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The Role of NLP in Redefining Business for Sustainable Success

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Abstract: *In the era of modern enterprises, integrating sustainable practices into business operations has become essential for long-term success. Natural Language Processing (NLP), a subfield of artificial intelligence, plays a pivotal role in advancing corporate sustainability by enabling the analysis of vast, unstructured textual data such as sustainability reports, social media content, and corporate communications. This work explores the application of NLP techniques in achieving sustainable business goals through a comprehensive review of recent studies. It highlights how NLP tools, ranging from sentiment analysis and text mining to advanced transformer-based models like BERT enhance ESG (Environmental, Social, and Governance) evaluation, detect green washing, and align corporate disclosures with the United Nations Sustainable Development Goals (SDGs). The research identifies major challenges in sustainable business adoption, including the trade-off between profitability and sustainability, consumer trust issues, and supply chain constraints. The findings affirm that NLP not only improves transparency and reporting accuracy but also supports real-time monitoring and strategic decision-making. Future directions include the development of multilingual and sector-specific NLP pipelines, integration with third-party data sources, and adoption of Explainable AI to ensure ethical and interpretable outcomes. Overall, this work underscores the transformative potential of NLP in redefining sustainable business practices.*

Keywords: Groundwater contamination, heavy metals, Panchkula, Haryana, arsenic, lead, groundwater quality, public health.

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1. Introduction

Natural Language Processing (NLP) is a subset of Machine Learning domain which enables a computer system to understand, analyze and generate the human language. NLP offers numerous real-world applications in various diverse fields such as medical science, search engines, business intelligence, chat bots etc. With the enormous amount of data generated from different sources like social media, websites, businesses, NLP has become a crucial tool for gaining meaningful insights as well as automating different tasks [1].

As the businesses are rapidly expanding thereby demand for sustainable practices in the business is also on rise. Companies that incorporate sustainable practices in their operations highly enhance their social as well as environmental impact and also secure long-term success as compared to organizations which don't include sustainable development goals in their practices. Recent studies have shown that the majority of the consumers also give preference to the products or brands which they believe are beneficial for the environment or society. Apart from that the governments as well as international organizations are also implementing policies which aim to achieve sustainable development goals. Lot of emphasis is given to develop environmentally friendly policies and the companies which fail to comply face risk of financial penalties as well as damage to their reputation [2]. In brief, the key for long term survival of a business is sustainability.

The concept of corporate sustainability is complex because of the diverse nature of firm operations. Sustainability disclosures made by the organizations are ambiguous, incomplete and unreliable most of the time. NLP is an important tool for enhancing ESG marketing for organizations. Apart from that NLP also assists in automated analysis of data helping corporate firms save time and effort with a high level of accuracy. NLP also provides deeper insights into the ESG performance of a company, enabling them to identify their strong areas and the areas in which they can improve [3]. As a result, corporate firms can plan their sustainable strategies for both long and short term. Overall, we can say that NLP plays a very crucial role in redefining present business standards for achieving sustainable development goals.

2. Sustainable Business: Concepts, Requirements and Challenges

This section explains the concept of sustainable development and various terms related to it. Sustainable business is a business whose objective is to have some positive impact on the environment, community, society or economy. It is also known as green business. The concept of sustainable business is important because if the corporate firms fail to comply with sustainable

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objectives then many negative things such as environmental degradation, social injustice can happen. Therefore organizations before making policies take sustainable goals into consideration in order to ensure that short term profit doesn't become a liability in terms of environmental, social, economic damage.

The three main pillars of sustainable business are:

- Social
- Economic
- Environmental

These pillars of sustainable business are shown in Figure1. These pillars are sometimes also referred to as people, planet and profit and are concerned with the way in which businesses impact people, environment and natural resources and economic development [4].

2.1 Challenges in Achieving Sustainability in Modern Enterprises

Different challenges include:

- **Balance between Profit and Sustainability**

  One of the major challenge's businesses faces now-a-days is to find the right balance between profit and sustainability. Achieving sustainability in companies requires beforehand investment in eco-friendly technology, ethical supply chains which are very expensive. As a result, many times these firms compromise on sustainability due to excessive investment required for it.

- **Lack of Awareness about Sustainability**

  The concept of sustainability is quite broad as a result many businesses struggle to comply with sustainable development goals.

- **Lack of Consumer Trust on Company Policies**

  Another challenge is that faced by many companies is the lack of consumer trust because many companies just use the concept of greenwashing without actually following sustainability policies properly.

- **Supply Chain Challenges**

  Another challenge especially for small and medium companies is to develop a strong supply chain model without compromising sustainability goals.

3. Related Work

This section explains the work done by various researchers regarding the role of natural

language processing in business for achieving sustainable success.

Amel, et al. 2021 used Natural Language Processing and Machine Learning for examining alignment of corporate sustainability reports with UN Sustainable Development Goals. They used a logistic regression classifier, support vector machines and a fully connected neural network for checking the compliance of an organization's policies with sustainable development goals. The study proved very helpful for investors to integrate SDG alignment into portfolio construction. The major limitations of the study were that as it relies only on self-reported data by companies so there is a great risk of green washing. In future company reports can be combined with third party data like NGO's and news for better analysis and leverage transformer models such as BERT can be used [5]. Kang et al., 2022 carried research using Natural Language Processing methods for analyzing the annual sustainability reports generated by the companies.

They used sentence similarity and sentiment analysis for evaluating thematic trends present in corporate sustainability reports. In the study 60 reports from 2011 to 2020 from 6 global leaders (BASF, IKEA, Nestlé, Toyota, Walmart, M & S) were analyzed. The study was very beneficial for companies for generating better sustainability reports. Another key finding of this work was the identification of green washing by sentiment analysis which is used by the companies to improve their reputation in times of crisis. The identification of green washing in sustainable reports is very helpful for continuous monitoring and evaluation. The authors concluded that in future sustainability reports from large numbers and different types of companies can be analyzed for better analysis [6].

Gutierrez-Bustamante et al., 2022 used text mining and natural language processing techniques to evaluate the compliance of Nordic companies with the Global Reporting Initiatives (GRI) framework. A quantitative ranking score based on index matching was developed for semantic valuation. Results showed that Latent Semantic Analysis (LSA) and Global Vectors (GloVE) are the best methods. The key finding is that Report structure and clarity significantly influence NLP model effectiveness [7].

Polignano et al., 2022 proposed a pipeline based Natural Language Processing and Information Retrieval (IR) based system to automatically analyze corporate sustainability reports in closed file formats like PDFs was developed. OCR and text extraction tools were used to convert these reports into machine readable textual format. It used sustainability reports from 134 Italian companies from 27 different sectors. The results offered consistent analysis across differently formatted reports and automated tedious manual

work of identifying GRI topics in lengthy reports [8]. This method was helpful for detection of green washing which violates GRI's balance principle. The authors concluded that future models can be enhanced in terms of efficiency, robustness etc.

Dash et al., 2023 examined strategies for sustainable marketing and the role of social media using Natural Language Processing. In their study they collected 33 articles published in Scopus from 1991 to 2022. To provide classification and prediction of various sustainable marketing trends two tools; KNIME ((Konstanz Information Miner) used for pre-processing and text-mining and VOS viewer (for bibliometric and co-occurrence analysis) were used by them. For predicting the latest trends, the concept of text mining and semantic analysis was used. The top trends observed in the study were; Green Marketing and Consumer Behavior, Sustainable Social Media Marketing, and Influencer Social Media Marketing Practices. The study implied that digital and social media marketing are essential for sustainability and NLP tools are very much valuable for future marketing trend analysis. The authors concluded that in future analysis can be done by incorporating keywords like digital marketing and bibliometric and empirical research methods can be combined for better results. For better results future practitioners will need to integrate advanced digital tools such as artificial intelligence (AI), machine learning (ML), augmented reality (AR), and virtual reality (VR) into social media marketing strategies and also the negative role of social media in sustainable marketing strategies should be explored [9].

Culpi et al., 2024 explored the orientation of business towards sustainability using Natural Language Processing for analyzing corporate communications. The study highlighted the evolutionary nature of social norms in shaping business sustainability. It underscores the power of NLP in sustainability research and encourages nuanced differentiation between types of enterprises and their unique contexts [10].

Gupta et al., 2024carried out a systematic study to assess alignment of Indian IT companies with Environmental, Social, and Governance (ESG) standards by analyzing their sustainability reports. They used a hybrid natural language processing model which combined BERT (Bidirectional Encoder Representations from Transformers) and YAKE (Yet Another Keyword Extractor) Reports from top seven Indian firms were used for analysis. The research was able to identify ESG keywords with 98% accuracy. The study demonstrated that most of the firms focused heavily on environmental factors while governance was mostly underrepresented. This research work paved a way for an adaptable pipeline for analyzing other domains or sectors [11].

Balcioglu et al., 2024 analyzed the integration of Artificial Intelligence into sustainable business practices in U.S. based firms. The key objective was to identify the role of AI in enhancing sustainability. 263 sustainability disclosures from 41 firms across 13 industries were analyzed by text mining and NLP based techniques. The research highlighted the importance of AI in achieving business sustainability transformation. Social sustainability (e.g., fairness, mental health, diversity) is still emerging but growing in relevance [12].

Cruciata et al., 2024 carried out systematic research to study environmental values displayed through a company's homepage in order to determine whether they can serve as a proxy indicator for its actual environmental performance, specifically the B-Lab Environmental Index (used in B-Corp certification). In order to analyze the textual content of a company's homepage Zero-Shot Text Classification (ZSTC) with a BERT-derived NLP model was used. The research provided a cost-effective alternative to traditional survey-based ESG assessments and provided sufficient evidence to support that external communication (web content) can reflect internal sustainability practices adopted by a company [13].

Lui et al., 2024 carried out systematic study to investigate the effect of thematic content, sentiment, and readability of sustainability reports on financial performance of corporate firms using Natural Language Processing techniques. The objective of the study was to fill the gap between qualitative ESG narratives and quantifiable financial metrics. 206 sustainability reports from 30 top firms listed on the Singapore Exchange (SGX) (Straits Times Index, 2015-2021) were analyzed. This study showed that well-structured, transparent, and community-oriented sustainability disclosures can improve both operational profitability and investor perception. It further confirmed that qualitative disclosures can be systematically quantified and linked to financial outcomes using different NLP tools [14].

Yiğit Açikgöz et al., 2024 proposed a novel, data-driven approach to assess sustainable corporate reputation by using citizen feedback on municipalities using machine learning and sentiment analysis. The study used citizen comments on five local municipalities in Antalya, Turkey. They used Support Vector Machines (SVM) for sentiment classification, text mining for keyword extraction and Word Cloud Visualization using Seaborn. The research demonstrated the role of Artificial Intelligence and Natural Language Processing in forming public policy and governance and also implied that this method is transferable to private sectors and other public institutions [15].

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Ong et al., 2025 studied the use of Explainable Natural Language Processing (XNLP) for addressing sustainability in corporate sustainability analysis. The approach combined linguistic understanding (via NLP) with explainable AI (XAI) to support analysts for making more accurate and scale assessments of sustainability reports. The study highlighted XNLP as a transformative tool for corporate sustainability analysis [16].

4. Advantages of NLP in Business Sustainability

NLP has emerged as a powerful tool to redefine business in the age of sustainability. There are many advantages that NLP has in business sustainability. Different advantages are explained below:

- **Enhanced Customer Experience**

NLP-powered chatbots, sentiment analysis, and feedback systems provide 24/7 support and real-time customer insights.

- **Operational Efficiency**

It automates document processing, email sorting, and customer interactions, reducing manual labor and resource consumption.

- **Market Intelligence**

NLP extracts trends and insights from unstructured data (e.g., social media, reviews) for sustainable product innovation and marketing.

- **Risk Management**

It identifies early signals of reputational, financial, or environmental risks from media, reports, and social data.

- **Compliance & ESG Reporting**

NLP assists in parsing complex regulatory documents and generating reports aligned with sustainability standards.

5. Disadvantages of NLP in Business

While NLP unlocks new efficiencies and strategic insights, companies must tread carefully around ethical and technical limitations. Combining NLP with responsible governance ensures a path to sustainable success. Disadvantages are as given below:

- **Data Privacy Concerns**

Processing sensitive customer data can raise ethical and legal issues (GDPR, etc.).

- **Bias and Fairness**

NLP models trained on biased data can reinforce stereotypes and discriminatory behavior.

- **High Initial Costs**

Developing or integrating NLP systems requires significant investment in technology and skilled talent.

- **Complexity of Language**

Slang, multilingualism, and domain-specific jargon can reduce accuracy.

- **Dependency on Data Quality**

Poor-quality input data can lead to misleading or incorrect outputs.

6. Case Studies

The real-world applications of NLP in business sustainability are as given below:

6.1 Unilever: Talent Acquisition Using NLP

Unilever adopted NLP tools for CV screening and initial candidate engagement. It reduced recruitment time by 75%, enhanced fairness by using AI to standardize evaluations. It lowered environmental impact by minimizing travel and paper usage.

6.2 IBM: Watson for Environmental Sustainability

IBM's NLP-based Watson AI analyzes climate data, research papers, and policy documents. It helped clients in agriculture and energy optimize resource use and reduce carbon footprint. It improved decisions that balance economic and environmental goals.

6.3 HSBC: ESG Data Analysis

HSBC uses NLP to analyze ESG (Environmental, Social, Governance) disclosures and news. Itenables better risk assessment and sustainable investment decisions. It aligns financial decisions with long-term climate and social goals.

6.4 Patagonia: Social Sentiment Monitoring

Patagonia uses NLP to track social media for sustainability concerns and brand sentiment. It has improved customer trust and realigned strategies based on values feedback. The result is that they reinforced their environmentally responsible branding and actions.

6.5. Evaluating Sustainability Reports of Nordic Companies

Gutierrez Bustamante & Espinosa-Leal, 2022 applied NLP and text mining techniques to analyze corporate sustainability reports published under the GRI framework by publicly listed Nordic firms. They used Latent Semantic Analysis (LSA) and GloVe embeddings to compute semantic similarity and generate quantitative affinity scores, demonstrating that automated NLP models can assess compliance with sustainability standards at scale. It enables corporate benchmarking, transparency, and faster sustainability performance assessment across companies.

6.6 Explainable NLP for Corporate Sustainability Disclosure

Ong et al., 2025 developed an Explainable NLP (XNLP) framework to address subjectivity and bias in corporate sustainability assessment. Leveraging lexical, semantic, and syntactic analysis integrated with explainable AI (XAI), the system enhances interpretability and trust in automatic evaluations of sustainability

disclosures. It promotes reliable decision-making by auditors, regulators, and investors when evaluating ESG disclosures.

6.7 CHATREPORT: LLM-Based Benchmarking against TCFD Guidelines

Ni et al., 2023 introduced **CHATREPORT**, a domain enhanced large language model powered tool that assesses corporate climate risk disclosures by aligning content with the Task Force on Climate-related Financial Disclosures (TCFD) recommendations. It provides stakeholders including investors and regulators with consistent, scalable, and expert informed evaluation of climate related financial risks [17].

7. How NLP is Transforming Sustainable Business

- **Automation of Sustainability Disclosure Analysis**

NLP enables scalable processing of large volumes of ESG or GRI reports transforming texual disclosures into actionable metrics.

- **Mitigating Bias and Ensuring Trust through Explainable Methods**

XNLP approaches provide interpretability, which reduces subjectivity in outcomes and improves stakeholder trust.

- **Domain Enhanced LLMs for Benchmarking**

Tools like CHATREPORT combine expert prompts with language models to assess real world sustainability frameworks like TCFD systematically.

- **Semantic Scoring for Objective Comparisons**

Embedding and semantic similarity techniques, as demonstrated in Nordic reporting studies, help rank and compare firms on sustainability alignment.

8. Conclusion and Future Scope

The literature clearly illustrates the transformative impact of Natural Language Processing (NLP) in promoting sustainable business practices. NLP is being used across diverse applications from marketing trend prediction, ESG compliance, and greenwashing detection, to the alignment with UN Sustainable Development Goals. The reviewed studies demonstrate that NLP, often enhanced by machine learning and explainable AI, is a powerful tool for analyzing unstructured corporate data such as sustainability reports, social media content, and public feedback. The key insights from the study are the utility of tools like BERT, GloVe, VOSviewer, and hybrid models in extracting actionable insights, and the growing emphasis on integrating sentiment analysis and thematic mining to assess corporate commitment to sustainability. The use of NLP in sustainability reporting not only improves transparency but also provides a

mechanism for monitoring environmental and social commitments in real time. Furthermore, novel contributions such as Explainable NLP (XNLP) and automated pipelines for PDF analysis signify a shift toward more robust and scalable frameworks. Overall, NLP proves to be a crucial enabler of sustainability in business, offering scalable, objective, and cost-effective ways to evaluate and enhance corporate reputation, stakeholder trust, and long-term strategy alignment.

In the future for better reliability, corporate sustainability disclosures can be integrated with third party sources like NGO reports, news media, and audit data to reduce risks like greenwashing. Adoption of advanced transformer-based models such as BERT, RoBERT etc. can be done for better semantic understanding and domain specific fine-tuning. Decision making in business to make it more sustainable can be improved by developing real-time NLP based feedback systems that can collect the real time data from customers, investors through different social media platforms and public forums. The use of Explainable NLP (XNLP) should be increased to ensure transparency in automated decision-making processes, particularly in contexts like ESG compliance where accountability is critical.

NLP models that support multilingual and culturally diverse contexts, particularly for global corporations operating across heterogeneous regulatory environments should also be explored.

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