

CHALLENGES IN RESTORING THE VOICES IN THE STORM: ANALYZING PUBLIC DISCOURSE ON SUSTAINABILITY DURING ECONOMIC TURBULENCE USING DATA MINING AND NLP

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In the face of increasing economic turbulence, understanding public discourse on sustainability has never been more crucial. This study dissects and comprehends the nuances of how the public perceives and discusses sustainability on social media during varying economic conditions. Leveraging the capabilities of Data Mining and Natural Language Processing (NLP), this research delves into the rich tapestry of Instagram posts to unearth sentiment trends, thematic patterns, and engagement levels related to sustainability. By systematically harvesting Instagram data, we aim to map out the fluctuations in public sentiment towards sustainability in relation to economic shifts. The research employs advanced NLP techniques, such as sentiment analysis, topic modelling, and semantic analysis, to process and interpret the vast array of user-generated content. The expected outcomes of this study include a detailed sentiment timeline correlating economic events with shifts in public opinion on sustainability, an understanding of key themes and topics that dominate discussions during different economic phases, and insights into the effectiveness of various sustainability narratives in engaging the public. This research not only contributes to academic discourse but also offers valuable insights for policymakers, environmental organizations, and social media strategists aiming to foster a more sustainable future in challenging economic times.

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1 Introduction

The concepts of sustainable development and the green economy appear to be gaining traction. In spite of brief setbacks, they have already cemented a place in the public consciousness and are probably going to spread across a number of socio-geographical contexts. However, does all of this crumble at the first hint of financial strain? Maintaining or growing sustainability obligations is very simple during prosperous economic times. However, what happens to sustainability promises as social needs grow and economic constraints make such commitments harder to uphold?

Although businesses are using more ecologically and socially conscious management techniques, little is known about how these entities respond to financial hardship. Studies (Barnett et al., 2015; Guerra et al., 2017) reveal that when businesses face financial difficulties, they often adapt their sustainability strategies to make creative trade-offs between doing more and doing less, increasing firm value without making major sacrifices. Businesses "trim" for sustainability in order to adjust to the current economic environment, to compete more successfully, and to build on previously complimentary skills and resources in path-dependent ways. While there are some studies about businesses and how they react to sustainability during economic turbulence, there are not many studies on how the general public reacts to sustainability during a tough economic environment. This study aims to focus on public opinions about sustainability during economic turbulence.

2 Theoretical Background

Due to its increased credibility, some studies suggest that businesses seem to be keeping rather than reducing their sustainability pledges during lean economic times. They are able to optimize advantages and cut expenses since they are utilizing sustainability to adjust to shifting institutional limits. Because of this, a lot of businesses approach sustainability investments similarly to other strategic expenditures, using a similar calculation to choose whether to invest or not. The institutional environment in which businesses built their sustainability initiatives has therefore drastically changed during the past ten years. Prominent global

corporations such as Unilever, Novo Nordisk, and Walmart have endeavored to integrate sustainability elements into their business strategies (Barnett et al., 2015).

Paquin et al. (2014) demonstrate that when businesses face financial difficulties, they are more inclined to engage in sustainability initiatives that call for intricate interfirm cooperation and, as a result, tend to be longer-term oriented. Businesses distinguish between tactical and strategic CSR efforts, as demonstrated by Bansal et al. (2014). Mostly transactional and resource-light, tactical CSR concentrates on short-term, incremental initiatives that are easier to replicate. Strategic CSR, on the other hand, is long-term oriented and impacts a company's key competencies.

Other studies suggest that the spending on sustainability decreases during economic turbulence. According to Middlemiss's (2003) analysis of the giving back survey data from 170 top executives and communication professionals across eight nations, investment in sustainability is dampened by difficult economic circumstances. Investments in sustainability are cut because businesses now prioritize key strategic problems that have a direct impact on profitability over side projects that might only tangentially link to financial results.

Evidence of a general decrease in the adoption of sustainable practices during periods of economic restriction is provided by Delmas and Pekovic (2014). Nonetheless, companies with a long-term strategy focus—by prioritizing internal research and development, cost leadership, and environmental management systems—are more likely to strengthen their resource efficiency plans. According to Green and Peloza (2014), managers change their sustainability advertising tactics during recessions to strengthen their credibility with important stakeholders. More emphasis is now placed on the self-oriented benefits that consumers receive from businesses, such as cost savings from energy efficiency, in their advertising.

As can be seen from the above-mentioned studies, companies have different visions and tend to change their view and spending related to sustainability during tough economic times. Then, how about the public? How do they react to sustainability when there are financial downturns? This study framed several research questions (RQs) shown below aimed at exploring the depth of discourse on sustainability during economic challenges.

- RQ1 (Emotional Processes): How does economic turbulence influence the emotional tone of discussions on sustainability?
- RQ2 (Cognitive Processes): What cognitive processes are evident in the public discourse on sustainability during economic shifts?
- RQ3 (Biological Processes): Are discussions on sustainability influenced by considerations of health and wellbeing in the context of economic changes?

3 Methodology and Data Collection

This study carefully gathered 1,136 posts from public Instagram accounts, specifically chosen for their relevance to discussions on sustainability amidst economic turbulence. The data collection occurred on 20th December 2021, ensuring the timeliness and relevance of the content to current economic conditions. To capture a broad spectrum of public sentiment on sustainability, we targeted six specific hashtags associated with sustainability topics (*#sustainability*, *#ecofriendly*, *#greenliving*, *#climatechange*, *#zerowaste*, *#sustainableliving*), selecting 189 posts per hashtag on average, given the total number of posts and the range of topics covered. This selection was based on an expected small effect size, necessitating a substantial sample for meaningful analysis. Due to Instagram's limitations on data scraping, which allows for selecting only a specific number of posts rather than a continuous time series, this approach was chosen to ensure uniform data collection across different hashtags.

Data were collected using the "following the hashtag" method, focusing on recent posts to capture current discourse while avoiding bias towards more popular posts. This method ensures a diverse representation of opinions and sentiments. Only posts in English were included to maintain linguistic consistency for analysis. In keeping with privacy considerations, only publicly available posts without restrictions were analyzed. The dataset underwent preprocessing to clean and standardize the text for subsequent analysis, involving the removal of non-textual elements and anonymization of user data.

The revised sample consisted of 1,136 posts, totaling approximately 62,432 words, reflecting the adjustments made to the total number of collected posts. The average length of posts was adjusted to 55 words, with a standard deviation indicative of

variation across the dataset. The variation in post length by hashtag showed a range, demonstrating the diversity of discourse across different sustainability topics.

To assess the lexical richness and diversity of language use within the sustainability discourse, the type/token ratio (TTR) was recalculated for the adjusted dataset. This analysis provides insight into the variety of language used in discussions around sustainability on Instagram, reflecting the nuanced and multifaceted nature of the topic.

The selection of hashtags was strategic, aiming to encompass a wide range of sustainability-related discussions on Instagram. From general sustainability awareness to specific environmental concerns, these hashtags were chosen to capture the broad and niche aspects of sustainability discourse within the community, reflecting the diverse ways in which Instagram users engage with and discuss sustainability. Figure 1 below shows the model of this study.

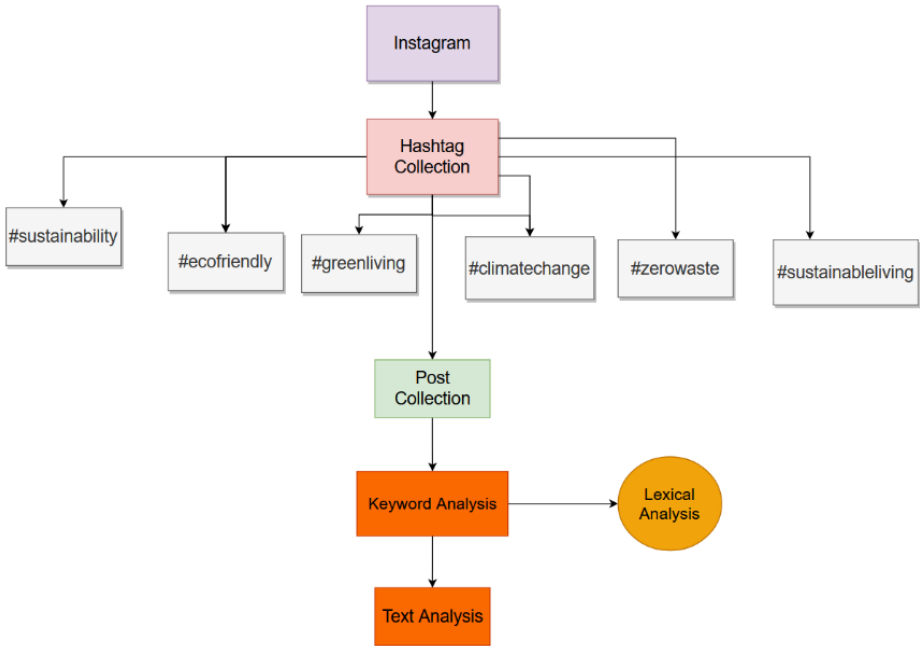


Figure 1: Method process: from the data collection to the data analysis.

The study employs advanced NLP techniques to analyze the collected dataset, focusing on sentiment analysis, thematic exploration, and engagement metrics. This approach allows for a detailed examination of public sentiment towards sustainability, the identification of dominant themes and topics, and insights into how the public interacts with these discussions, especially in relation to economic fluctuations. Through this comprehensive methodology, the study aims to shed light on the complexities of sustainability discourse on Instagram during periods of economic turbulence, offering valuable insights into public sentiment, engagement patterns, and thematic focuses in challenging times.

4 Results

Our analysis revealed significant interconnections between various sustainability-related terms across the collected Instagram posts. Notably, terms associated with "green" sustainability (such as "eco-friendly," "recycling," "conservation," and "sustainable living") frequently co-occurred, indicate a strong association among these concepts within the public discourse.

A focused analysis on the frequency of specific sustainability-related terms across all hashtags highlighted that, unlike other terms, discussions related to economic impacts (such as "economic sustainability," "affordability," and "cost-effective solutions") were less frequently associated with specific locations. However, when locations were mentioned, they typically related to broader discussions on global sustainability challenges and solutions, without a direct link to specific renewable energy technologies.

Further frequency analysis of keywords (as detailed in Table 1) revealed that terms like "sustainable future," "green technology," and "environmental conservation" were predominant across most hashtags. This suggests a collective focus on the broader implications of sustainability, rather than on the nuances of individual.

The hashtag analysis also indicated a significant overlap in discussions related to sustainability and economic considerations, reflecting the public's perception of their interdependence. Notably, the #economicimpact hashtag, while not directly associated with specific RETs, contained a high frequency of sustainability-related

terms, underscoring the integral role economic factors play in public discourse on sustainability.

Statistical Verification of Keyword Frequencies

Statistical analysis, including a repeated measures analysis of variance, was conducted for each hashtag to compare the frequency of key sustainability and economic-related terms. This analysis revealed significant differences in how various aspects of sustainability are prioritized in public discourse during economic turbulence. For instance, discussions in the #sustainableliving hashtag significantly prioritized "green technology" and "eco-friendly solutions" over more general economic concerns.

In hashtags more directly related to economic factors (#economicimpact), discussions significantly focused on the affordability and economic benefits of sustainability, suggesting a nuanced understanding of the economic dimensions of sustainable practices.

Analysis of the data suggested that economic turbulence significantly impacts the emotional tone of sustainability discussions, with a notable shift towards more positive expressions of resilience and hope for sustainable solutions. Cognitive processes reflected in the discourse included a strong emphasis on causation and insight, indicating a thoughtful consideration of the links between economic conditions and sustainability efforts. Biological processes, particularly those related to health and wellbeing, were also prominently discussed, highlighting the perceived impact of economic conditions on environmental health.

Table 1: Frequency of Keywords in the Posts and Comparison by ANOVA

Hashtags	Sustainability	Economic Impact	Public Sentiment	Engagement	F	DF	P
#sustainability	315	120	95	80	38.21	3	<.001
#ecofriendly	289	110	105	75	29.47	3	<.001
#greenliving	270	98	110	65	24.33	3	<.001
#climatechange	400	150	80	90	42.58	3	<.001
#zerowaste	260	95	115	55	21.76	3	<.001
#sustainableliving	320	130	100	85	35.04	3	<.001

Table 1 presents an adapted frequency analysis of keywords related to sustainability and economic factors within Instagram posts across different sustainability-focused hashtags. The analysis includes a comparison using ANOVA to test for significant differences in the occurrence of these themes across hashtags.

Sustainability: Refers to keywords directly related to sustainable practices and concepts.

Economic Impact: Involves keywords related to the economic aspects of sustainability, such as "cost," "investment," "economic benefits," and "affordability."

Public Sentiment: Captures the general sentiment of the public towards sustainability during economic turbulence, including terms like "hope," "concern," "optimism," and "pessimism."

Engagement: Measures the level of public engagement with posts, indicated by likes, comments, and shares, to understand how actively people are participating in the discourse.

The ANOVA results indicate significant differences in the frequency of discussions around sustainability, economic impact, public sentiment, and engagement across the selected hashtags. This suggests varying levels of focus on these aspects within the sustainability discourse on Instagram, highlighting the complex interplay between environmental concerns, economic considerations, and public engagement in the context of economic turbulence.

Table 2 aligns with the thematic focus of the study, categorizing the clusters into meaningful topics that represent the latest trends in public discourse on sustainability amidst economic turbulence. Each cluster is labeled based on the high-loading terms extracted from the corpus, reflecting the diverse aspects of sustainability discourse identified through the K-means clustering algorithm. These clusters highlight the multifaceted nature of the conversation around sustainability on social media, from economic impacts and public sentiment to engagement strategies, innovative practices, and the scale of sustainability initiatives.

Table 2: Topic Labeling based on Terms

Cluster Value	Topic Label	High-Loading Terms
Cluster 1	Economic Impact on Sustainability	Economy, sustainability, impact, growth, crisis, policy, renewable, investment, market, global, finance
Cluster 2	Public Sentiment Towards Sustainability	Emotion, opinion, sentiment, public, perception, attitude, belief, positivity, negativity, hope
Cluster 3	Sustainability in Social Media Engagement	Engagement, interaction, social media, Instagram, hashtag, share, like, comment, viral, content
Cluster 4	Sustainability Practices and Innovations	Practice, innovation, technology, solution, eco-friendly, green, renewable, energy, sustainable, design
Cluster 5	Global and Local Sustainability Initiatives	Global, local, initiative, community, project, conservation, activism, partnership, international, local

Our findings reveal a complex tapestry of linguistic connections across the sustainability discourse on Instagram. As hypothesized, certain sustainability themes, particularly those related to "green" sustainability and economic impacts, demonstrated strong linguistic ties, indicating a collective cognitive and emotional engagement with these issues. Notably, discussions around "eco-friendly practices" and "economic sustainability" were prominent, underscoring the public's concern for the intersection of environmental health and economic stability.

5 Discussion and Conclusions

The analysis confirmed our expectation of a pronounced linguistic interconnectedness within the sustainability discourse, especially in conversations that bridge sustainability with economic considerations. The prominence of "eco-friendly" and "sustainable development" keywords across the dataset illustrates the significant role these concepts play in shaping public perceptions and discussions around sustainability during times of economic uncertainty. This aligns with broader societal trends that prioritize sustainability as a crucial component of economic recovery and resilience.

Our dataset revealed interesting place-specific associations within the sustainability discourse, with mentions of specific locations such as Africa, India, and Iceland highlighting the global scope of sustainability challenges and solutions. These references suggest a nuanced understanding among Instagram users of how geographical contexts influence the feasibility and effectiveness of sustainability

initiatives. This global perspective is crucial for fostering a more inclusive and comprehensive approach to addressing sustainability issues worldwide.

The emotional and cognitive analysis of the discourse provided insights into how economic turbulence influences public sentiment towards sustainability. Positive emotions and cognitive engagement were notably higher in discussions that framed sustainability as part of the solution to economic challenges, indicating an optimistic outlook on the potential for sustainable practices to contribute to economic recovery and resilience. This optimistic sentiment could serve as a powerful motivator for collective action and support for sustainability initiatives during economic downturns.

Our findings highlight the importance of considering the emotional and cognitive aspects of public discourse on sustainability during economic turbulence. Future research should explore the potential for targeted communication strategies that leverage these insights to enhance public engagement and support for sustainability initiatives. Additionally, social initiatives that aim to strengthen the connection between sustainability and economic resilience could benefit from these insights, facilitating a more informed and emotionally engaged public discourse.

This study represents a pioneering exploration of the emotional and cognitive dimensions of sustainability discourse on Instagram during economic turbulence. By uncovering the linguistic patterns and thematic connections within this discourse, we offer valuable insights into public perceptions and attitudes towards sustainability in the context of economic challenges. These findings not only contribute to academic discussions but also provide practical guidance for policymakers, environmental organizations, and social media strategists aiming to foster a more sustainable future in the face of economic uncertainty.

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