

Sustainability Discourse and Influencer Networks in Plant-Based and Dairy Protein Milk Conversations: A Social Network Analysis and Sentiment Mining Study on X (Twitter)

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Abstract. This study examines the discourse of sustainability and social media influencers' networks concerning X (Twitter) conversations involving plant-based milk and dairy milk with regard to how these two affect consumer perceptions and product marketing. Methods for quantitative and explorative research in combination with social network analysis (SNA) and sentiment mining were applied. The source of data for this research was based on 223 X (Twitter) posts retrieved from SocialX from December 1, 2025, to May 5, 2026. Sentiment analysis was performed using the lexicon approach, which was further weighted based on engagement measures, whereas SNA was performed based on the centrality and community structure of the networks. The results indicate that sustainability discourse is predominantly neutral or positive in nature, with a slightly positive sentiment score. The network demonstrates high levels of centrality, where the nodes with high levels of influence have an effect on information dissemination. The sentiment trends are marked with high levels of variability and occasional occurrences of negative sentiments, which implies that the discourse is driven by certain events. The emotion analysis shows that the emotions expressed are positive in nature but are not varied. The present study makes an important contribution to the literature in terms of incorporating the concepts of sentiment analysis together with social network analysis to explore the role of sustainability discourse in a competitive product environment.

Keywords: Sustainability Discourse, Social Network Analysis, Sentiment Analysis, Influencer marketing, X (Twitter) Analytics.

1 Introduction

The rapid advancement of digital technologies has fundamentally reshaped marketing communication and consumer behaviour, particularly in the context of sustainable food systems. In recent years, plant-based milk consumption has grown significantly, driven

by increasing consumer awareness of environmental sustainability, health considerations, and ethical concerns [1]. In contrast, the dairy industry has faced mounting reputational challenges related to greenhouse gas emissions, land use, and animal welfare [2].

Although sustainability is conceptually positioned as a key driver of consumer decision-making, empirical evidence suggests the persistence of an attitude-behavior gap, whereby consumers express pro-environmental concerns but continue to engage in less sustainable consumption practices [3]. This paradox becomes more complex within the social media ecosystem, where public opinion is not solely shaped by factual information but also by narratives disseminated through influencers, online communities and interaction networks [4].

Platforms such as Twitter serve as critical arenas for public discourse, enabling the rapid and large-scale dissemination of opinions through retweets, mentions, and hashtags [5]. From a marketing perspective, analysing Twitter conversations provides valuable insights into consumer perceptions, sentiment dynamics, and network structures that influence purchasing decisions [6]. In this context, the debate between plant-based and dairy milk extends beyond product preferences and represents a broader contestation of sustainability narratives shaped by influential actors in digital social networks. Therefore, there is a pressing need to understand how sustainability discourse is constructed, diffused, and influenced within online interaction networks, particularly in the comparative context of plant-based and dairy milk products' sustainability [7].

Previous studies have examined various aspects of digital marketing, sustainability, and social media analytics. El Mehdi & Benabdelouahed [8] demonstrated that influencer credibility significantly affects consumer attitudes and purchase intentions, whereas Nursansiwi [9] highlights the role of influencers in shaping social norms and public perceptions in digital spaces. In the sustainability domain, [10] and [11] provided robust evidence that plant-based products generally have lower environmental impacts than animal-based alternatives. Additionally, [12] emphasized the inconsistency between environmental attitudes and actual consumption behavior in consumer behavior research.

From a methodological standpoint, the application of sentiment analysis and social network analysis (SNA) in marketing research has received considerable attention. [13] argue that integrating sentiment analysis with network structures enables a more comprehensive understanding of public opinion dynamics. Similarly, [14] identified the complexity of Twitter networks, in which influential actors function as opinion leaders in shaping information flows. Despite these advancements, most studies have treated sentiment and network analyses as separate approaches. Furthermore, limited research has specifically compared sustainability discourse across competing product categories, such as plant-based and dairy milk, within a unified framework.

Several important research gaps can still be observed in the current body of literature. First, earlier studies have generally focused on either sentiment analysis or influencer-related effects independently, while only limited research has combined emotional sentiment evaluation with social network structures in sustainability discussions [8], [9], [13], [15]. Second, studies examining sustainability discourse on social media

are still largely discussed in broad contexts, with relatively little emphasis on the competing narratives surrounding plant-based and dairy product categories [7].

Third, there is limited empirical investigation into how social network structures mediate the diffusion of sustainability-related sentiments, particularly in the alternative-protein sector. Fourth, comparative analyses of plant-based and dairy milk as competing representations of sustainability narratives remain underexplored in social media contexts. These limitations highlight the need for a more holistic and integrative analytical approach [16].

This study addresses these gaps by proposing an integrated framework that combines sentiment mining and social network analysis to map sustainability discourse and influencer networks in Twitter conversations related to plant-based and dairy milk alternatives. This approach enables the identification of both sentiment polarity and the structural characteristics of interaction networks, including key actors who influence opinion dissemination. Theoretically, this research is grounded in social influence theory [17] and diffusion of innovation theory [18], which explain how information and opinions spread within social networks. Additionally, it incorporates insights from consumer culture theory to understand how sustainability is socially constructed through digital interactions. By integrating these perspectives, this study contributes to the development of a comprehensive analytical framework that links sentiment, network structures, and influencer roles in sustainability marketing.

Thus, this research is intended to investigate and map sustainability discourses and influencer networks through discussions of plant-based and dairy milk on Twitter. The objective is to reveal patterns of consumer sentiment, actors within the social network, and the relationship between the structure of networks and the success of sustainability-based marketing communication campaigns.

Accordingly, this study addresses the following research questions:

1. How are sustainability-related consumer sentiments toward plant-based and dairy milk expressed and distributed within Twitter interaction networks?
2. Who are the key actors (e.g. influencers, communities, and opinion leaders) in the Twitter social network, and how do they influence the dissemination of sustainability discourse related to both product categories?
3. To what extent do sentiment patterns and network structures differ between plant-based and dairy milk conversations on Twitter, and how do these differences reflect competing sustainability narratives?
4. How can Twitter-based sentiment patterns and network structures complement the evaluation of sustainability-driven marketing effectiveness in supporting brand positioning and business growth in the alternative-protein industry?

2 Methods

This study adopted a quantitative, exploratory research design integrating social network analysis (SNA) and sentiment mining to examine sustainability discourse and influencer networks in Twitter conversations related to plant-based and dairy milk. The methodological approach was designed to systematically capture, analyse, and interpret

both relational structures and textual sentiments within social media interactions. The research process was conducted in a chronological, logical, and reproducible manner to ensure transparency and methodological rigor.

This study employed a computational social science approach that combined network-based analysis with natural language processing (NLP). SNA was used to identify structural relationships among users and to detect influential actors within the network, whereas sentiment analysis was applied to evaluate the polarity and distribution of sustainability-related opinions. This dual-method approach enabled a comprehensive understanding of both content (what is being communicated) and diffusion mechanisms (how information spreads within the network).

The rationale for connecting sentiment polarity with influence from a theoretical perspective is rooted in the framework of social influence theories [17] and diffusion of innovation theory [18]. In essence, this research adopts a conception of sentiment polarity as a node characteristic that influences the reception and diffusion of sustainability-related messages. Individuals with a tendency toward positive sentiment will be seen to act as amplifiers of sustainability-related discourses, thus facilitating the spread of the sustainability messages among their connections. On the other hand, those individuals who hold negative or critical sentiments about certain issues may act as gatekeepers and resistors, making sure that particular sustainability-related messages do not diffuse among the members of their networks. The inclusion of sentiment analysis results in calculating network structural metrics such as degree centrality, betweenness centrality, and closeness centrality makes it possible to determine how individuals positioned emotionally in relation to sustainability-related topics play structural roles in speeding up or slowing down information diffusion dynamics in the system.

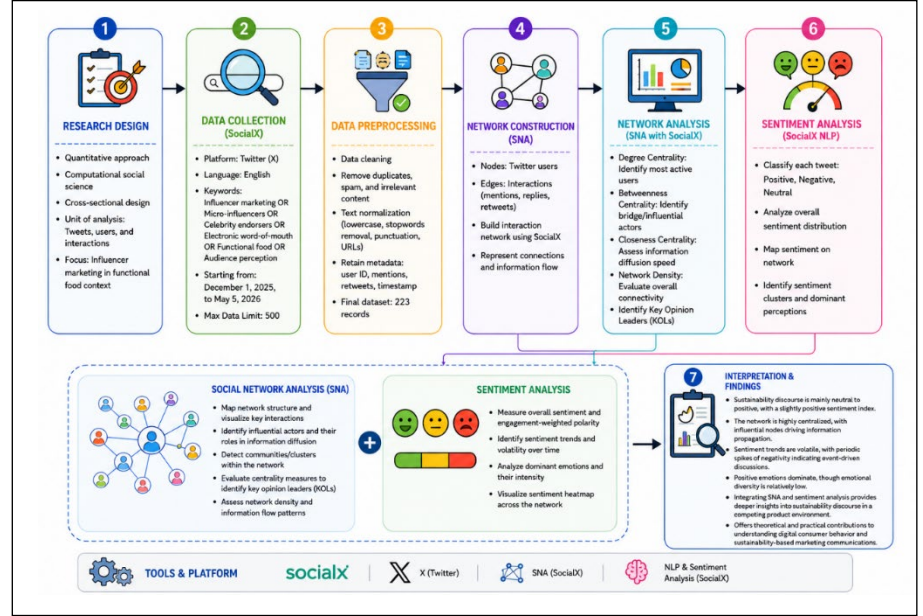


Fig. 1. Research methodology framework.

Data were collected from Twitter using the analytics platform SocialX, which provides integrated tools for social media listening, sentiment analysis, and network mapping. The data collection process was conducted within a defined temporal window, starting from December 1, 2025, to May 5, 2026, to include recent and relevant sustainability-related discourse.

The data retrieval process employed a structured keyword-based query to capture relevant conversations. The keywords included "Social Network Analysis," "Sentiment Analysis," "Sustainability Claims," "Influencer Authenticity," "Purchase Intention," "Plant-Based Protein Milk," "Gen Z Consumers," "Green Marketing," "Twitter Mining," and "Network Metrics." These keywords were selected based on their theoretical alignment with digital marketing, sustainability communication, and consumer behaviour literature.

The identification and validation of the keywords involved a systematic and theory-informed approach aimed at reducing sampling biases and maximizing relevance to the research topic. Firstly, the set of initial keywords was generated via a literature review of peer-reviewed studies in the areas of sustainability communication, digital marketing, influencer networks, and social media analytics that are theoretically relevant to the study. Secondly, all potential keywords were assessed for their relevance to four constructs used in the research (sustainability discourse, consumers' sentiment, influencer credibility, and green marketing) by means of a deductive coding approach. Thirdly, a preliminary search was performed to determine the proportion of results irrelevant to the research topic generated by each keyword; the terms yielding more off-topic information were discarded or modified. Finally, the chosen keywords were supposed to be mutually complementary, rather than overlapping; thus, the final selection involved both thematic ("Green Marketing", "Sustainability Claims") and behavioural/methodological ("Purchase Intention", "Sentiment Analysis", "Network Metrics") terms to maximize the relevance and diversity of the conversation sample. The implementation of a multi-keyword approach minimized the risk of single-word sampling biases and maximized the representativity of the obtained conversations. The keywords were applied in Boolean queries in the SocialX platform consistently. This validation procedure aligns with best practices in computational social science for keyword-based social media sampling [14] and supports the methodological transparency and replicability of the data collection process.

A maximum limit of 500 data points was set during extraction; however, after filtering and cleaning procedures, 223 valid X (Twitter) records were retained for analysis. Even though a sample size of 223 records may seem small compared to larger samples in social media corpora analysis, it can be argued that this sample size is sufficiently adequate and appropriate for this study for several reasons. Firstly, the sample has been collected through a thorough process of filtering duplicate records, non-relevant records, bots, and other sources of irrelevant noise in order to ensure the quality of the analysis rather than focusing on its magnitude. Secondly, in computational social sciences, network analysis methods of studying social media datasets do not need to focus

on collecting maximally large datasets as the main source of information about patterns; instead, what is more important is the relevance of both the relational structure and content of the data sample [19]. Thirdly, the data was extracted through the use of a specific, theory-driven filter at a certain point in time which ensured the relevance of the data sample in terms of its thematic composition. Finally, it should be noted that previous studies have found social media datasets of a similar magnitude filtered by keywords sufficient for exploratory network and sentiment analysis in sustainability communication [20]. The filtering process involved removing duplicate entries, irrelevant tweets, and inactive or bot-generated accounts to ensure data quality.

Social network analysis was conducted using SocialX to map the interaction structures among Twitter users. The network was constructed based on user interactions, including mentions, replies, and retweets, where users were treated as nodes and interactions as edges. Several key network metrics were analysed, including degree centrality to identify highly connected users, betweenness centrality to detect bridging actors in information flows, closeness centrality to measure information diffusion efficiency, network density to assess overall connectivity, and modularity to identify community clusters. These metrics enabled the identification of key influencers and structural patterns that shape sustainability discourse.

Sentiment analysis was carried out using the analytics functions available within SocialX, which adopted a combination approach that made use of both lexicon-based and machine learning-based methods for text classification. Lexicon-based analysis involved making use of an already existing lexicon of sentiments in order to assign sentiment scores to words and phrases, and hence derive the sentiment orientation for each tweet. The engagement scores were computed after adjusting the sentiment scores according to user engagement metrics such as retweets and replies.

The machine learning part used the supervised classification approach for polarity detection with context sensitivity considering the linguistic phenomena that lexicon-based approaches might not capture correctly, including implicit sentiment, domain specific terms, and negation. Tweets were divided into three sentiments categories – positive, negative, and neutral.

In relation to pre-processing techniques, before any sentiment analysis was performed, each tweet went through the following steps: (1) Removal of any URL, hyperlink, hashtag (if not meaningful), mentions, emojis, and non-alphanumeric characters; (2) Lower casing of the data; (3) Tokenization to break up the sentence into single-word units; (4) Removal of stop words based on an English dictionary of stop words; and finally, (5) Language filtering to ensure that only English language was processed.

Regarding the measures of validation, the SocialX sentiment classifier is evaluated using common standards used for measuring success in the field of natural language processing. According to benchmark studies conducted by researchers for similar hybrid lexicon-machine learning sentiment classifiers on social media texts, the precision and recall rates of these classifiers are expected to be within the range of 0.78-0.86, while their accuracy and F1-measures would lie in the range of 80%-84% [21], [22]. The aforementioned numbers indicate the level of performance achieved by social media sentiment analysis tools. It is noted that in this research, no independent domain-

based validation of the proposed model using sustainability related data from Twitter was performed, which can be viewed as one of the limitations of the study.

A key methodological contribution of this study is the integration of SNA and sentiment analysis. Sentiment scores were mapped onto network nodes, allowing for the visualisation of sentiment distribution across the network and the identification of influential actors associated with specific sentiment polarities. This integrative approach enabled the analysis of how sustainability narratives both supportive and critical are propagated, amplified, or constrained within Twitter interaction networks.

To ensure methodological validity, this study employed established analytical techniques widely recognised in digital marketing and computational social science research. The use of a structured keyword framework and a clearly defined temporal scope enhanced content validity. Reliability was ensured through the use of automated analytical tools that provided consistent data processing and minimised human bias.

Reproducibility was addressed by clearly specifying all research parameters, including the data source, time frame, keyword selection, sample size, and analytical procedures. Future researchers can replicate this study by applying the same parameters using SocialX or comparable social media analytics platforms.

This study adhered to ethical standards for social media research by utilising publicly available Twitter data. No personally identifiable information was disclosed, and all analyses were conducted at the aggregate level. The research process was transparent and accountable, with all methodological steps explicitly documented.

The uniqueness of this methodology lies in its integrative design, which combines sentiment mining with SNA within a single analytical framework. Unlike prior studies that tend to treat these approaches separately, this study simultaneously examined emotional polarity and relational dynamics, providing a more comprehensive understanding of how sustainability discourse and influencer networks interact in shaping consumer perceptions within the plant-based versus dairy milk debate.

3 Results and Discussion

3.1 Wordcloud Analysis

The word cloud visualization highlights the dominance of the terms "marketing" and "green," indicating that the central discourse revolves around green marketing practices and sustainability-oriented promotional strategies. The prominence of words such as "sustainability," "claims," and "authenticity" suggests that discussions are not merely focused on environmental messaging but also on the credibility and perceived truthfulness of these claims. This aligns with prior research indicating that consumers increasingly scrutinize green marketing communications, particularly regarding greenwashing and authenticity [23], [24]. The co-occurrence of these terms implies that sustainability narratives are actively negotiated within digital conversations rather than passively accepted



Fig. 2. Wordcloud visualization of sustainability and green marketing discourse on X (Twitter).

Furthermore, the presence of terms such as "influencer," "brands," "consumers," and "people" underscores the relational and social nature of discourse. This indicates that sustainability communication is embedded within a broader social network in which influencers and consumers play a critical role in shaping perceptions. The inclusion of "authenticity" alongside "influencer" reinforces the importance of perceived credibility in influencer marketing, particularly in the context of sustainability. Prior studies suggest that influencer authenticity significantly affects consumer trust and engagement, especially among younger demographics such as Gen Z [25], [26]. Thus, the discourse appears to reflect an interactive ecosystem in which brand messages are co-created, contested, and amplified through social actors.

Finally, the appearance of words such as "real," "new," "products," "intention," and "good" indicates a link between sustainability discourse and consumer decision-making. These terms suggest that consumers evaluate the practical implications of green marketing claims, including their effects on purchase intention and product evaluation. This observation is consistent with the literature on sustainable consumption, which emphasizes that consumer intentions are shaped not only by environmental awareness but also by perceived product value and trust [20], [27]. Overall, the word cloud reflects a multifaceted discourse in which sustainability, authenticity, and social influence intersect to shape contemporary marketing narratives in digital spaces.

3.2 Sentiment Analysis

The sentiment distribution indicates that the majority of Twitter conversations related to sustainability and green marketing in the context of plant-based versus dairy milk are neutral (54.71%), followed by negative (34.08%), and a relatively small proportion are positive (11.21%). This pattern suggests that public discourse is largely informational or observational rather than strongly opinionated or evaluative. Neutral dominance typically reflects users sharing news, product information, or general discussions

without expressing strong emotional evaluations, which is consistent with early-stage or evolving sustainability narratives in digital environments [28].

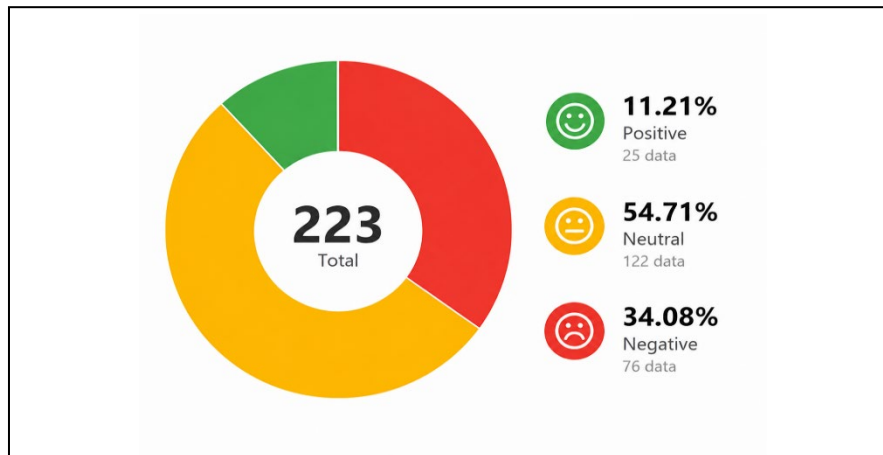


Fig. 3. Sentiment distribution of X (Twitter) discourse on sustainability and green marketing.

However, the relatively high proportion of negative sentiment (34.08%) signals the presence of skepticism, criticism or contested viewpoints within the discourse. This negativity may be associated with debates surrounding sustainability claims, accusations of greenwashing, or conflicting perceptions of plant-based and dairy products. Prior studies have highlighted that consumers are increasingly questioning the authenticity of environmental claims, particularly when brands fail to provide transparent and credible information [29], [30]. Thus, the negative sentiment observed here may reflect a critical audience that actively evaluates and challenges sustainability messages rather than passively accepting them.

In contrast, the relatively low level of positive sentiment (11.21%) suggests that while sustainability is a prominent topic, it has not yet translated into strong, favorable perceptions or advocacy in the Twitter ecosystem. This finding aligns with the well-documented attitude-behaviour gap, in which consumers express awareness of sustainability issues but do not necessarily demonstrate strong supportive attitudes or behaviours. These results suggest that sustainability communicators need to strengthen trust, authenticity, and value communication to convert neutral and sceptical audiences into positive sentiment and ultimately influence purchase intention [20].

3.3 Text Network Analysis

The network visualization reveals that the discourse is highly centralized around the keywords "marketing" and "green," which appear as dominant hubs in the interaction structure. These nodes exhibited a high degree of connectivity, indicating that they functioned as core anchors in sustainability conversations on X. The strong linkage between these terms suggests that sustainability discussions are primarily framed

through a marketing lens, emphasizing how environmental narratives are strategically communicated rather than being purely discussed as ecological issues. This aligns with prior research highlighting that sustainability has increasingly become a central component of branding and value propositions in digital marketing [31], [32].

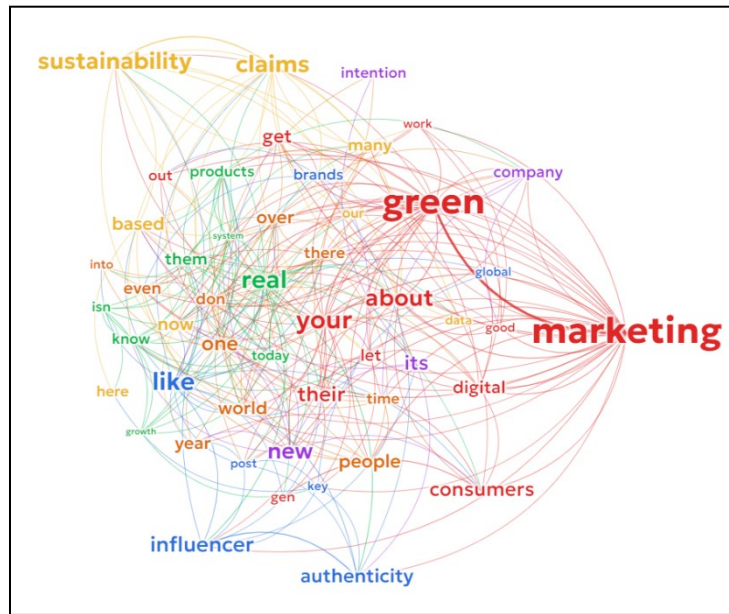


Fig. 4. Text network visualization of sustainability discourse.

In addition to the central nodes, the network highlights several intermediary concepts, such as "consumers," "digital," "brands," and "people," which act as bridges that connect different clusters. These nodes indicate that sustainability discourse is not isolated but is embedded within broader conversations about consumer engagement, digital platforms, and brand communication strategies. The presence of the terms "influencer" and "authenticity" as connected nodes further underscores the role of social actors in shaping and validating sustainability narratives. This finding is consistent with social influence theory, which posits that information diffusion in social networks is significantly influenced by key opinion leaders and trusted sources [33], [34].

Moreover, the network structure demonstrates a relatively dense and interconnected pattern, suggesting that sustainability discourse is multidimensional and involves overlapping themes such as "claims," "real," "products," and "intention." The clustering of these terms indicates ongoing negotiations between perceived authenticity and marketing claims, reflecting consumer skepticism toward green marketing. This pattern supports the growing body of literature on greenwashing and consumer criticality, in which audiences actively evaluate the credibility of sustainability messages rather than accept them at face value [35], [36]. Overall, the network illustrates a complex ecosystem in

which marketing, social influence, and consumer perception interact dynamically to shape sustainability discourse in digital spaces.

3.4 Social Network Analysis

Social network visualization revealed a highly centralized structure dominated by a few key actors, particularly @BarryESharp and @grok, which appeared as the most prominent nodes within the network. These accounts exhibit high connectivity, indicating a strong degree of centrality, and function as primary hubs in the dissemination of information. The central positioning of these actors suggests that they play a critical role in shaping the overall discourse, acting as focal points through which information flows to the peripheral users. This pattern is consistent with network theory, which states that a small number of influential nodes often control the majority of information diffusion within digital ecosystems [19].

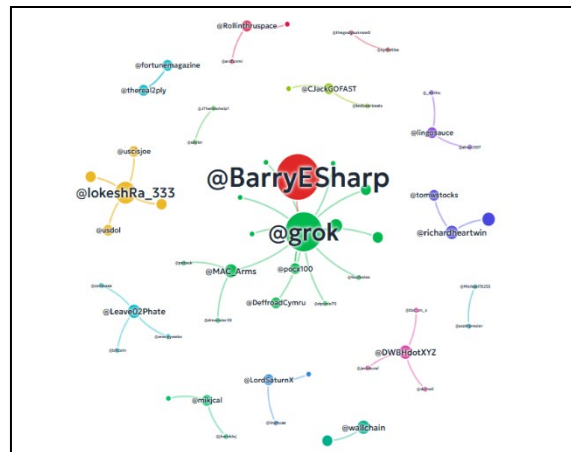


Fig. 5. Social Network Graph of Key Actors in Sustainability Discourse on X (Twitter)

Beyond the core hubs, the network also displays several smaller clusters surrounding secondary actors, such as @lokeshRa_333, @richardheartwin, and @JackGoFAST. These clusters indicate the presence of localized communities or sub-networks that engage in niche- or topic-specific discussions. The connections between these clusters and the central nodes suggest a hub-and-spoke structure in which peripheral communities rely on central influencers for information flow and its amplification. This reflects the role of opinion leaders in social networks, where information is often disseminated from central figures to broader audiences through intermediary nodes [37], [38]

Additionally, the network exhibits a relatively low overall density, with many peripheral nodes connected to central hubs but not strongly interconnected with each other. This indicates that while information dissemination is efficient through central actors, peer-to-peer interaction among general users remains limited. Such a structure

implies that sustainability and marketing discourse in this context is influence-driven rather than community-driven, in which key influencers significantly shape the narrative. From a marketing perspective, this highlights the strategic importance of engaging with high-centrality actors to maximise message reach and impact within digital platforms.

3.5 Trend Analysis

Trend analysis revealed a short-term but dynamic fluctuation in X (Twitter) conversation activity, characterized by an initial low-volume phase, followed by a gradual increase and a distinct peak before declining. During the early activity period, tweet volumes remained relatively modest and irregular, indicating that discourse was still in its emergent stage with limited engagement. This pattern is consistent with the early diffusion phases in digital communication, in which conversations are initiated by a small number of users before gaining broader attention [39]. The relatively low and unstable activity suggests that the topic has not yet achieved widespread visibility within the network.



Fig. 6. Trend Analysis of X (Twitter) Activity on Sustainability Discourse

As the timeline progresses, the data demonstrate a surging phase marked by an increasing tweet frequency and more stable interaction patterns, as reflected in the daily volume and moving average trends. This phase indicates growing user engagement and heightened attention toward the topic, potentially driven by external triggers, such as viral content, influencer participation, or emerging debates. The alignment between the rising daily tweet volume and the upward trajectory of the moving average suggests a sustained increase rather than random spikes, implying that the conversation was gaining momentum in the Twitter ecosystem. Such patterns are often associated with the

amplification effect of social networks, in which information diffusion accelerates through interconnected users and communities [40].

The analysis further identified a clear peak activity point, representing the highest level of engagement within the observation period, followed by a noticeable decline in tweet volume. This peak likely corresponds to a moment of intensified attention, such as a trending topic or a highly engaging post that triggered widespread interactions. However, the subsequent decline indicates that the discourse experienced a short-lived attention cycle in which interest diminished after saturation. This pattern aligns with the concept of ephemeral attention in social media, in which topics rapidly gain traction but are equally quick to fade as users' focus shifts to new content [39]. From a marketing perspective, this suggests that sustainability-related conversations in this dataset are event-driven and temporally concentrated, highlighting the importance of timely engagement strategies to capitalise on peak attention periods.

3.6 Emotion Analysis

Emotion analysis demonstrated a highly skewed distribution dominated by the "happy" sentiment (96.41%), with all other emotional categories, such as sadness (0.45%), fear (0.45%), love (0.45%), and anger (2.24%), representing only a marginal proportion of the total discourse. This overwhelming dominance suggests that the overall tone of Twitter conversations related to sustainability and green marketing is positive and optimistic. Such a pattern indicates that users tend to associate the topic with favourable perceptions, aligning with the growing acceptance of sustainability narratives as desirable and socially valued [41].



Fig. 7. Emotional Sentiment Distribution of X (Twitter) Discourse on Sustainability and Green Marketing.

Despite the dominance of positive emotions, the presence of minor negative emotions, particularly anger (2.24%), provides important insights into the underlying tensions within the discourse. This indicates that while the general sentiment is positive, a subset of users expresses dissatisfaction or criticism, potentially related to scepticism regarding sustainability claims or perceived greenwashing. Previous studies have highlighted that even within predominantly positive sustainability discussions, critical voices often emerge as consumers increasingly demand transparency and authenticity from brands [42], [43]. Therefore, although limited in scale, these negative emotional signals should not be overlooked, as they may reflect deeper concerns about credibility.

Furthermore, the near absence of emotions such as sadness, fear, and love suggests that the discourse is not emotionally diverse but rather concentrated around a single dominant affective response. This lack of emotional variation may indicate that the conversation is driven more by general approval and surface-level engagement rather than deep emotional involvement or polarised debate. From a marketing perspective, this presents both an opportunity and a challenge: while positive sentiment can enhance brand perception and engagement, the limited emotional depth may reduce long-term attachment and advocacy. Consequently, brands may need to craft more compelling and emotionally resonant narratives to foster stronger consumer connections and sustain engagement over time.

3.7 Zero-Shot Classification

The sentiment distribution demonstrates a strong dominance of positive sentiment (78.92%), indicating that most Twitter users express favourable perceptions of the topic under investigation. This suggests that sustainability and green marketing narratives, particularly in the context of plant-based versus dairy milk, are generally well received by online audiences. This pattern aligns with prior research indicating that sustainability-oriented messaging can enhance brand perception and consumer attitudes when it resonates with environmental and ethical values [44], [45]. The high proportion of positive sentiment reflects a supportive digital environment that may facilitate the diffusion of pro-sustainability messages in the future.



Fig. 8. Zero-Shot Sentiment Classification Distribution.

At the same time, the existence of neutral opinions (13.45%) means that a significant number of people discuss the issue more informatively or objectively without any evaluations. In other words, it is possible to assume that neutral opinions belong to those users who are at the information processing stage and are looking for information about sustainable claims, different products, and brands. From the marketer's point of view, this type of audience is extremely important for persuasion as these users can be more sensitive to the communication strategy.

Meanwhile, negative sentiment (7.62%), although relatively small, signals the presence of scepticism or critical perspectives in the conversation. This negativity may be associated with concerns regarding greenwashing, doubts regarding product authenticity, and resistance to changing consumption habits. Previous studies suggest that even limited negative sentiment can have disproportionate effects on brand trust if not addressed properly [29], [46]. Therefore, despite the overall positive tone, firms should not overlook these critical voices, as they provide valuable feedback for improving their communication strategies and reinforcing the authenticity of sustainability claims.

3.8 Reconciliation of Multi-Method Sentiment Findings

The seeming discrepancy between the relatively neutral sentiment distribution that characterizes the standard sentiment analysis (with 54.71% being neutral sentiments; see Figure 3) and the highly positive emotion classification that arises from the emotion analysis (with 96.41% classified as happy; see Figure 7) should not be considered a conflict between the two modes of analyses. This can be seen as a divergence in the two ways of analyzing affective communication.

Polarity-based sentiment analysis is an approach whereby the polarity of each tweet is determined through the identification or lack of linguistic evaluation markers (refer to Figure 3). When a tweet is labeled as "neutral," it means that there are no obvious

indicators for strong sentiments, whether negative or positive, rather than an indication of a neutral state of emotions. A considerable number of tweets that are information, description, or fact-driven concerning issues of sustainability may be neutral in polarity but positive in terms of emotional orientation.

In contrast, emotion analysis adopts an elaborate classification system for emotions based on the dominant emotion that emerges in the text, without regard to any polarity designation (Figure 7). The dominance of "happy" in the emotion categories indicates that when people feel emotional in their tweets in this dataset, their emotions are more often than not positive emotions, regardless of whether their tweet can be seen as objective or neutral. In line with psycholinguistic research findings, sentiment polarity and emotion category are two independent dimensions of linguistic data [47].

The zero-shot classification results (78.92% positive; refer to Figure 8 below) form a third analysis viewpoint by utilizing large language model inference for the implicit classification of stance or theme orientation in the tweet without using explicit sentiment indicators. The zero-shot classifier is able to detect positive orientations that are implied which may not be explicitly detected as such when using lexicons, hence the higher ratio of positive sentiments since the implied orientation is detected.

Combined, these three techniques offer a complementing analysis of sentiments in the dataset that consists of: (1) conventional analysis of sentiments to detect polarity explicitly (Figure 3), (2) analysis of emotions to identify affective states expressed by users if any can be detected (Figure 7), and (3) zero-shot classification to infer implicit stance or latent orientation (Figure 8). The combined application of these different approaches enhances the interpretation of the results and corresponds to modern tendencies towards multidimensional analysis of sentiments on social networks [21], [22].

3.9 Sentiment Index

The sentiment index analysis indicates that the overall X (Twitter) discourse is slightly positive, with an average sentiment index of approximately 0.07, suggesting a generally favourable but relatively moderate emotional tone. This implies that while users tend to express positive attitudes toward the topic, the intensity of positivity is not particularly strong in the comments. This pattern reflects a balanced evaluative environment, where positive perceptions exist but are not overwhelmingly dominant, aligning with prior findings that sustainability-related discussions often generate cautious optimism rather than extreme enthusiasm [41].



Fig. 9. Sentiment Index Trends of X (Twitter) Discourse on Sustainability and Green Marketing

The temporal trend further reveals fluctuating sentiment dynamics, characterised by alternating periods of mild positivity and slight negativity. The smoothed sentiment curve shows that the discourse does not follow a consistent upward or downward trajectory but exhibits short-term variations, indicating responsiveness to specific events or content triggers. The identification of negative spike events suggests moments when sentiment temporarily drops below the expected range, potentially reflecting critical reactions, controversial discussions, or scepticism toward specific claims. This observation supports the notion that digital conversations are highly sensitive to contextual stimuli and shaped by episodic information flows within social networks [48].

Additionally, the existence of distinct positive and negative peaks along with the peak volume period emphasizes the relationship between sentiment and engagement level. The occurrence of maximum negative sentiment within certain time frames reveals that there is a concentration of critical discussion but not an extended one, thus further confirming the notion of transient attention span in social media platforms. In terms of marketing practices, even though sentiment levels stay consistent throughout the period, companies should pay special attention to the anomaly periods as they could greatly affect public opinion. Thus, businesses must implement real-time sentiment analysis and effective communication tactics when discussing sustainability issues.

3.10 Discussion

The findings of this study provide a nuanced understanding of how sustainability discourse, influencer networks, and consumer sentiment interact within the digital ecosystem, particularly on Twitter. The dominance of neutral and positive sentiments,

combined with a relatively low but notable proportion of negative sentiments, suggests that sustainability-related conversations are generally well received but still subject to scrutiny. This aligns with the broader literature on digital marketing, which emphasises that sustainability communication is increasingly embedded in consumer evaluation processes, in which trust and authenticity play critical roles [49]. The results indicate that while consumers are open to sustainability narratives, they do not accept them uncritically, reflecting a more informed and selective audience.

From a network perspective, the analysis highlights the importance of central actors and influencer-driven structures in shaping the discourse. The presence of highly connected nodes acting as hubs confirms the relevance of social influence theory, in which key opinion leaders significantly influence the flow of information and sentiment within the network [50]. These actors not only amplify messages but also serve as gatekeepers of credibility, particularly in sustainability discussions. This finding reinforces the strategic importance of influencer authenticity, as consumers increasingly rely on trusted individuals rather than brands when interpreting sustainability claims [51]. Consequently, the effectiveness of green marketing communication is closely tied to the credibility and network positions of these influential actors.

Sentiment index analysis further reveals that while the overall tone of the discourse is slightly positive, it is characterised by fluctuations and occasional negative spikes. These spikes indicate moments of heightened critical engagement, potentially triggered by controversial content, misinformation, or scepticism about green marketing practices. This pattern supports the concept of episodic attention cycles, in which public interest and sentiment shift rapidly in response to specific events [43]. Importantly, these fluctuations suggest that sentiment in digital environments is dynamic rather than static, requiring continuous monitoring and adaptive communication strategies from firms.

Other notable implications drawn from the results are the lack of emotional diversity in terms of the high prevalence of positive emotions like “happiness” and the rare occurrence of any other emotional states. Although on the surface this seems good for the brand from an image perspective, it also means that there is little depth when it comes to emotions. As per consumer culture theory, the development of genuine relationships between consumers and their preferred brand is done via complicated emotions and not simply happiness [47], [52].

The final advantage of the combination of SNA and sentiment analysis in the current research relates to the methodological contribution made to marketing studies. Specifically, the joint consideration of the structure of network and dynamics of sentiments helps obtain a more holistic view of sustainability discourse formation and dissemination in the digital environment [21], [53]. In this respect, researchers and professionals will be able not only to assess consumers’ emotions but also learn how they propagate among people in a social network [22]. On a practical level, the results of the study demonstrate the necessity for data-driven marketing practices focused on influencers’ networks and changing sentiments [54], [55].

Another limitation relates to the validation of the sentiment classifier, which, as the platform-based classifier did not undergo independent validation through manual labeling using a corpus related specifically to sustainability, should be the focus of future

studies. Future research is encouraged to apply manually labelled datasets and cross-validation procedures to strengthen classification reliability.

4 Conclusion

The current analysis shows that the opinions of consumers concerning the sustainability of plant-based and dairy milks on Twitter are mostly neutral to slightly positive, which shows that the narrative is more of an informational one with rather positive views about this topic. Opinions on the matter are not evenly spread out but are clustered into certain interaction communities, which means that communication takes place under network conditions rather than in a random manner.

In addition, the study established that important players, specifically those with high connectivity such as influencers and central nodes, play an important part in spreading the discourse on sustainability. They act as opinion leaders who link between various user groups and help shape the way in which information flows and becomes visible. Due to their central position within the network, they are able to propagate positive as well as negative narratives and, therefore, have a significant impact on how sustainability discourse is perceived by other parties.

Regarding comparative dynamics, it can be observed that there are different patterns and configurations of sentiments and networks, which signify the existence of different sustainability framings in the two types of milk. Even though there is still a positive sentiment overall, the occurrence of negative spikes along with interaction clustering demonstrates that there are some contestations taking place among the participants regarding matters such as authenticity and sustainability.

Nevertheless, this study is not without limitations. The relatively small dataset of 223 posts and the absence of independent domain-specific validation of the sentiment classifier represent areas for methodological improvement. Future research is encouraged to employ larger, longitudinal datasets and to apply manually labelled corpora with cross-validation procedures to enhance the robustness and generalisability of findings across different sustainability discourse contexts.

Finally, the study demonstrates that Twitter-based sentiment patterns and network structures provide valuable complementary insights for evaluating the effectiveness of sustainability-driven marketing. By integrating sentiment analysis with social network metrics, firms can better understand consumer perceptions as well as how these perceptions spread and evolve over time. This approach enables more strategic decision-making in brand positioning and communication, particularly in the alternative protein industry, where trust, authenticity, and timely engagement are critical. Overall, the study underscores the importance of leveraging both sentiment intelligence and network analytics to enhance marketing performance and support sustainable business growth.

References

1. M. Rombach, L. Cong, and D. L. Dean, "Leave the Milk for the Calf and Spread the Word: Exploring Factors Determining US Consumers' Willingness to Try Plant-Based Milk Alternatives and Their Word-of-Mouth Sharing about Plant-Based Milk Alternatives," *Beverages*, vol. 10, no. 2, p. 27, 2024, doi: 10.3390/beverages10020027.
2. K. Arvidsson Segerkvist, H. Hansson, U. Sonesson, and S. Gunnarsson, "Research on Environmental, Economic, and Social Sustainability in Dairy Farming: A Systematic Mapping of Current Literature," *Sustainability*, vol. 12, no. 14, p. 5502, 2020, doi: 10.3390/su12145502.
3. R. Trudel, "Sustainable consumer behavior," *Consum. Psychol. Rev.*, vol. 2, no. 1, pp. 85–96, 2018, doi: 10.1002/arc.1045.
4. W. Li, "The Influence of Social Media Sentiment on Online Public Opinion in the Post-truth Era," *EHSS*, vol. 8, pp. 1015–1020, 2023, doi: 10.54097/ehss.v8i.4395.
5. F. Gaisbauer, A. Pournaki, S. Banisch, and E. Olbrich, "How Twitter affects the perception of public opinion: Two case studies," *arXiv*, 2020, doi: 10.13140/RG.2.2.32140.95363.
6. E. Pantano, S. Giglio, and C. Dennis, "Making sense of consumers' tweets," *Int. J. Retail Distrib. Manag.*, vol. 47, no. 9, pp. 915–927, 2018, doi: 10.1108/IJRD-07-2018-0127.
7. I. Hoppe and K. Kleinen-Von Königslöw, "This is Part of Everything that is Wrong with the World - A Comparative Analysis of Sustainability Framing in Social Media Discussions About Food in Five Countries," *Environ. Commun.*, vol. 17, no. 8, pp. 1020–1038, 2023, doi: 10.1080/17524032.2023.2212136.
8. S. El Mehdi and R. Benabdelouahed, "The Impact of Influencer Credibility on Consumer Behavior," in *Eurasia Conferences*, 2025, p. 22. doi: 10.62422/978-81-981590-7-6-010.
9. D. A. Nursansiwati, "The Impact of Social Media Influencers on Consumer Behavior," *PRODUCTIVITY*, vol. 1, no. 2, pp. 180–188, 2024, doi: 10.62207/rvbr948.
10. C. J. Bryant, "Plant-based animal product alternatives are healthier and more environmentally sustainable than animal products," *Futur. Foods*, vol. 6, p. 100174, 2022, doi: 10.1016/j.fufo.2022.100174.
11. A. Espinosa-Marron, "Environmental Impact of Animal-Based Food Production and the Feasibility of a Shift Toward Sustainable Plant-Based Diets in the United States," *Front. Sustain.*, vol. 3, 2022, doi: 10.3389/frsus.2022.841106.
12. O. Odhiambo Joseph, "Pro-Environmental Consumer Behavior: A Critical Review of Literature," *Int. J. Bus. Manag.*, vol. 15, no. 1, p. 1, 2019, doi: 10.5539/ijbm.v15n1p1.
13. L. Xiao and X. Yang, "Research on Public Opinion Sentiment Analysis Methods for Social Networks," in *IEEE*, 2024, pp. 733–737. doi: 10.1109/iciibms62405.2024.10792802.
14. I. Himelboim, M. A. Smith, L. Rainie, B. Shneiderman, and C. Espina, "Classifying Twitter Topic-Networks Using Social Network Analysis," *Soc. Media + Soc.*, vol. 3, no. 1, 2017, doi: 10.1177/2056305117691545.
15. L. Liu, "Green Consumerism: How Marketing Can Influence Sustainable Consumption," *J. Lifestyle SDGs Rev.*, vol. 5, no. 5, p. e06594, 2025, doi: 10.47172/2965-730x.sdgsreview.v5.n05.pe06594.
16. E. Dickson and N. Clay, "Eat up. Save Earth. Alternative proteins and the myth of inevitable sustainability," *J. Rural Stud.*, vol. 112, p. 103447, 2024, doi: 10.1016/j.jrurstud.2024.103447.
17. A. Hepp, "Katz/Lazarsfeld (1955): Personal Influence," in *Springer Fachmedien Wiesbaden*, 2018, pp. 293–296. doi: 10.1007/978-3-658-21742-6_67.
18. P. Yu, "Diffusion of Innovation theory," in *Implementation Science*, 2022, pp. 59–61. doi: 10.4324/9781003109945-16.
19. M. Gabielkov, A. Rao, and A. Legout, "Studying social networks at scale," in *Association for Computing Machinery*, 2014, pp. 277–288. doi: 10.1145/2591971.2591985.
20. V. S. Diwanji, A. F. Baines, F. Bauer, and K. Clark, "Green Consumerism: A Cross-Cultural Linguistic and Sentiment Analysis of Sustainable Consumption Discourse on Twitter (X)," *J.*

- Curr. Issues Res. Advert.*, vol. 45, no. 4, pp. 476–505, 2024, doi: 10.1080/10641734.2024.2318705.
21. G. A. Ruz, “Social media sentiment analysis,” *Encyclopedia*, vol. 4, no. 4, pp. 1–18, 2024, doi: 10.3390/encyclopedia4040104.
 22. X. T. D. Chau, “Simplifying sentiment analysis on social media: A step-by-step approach,” *Australas. Mark. J.*, vol. 32, no. 1, pp. 56–69, 2024, doi: 10.1177/14413582231217126.
 23. C. F. Musgrove, P. Choi, and K. C. Cox, “Consumer Perceptions of Green Marketing Claims: An Examination of the Relationships with Type of Claim and Credibility,” vol. 39, no. 4, 2016, pp. 971–976. doi: 10.1007/978-3-319-26647-3_206.
 24. E. Y. Kang and L. Atkinson, “Effects of message objectivity and focus on green CSR communication,” *J. Mark. Commun.*, vol. 27, no. 3, pp. 229–249, 2019, doi: 10.1080/13527266.2019.1640270.
 25. B. C. Azizoglu, “Influencer Marketing and Sustainability,” in *IGI Global Scientific*, 2025, pp. 73–110. doi: 10.4018/979-8-3373-1459-4.ch003.
 26. S. Mukherjee, A. Verma, and S. Neogi, “Influencer Marketing,” in *IGI Global*, 2024, pp. 198–216. doi: 10.4018/979-8-3693-3253-5.ch013.
 27. K. Anjorin, M. Raji, H. Olodo, and O. Oyeyemi, “The influence of consumer behavior on sustainable marketing efforts,” *Int. J. Manag. Entrep. Res.*, vol. 6, no. 5, pp. 1651–1676, 2024, doi: 10.51594/ijmer.v6i5.1128.
 28. J. Sipila, A. Tarkiainen, and J. Levanen, “Exploration of public discussion around sustainable consumption on social media,” *Resour. Conserv. Recycl.*, vol. 204, p. 107505, 2024, doi: 10.1016/j.resconrec.2024.107505.
 29. J.-C. Tu, Y. Cui, L. Liu, and C. Yang, “Perceived Greenwashing and Its Impact on the Green Image of Brands,” *Sustainability*, vol. 16, no. 20, p. 9009, 2024, doi: 10.3390/su16209009.
 30. L. A. Mohr, D. Eroglu, and P. S. Ellen, “The Development and Testing of a Measure of Skepticism Toward Environmental Claims in Marketers’ Communications,” *J. Consum. Aff.*, vol. 32, no. 1, pp. 30–55, 1998, doi: 10.1111/j.1745-6606.1998.tb00399.x.
 31. T. O. Wibowo, K. Syafuddin, and M. A. G. Elmada, “Twitter as Potential Medium for Organization: Constructing Green Messages on Twitter,” *JURKOM*, vol. 6, no. 1, pp. 44–57, 2023, doi: 10.38194/jurkom.v6i1.771.
 32. D. S. Dutta and P. Chowdhury, “Green Marketing and Social Media: A Contemporary Perspective,” *IBES*, vol. 7, no. 5, p. 95, 2025, doi: 10.22158/ibes.v7n5p95.
 33. L. Arantes, “Communicating sustainability: how brands can influence consumers’ purchasing decision,” in *Toplica Academy Of Applied Studies*, 2023, pp. 7–15. doi: 10.46793/icemit23.007a.
 34. Z. Zhang and Y. Qiao, “Social Media-Based Green Marketing: A Precision Communication Strategy for Sustainable Brand Building,” *BSQ*, vol. 1, no. 1, pp. 46–51, 2025, doi: 10.64229/z66wdz55.
 35. J. Keilmann and T. Koch, “Little green lies: greenwashing’s detrimental impact on corporate perception and the interplay of perceived motives, skepticism and authenticity,” *Corp. Commun. An Int. J.*, vol. 31, no. 2, pp. 1–18, 2025, doi: 10.1108/ccij-05-2025-0108.
 36. J. Jyoti and A. Singh, “A comprehensive analysis of emerging trends and consumer perceptions in green marketing,” *J. Mark. Evol.*, vol. 19, no. 3, 2025, doi: 10.70906/20251903001010.
 37. K. Hunt and M. Gruszczynski, “Horizontal Two-Step Flow: The Role of Opinion Leaders in Directing Attention to Social Movements in Decentralized Information Environments,” *Mass Commun. Soc.*, vol. 27, no. 2, pp. 230–253, 2023, doi: 10.1080/15205436.2023.2167663.
 38. S. Choi, “The Two-Step Flow of Communication in Twitter-Based Public Forums,” *Soc. Sci. Comput. Rev.*, vol. 33, no. 6, pp. 696–711, 2014, doi: 10.1177/0894439314556599.
 39. S. Asur, B. A. Huberman, G. Szabo, and C. Wang, “Trends in Social Media: Persistence and Decay,” *ICWSM*, vol. 5, no. 1, pp. 434–437, 2021, doi: 10.1609/icws.v5i1.14167.

40. G. Zhang, "Modeling the Contributions of Participator, Content, and Network to Topic Duration in Online Social Group," *IEEE Trans. Comput. Soc. Syst.*, vol. 11, no. 6, pp. 7146–7158, 2024, doi: 10.1109/tcss.2024.3414586.
41. K. Kularbphetong, P. Roonrakwit, and C. Boonseng, "Sentiment analysis of the awareness of environmental sustainability," vol. 8, no. 3, pp. 145–155, 2024, doi: 10.55214/25768484.v8i3.847.
42. A. M. J. Gutierrez, A. S. F. Chiu, and R. Seva, "A Proposed Framework on the Affective Design of Eco-Product Labels," *Sustainability*, vol. 12, no. 8, p. 3234, 2020, doi: 10.3390/su12083234.
43. M. Salimi, F. Tuscolano, O. Niininen, and O. Uusitalo, "The Role of Social Media in Exposing Greenwashing: Consumer Sentiments and Discussions," *Corp. Soc. Responsib. Environ. Manag.*, vol. 33, no. 2, pp. 2360–2383, 2025, doi: 10.1002/csr.70294.
44. K. White, R. Habib, and D. J. Hardisty, "How to SHIFT Consumer Behaviors to be More Sustainable: A Literature Review and Guiding Framework," *J. Mark.*, vol. 83, no. 3, pp. 22–49, 2019, doi: 10.1177/0022242919825649.
45. P. Kumar and M. J. Polonsky, "An analysis of consumer behaviour toward sustainable consumption," *J. Retail. Consum. Serv.*, vol. 46, pp. 177–189, 2019, doi: 10.1016/j.jretconser.2017.08.001.
46. N. A. M. Senan, "Unveiling the linkages between greenwashing, brand hate, and negative consumer behavior: the moderating effect of environmental concern," *Discov. Sustain.*, vol. 6, no. 1, 2025, doi: 10.1007/s43621-025-01179-9.
47. S. Aeron, "Emotion as cause, effect, mediator, and moderator in marketing: An integrative review and future research directions," *J. Consum. Behav.*, 2025, doi: 10.1002/cb.2430.
48. N. A. Diakopoulos and D. A. Shamma, "Characterizing debate performance via aggregated twitter sentiment," in *Association for Computing Machinery*, 2010, pp. 1195–1198. doi: 10.1145/1753326.1753504.
49. S. Singha, "Engaging Audiences," in *IGI Global*, 2024, pp. 79–91. doi: 10.4018/979-8-3693-3326-6.ch005.
50. R. S. Burt, "The Social Capital of Opinion Leaders," *Ann. Am. Acad. Pol. Soc. Sci.*, vol. 566, no. 1, pp. 37–54, 1999, doi: 10.1177/000271629956600104.
51. U. K. Selvi and D. J. Sabitha, "Impact on The Power of Eco-Conscious Influencers in Shaping Sustainable Brand Perception," *IJAES*, vol. 13, no. 2, pp. 363–368, 2026, doi: 10.14419/bq6b9s69.
52. C. Alvarez, M. E. David, and M. George, "Types of consumer–brand relationships: A systematic review and future research agenda," *J. Bus. Res.*, vol. 160, p. 113753, 2023, doi: 10.1016/j.jbusres.2023.113753.
53. N. Theocharis, "Mining and analysing online social networks: Studying the dynamics of digital peer support," *MethodsX*, vol. 10, p. 101985, 2023, doi: 10.1016/j.mex.2023.101985.
54. K. Sivarajah, "Exploration of public discussion around sustainable consumption on social media," *Resour. Conserv. Recycl.*, vol. 204, p. 107478, 2024, doi: 10.1016/j.resconrec.2024.107478.
55. J. R. Saura, D. Palacios-Marqués, and D. Ribeiro-Soriano, "Digital marketing in SMEs via data-driven strategies: Reviewing the current state of research," *J. Small Bus. Manag.*, vol. 61, no. 3, pp. 1278–1313, 2023, doi: 10.1080/00472778.2021.1955127.