A Systematic Review of Sustainable Supplier Selection Using Advanced Artificial Intelligence Methods

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Keywords: Sustainable Supplier Selection, Sentiment Analysis, Text Analytics, Multi-Criteria Decision-Making (MCDM).

Abstract: Artificial intelligence (AI) algorithms have significantly advanced various fields, driving innovation in domains such as healthcare, finance, and sustainability. In the realm of sustainable development, selecting suppliers is crucial for promoting environmental responsibility and safeguarding the well-being of future generations. This complex decision-making process requires evaluating suppliers across numerous criteria. Multi-Criteria Decision-Making (MCDM) and AI techniques, including Natural Language Processing (NLP), Deep Learning (DL), and Machine Learning (ML), have emerged as powerful tools to address these challenges. However, these methods often face transparency issues and the risk of greenwashing, which can erode trust in sustainability assessments. To address this, we conducted a systematic literature review (SLR) of 44 papers published between 2019 and 2024, sourced from databases such as Springer (12 papers), IEEE Xplore Digital Library (11 papers), and Science Direct (21 papers). This review offers an equitable analysis of MCDM and AI models (NLP, DL, ML) for evaluating both supplier sustainability and the risk of greenwashing. Additionally, sentiment analysis techniques are integrated to enhance transparency and provide insights into stakeholder perceptions.

1 INTRODUCTION

In the rapidly evolving landscape of sustainability, the ability to effectively analyze and interpret vast amounts of data has become crucial. With the increasing complexity of sustainability assessments, leveraging advanced technologies and methodologies is essential for making informed decisions. Cutting-edge approaches in data analysis and artificial intelligence are pivotal in enhancing our understanding of sustainability practices, particularly in evaluating supplier performance across various dimensions.

In the current global context, heightened environmental concerns have propelled the selection of sustainable suppliers to the forefront of corporate priorities. Yet, evaluating these suppliers solely based on sustainable criteria reveals inherent imperfections, emphasizing the pressing need for a comprehensive assessment of their sustainability. This imperative stems from the timeless definition outlined by the United Nations Brundtland Commission in 1978, which advocates for meeting present needs without compromising the ability of future generations to meet their own.

Currently, evaluating supplier sustainability based on (Environmental, Social, Governance) ESG criteria and the Triple Bottom Line (TBL)—encompassing economic, social, and environmental dimensions—is gaining momentum as the gold standard. This approach offers a comprehensive perspective on supplier performance, including environmental stewardship, social responsibility, and transparent governance practices.

However, the multifaceted nature of these criteria presents a complex decision-making landscape, prompting the adoption of Multi-Criteria Decision-Making (MCDM) methods to facilitate the selection of sustainable suppliers. MCDM methods systematically evaluate multiple, often conflicting, criteria such as environmental impact, social responsibility, and economic performance. By using quantitative and qualitative data, MCDM helps prioritize suppliers who best align with sustainability goals, minimizing subjective biases through a structured framework.

Machine Learning (ML) and Deep Learning (DL) techniques further enhance the objectivity of this se-

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lection process by analyzing vast amounts of data from social media and sustainability reports with high precision and consistency. These technologies identify patterns and insights that might be missed by human evaluators, enhancing the objectivity and efficiency of ESG criteria analysis in supplier evaluations.

Nevertheless, reliance solely on objective evaluation methods poses risks, such as greenwashing and opacity. Greenwashing refers to the practice where companies misleadingly present their sustainability initiatives to maintain a positive image while maximizing profits, often at the expense of transparency and genuine environmental impact (Vinella et al., 2023).

Herein lies the significance of sentiment analysis as a complementary method, augmenting the credibility and transparency of supplier evaluations. By providing insights into stakeholders' perceptions and sentiments, sentiment analysis enriches evaluation processes, fostering a more balanced and transparent approach to supplier sustainability assessment.

Moving forward, in Section 2, we outline the planning of our Systematic Literature Review, followed by the presentation of Results and discussion in Section 3. Finally, we conclude with overarching highlights and propose avenues for further research in Section 4.

2 SYSTEMATIC LITERATURE REVIEW PLANNING

2.1 Research Questions

Aiming to explore the application of web-based and data-driven methodologies in sustainable supplier selection and greenwashing detection, the following research questions (RQ) were established:

- RQ1. What criteria and web-based data sources are essential for evaluating sustainable supplier?
- RQ2. What advanced methods and data science approaches for sustainable supplier selection?
- RQ3. How can web-driven sentiment analysis and text analytics contribute to detecting greenwashing?

Subsequently, we determined the initial research in the research databases. In relation to the keywords, three groups were formed:

- Group1: (”sustainable supplier selection”,”ESG”, ”sustainability evaluation”,”assessment criteria”,)
- Group2: (”MCDM”,”sentiment analysis”, ”text analytics”,”Artificial Intelligence”)
- Group3: (”greenwashing detection”, ”greenwashing”, ”detection of eco-washing”)

2.2 Search Strategy

The search strategy combines the key concepts of our research questions in order to retrieve accurate results. It is an organized structure of keywords, including ”sustainable supplier selection”, ”MCDM”, ”sentiment analysis”, and ”greenwashing” as well as ESG criteria (environmental, social, and governance) , all related to our research questions. We then added synonyms, variations, and related terms for each keyword, including ESG criteria, triple bottom line criteria (environmental, social, and economic) . The use of Boolean operators (AND and OR) allows us to explore different combinations of search terms to improve the relevance and comprehensiveness of the results obtained. The final search string is (Greenwashing OR ”sustainable supplier” OR ”responsible supplier” OR ”ESG”) AND (”sentiment analysis” OR ”MCDM” OR ”artificial intelligence” OR ”text analytics”)

2.3 Selection Criteria

After obtaining the search results from different sources, a set of inclusion and exclusion criteria was applied to help identify relevant primary studies. Therefore, Inclusion Criteria (IC) are used to select primary studies that indicate web-based analytical approaches and methods used for sustainable supplier selection, such as MCDM , Artificial Intelligence (AI) and sentiment analysis, or methods such as MCDM and sentiment analysis contributing to greenwashing detection. As for the Exclusion Criteria (EC), they are used to eliminate those primary studies that do not address the main topics searched in this Systematic Literature Review (SLR), are not available, or are directly related to an included primary study by the same author.

- Inclusion Criteria (IC):
  - — Publications published in peer-reviewed journals (articles and conference papers)
  - — Publications published in English
  - — Publications published between 2019 and 2024
  - — Publications that are related to the research questions
  - — Publications that match one of the search items
  - — Publications that have examples of best practices
  - — Publications that are related to higher education institutions/universities

- Exclusion Criteria (EC):
  - Publications not published in peer-reviewed journals (books and chapters)
  - Publications not published in English
  - Publications not published between 2019 and 2024
  - Publications that are not related to the research questions
  - Publications that do not match any of the search items
  - Publications that do not have examples of best practices
  - Publications that are not related to higher education institutions/universities

2.4 Data Collection

The search process integrates the main concepts of our research questions to obtain precise results. The chosen sources are listed in the table 1, along with the associated number of papers.

Table 1: Search results by Resource.

Resource	Number of papers
springer	778
IEE Xplore Digital Library	35
ACMDigital library	103
Science Direct	123
Total	1039

After filtering the papers by excluding those based on reading the abstracts, excluding more based on reading the introductions, removing duplicate papers, and excluding those with file not found errors, we adopted 44 papers for this SLR. Table 2 presents the filtered search results by resources.

Table 2: Filtered search results by resources.

Resource	Number of papers
springer	12
IEE Xplore Digital Library	11
ACMDigital library	0
Science Direct	21
Total reading	44

3 RESULTS AND DISCUSSION

3.1 Criteria Enumeration for Sustainable Supplier Evaluation

To accurately evaluate sustainable suppliers, identifying comprehensive sustainability criteria is essential. These criteria, encompassing environmental, social, governance (ESG), and economic factors, form the foundation for data collection and analysis. In the context of sustainable supplier evaluation, the enumeration of criteria plays a crucial role in both the Multi-Criteria Decision-Making (MCDM) process and in Natural Language Processing (NLP)-based sentiment analysis.

In MCDM, criteria such as carbon footprint, resource efficiency, ethical labor practices, and supply chain transparency are carefully defined. Common MCDM techniques like the Analytic Hierarchy Process (AHP) or Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) can be employed to weigh and rank suppliers based on these criteria. The effectiveness of MCDM hinges on a robust, well-defined set of criteria, as it directly influences the decision model's accuracy and relevance.

During the sentiment analysis phase, these sustainability criteria guide the process of extracting meaningful information from large amounts of unstructured textual data, such as user reviews, social media posts, or reports. Various NLP techniques can be employed to capture stakeholder perceptions and detect potential greenwashing.

Aspect-Based Sentiment Analysis (ABSA) allows for granular sentiment analysis by associating specific criteria (e.g., environmental impact, working conditions) with corresponding opinions. For example, user reviews can be parsed to identify opinions tied to specific sustainability aspects (e.g., "The supplier uses renewable energy, but their labor conditions are questionable"). ABSA helps determine how stakeholders feel about each criterion, providing insights into the supplier's performance on multiple fronts.

Named Entity Recognition (NER) can be used to identify and classify named entities (e.g., organizations, materials, processes) mentioned in textual data. In sustainable supplier selection, NER could be employed to highlight references to specific criteria such as "carbon emissions," "fair trade," or "energy efficiency," ensuring that the analysis focuses on relevant sustainability aspects.

Latent Dirichlet Allocation (LDA), a topic modeling technique, can uncover hidden topics and themes related to sustainability in large text corpora. This could help identify emerging sustainability concerns, such as environmental degradation or unethical sourcing practices, that may not have been previously considered in the criteria set.

Machine learning models like Support Vector Machines (SVM), Random Forests, or deep learning models such as BERT (Bidirectional Encoder Representations from Transformers) can classify text according to positive, negative, or neutral sentiments toward sustainability criteria. These models are highly effective when applied to large datasets of stakeholder feedback, allowing the identification of trends in perception.

One of the key challenges is identifying greenwashing, where companies make exaggerated or false claims about their sustainability efforts. Textual entailment or stance detection methods can be applied to detect inconsistencies between what companies say (e.g., in reports or press releases) and actual stakeholder experiences (e.g., in reviews). These techniques help cross-verify the authenticity of sustainability claims, flagging companies that may be engaging in deceptive practices.

Combining MCDM with NLP methods enhances supplier evaluation by ensuring both quantitative and qualitative assessments are taken into account. MCDM methods can assign weights to different sustainability criteria based on their importance, which can then be applied in sentiment analysis to prioritize feedback on higher-weighted criteria (e.g., giving more importance to environmental impact over cost). Additionally, NLP-derived insights from stakeholder reviews or social media can complement quantitative metrics (e.g., carbon emissions, energy usage), adding a layer of sentiment-driven decision-making that captures public perception and trust.

The combined use of MCDM and advanced NLP techniques allows for a thorough evaluation of sustainable suppliers, ensuring transparency and reducing the risk of greenwashing. By leveraging methods like ABSA, NER, LDA, and sentiment classification, organizations can extract critical insights from vast amounts of unstructured data, aligning the evaluation process with core sustainability criteria and improving decision-making accuracy.

Conducting a comprehensive evaluation of sustainable suppliers requires more than just assessing environmental criteria. Critical studies have underscored this limitation, driving many organizations to integrate additional dimensions such as social, economic, and governance criteria into their supplier evaluation processes (Khan et al., 2021; Ahmadi et al., 2020). As a result, companies increasingly use frameworks like the Triple Bottom Line (TBL), which encompasses economic, social, and environmental dimensions (Omair et al., 2021; Rani et al., 2020; Hoseini et al., 2020; Cheng et al., 2023; Konys, 2019; Gidiagba et al., 2023; Wang et al., 2024; Menon and Ravi, 2022; Tavana et al., 2023), or ESG (Environmental, Social, and Governance) criteria to ensure a well-rounded assessment of sustainability (Khan et al., 2021; Fischbach et al., 2024; Gupta et al., 2024; Daying and Zi'Ao, 2023).

Incorporating Industry 4.0 criteria has become increasingly important, aligning modern technological advancements with sustainability goals (Tavana et al., 2023; Fallahpour et al., 2021). Additionally, resilience criteria—evaluating suppliers' ability to withstand and recover from disruptions such as natural disasters or economic crises—are vital. These criteria focus on risk management, supply chain transparency, and flexibility, ensuring suppliers can navigate unforeseen challenges while maintaining business continuity (Ghamari et al., 2022; Gökler and Boran, 2023; Mohammed et al., 2019).

Therefore, a supplier's sustainability should be evaluated holistically rather than solely through ecological metrics, emphasizing the need for comprehensive sustainability practices. Integrating diverse criteria into text analytics and data science methodologies is essential for a thorough assessment of suppliers. This approach includes evaluating environmental impacts, social responsibility, and governance practices, ensuring alignment with corporate social responsibility and ethical business standards. Adopting such a multi-faceted evaluation approach is crucial for leveraging information retrieval and text analytics, social analysis, and web mining to enhance the accuracy and transparency of sustainability assessments. This alignment with advanced data-driven techniques not only supports more robust supplier evaluations but also addresses potential greenwashing, thus promoting long-term business success and sustainability goals.

The Table 3 illustrates some examples of criteria for evaluating sustainable suppliers.

3.2 Web-Based Data Sources for Evaluating Sustainable Suppliers

To effectively evaluate supplier sustainability, leveraging web-based data sources is essential for a thorough and accurate assessment. Key data sources include company reports, which provide detailed insights into ESG practices through annual and integrated reports, adhering to international regulations such as the Corporate Sustainability Reporting Directive (CSRD) (Twinamatsiko and Kumar, 2022). In addition, web-based data from social media platforms, including tweets, news articles, and press releases, offer valuable perspectives on public sentiment and expert opinions regarding a company's ESG performance (Biju et al., 2023; Fischbach et al., 2024). Further, academic and industry studies on global supply chain risks provide context and additional information on supplier practices at various levels (Chu et al.,

Table 3: Criteria for evaluating sustainable suppliers.

Dimension	Criteria	Definition
Environmental	Wastewater	Suppliers should manage wastewater to minimize pollution.
	Air emissions	Suppliers should reduce emissions to improve air quality.
	Friendly materials	Suppliers should use sustainable materials to reduce environmental impact.
	Resource consumption	Suppliers should conserve resources throughout production.
	Carbon emissions reduction	Suppliers should strive to minimize their carbon emissions to mitigate climate change impacts.
	Eco-friendly packaging	Suppliers should use sustainable packaging materials.
	Pollution control	Suppliers should prevent pollution to protect ecosystems.
	Renewable electricity and energy	Suppliers should use clean energy sources for sustainability.
Social	Work contract	Suppliers should provide stable work contracts to their employees.
	Health insurance at work	Suppliers should ensure that their employees are protected by health insurance.
Economic	Quality	Suppliers should strive to provide products or services meeting agreed-upon quality standards to ensure customer satisfaction and product sustainability.
	Flexibility	Suppliers should be able to adapt quickly to changes in demand, design, or other requirements to ensure an agile and efficient supply chain.
	Service	Suppliers should provide responsive and quality customer service, delivering support and appropriate solutions throughout the business relationship.
Governance	Compliance	Sustainable suppliers should demonstrate compliance with relevant laws, regulations, and industry standards.
	Transparency	Sustainable suppliers should uphold transparency in their operations, providing clear and accessible information.
Industry 4.0	Industry 4.0 Training and Awareness	Suppliers should offer Industry 4.0 training and awareness programs to their employees to enhance their skills, which can contribute to better utilization of sustainable technologies and reduced environmental impact.
	Information technology (IT) facilities	Suppliers should have adequate IT facilities, computers, and high-speed internet access to support the adoption and effective use of Industry 4.0 technologies, which can promote more efficient and environmentally friendly production.

2019). By integrating these diverse web-based data sources, organizations can achieve a more comprehensive and nuanced evaluation of suppliers' sustainability practices.

3.3 MCDM Methods for Evaluating Supplier Sustainability

The evaluation of sustainable suppliers is based on a multitude of criteria. This diversity of criteria creates a MCDM challenge, requiring a holistic evaluation that considers all these dimensions. Companies are faced with the complexity of weighing and comparing these often conflicting criteria to select the most sustainable suppliers. For example, prioritizing criteria such as environmental impact may conflict with economic considerations such as cost. Corporate governance, including transparency and business ethics, as well as corporate governance practices, are also crucial but often difficult to quantify elements. Thus, companies must use advanced MCDM methods to integrate these criteria in a balanced way and make informed decisions regarding the selection of sustainable suppliers. A series of articles focuses on the application of MCDM methods for selecting sustainable suppliers (Hoseini et al., 2020; Wang et al., 2024; Menon and Ravi, 2022; Fallahpour et al., 2021; Gökler and Boran, 2023; Yildizbasi and Arioz, 2022; Gidiagba et al., 2023; Zhang et al., 2021; Puška et al., 2022; Khan and Ali, 2021; Masoomi et al., 2022; Liu et al., 2019b; Chang et al., 2023; Liu et al., 2019a; Varriale et al., 2024). Authors in (Omair et al., 2021) introduce a decision support framework for supplier prioritization using a MCDM approach. This framework combines the Analytical Hierarchical Process (AHP) and the Fuzzy Inference System (FIS). AHP is employed to determine key sustainability criteria, while FIS assesses the sustainability index of each supplier based on these criteria. Expert opinions are incorporated linguistically to account for the subjectivity in decision-making, and fuzzy logic is used to manage uncertainties. (Rani et al., 2020) proposes a Pythagorean fuzzy sets (PFSs), an extension of intuitionistic fuzzy sets (IFSs), to manage uncertainty and ambiguity. This study develops an approach using PFSs and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method to address sustainable recycling partner selection problems with unknown decision experts and criteria weights. The study in (Tavana et al., 2023) introduces a decision support system for evaluating and prioritizing suppliers in public–private partnership projects. The approach involves two stages: first, assessing six potential suppliers using economic, circular, social, and Industry 4.0 criteria with a novel group BWM method; and second, using fuzzy inference rules and a FIS structure to map non-linear relationships between the criteria and the final score. The FIS includes 625 rules. The approach was validated using data from an offshore wind farm project and the expertise of four specialists. Sensitivity analysis revealed that the FIS output is most sensitive to Industry 4.0 criteria.

The discussed works present robust methodologies for evaluating and prioritizing sustainable suppliers, utilizing advanced MCDM techniques such as AHP, FIS, and Pythagorean fuzzy sets. However, a notable limitation across these studies is the limited consideration of user feedback in the evaluation process. While these frameworks meticulously assess suppliers based on a comprehensive set of criteria—including environmental, social, economic, and Industry 4.0 dimensions—they often overlook the critical perspective provided by end-users and stakeholders.

The MCDM approach is one of the most commonly used methods. However, a limitation of current multi-criteria models for supplier selection and performance evaluation lies in the models themselves. Methods like the Analytic Hierarchy Process (AHP), the Analytic Network Process (ANP), and the Fuzzy Analytic Hierarchy Process (Fuzzy AHP) are widely applied in most studies. These methods require decision-makers to make judgments based on comparisons. While they are effective for handling vague or qualitative information, they often restrict the number of factors and suppliers that can be analyzed simultaneously.

3.4 Exploring Artificial Intelligence Approaches for Supplier Sustainability Evaluation

The use of artificial intelligence in the evaluation of sustainable suppliers enhances companies' ability to effectively implement ESG criteria in their procurement processes.

AI methods excels in processing large volumes of data (Zekhnini et al., 2023), making it particularly suitable for analyzing vast datasets such as those related to ESG performance. Its ability to efficiently process large amounts of information and identify patterns and trends within the data significantly enhances its effectiveness in evaluating supplier sustainability. This capability to handle big data sets AI apart as a powerful tool for sustainability assessment and decision-making in procurement processes. In the context of supplier evaluation, artificial intelligence methods are divided into three categories: Machine Learning (ML), Deep Learning (DL), and Natural Language Processing (NLP). Each category has distinct applications.

3.4.1 Machine Learning Approaches

ML has recently attracted more attention as a result of its effectiveness in a variety of applications ranging from image categorization to a variety of decision-making challenges. The applications of ML approaches have increased dramatically in recent years due to the explosion of data. In a predictive setting, methods such as data envelopment analysis supervised learning, and unsupervised learning has shown very outstanding performance. Furthermore, machine learning can tolerate inaccuracies, uncertainty, and imprecise information to achieve robustness when replicating human decision-making behavior. These functions not only solve the problem of scalability and rapidity, but they also reduce the drawbacks of earlier approaches and meet the demands of ever more difficult supplier networks (Jagyasi and Raut, 2023). In (Kulkarni et al., 2023; Baqi et al., 2022), authors emphasize using AI to optimize the analysis of suppliers' ESG data, thereby facilitating ESG performance monitoring and measurement. Additionally, (Ahmad et al., 2023) proposes using ML to analyze ESG data in the context of sustainability, with a focus on auto mating data collection and analysis. Furthermore, in the context of evaluating sustainable suppliers, employing ML techniques, particularly regression analysis, could be considered to analyze ESG data and identify correlations with company performance, thereby contributing to more responsible investment decisions (Twinamatsiko and Kumar, 2022). Concurrently, AI can also play a vital role in reducing greenhouse gas emissions by enabling precise data analysis and identifying areas where companies can enhance their environmental sustainability (Gaur et al., 2023).

These various approaches illustrate the diversity of methods and applications of AI in assessing sustainable suppliers, offering unique perspectives on how this technology can promote sustainability within businesses.

The results of the experiment demonstrated the effectiveness of this approach, with most classification algorithms achieving an accuracy of over 90%. Specifically, models such as LGBM, extra tree, gradient boosting, and decision tree exceeded expectations by achieving an accuracy of over 99%.

(Abdulla et al., 2019) proposes a hybrid model for supplier selection by integrating AHP with a machine learning model. They utilized a decision tree classifier to distinguish between good and bad suppliers.

ML methods are used for predicting financial performance from ESG data, as well as for calculating ESG scores from financial data, where experiments have shown that ML algorithms, particularly gradient boosting and XGB, yielded accurate predictions. Furthermore, anomaly detection techniques based on ML, particularly the Local Outlier Factors (LOF) model, can be deployed to identify outliers or unusual values in ESG datasets, thus providing a robust methodology for detecting any noise or malicious data manipulation that could compromise their integrity and reliability (Lee et al., 2022)

3.4.2 Deep Learning Approaches

In recent years, various deep learning methods have been applied to the field of sustainable supplier selection, leveraging their ability to handle complex, high-dimensional data and capture intricate patterns (Nicherala et al., 2022).. Techniques such as Convolutional Neural Networks (CNNs) have been used for their strength in feature extraction and pattern recognition, especially when dealing with large datasets that include images or spatial data. Recurrent Neural Networks (RNNs) and their variants, like Long Short-Term Memory (LSTM) networks, are employed to analyze sequential data, such as time-series information related to supplier performance. Autoencoders have been utilized for dimensionality reduction and anomaly detection, helping to identify outliers and inconsistencies in supplier data. Furthermore, hybrid models combining deep learning with traditional methods, like Decision Trees or the Analytic Hierarchy Process (AHP), have been developed to enhance decision-making by integrating structured decision frameworks with the powerful data processing capabilities of deep learning.

Another recent study in the realm of sustainability and ESG data utilizes advanced DL techniques to analyze ESG data. In this experiment, deep learning techniques were employed to classify news articles into ESG labels. Specifically, embedding and Bi-LSTM (Bidirectional Long Short-Term Memory) models were utilized for this multi-class classification task. The results indicated significant performance improvements when employing these deep learning techniques, achieving a maximum prediction score of 0.8582 without processing Stop Words and 0.8936 after processing Stop Words. This demonstrates the effectiveness of deep learning in accurately categorizing news articles based on their ESG attributes. Additionally, the experiment highlighted the importance for institutions to promptly address ESG issues to safeguard their reputation and value, given the rapid dissemination of company-related information through the media. Therefore, the utilization of deep learning models like Bi-LSTM showcases their capability to efficiently analyze and categorize news articles, providing valuable insights into companies' ESG activities and facilitating timely responses to emerging issues.(Lee et al., 2022)

3.4.3 NLP and Web-Driven Sentiment Analysis Approaches

Natural Language Processing (NLP) is a branch of artificial intelligence that deals with language processing and knowledge extraction. There are multiple applications of NLP, from sentiment analysis to keyword extraction, text classification, and text summarization. Since NLP plays a crucial role in text analysis, advanced techniques such as BERT and YAKE are used to explore and understand sustainability reports, particularly focusing on ESG aspects. BERT is a pre-trained language model that supports tokenization. It uses a tokenization technique called ”Word-Piece,” which breaks down words into smaller subunits called ”subwords” for a more efficient and flexible representation of language. However YAKE excels at keyword extraction by automatically analyzing a text to identify the most important terms especially related to sustainability criteria and values. A data preprocessing phase is prominent after data collection, where BERT tokenization can be employed. This involved subdividing the data into keywords, with ESG subcategories associated with the extracted keywords and identified sustainability criteria (Gupta et al., 2024). The ESG-Miner is a sophisticated tool designed to evaluate companies' ESG performance through the analysis of news headlines. It begins by automatically detecting specific companies mentioned in headlines using named entity recognition and string matching with TF-IDF and cosine similarity. Then, it classifies these headlines in two steps: first, by determining their ESG relevance using ML and DL models such as BERT, TF-IDF, and SVM; second, by assigning relevant headlines to one of the three ESG categories. For sentiment analysis, the tool identifies whether the company's behavior mentioned is perceived as neutral, positive, or negative, using a classifier trained on a manually annotated corpus (Fischbach et al., 2024). An other study focuses on the selection of regions in the global supply chain, taking regional differences into account. While the global supply chain offers advantages such as increased flexibility and cost reduction, it also presents various risks depending on the regions. The objective of this research is to identify these regional risks through an analysis based on text mining. To achieve this, a corpus of 11 well-cited and relevant academic articles on global supply chain risk management was compiled. These articles were imported into RStudio for text data preprocessing using the tm and tidytext packages. Additionally, the words were transformed into their stems using the SnowballC package. Authors in (Chu et al., 2019) focus on measuring the ESG impacts in African cities using topic-based sentiment analysis methodologies applied to datasets collected from social media platforms. The aim is to understand the population's perception of ESG impacts, given their significant influence on society. The process begins with Data Collection: The study utilizes basic keywords from the 40 Cities framework, covering themes aligned with the Sustainable Development Goals (SDGs). Data is collected from social media platforms like Twitter using Snscrape, and from web pages via Google Search using Selenium and Trafilatura. Then, in the Data Filtering phase: Tweets containing both city names and keywords are considered relevant.

3.5 Greenwashing Avoidance Using Sentiment Analysis

Despite the effectiveness of mentioned methods and approaches instead of objective evaluation methods based on criteria for sustainable suppliers, these evaluations remain insufficient as it does not account for the risk of greenwashing. Greenwashing is ”the dissemination of false or deceptive information regarding an organization's environmental strategies, goals, motivations, and actions”(Aronczyk et al., 2024),referring to the practice of misleadingly or exaggeratedly presenting a company's practices or products as environmentally friendly when they may not necessarily be so.

Sentiment analysis plays a crucial role in detecting and avoiding greenwashing by enabling a critical evaluation of corporate communications. In the case of Pathways Alliance, this method helps identify indicators of greenwashing by analyzing the tone and perception of public messages, thereby revealing potential discrepancies between sustainability promises and actual actions. (Aronczyk et al., 2024). Another study shows that sentiment analysis is conducted using a qualitative approach, particularly analyzing Twitter data related to ”ESG” and ”greenwashing”. The methodology relies on the use of MAXQDA software, which provides a reliable solution for analyzing qualitative data, including sentiments expressed in tweets. To perform this analysis, researchers extracted tweets containing the keywords ”ESG” and ”greenwashing” separately. Subsequently, they utilized MAXQDA software to analyze this data and assess the sentiments expressed in the tweets. MAXQDA evaluates sentiments by assigning a sentiment score to each word in the lexicon used, categorizing words in terms of positive, neutral, or negative connotations. Tweets are then automatically coded with sentiment labels, enabling rapid capture of public sentiment on a specific research topic. The results of this sentiment analysis revealed a positive correlation between sentiments toward ESG and greenwashing. This indicates that concerns regarding greenwashing have increased proportionally with interest in ESG-related issues (Biju et al., 2023).

4 CONCLUSIONS

In this SLR, we have explored the growing trend of sustainable supplier evaluation in today's business landscape, where sustainability has become a major concern. However, evaluating the sustainability of suppliers poses a complex challenge that requires a holistic approach, considering various criteria and data sources. Furthermore, we have discussed various evaluation methods available, including multi-criteria decision-making (MCDM) and artificial intelligence approaches such as machine learning and deep learning. These methods enable a comprehensive analysis of supplier performance across a diverse range of criteria, thereby facilitating informed and data-driven decision-making.

While many traditional methods such as multi-criteria decision-making (MCDM), machine learning, and deep learning are used for this evaluation, they present potential risks of greenwashing and lack of transparency. It is important to note that most existing studies primarily focus on evaluating sustainable suppliers based on expert opinions in the field. However, this approach may be limited as it does not always consider the opinions and sentiments of end-users and public feedback, which can offer important perspectives on the actual sustainability of suppliers.

With this in mind, a promising future approach would be to integrate user feedback analysis into the process of evaluating sustainable suppliers. By examining user feedback on supplier services, valuable insights could be obtained into their performance in terms of sustainability perceived by consumers. This approach would complement traditional evaluations based on expert opinions with data from direct and authentic sources, thus providing a more comprehensive and balanced perspective on supplier sustainability.

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