are culturally, politically, and historically different likewise their social, environmental and economic settings. Therefore, dealing individually with such issues for an organization's SC has shifted to rather an integrated and higher-order concept of sustainability in SC. A major advancement in this field of SSCM has been noted in the mid of 1990s [70] with a more extensive focus to address questions like whether it is beneficial to be sustainable and how to assess the sustainability performance of an organization and its SC. Therefore, it is an established fact now that an organization's sustainability is only possible if sustainability issues are addressed at each level of the SC [60].

While, there have been many attempts in research to define SSCM, a relatively less literature is available as compared to the literature in sustainability. Many authors have tried to build a relationship between conventional SC and sustainability dimensions [12, 15, 22, 60] as SSCM addresses both inter- and intra-organizational interactions and interactions among sustainability dimensions. A number of literature reviews on SSCM has been published in recent years [2, 14, 15, 32, 44, 71]; nevertheless, there is no agreement on a standardized definition of SSCM. These literature reviews have helped to better understand the current state of the research in this field and the future research areas of advanced theoretical concept development [14, 70]. The goals of an SSCM are to provide a maximum value to all stakeholders and to fulfill customer requirements by achieving sustainable flows of products, services, information, and capital as well as enabling the cooperation among SC participants [10].

2.2 Performance measurement in SSCM

The topic of performance measurement in SCs, i.e. to what extent the objectives are achieved, has gained considerable attention both in academics and practice [58]. The performance measurement helps to increase the level of understanding and collaboration among the SC partners and to increase the SC wide integration [17, 51]. In the past, different indicators were used to measure performance at different levels in an SC [42]. Numerous traditional SC measures such as: "customer satisfaction", "service or responsiveness", "cost", etc. [9, 68] have been developed so far. However, these measures are not sufficient to describe the performance related to sustainable SCs as they were designed primarily for the performance measurement of SCs in general. Until today, researchers and practitioners are facing challenges to develop an integrated multidimensional framework to measure and manage SSCM, particularly the incorporation of social dimension into the performance measurement system (PMS) [15, 27, 60, 71].

As mentioned above, there is a critical need to expand the research in sustainability-related performance measurement of SCs with suitable performance measurement indicators. This requires the development of a standardized and coherent list of SPIs in order to measure the performance of sustainable SCs. There are different guidelines and standards that had identified the need, and provide measures to evaluate SC performance across different sustainability dimensions. For example, for the environmental dimension such as ISO 14001 [38], EMAS [20], for the social dimension such as ILO [36], SA8000 [75], or for multiple dimensions of sustainability such as GRI guidelines [29], UNGC's ten principles [77].

One of the main challenges in sustainability-related performance measurement is to adopt the right and appropriate set of SPIs. In fact, wrongly selected indicators can lead to a performance degradation of an SC. An SC wide competitive advantage can only be achieved by continuously monitoring the performance information of SPIs from all sustainability dimensions at regular periods. Moreover, the understandability of SPIs to all participants is mandatory for the better SC efficiency. Therefore, SPIs have to be designed in a way that they can be well communicated to everyone involved in the SC.

2.3 Sustainability performance indicators

Sustainability, as mentioned above, is a composite approach that has combined and balanced targets in all three sustainability dimensions. In order to assess the sustainability-related performance of an SC, a system of indicators is required. In literature, substitutional terms such as ‘indicators’, ‘metrics’ and ‘measures’ are used for the performance measurement. Neely et al. [52] have defined performance measures as “a metric used to quantify the efficiency and/or effectiveness of an action”. Saisana and Tarantola [67] have defined indicators as “pieces of information that summarize the characteristics of a system or highlight what is happening in a dynamic system” in order to assess the current state of the system. Indicators are categorized as: quantitative and qualitative [9, 73], financial and nonfinancial [1, 23], absolute and relative [3], and also based on their hierarchical (strategic, tactical, operational levels) focus [17, 30]. Relatively few publications provided a systematic analysis to identify and compare indicators for the performance measurement in sustainable SCs, and have revealed a lesser interest in the field of developing PMS [32, 73]. Indicators can communicate the actual situation of a complex system such as SC or sustainable SC. Furthermore, indicators that are used to measure the current performance of SSCM are described as sustainability performance indicators (SPIs) in this research work. As defined by Erol et al. [22], an SPI is an expression used to provide information related to the performance of an organization’s sustainability efforts. SPIs assist in the decision-making process within an organization engaged in sustainability. They also help to evaluate the related efforts that an organization has conducted to improve its sustainability performance. A standard set of SPIs not only provides a common foundation for both the organization and its stakeholders but also helps them to understand the extent of an organization’s sustainability efforts [5]. SPIs illustrate the magnitude and the direction of change for the phenomena being measured [43]. Therefore, SPIs are defined as

“Indicators that help to measure the performance of an organization at least in one of the three dimensions of sustainability”.

The selection of the right and balanced set of SPIs is a critical concern and requires a systematic approach. In terms of sustainability performance measurement, a balanced set of indicators that covers both the financial and non-financial aspects of performance is required [18]. On the one hand, appropriately selected SPIs help to assess and track an organization sustainability performance. On the other hand, they help organizations in communicating and implementing their strategies at operational and tactical levels [1]. Therefore, SPIs must be designed carefully as they can deeply affect the organization’s strategic, tactical and operational planning and control if they do not convey the optimal meaning [17, 30]. In order to better understand the problem and improve confidence, decision-makers are required to analyze the sustainability performance from different viewpoints [22]. It is only possible by considering each possible indicator for the sustainability performance assessment.

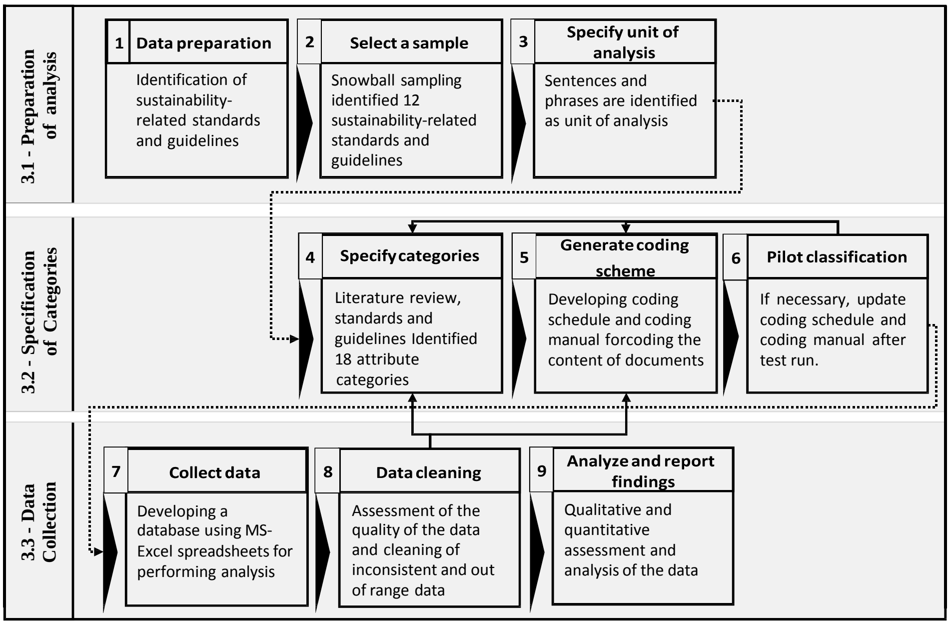
3. RESEARCH METHODOLOGY

In order to address the research question mentioned in section 1, a content analysis approach was selected to obtain data from existing documents and to reduce documentary material into more pertinent and manageable bits of data [19, 80]. A structured content analysis approach consisting of three main steps was followed [13, 37, 63], as shown in figure 1 and explained in next subsections.

3.1 Preparation of analysis

Content analysis involves reading and rereading of a huge amount of documents [63]. At first, a decision was taken regarding the selection of mass media in order to identify and collect the sample documents for addressing the problem [19, 47, 63]. In accordance with the research question, it was decided to restrict this research only to sustainability-related standards and guidelines. Furthermore, it was found that not a wide range of standards and guidelines exist to deal with sustainability-related issues. Therefore, every single opportunity was availed to identify available standards or guidelines to include in the content analysis.

Figure 1: Content analysis methodology, adapted from [13, 37, 63]



The selection of the sampling technique and other questions related to the published dates, cross-cultural data, inclusion or exclusion of a particular set of data, etc. were addressed at this step [13, 63]. For this exploratory research, non-probability snowball sampling technique [13, 47] was adopted. Standards or guidelines related to at least one aspect of sustainability and published or available in the English language were identified and selected. The relevance and appropriateness with the topic were ensured by reading each of the selected standards and guidelines in detail. The next step was to define the unit of analysis in order to make decisions about what to be counted and analyzed during the study. In content analysis, words, sentences, phrases, paragraphs, subjects or themes, dispositions, and images can be used as a unit of analysis [13, 19, 37, 63, 80]. Therefore, sentences and phrases were used as the unit of analysis to identify SPIs in standards and guidelines.

3.2 Specification of categories

At this step of the content analysis, attribute categories for the classification and structuring/restructuring of the content were defined. Categories can be single, multiple, assumed or inferred [80]. For this research, a single categorization scheme was used in which an SPI can relate to only one category. In addition, to increase the validity and extract more information from the content, both assumed and inferred categories [19, 37, 80] were used to classify units of analysis. Assumed categories were based on the initial literature review of scientific publications, standards, and guidelines. Inferred categories emerged from the research question and the data [65]. To recognize the main impacts of an organization on each sustainability dimension, table 1 describes attribute categories and the type of categorization.

Table 1: Overview of attribute categories

Sustainability	Attribute categories	Type
Environmental	Energy efficiency [1,2,8,10,14], material efficiency [2,6,8,11,13,14], water management [2,3,11,13], waste management [2,3,7,13] emissions [2,3,6,8,10,11,13], land use [2,3,8,11,13], environmental compliance [2,4,6,7,13], supplier assessment [4,7,12]	Single, assumed, inferred
Social	Human rights and anticorruption [2,3,5,9,11,12], human resource [3,6,8,11,12], health and safety [2,3,5,6,8,9,11,12,13], training and education [2,3], consumer issues [2,5,12], social compliance [2,5,12]	Single, assumed, inferred
Economic	Stability and profitability [2,3,11,12,13], income distribution [2,3,4,8,12], market competitiveness [2,5,11,13], sustainability expenditures [2,3,8,11]	Single, assumed, inferred
[1][4], [2][6], [3][7], [4][8], [5][16], [6][28], [7][31], [8][34], [9][45], [10][48], [11][49], [12][61], [13][74], [14][79]		

The environmental sustainability dimension has attribute related to the input such as energy, water, material, etc. and the output such as waste, emissions, etc. In order to measure the environmental sustainability performance of an organization, environmental sustainability was categorized into eight attribute categories as shown in table 2.

Table 2: Environmental sustainability attribute categories

	Attribute category	Definition
Environmental Sustainability	Energy efficiency (A_1)	It classifies information related to the total energy consumption from all forms of renewable as well as non-renewable energy sources and specific energy consumption within an organization.
	Material efficiency (A_2)	It deals with all forms of material input and classifies SPIs related to the total material input as well as renewable, hazardous and recycled material input of an organization.
	Water management (A_3)	It describes all forms of water consumption and classifies SPIs related to the total water consumption as well as the total water discharge and the quality of water discharge.
	Waste management (A_4)	It classifies information related to all forms of waste produced and recycled by an organization i.e. the total waste produced, total hazardous waste produced, and the total amount of waste recycled.
	Emissions (A_5)	It collects information related to all forms of emissions by an organization and classifies SPIs related to the total GHGs emission (direct and indirect GHGs), ozone-depleting substances, VOCs, NOx, SOx, and particulate matters.
	Land use (A_6)	It deals with the information related to the area of land used for conducting organization's operations and classifies SPIs related to the total land area used by an organization.
	Environmental compliance (A_7)	It collects information related to the compliance with environmental regulations and classifies SPIs related to the number of fines for non-compliance, the total number of environmental accidents, and the total number of environmental standards and certificates obtained by an organization.
	Supplier assessment (A_8)	It collects information related to suppliers' environmental performance and their selection criteria. It classifies SPIs that measure a supplier's sustainability-related performance and the number of local or national suppliers.

The identification of attribute categories in the case of social sustainability has posed many difficulties due to the lack of existing research in this dimension. Social sustainability of an organization is the way in which it manages its responsibilities towards its social and human capital [25]. In order to measure the social sustainability performance of an organization, social sustainability was categorized into six attribute categories as shown in table 3.

Table 3: Social sustainability attribute categories

	Attribute category	Definition
Social Sustainability	Human rights and anti-corruption (A_9)	It collects information related to the corruption and the violation of basic human rights. It classifies SPIs related to incidents of discrimination, forced and child labor, corruption, and violation of the rights to the freedom of association.
	Human resource (A_{10})	It deals with all forms of information related to the management of human resource. It classifies SPIs related to the total number of jobs created, the ratio of male and female employees, the number of local and national employees, turn-over rates, employees' benefits, employees' satisfaction, and employees' per-formance evaluations.
	Health and safety (A_{11})	It collects information regarding health and safety issues related to the work in an organization. It classifies SPIs related to the number of injuries and illness, days lost due to occupational injuries, and fatalities associated with the work.
	Training and education (A_{12})	It deals with the training and education opportunities provided to employees. It classifies SPIs related to the number of employees given training and the hours of training provided to both male and female employees of the organization.
	Consumer issues (A_{13})	It classifies information related to consumer issues such as consumer's complaints, product returns, and incidents of misleading, deceptive or fraudulent information to the consumer by an organization.
	Social compliance (A_{14})	It describes information related to the compliance with social regulations and classifies SPIs that measure the number of fines for non-compliance and the total number of social standards and certificates obtained by an organization.

Economic sustainability of an organization outlines the distribution and flow of financial resources among organization's stakeholders and its impact on the environment and the society [26]. In order to measure the economic sustainability performance of an organization, economic sustainability was categorized into four attribute categories as shown in table 4.

Table 4: Economic sustainability attribute categories

	Attribute category	Definition
Economic Sustainability	Stability and profitability (A_{15})	It illustrates the financial health of an organization. This attribute category classifies information related to total sales/revenue, operating profit, free cash flow, and the total number of products produced.
	Income distribution (A_{16})	It deals with information related to salaries and benefits given to employees, payments made to government and community. It classifies SPIs related to payments made to the government in the form of taxes, employee wages and benefits, community investments, and operating costs.
	Market competitiveness (A_{17})	It deals with the information related to an organization's economic performance as compared to its competitors in the same market. It classifies SPIs related to an organization's market share performance, the offering of competitive wages and the earning per share performance.
	Sustainability expenditures (A_{18})	It describes and considers an organization's economic performance in terms of organization's spending on sustainable initiatives, local procurement, as well as expenditures on research and development for a particular period of time.

This theory based categorization scheme of assumed and inferred categories with clear definitions has enhanced the coding process whereas internal validity of the findings has increased by discussion within the research team. The content analysis involved a process of coding [47] in which communications from different sources were coded systematically using a defined conceptual methodology in order to identify the explicit characteristics of the communication. Tags were placed on units of analysis for the purpose of assigning data in groups [13]. The degree of inferences i.e. manifest content and latent content [13, 63] were also taken into consideration in the classification of the content. The reliability (inter-coder and intra-coder) in making inferences [53] and a reliable coding process involved a two-step approach. In step 1, a coding schedule was designed that contains all information about the item being coded and in step 2, a coding manual was developed that acted as a statement of instructions for coders [13]. With a provided set of written instructions, the coding manual increased the consistency of the coding process and the reliability by continuously reminding coders about the rules for coding the data.

Later, the pilot classification was conducted to test the comprehensiveness of the categorization scheme and the coding process, in order to identify any weakness in the content analysis approach [37] as data collected may not always be classified in one particular category. All sorts of discrepancies were removed at this stage by revising and refining the categories [63] and the coding manual in order to achieve the content analysis' goals and increase the robustness of the coding process. The metrics of IChemE [35] and UNGC's ten principles [77] were selected for the test run.

3.3 Data collection and analysis

The data collection process involved the actual coding of the content after defining the unit of analysis, attribute categories and developing the coding manual. It involved the collection of facts and inferences made from the content and acted as a truthful representation of the phenomenon under study [37]. Afterward, data cleaning was performed to ensure the consistency, dealing with missing values, and for the treatment of obscurity and inappropriateness in the collected data [37, 47]. At this step, inconsistent and out of range data was excluded from the final dataset [47]. The pilot classification has helped to remove initial inconsistencies but a detailed quality assessment including reliability and validity were carried out at this step. Furthermore, reliability was ensured through the re-coding process. In which content of standards and guidelines were reviewed repeatedly by applying the above seven steps of the content analysis. Following this approach of classification, definitions from the coding manual, pilot test, and re-coding had ensured the stability and consistency of the research process.

The final step in the content analysis methodology was to analyze the data and report the results using different quantitative and qualitative techniques in association with the research question [63]. Statistical techniques (e.g. descriptive statistics) were used to present findings and produce required information from the data. The content analysis has provided a needed starting point for the development of a conceptual structure and a suggested set of coherent SPIs for measuring the performance of SSCM. The results and findings of the content analysis are discussed in the next section.

4. RESULTS AND DISCUSSION

The classification of SPIs has resulted in a quantitative dataset from the qualitative content of standards and guidelines and a spreadsheet database was generated for further data analysis. This section of the research paper describes the results of the empirical data analysis in detail. It presents and discusses the findings in a way that provides some practical guidance for researchers and practitioners in the field of SSCM. At first, the background information and several descriptive features about the selected standards and guidelines will be analyzed and presented. Afterward, an analysis of the identification of SPIs is given. Then the frequency analysis of SPIs that appeared in the standards and guidelines is provided. In subsection 4, distribution of SPIs is discussed. Finally, subsection 5, discusses different sustainability dimensions cited in the standards and guidelines.

4.1 Sample and descriptive analysis

In total twelve standards and guidelines were identified as mentioned in table 5. Out of which GRI [29], OECD [56], and IChemE [35] are the only three SC sustainability-related guidelines that directly address the three dimensions of the TBL. UNGC's ten principles [77] and ISO 26000 [40] addresses only two dimensions i.e. environmental sustainability and social sustainability. All of the others address only one sustainability dimension. The descriptive analysis reveals that the social dimension was addressed 129 times, environmental dimension 94 times and the economic dimension 12 times. Therefore, a total number of 235 instances of information were identified.

As mentioned in the methodology section, each sustainability dimension consists of different attribute categories. After careful identification and selection, the content of the information provided in standards and guidelines was classified according to attribute categories mentioned in section 3.4. This has resulted in some variations between the original classification (presented in the specific standards and guidelines) and the classification proposed here for the development of an SC sustainability performance assessment system.

The results in table 5 represent the distribution of identified SPIs from the selected sample as well as their association with attribute category of the respective sustainability dimension. A tick (✓) symbol is used in the table if an SPI is identified for an attribute category and cross (x) symbol is used if there is no SPI identified for an attribute category. Furthermore, it shows that how an attribute category and its related SPIs were addressed by each standard or guideline. This new formation has led to a very interesting conclusion and revealed that five out of twelve standards and guidelines has addressed attribute categories of all three sustainability dimensions whereas two standards and guidelines have addressed attribute categories of two sustainability dimensions and remaining five standards and guidelines has addressed attribute categories of only one sustainability dimension.

Table 5: Sustainability attribute categories and their relation to each standard and guideline

Sustainability	#	Attribute category	UNGC	ISO 14001	SA 8000	ILO	ISO 14031	GRI	EMAS	OECD	ISO 26000	IChemE	Green SCOR	OHSAS 18001
			Standards/Guidelines											
Environmental	A_1	Energy efficiency	✓	✓	x	x	✓	✓	✓	x	✓	✓	x	x
	A_2	Material efficiency	✓	✓	x	x	✓	✓	✓	x	✓	✓	x	x
	A_3	Water management	✓	✓	x	x	✓	✓	✓	x	✓	✓	✓	x
	A_4	Waste management	✓	✓	x	x	✓	✓	✓	x	✓	✓	✓	x
	A_5	Emissions	✓	✓	x	x	✓	✓	✓	✓	✓	✓	✓	x
	A_6	Land use	✓	✓	x	x	✓	✓	✓	x	✓	✓	x	x
	A_7	Environmental compliance	x	x	x	x	✓	✓	✓	x	✓	✓	x	x
	A_8	Supplier assessment	✓	x	x	x	x	✓	x	x	✓	✓	x	x
Social	A_9	Human rights and anti-corruption	✓	x	✓	✓	x	✓	x	✓	✓	✓	x	x
	A_{10}	Human resource	✓	x	✓	✓	x	✓	x	✓	✓	✓	x	x
	A_{11}	Health and safety	✓	x	✓	✓	x	✓	x	✓	✓	✓	x	✓
	A_{12}	Training and education	✓	x	✓	✓	✓	✓	x	✓	✓	✓	x	✓
	A_{13}	Consumer issues	x	x	x	x	x	✓	x	✓	✓	x	x	x
	A_{14}	Social compliance	x	x	x	x	x	✓	x	x	✓	✓	x	x
Economic	A_{15}	Stability and profitability	x	x	x	x	x	✓	x	x	x	✓	x	x
	A_{16}	Income distribution	x	x	x	x	x	✓	x	✓	✓	✓	x	x
	A_{17}	Market competitiveness	x	x	✓	x	x	✓	x	✓	✓	x	x	x
	A_{18}	Sustainability expenditures	x	x	x	x	✓	✓	x	x	✓	✓	x	x

UNGC=UNGC's ten principles [77], ISO 14001=Environmental management system [38], SA8000=Social accountability 8000 [75], ILO=International labor organization [36], ISO 14031:2013=Environmental performance evaluation [39], GRI= Global reporting initiative [29], EMAS=Eco-management and audit scheme [20], OECD=Organization for economic co-operation and development guidelines for multinational enterprises [56], ISO 26000=Social responsibility [40], IChemE= Institution of chemical engineers [35], SCOR=SC operational reference [69], OHSAS 18001=Occupation health and Safety assessment series [57]

4.2 SPIs identification in Standards and Guidelines

In order to identify and select SPIs from standards and guidelines, the content must have certain characteristics. These characteristics named indicator selection criteria, given in table 6, are based on the review of the already published literature [9, 41, 55]. Twelve standards and guidelines were analyzed and the proposed coding scheme helped to collect data in the Microsoft-Excel spreadsheet. Indicators cited in tables, figures, lists or anywhere in the text of standards and guidelines were identified. At first, identified instances of information were selected based on the indicator selection criteria. If an instance of information met the selection criteria, then it was processed further to affiliate with attribute categories mentioned in section 3.4.

In addition, a unique identification number was assigned to each SPI in the coding manual. All instances related to sustainability and its dimensions were documented by using an iterative process. Indicators with similar meanings were classified together such as “reduction in emission”, “decrease in the emission” or “decreasing in the emission”, etc. During the coding process, it becomes obvious that some instances of information were related to more than one attribute category. In such cases, indicators were processed using the coding schedule and the coding manual to categorize them accurately. Each attribute category classifies SPIs from standards and guidelines by following data collection process mentioned in section 3.7. The next step after collecting general sustainability-related information from the selected standards and guidelines is to examine attribute categories and associated instances in detail. The coded list of SPIs for each sustainability dimension is given in table 7.

Table 6: Indicator selection criteria

#	Characteristics	Description	References
1	Sustainability context	An indicator should reflect an organization's economic, environ-mental and/or social performance	21, 24, 55
2	Stakeholder inclusiveness	An indicator should be relevant to internal and/or external stakeholders	21, 55
3	Measurable	An indicator should provide the possibility to measure the progress over time, either qualitatively or quantitatively	1, 22, 55
4	Balance	A balanced indicator reflects both positive and negative perfor-mance	1, 41
5	Comparability	An indicator should have a target level or baseline and can sup-port in analyzing relative performance to other organizations	21, 24
6	Accuracy / Reliability	An indicator's performance should be verifiable, reproducible, consistent, transparent and bias-free	21, 24, 76
7	Clarity	An indicator should be simple and understandable to a wide range of audiences	21, 41, 76
8	Timeliness	An indicator should provide the possibility to generate and measure data over a period of time	21, 55

In the environmental sustainability dimension, three SPIs for the *'energy efficiency'* attribute category were identified that define and measure the energy-related environmental sustainability performance of an organization. Similarly, by implementing the content analysis methodology, six unique SPIs *for the 'material efficiency',* six for the '*water management'*, six for the '*waste management'*, eight for the *'emissions'*, two for the '*land use'*, one for the '*environmental compliance'*, and two SPIs for the '*supplier assessment'* attribute category were identified that define and measure the environmental sustainability performance of an organization.

Table 7: Number of sustainability performance indicators (SPIs) identified from standards and guidelines

	Sustainability dimensions		
	Environmental	**Social**	**Economic**
Attribute categories	A_1 Energy efficiency **(3)**	A_9 Human rights and anti-corruption **(5)**	A_{15} Stability and profitability **(1)**
	A_2 Material efficiency **(6)**	A_{10} Human resource **(10)**	A_{16} Income distribution **(4)**
	A_3 Water management **(6)**	A_{11} Health and safety **(3)**	A_{17} Market competitiveness **(2)**
	A_4 Waste management **(6)**	A_{12} Training and education **(4)**	A_{18} Sustainability expenditures **(3)**
	A_5 Emissions **(8)**		
	A_6 Land use **(2)**	A_{13} Consumer issues **(3)**	
	A_7 Environmental compliance **(1)**	A_{14} Social compliance **(1)**	
	A_8 Supplier assessment **(2)**		

(#) is the total number of SPIs identified for each attribute category

In the social sustainability dimension, five unique SPIs for the *'human rights and anti-corruption'* attribute category were identified that define and measure the social sustainability performance of an organization for this attribute category. Similarly, ten unique SPIs for the '*human resource'*, three for the '*health and safety'*, four for the '*training and education'*, three for the '*consumer issues'*, and one for the '*social compliance'* attribute category were identified that define and measure the social sustainability performance of an organization.

To measure the performance of the economic dimension of SSCM, one SPI for the attribute category of '*stability and profitability'* was identified in the standards and guidelines that define and measure the economic sustainability performance of an organization with reference to this attribute category. Similarly, four unique SPIs for the '*income distribution'*, two for the *'market competitiveness'* and three SPIs for the '*sustainability expenditures'* attribute category were identified that define and measure the economic sustainability performance of an organization.

4.3 Number of SPIs' occurrences in Standards and Guidelines

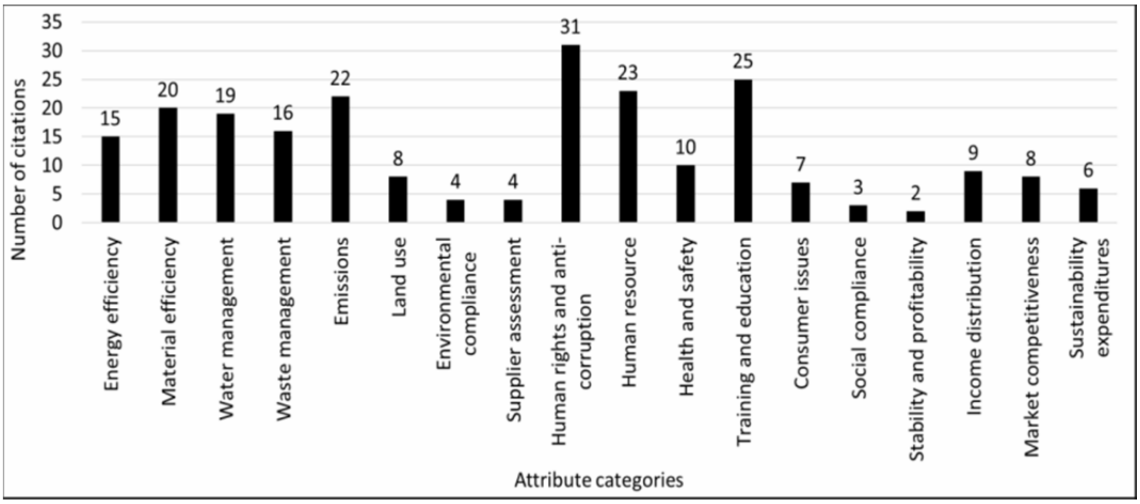
Indicators of sustainability-related performance measurement were identified, extracted, coded and documented in a list of SPIs to perform frequency analysis as shown in Figure 2. Frequency analysis carried out to determine how often an indicator appeared in the standards and guidelines and yielded a higher level of understanding of the use of identified SPIs. The frequency graph represents the distribution of SPIs in the standards and guidelines for each attribute category of the three sustainability dimensions and revealed the total number of times an attribute category was cited in the selected sample of standards and guidelines.

For the environmental dimension of sustainability, 34 SPIs has been identified for all eight attribute categories. These identified SPIs were cited 108 times by all standards and guidelines in the sample. Similarly, for the social sustainability dimension, 26 SPIs were identified in the standards and guidelines for all six attribute categories. These identified SPIs were cited for 99 times in the whole sample. Furthermore, for the four attribute categories of economic sustainability dimension, 10 SPIs were identified and these SPIs were cited 25 times in the selected sample of the standards and guidelines as given in table 8.

SPIs were counted as one citation per standard and guideline for the frequency analysis. It means an SPI citation is counted as one if an indicator has one or more instances of information for the same indicator in one particular standard or guideline. In some cases, for the SPIs list, indicators were ungrouped and in some cases for simplicity purpose same indicators were counted twice, i.e. the same citation was used for more than one sustainability dimension. An example of such indicator is *"compliance category"* which was counted twice in the SPIs list as some scientific literature articles do not cite the environmental and social compliance separately. Furthermore, in the case of gender-specific indicators, SPIs were developed separately for both genders in the list with the same source of reference.

Examples of such SPIs are present in '*human resource*', '*market competitiveness*' and '*training and education*' attribute category.

Figure 2: Total number of citations for each attribute category



It was revealed from the content analysis that 49% of the identified SPIs addressed the environmental dimension of the TBL whereas 37% addressed the social dimension and only 14% addressed the economic sustainability dimension of the TBL. Furthermore, in the environmental dimension of the TBL, '*emissions*' attribute category is the most influential in terms of a number of SPIs' citations i.e. 22 times. In social dimension, '*human rights and anti-corruption*' was most the cited attribute category i.e. 31 times and in economic dimensions, '*income distribution*' was the most cited attribute category i.e. 9 times in the selected standards and guidelines.

Table 8: Sustainability performance indicators' (SPIs) frequency analysis

	Environmental sustainability	Social sustainability	Economic sustainability	Total
Total SPIs' citations for each standards and guidelines	108 (46%)	99 (43%)	25 (11%)	232
Total number of SPIs cited in standards and guidelines	34 (49%)	26 (37%)	10 (14%)	70

4.4 Distribution of SPIs in standards and guidelines

How SPIs were coded using the content analysis methodology and from which standard or guidelines these were identified is shown in table 9 (see appendix). The distribution of the whole list of SPIs for the three sustainability dimensions with the original source is explained in the table.

Each attribute category represents a set of SSCM goals that an organization needs to assess in order to manage and evaluate its sustainability performance. For example, the goals of the '*energy efficiency'* attribute category are the increase in the use of renewable energy, and decrease in the use of total energy consumption by reducing the specific energy consumption in processes and by building more energy efficient infrastructure. To achieve '*energy efficiency'* attribute category's goals three SPIs were identified. The first SPI of the *'energy efficiency'* attribute category, "total annual energy consumption of an organization" is coded as *'E11'*. Instances of information regarding this SPI were found in UNGC [77], ISO 14001 [38], ISO 14031 [39], GRI [29], EMAS [20], ISO 26000 [40] and IChemE [35]. The second

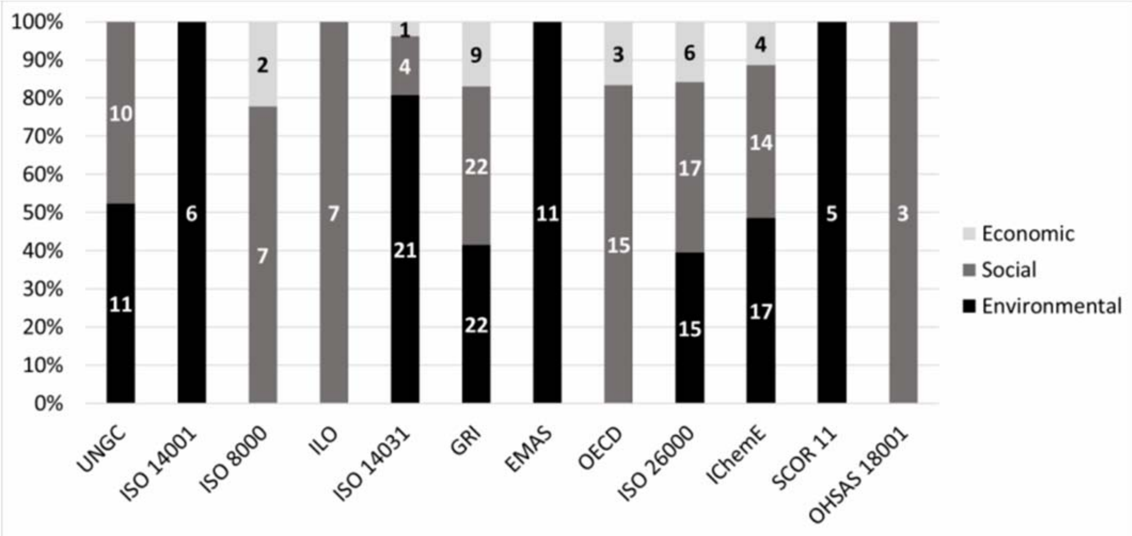
SPI for this attribute category "specific annual energy consumption of an organization" is coded as *'E11s'* and instances of information regarding this SPI were found in ISO 14031 [39], GRI [29] and IChemE [35]. The third SPI for this attribute category "total annual renewable energy consumption of an organization" is coded as *'E12'* and instances of information regarding this developed indicator were found in ISO 14031 [39], GRI [29], EMAS [20], ISO 26000 [40] and IChemE [35] as given in table 9.

Similarly, by following this structured methodology, the goals of the other attribute categories for three sustainability dimensions were considered and SPIs were documented, classified, and coded. In addition, each identified SPI has specific unit and procedure for the performance measurement. Therefore, the content analysis methodology applied in this research has led to a coherent and comprehensive list of quantitative SPIs which can be used as a core list of SPIs for future research. Furthermore, this structured and well-defined categorization scheme can help researchers in the field of sustainability performance measurement in order to conduct further research that, as well, increases the reliability of the presented attribute categories.

4.3 Dimensions of sustainability

From the content analysis of standards and guidelines, 70 SPIs were identified that had met the indicator selection criteria and can be used for the assessment of sustainability performance of an SC, as given in table 9 (see appendix). It was revealed from the content analysis that not all standards and guidelines address the three sustainability dimensions as shown in figure 3. This figure shows the internal distribution SPIs of attribute categories of each sustainability dimension across the selected standards and guidelines. In the selected sample of standards and guidelines, the environmental and social sustainability dimensions were cited most often. This might be due to the availability of well-established SPIs for the economic sustainability dimension [44] as compared to other dimensions. Another possibility could be the need to achieve the same level of development for three sustainability (environmental, social, economic) dimensions. Furthermore, the content analysis has also revealed that GRI (53), ISO 26000 (38), IChemE (35), ISO 14031 (26), and the UNGC's ten principles (21) are among the top five standards and guidelines with the highest number of SPIs' citations.

Figure 3: Distribution of three sustainability dimensions across the selected standards and guidelines

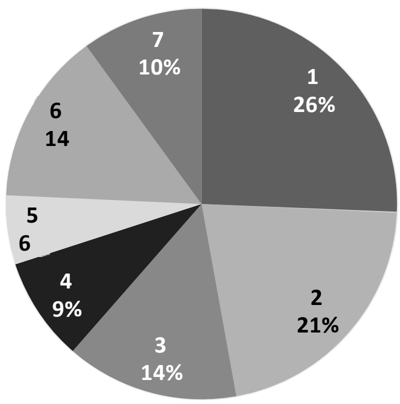


5. CONCLUSIONS

The main objective of this research article was to conduct a detailed content analysis of standards and guidelines in order to identify the use of indicators for SSCM and to understand the process of sustainability-related performance measurement. In addition, the study aimed to assess how SPIs from standards and guidelines are helping organizations in the implementation and monitoring of sustainability initiatives taken to achieve their sustainability goals.

The objectives of the study have guided to adopt a structured content analysis approach in order to address the research question posed at the start of this study. Given the importance of identifying and defining key attribute categories in the environmental, social and economic dimensions of sustainability, this article offers an exclusive contribution to the existing research. At the start, 232 instances of sustainability performance related information were identified within twelve standards and guidelines. Precise interpretation, restructuring, and standardizing have led to the identification of 70 unique SPIs. 26% of SPIs were cited only once within the sample but 30% were cited five times or more as shown in figure 4. These SPIs, addressed a range of core issues: for environmental sustainability, core issues were energy efficiency, material efficiency, water management, waste management and emissions; for social sustainability human rights, human resources, health and safety, and training and education were the core cited issues; for the economic sustainability, market competitiveness and income distribution were the core issues. Out of 18 key attribute categories, the most represented attribute categories were emissions and human resource, which were cited in 9% and 13% respectively in the sample.

Figure 4: Frequency of citation for each SPI



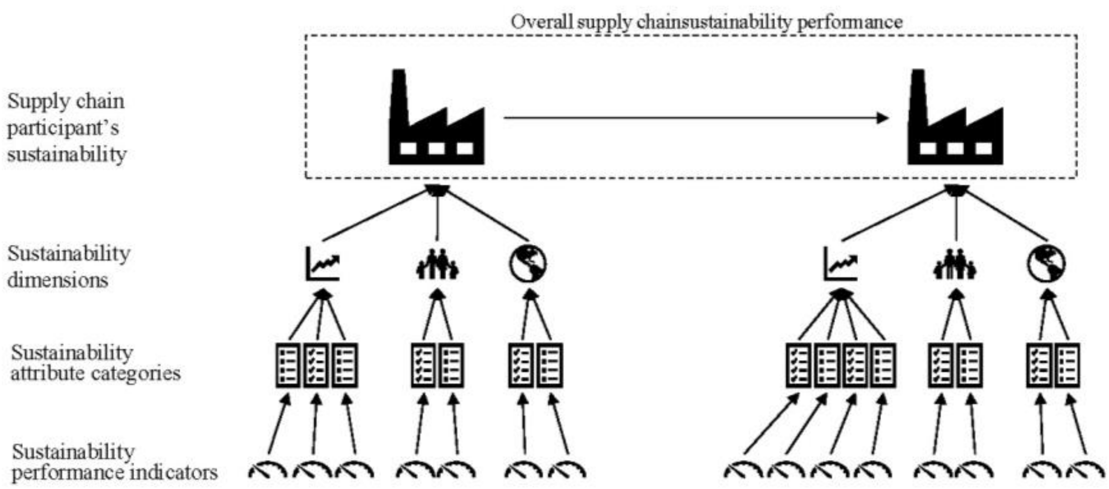
5.1 Contribution to sustainability performance assessment of supply chains

This research paper provides a comprehensive content analysis of SPIs in the SSCM context. To the best of authors' knowledge, no similar study has been conducted that analyzed SPIs from the sustainability-related standards and guidelines. The content analysis methodology explained in this research article can additionally serve as an example for future research in the field of SSCM. This study has revealed a clear lack of well-defined scope, span, and definitions of sustainability attribute categories, despite the efforts made in the scientific literature to define attribute categories. The systematic and structured approach of selecting assumed and inferred attribute categories from the scientific literature as well as from the standards and guidelines has helped to minimize the research gap and to prepare the ground for further theory research building in SSCM. Furthermore, the comprehensive attribute categories definitions have helped to overcome major weaknesses in the previous research regarding attribute categories of each sustainability dimension.

This research paper has numerous implications for SPIs and the assessment of the sustainability-related performance of an organization and its SC. On the one hand, it has helped to identify SPIs for the measurement of sustainability-related performance of an organization. On the other hand, it has provided a unified approach to sustainability assessment in terms of attribute categories for the three sustainability dimensions. According to the TBL, a concept of attribute categories was structurally built from the analyzed literature and the published standards and guidelines for measuring the sustainability-related performance of SCs. The proposed attribute categories help to consolidate SPIs published in different standards and guidelines. These consolidated SPIs can be used across all functions of SSCM and provide a reasonable base to compare and evaluate different SCs or different participants of an SC. Additionally, the proposed list of SPIs has provided a solid foundation for quantitatively measuring the performance of an organization.

Furthermore, a conceptual framework, based on the identified list of SPIs in this research paper, to assess the sustainability performance of supply chains is proposed that can help in evaluating the sustainability performance of a supply chain at five hierarchical levels as shown in figure 5. At first, the performance is measured at the performance indicators' level. The performance scores at the indicators' level are aggregated to the next hierarchical level represented by the sustainability attribute categories. In order to assess the performance at each sustainability dimension, the performance scores of attribute categories for a particular sustainability dimension are aggregated. The aggregated performance scores of each sustainability dimension enable the evaluation of sustainability performance at the supply chain participants' level. The sustainability performance scores of each supply chain participant are aggregated to evaluate the sustainability performance of the uppermost hierarchical level i.e. the overall supply chain sustainability performance.

Figure 5: Supply Chain Sustainability Performance Measurement



5.2 Limitations and future research

Certainly, many improvements and specifications can be added to this frame of reference. It should be noted that only international standards and guidelines, available in the English language, were considered for the purpose of this research work but employing more standards and guidelines from different geographical areas and languages might have some different effects on the results. Despite this limitation, the study has provided a clear list of SPIs for key attribute categories and provides a strong basis for the implications to measure the sustainability-related performance of an organization and associated SC. To the best of authors' knowledge, no previous research in analyzing standards and guidelines for SSCM in detail has been identified. Therefore, considering a sample of twelve standards and guidelines for this research purpose is justified.

The content analysis approach is applied due to its significance, but the research can be expanded by implementing other research analysis techniques. Another limitation of this research is the sample selection methodology. Other sample selection methodologies, apart from snowball sampling, might lead to a different set of standards and guidelines.

One of very important future research direction would be to identify and analyze SPIs from other sources of mass media such as books, peer-reviewed scientific articles, conference papers, magazines, etc. It will help to understand the current state of literature by cross-referencing it to the results of this study. Furthermore, it can help to develop a unified list of SPIs that can assess the composite performance of an SC for each sustainability dimension. This can lead to a standardized approach for assessing sustainability by developing a sustainability-related PMS for SC.

In accordance with the results of this study, there is a need to emphasize especially on the social sustainability dimension from the stage of indicators development to the stage of development of a PMS. In addition, interrelation among all three sustainability dimensions and how it can be established, and the need for cross-cutting SPIs are a future area of research. The current list of SPIs developed in this research has provided the possibility to upgrade, after a successful research and development of new multidimensional indicators. On the one hand, it could help the organization to expand their focus on achieving interconnectedness among sustainability dimensions. On the other hand, it will provide the opportunity of managing different issues among sustainability dimensions. Future research in these directions will help to further enhance and standardize the process of performance measurement of SSCM.

6. APPENDIX

Table 9 Distribution of sustainability performance indicators

	Attribute Category	Sustainability Performance Indicators	Standards and Guidelines
Environmental sustainability dimension	A_1	Total annual energy consumption of an organization[1,2,4,5,9,12,13,14]	1, 2, 5, 6, 7, 9, 10
		Specific annual energy consumption of an organization [2,3,4,5,13,14]	5, 6, 10
		Total annual renewable energy consumption of an organization [4,5,12,13]	5, 6, 7, 9, 10
	A_2	Total annual material consumption of an organization [1,2,4,5,12,13,14]	1, 2, 5, 6, 7, 9, 10
		Specific annual material consumption of an organization [2,4,10,12,13,15]	5, 10
		Total annual renewable material consumption of an organization [1,4,5,9,13]	6, 7, 9
		Total annual recycled/reused material consumption of an organization [3,4,9,12,14,15]	1, 5, 6, 7, 9, 10
		Total annual hazardous materials consumption of an organization [4,5,12,13,15]	9
		Specific annual hazardous materials consumption of an organization [4,5,12,13]	10
	A_3	Total annual volume of water consumption within an organization [1,2,4,9,12,13,14]	1, 6, 7, 9, 10
		Specific annual volume of water consumption within an organization [1,2,4,9,12,13]	5, 10
		Total annual volume of water recycled/reused by an organization [3,12]	1, 5, 6, 9, 10

	Attribute Category	Sustainability Performance Indicators	Standards and Guidelines
		Percentage of annual volume of water recycled/reused by an organization [3,12,13]	6
		Total annual volume of wastewater discharged by an organization [1,2,4,5,9,11,13,14,15]	1, 5, 6, 11
		Specific annual volume of wastewater discharge by an organization [1,2,4,9,11,13,14]	2, 5
	A_4	Total annual amount of waste generated by an organization [1,3,4,9,11,12,13,14]	2, 5, 6, 7, 9, 11
		Specific annual amount of waste generated by an organization [1,3,4,9,11,12,13,14]	5, 10
		Total annual amount of hazardous waste generated by an organization [1,13,14]	1, 5, 6, 7, 9
		Specific annual amount of hazardous waste generated by an organization [1,13,14]	10
		Specific annual amount of waste recycled/reused by an organization [4,5]	5
		Percentage of waste recycled/reused by an organization [4,5]	11
	A_5	Total annual amount of direct GHGs (CO2, CH4, N2O, HFCs, PFCs, SF6, NF3) emissions (Scope-1) by an organization [4,5,9,11,13,14]	1, 5, 6, 7, 9, 11
		Total annual amount of indirect GHGs emissions (Scope-2) by an organiza-tion [4,5,9,11,13,14]	6
		Total annual amount of other GHGs emissions (Scope-3) by an organization [4,5,9,11,13,14]	6
		Specific annual GHGs emission (Scope-1 & Scope-2) by an organization [4,5,9,11,13,14]	5, 6
		Total annual amount of ozone-depleting substances by an organization [1,2,13]	5, 6
		Specific annual amount of ozone-depleting substances by an organization [3,12,13]	10
		Total annual amount of particulate matter emissions by an organization [1]	5,6
		Total annual air emission by an organization [1,2,4,5,9,11,13,14,15]	1, 2, 5, 6, 7, 9, 11
	A_6	Total size of the operational site/facility [2,4]	1, 2, 5, 6, 7, 9, 10
		Specific size of the operational site/facility [2,4]	10
	A_7	Total annual number of non-compliance with environmental regulations [1,3,4,5,9,10,11,12,14,15]	5, 6, 9, 10
	A_8	Percentage of suppliers' subject to sustainability assessment [3,4,5,9,12,13,15]	1, 6, 10
		Percentage of local/national/provincial suppliers of an organization [4,12,13]	9
Social sustainability dimension	A_9	Total annual number of incidents of discrimination in an organization [1,2,10]	1, 3, 4, 6, 8, 9, 10
		Total annual number of incidents where the right to freedom of association and the effective recognition of the collective bargaining are violated [8,10]	1, 3, 4, 6, 8, 9
		Total annual number of incidents of forced labor in an organization [10]	1, 3, 4, 6, 8, 9, 10
		Total annual number of incidents of child labor in an organization [1,3,8,10]	1, 3, 4, 6, 8, 9, 10
		Total annual number of incidents of corruption by an organization [2,3,8,10]	1, 6, 8, 9
	A_{10}	Total annual number of employees in an organization [1,5,6,13]	6, 10
		Total annual number of female employees in an organization [1,6,8,13]	6, 10
		Total annual number of new male employees in an organization [2,4,6,8,13]	10
		Total annual number of new female employees in an organization [2,4,6,8,13]	10
		Total annual number of male employees from the region [1,4,6,8,13]	6, 8, 9
		Total annual number of female employees from the region [1,4,6,8,13]	6, 8, 9
		Total annual number of male employees' turnover [1,3,4,13]	6, 10
		Total number of female employees' turnover [1,3,4,13]	6, 10
		Total number of employees entitled to life insurance, healthcare, parental leaves, dividend, retirement provision, bonuses, injury payments, etc. in an organization [1,10,12]	1, 3, 4, 6, 8, 9
		Total annual number of employees receiving annual performance reviews [4,13]	6
	A_{11}	Total annual number of non-fatal occupational health and safety related accidents occurring in the course of work [2,4,10,12,13,15]	1, 3, 4, 6, 8, 9, 12

Dimension	Attribute Category	Sustainability Performance Indicators	Standards and Guidelines
		Total annual number of days lost due to occupational health and safety related accidents [1,6,12,13]	6, 10
		Total annual number of fatalities due to occupational health and safety related accidents [12]	6, 12
	A_{12}	Average hours of training per employee in an organization [1,9,12,13,15]	1, 5, 6, 8, 9, 10
		Average hours of training for female employees in an organization [1,9,12,13]	1, 5, 6, 8, 9, 10
		Average hours of training for male employees in an organization [1,9,12,13]	1, 5, 6, 8, 9, 10
		Total number of employees given training in an organization [1,2,4,5,15]	3, 4, 5, 6, 8, 9, 12
	A_{13}	Total annual number of incidents of consumer complaints [1,13]	6, 8, 9
		Total annual number of incidents of engaging in misleading, deceptive, fraudulent or unfair practice [9]	6, 8, 9
		Total annual number of products returns (reclaimed products) [5,9,12]	9
	A_{14}	Total number of non-compliance with social criteria or regulations [4,5,9,10,11,12,13]	6, 9, 10
Economic sustainability dimension	A_{15}	Total annual sales/revenue of the organization [1,11,12,13]	6, 10
	A_{16}	Total annual amount of wages and benefits given to employees by an or-ganization [1,2,3,6,10,12]	6
		Total annual payments made to the Government (taxes) by an organization [3,13]	6, 8, 9, 10
		Total annual amount of community investment by an organization [1,2,3,4,6,8,13]	6, 9, 10
		Total annual operating cost of an organization [2,4,12,15]	6
	A_{17}	Ratio of entry-level wage given to male employees in an organization to the minimum wage in a specific country or industry [1,4,6,8]	3, 6, 8, 9
		Ratio of entry-level wage given to female employees in an organization to the minimum wage in a specific country or industry [1,4,6,8]	3, 6, 8, 9
	A_{18}	Percentage of procurement budget spent on local suppliers [4]	6, 9
		Total annual sustainability expenditures by an organization [1,2,3,4,5,15]	5, 6, 9
		Total research and development expenditure by an organization [1,12]	10

1[6], 2[7], 3[8], 4[32], 5[33], 6[34], 8[45], 9[46], 10[61], 11[62], 12[74], 13[79], 14[81], 15[82]

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