

Digital Discourse on Bottled Drinking Water: A Social Network Analysis and NLP Approach

Maryam Kassem¹, Vanessa Ghafar², Asep Miftahuddin³

Faculty of Economics and Business Education, Universitas Pendidikan Indonesia, Indonesia

Author Email: Realmaryamkass@upi.edu¹, Vanessa@upi.edu²,
Asepmiftahuddin@upi.edu³

Abstract. This study aims to examine digital public discourse regarding bottled drinking water on X/Twitter using a multidimensional social media analytics approach. The data consisted of 714 public conversations collected through the SocialX platform during the observation period from January to May 2026. Several computational analytical techniques were employed, including sentiment analysis, emotion analysis, text network analysis (TNA), social network analysis (SNA), trend analysis, and zero-shot classification. The findings reveal that public conversations were predominantly characterized by neutral and positive orientations, indicating that bottled drinking water is generally perceived as a practical and widely accepted consumption product. Emotion analysis further demonstrates that “happy” was the dominant emotional category, reflecting routine and functional consumption experiences within digital discussions. Text network analysis identified several interconnected thematic clusters related to bottled drinking water consumption, pricing, packaging, environmental concerns, and microplastic issues. In addition, the social network structure showed moderately fragmented interaction patterns centered around several influential accounts rather than a fully centralized communication network. Trend analysis also indicated a continuous increase in discussion intensity throughout the observation period, suggesting growing public attention toward bottled drinking water and sustainability-related issues. Overall, this study provides a comprehensive understanding of digital discourse surrounding bottled drinking water and contributes to the literature on consumer communication, social media analytics, and sustainability discourse in online environments.

Keywords: Bottled drinking water; Natural Language Processing (NLP); Social Network Analysis (SNA); Social media analytics; Sustainability discourse

1 Introduction

In numerous areas across the globe, bottled drinking water has become a customary norm of daily living. There is an increasing correlation between the growing demand for bottled drinking water and the development of modern lifestyles, the increasing pace of consumer mobility, and the demand for functional solutions that aid everyday

hydration. The rapid development of urban lifestyles together with the gradual increase of consumer mobility and the changing patterns of consumer behavior have led a growing number of countries to rely on ready-to-consume packaged products [1], [2]. In today's world of consumption, bottled drinking water is more than a packaged hydration solution. Rather, it has become a component of the modern lifestyles of consumers that emphasizes hygiene, an enhanced standard of living, and convenience [3], [4]. The increased consumption of packaged drinking water has an almost unprecedented impact on the shifting boundaries of the market and the changing consumption behavior patterns.

Notwithstanding the convenience of bottled drinking water, it remains linked to ongoing environmental and sustainability problems. One of the impacts of bottled drinking water is the prevalence of single-use plastics, which increases environmental pollution and plastic waste in many countries [5], [6]. For this reason, the concerns of environmental accountability and the inadequacies of waste management and recycling have been brought to the forefront of public discourse regarding bottled drinking water products [7], [8]. The environmental accountability of consumers has been shown to influence the development of product packaging and the purchasing processes of consumers in research literature [9], [10]. In this context of sustainability, waste management and reduction, and eco-friendly packaging, responsible consumption and production have become the focus of consumer preferences [11], [12].

Simultaneously, consumer habits regarding the acquisition of information, and expressions of views, experiences, and feedback on products and brands have undergone changes due to the speedy progression of digital communication technologies. Social media have emerged as critical platforms where consumers discuss, in real time, the quality, pricing, packaging, and the use, and other related issues of products [13], [14]. As a result of this interaction, electronic word of mouth is becoming the most important variable that shapes the public's attitude and influences trust and perceptions of consumers in online environments [15], [16]. The debates on bottled drinking water are very pertinent as they relate to the issues of the balance between sustainability and affordability, packaging, and the waste it brings to normal day-to-day consumer activities.

The presence of extensive social media data permits researchers to analyze public discourse via computational methods. Techniques such as sentiment analysis, emotion analysis, Natural Language Processing (NLP), text mining, text network analysis (TNA), and social network analysis (SNA) enable the exploration of naturally occurring conversation that emerge within digital environments (Liu et al., 2025; Song et al., 2024). These methods allow researcher to identify dominant topics, semantic relationships, emotional tendencies, and interaction structures embedded in online discussions (Camacho et al., 2025; Feng et al., 2025). In addition, recent advices in artificial intelligent have and change the ability to classify large volumes of unstructured text data and uncover underlying patterns of public perception within social media conversation (Qi et al., 2025; Shen & Zhang, 2025).

Although studies on sustainability, green consumption, and consumer behavior have grown considerably, much of the existing literature continues to rely on survey-

based approaches and structured behavioral frameworks, including the Theory of Planned Behavior (Laheri et al., 2024). Previous studies have demonstrated that environmental knowledge, environmental concern, and sustainable purchasing intention are important determinants of responsible consumption (Al Mamun et al., 2025; Kotyza et al., 2024; Petrescu et al., 2025). In addition, more recent research highlights that social media engagement and green communication also play an important role in encouraging sustainability-oriented behavior and responsible consumption (Sun et al., 2022; Tian & Liu, 2022). However, these studies primarily explain sustainability from the perspective of individual behavioral intention, while relatively limited attention has been devoted to understanding how sustainability-related issues are naturally discussed and negotiated in digital communication environments. As consumers increasingly exchange opinions, environmental concerns, and consumption experiences through social media, computational analysis of naturally occurring online conversations offers complementary insights into sustainability discourse beyond those captured through conventional survey-based methods. Nevertheless, studies specifically examining bottled drinking water discourse using an integrated computational social media analytics perspective remain limited.

Recent studies also suggest that sustainability should not only be understood through individual purchasing decisions but also through communication processes that shape public understanding of environmentally responsible consumption. In digital environments, social media functions as a communication space where consumers exchange information, negotiate environmental concerns, and construct shared meanings regarding sustainable consumption. Therefore, this study interprets public discourse on bottled drinking water from the perspective of sustainability discourse, where conversations concerning packaging, plastic waste, environmental responsibility, and consumption practices collectively reflect broader sustainability-related concerns [36].

This gap is important because social media captures spontaneous public conversations that reflect how consumers discuss product quality, pricing, packaging, environmental responsibility, and everyday consumption experiences in real time. Unlike survey responses, these conversations emerge naturally through interactions among users, allowing sustainability-related concerns and responsible consumption practices to be expressed without predefined research instruments. Consequently, examining naturally occurring digital conversations provides a richer understanding of sustainability discourse as it evolves through public communication and social interaction.

This study adopts a computational social media analytics approach to investigate public discourse on bottled drinking water on the X/Twitter platform. Unlike previous studies that predominantly explain sustainability-related consumer behavior through structured survey-based approaches, this study analyzes naturally occurring public conversations to understand how environmental concerns, responsible consumption, and bottled drinking water are collectively discussed within digital environments. By integrating sentiment analysis, emotion analysis, text network analysis, social network analysis, trend analysis, and zero-shot classification into a single analytical framework, this study provides a comprehensive understanding of the semantic, emotional, relational, and temporal dimensions of bottled drinking water discourse. Accordingly,

this study contributes by extending sustainability-related research beyond individual behavioral intention toward the analysis of digitally emerging public discourse.

To steer the analysis, the subsequent research questions are presented:

1. RQ1. What are the representations of bottled drinking water in digital public discourse on X/Twitter?
2. RQ2. What are the primary themes and types of relationships that concern the semantics of discussing bottled drinking water?
3. RQ3. How are interaction patterns and influential actors structured within bottled drinking water communication networks?
4. RQ4. What do sentiment, emotional tendencies, and classification patterns reveal about public perception toward bottled drinking water?

2 Methodology

This study apply a quantitative approach Based on computational social media analytics to explore public discourse about bottled drinking water on X/Twitter. Instead of collecting data trough surveys the analysis focus on naturally occurring conversation generate by users within digital platforms. The growing use of computational social science has provided researchers with new opportunities to examine large volumes of online interactions and better understand on how public discussions emerge and involve across digital communication environments (Arvidsson et al., n.d.). At the same time, advances in data science Have straightened the capacity of social researchers to process and analyze unstructured social media data using computational, textual, network base analytical approaches (Arvidsson et al., n.d.).

To capture different dimensions of the discourse, this study integrated several complimentary analytical techniques, including Natural Language Processing (NLP), sentiment analysis, emotion analysis, text mining, text network analysis (TNA), and Social Network Analysis (SNA). The methods employed facilitate the analysis of conversations from various viewpoints. These methods include considering the contextual and emotional dimensions of the participants' textual exchanges and the interaction patterns among users. Techniques based on these methods may work for the analysis of online discussions because these discussions are dynamic and, to an extent, may be influenced by previous messages amongst the discussants. Prior studies provide some social media evidence that shows the profound influence of social media interactions on contact patterns, public engagement, and marketing interactions in the digital environment [30][31].



Fig. 1. Research Methodology Framework

Data were collected using the SocialX platform, a social listening and computational analytics platform designed to retrieve publicly available social media conversations. The observation period covered January to May 2026, resulting in 714 public X/Twitter conversations included in the final dataset. To improve retrieval consistency and minimize ambiguity, data collection employed English-language search keywords, namely "bottled water," "bottled drinking water," and "packaged drinking water." These keywords were selected because they directly represent the generic terminology most frequently used to describe bottled drinking water products across international online discussions.

Rather than relying on brand names or region-specific expressions, the study intentionally employed generic product-related keywords to maximize the retrieval of broad public discussions while reducing bias toward individual companies or localized terminology. English-language keywords were selected because they provide broader international coverage within X/Twitter and facilitate consistent retrieval across multilingual public conversations. Consequently, the dataset represents digitally emerging public discourse surrounding bottled drinking water rather than conversations associated with specific commercial brands.

Following data retrieval, duplicate posts, spam content, advertisements, hyperlinks, and conversations lacking substantive textual content were removed through the pre-processing procedures provided within the SocialX platform. After data screening and preprocessing, the final dataset consisted of 714 unique public conversations, which formed the basis of all subsequent analyses. The data set was considered sufficient to capture the diversity of discussion topics and interaction patterns relating to bottled drinking water for the length of the study. In the field of computational social media research, explanatory studies rely on diversity of themes, discourse and interaction, as opposed to purposeful generalizability [29]. Prior studies indicated that small to medium size social media data sets are sufficient for capturing behavioral communication and sentiment analysis, as well as the relationship structures that stem from the application of NLP and SNA frameworks [30, 32]. Therefore, the data set was appro-

priate for the application of sentiment analysis, text and network analysis, SNA, and the analysis of research trends.

The objective of this study was not statistical generalization toward the entire population of bottled drinking water consumers, but rather computational exploration of naturally occurring online discourse. Accordingly, dataset adequacy was evaluated based on thematic diversity, interaction richness, and discourse variation rather than sample representativeness alone. Previous computational social media studies similarly demonstrate that medium-sized social media datasets are appropriate for exploratory analyses using Natural Language Processing (NLP), Text Network Analysis (TNA), and Social Network Analysis (SNA).

Prior to reaching the analytical phase, the data set was screened for duplication, irrelevance, spamming, and conversations with a lack of substantial text. Several measures to enhance data quality and to ensure analytical consistency were subsequently applied. These measures consisted of the removal of hyperlinks, hashtags, usernames, and punctuation, along with other text elements that are not informative. Following this, text normalization and tokenization were performed, and noise within the data set was reduced and representations of the text were standardized, respectively. These steps of preprocessing are considered crucial in an NLP study because they enhance semantic consistency and boosts classification performance [33]. Also, preprocessing techniques that are frequently used in the classification of tweets based on their sentiments were adopted to facilitate text classification of the social media dataset based on its sentiments [34].

Sentiment analysis was conducted using the analytical pipeline embedded within the SocialX platform. According to the platform documentation, sentiment classification is implemented using a fine-tuned IndoBERT model hosted through HuggingFace. Each tweet was automatically classified into three sentiment categories (positive, neutral, and negative) based on the highest probability generated by the model. The platform also provides a confidence score for each prediction, allowing standardized sentiment classification across all observations.

Emotion analysis was performed using the built-in emotion classification model provided by the SocialX platform. Based on the platform documentation, the analytical pipeline utilizes the StevenLimcorn/indonesian-roberta-base-emotion-classifier model available through HuggingFace. The model assigns each conversation to the emotion category with the highest predicted probability and reports an associated confidence score. The resulting emotional categories include happy, sadness, anger, fear, and love, which were subsequently aggregated to identify overall emotional tendencies within the dataset.

Since both sentiment and emotion analyses were executed using the standardized analytical pipeline embedded within the SocialX platform, model retraining and parameter optimization were beyond the scope of this study. Nevertheless, the platform provides transparent documentation regarding the underlying transformer models and prediction confidence scores, enabling consistent and reproducible computational analysis across the collected dataset.

Different analytical techniques were used to examine discourse regarding the use of bottled drinking water from varied angles. A trend analysis was conducted to

identify the onset, increase, decrease, and cessation of interest and participation of the public in the discussions over the study period. Word cloud analysis was conducted to visualize the data and highlight keywords that appeared in the data spikes. Sentiment analysis was performed next to provide for the classification of discourse in the positive, natural, and negative to analyze the public sentiment of the bottled drinking water. Subsequently, the analysis of emotion was performed to reflect the emotional discourse in the conversations that was represented as happy, sad, angry, fearful and loving. The effectiveness of sentiment-based computational techniques to study the emotional discourse and the responsive public perception in the context of social media is well established in existing literature [30], [34].

To examine the patterns and clusters of discussion topics, we conducted a text network analysis (TNA) on the dataset and identified word co-occurrence patterns. This technique is useful to identify clusters and builds a semantic structure for digital conversations. Within the bottled drinking water discourse networks, social network analysis (SNA) was used to examine structures of communication, patterns of interaction and dominant actors. SNA has been popular to study relational structures, centrality of networks and communication flows within digital communities and online interactions [32]. Furthermore, to analyze the structural and connectivity patterns of communication networks, the principles of graph theory were used [35]. This analysis helped the study identify the structures and patterns of communication within the bottled drinking water discourse on X/Twitter.

Finally, to categorize the textual data in an NLP-focused manner without the need for labeled training datasets, zero-shot classification was implemented. This method was used to determine the higher-order classification of the perception orientations found in the discussions on bottled drinking water. Through the implementation of several methods, this research focused on public discourse on sustainability and analyzed behavioral and perceptual frameworks in social and digital contexts. This study adhered to the ethical requirements by analyzing data that are available in the public domain and by disclosing the results in a synthesized manner for scholarly purposes.

3 Results and Discussion

3.1 Data Overview

From January to May 2026, 714 public dialogues were collected from the X/Twitter dataset. The data collection was done using the search terms “bottled drinking water,” “bottled drinking water,” and “packaged drinking water.” The search terms’ diversity assisted in covering the scope of consumer dialogues on bottled drinking water. The diversity search terms employed facilitated the capture of dialogues on the consumer experience, product packaging, buying and sustainability concerns among others, even when the dialogues did not refer to the product directly.

The documented dialogues highlight the range of responses to bottled drinking water. They include responses to the pricing of bottled drinking water, concerns regarding the packaging of bottled drinking water, and the environmental consciousness of

the respondents, among other things. These conversations are a product of the various available online forums. The dataset helps fill the gap in the available public discourse by capturing the conversations focused on the product, as well as the comments on the sustainability of the product and the consumption habits of the respondents.

For those who study social media analytics from a computational stance, this dataset has enough variance to study communication and discourse surrounding bottled drinking water. In preliminary research within this field, emphasis is placed on the variety of themes, the types of discourses, and interactions over statistical generalization, which is often less significant [29]. Other studies have shown that small to medium social media datasets are sufficient for the analysis of sentiment, communication, and interaction frameworks through NLP and SNA [30], [32]. Therefore, the 714 conversations included in this study were deemed sufficient to perform analyses from a variety of dimensions including trends, sentiment, text networks, social networks, emotion, and zero-shot classification.

The distribution of discussion activity over time shows a gradual upward trend. During the observation period, the number of conversations related to bottled drinking water for January 2026 was around 80. The number of conversations for February grew to around 110 and for March, grew further to around 140. This increased level of engagement for the discussions indicates that the issue of bottled drinking water began to gain a presence and increased participation in the online discussion forums.

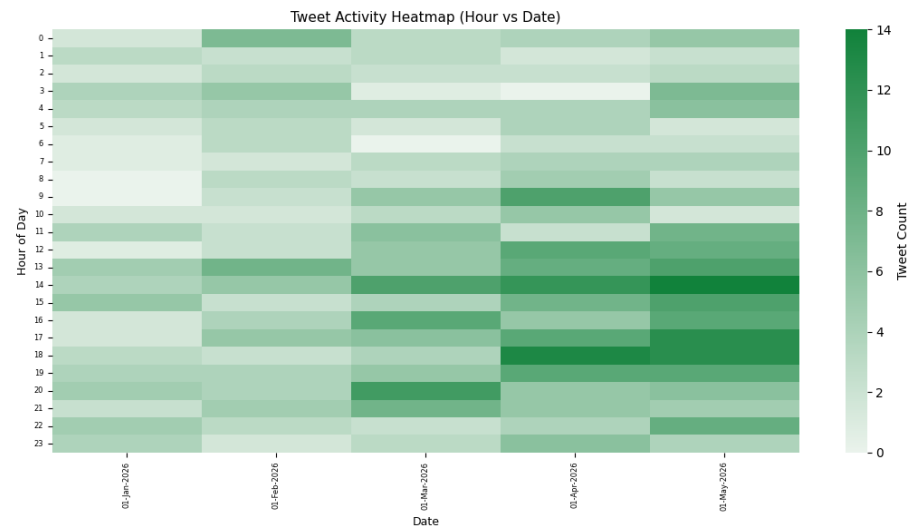


Fig. 2. Spread of X/Twitter conversations related to bottled drinking water over the study period

The total conversations increased most substantially in April 2026, reaching approximately 180 conversations. May 2026 marked the month with the most conversations, reaching approximately 204 conversations. This trend is also supported by the

active average trend shown in Figure 2. It indicates a steady increase throughout the period of observation, showing that this is not a short-term trend. This interest in public discussions relating to bottled drinking water is, in fact, a long-term trend.

A growing volume of conversations is likely linked to increasing interest in bottled drinking water and related topics including behavioral and environmental concerns, pricing, packaging, and sustainability. However, these data should be interpreted as patterns of communication, and not causalities. The dataset sufficiently captures the volume, extent, and temporal patterns of conversations, allowing for the analysis of public sentiments and digital communication regarding bottled water.

3.2 Word cloud Analysis

Bottled drinking water related public X/Twitter discussions were analyzed for term frequencies and used to create word clouds. During the observation period, the analysis was able to help categorize the textual data. The generated visualization shows larger terms as more frequent and more central to the discourse.

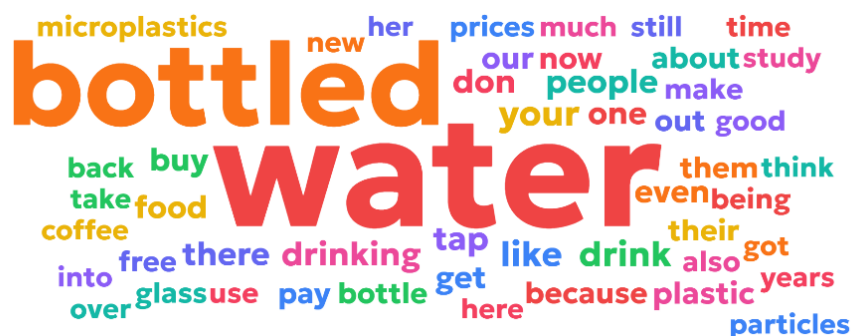


Fig. 3. Analysis using Word Clouds of Bottled Drinking Water Interactions on X/Twitter

As presented in Figure 3, the placement of the words "water" and "bottled" suggests that discussions focused largely on the consumption of bottled drinking water. The placement of these words indicates that, in the context of discussions held online, there is strong association with the needs of hydration, drinking behaviors, and water delivered in single use packaging.

Commonly discussed terms included "bottle," "buy," "drink," and "people." These terms illustrate a utilitarian and transactional quality within the context of the communicative interactions. Participants reported a variety of preferences regarding practices of consumption and purchase. The presence of these descriptors indicates that, within the communicative practice, bottled drinking water was both a standard, ubiquitous inclusion within the practices of everyday consumption and the notion of consumption as a specialized, infrequent practice.

Several other keywords were focused on the environment apart from those that were related to consumption, such as "microplastics." The addition of these terms

indicates that discussions regarding bottled drinking water are beginning to integrate with the environmental and health-related discussions. Moreover, the mention of microplastics shows and helps us understand that the concern over the environmental and health implications of plastic is beginning to capture the interest of the public.

Economic factors were also apparent in the use of the terms "prices," "pay," and "buy." These factors mean that issues of cost and purchasing power were present in public discussions. When it came to the supply of bottled drinking water, consumers thought about the service in terms of convenience, ease of access, and cost.

Synthesis of the word cloud reveals that public discussions regarding bottled drinking water are multifaceted. The primary themes are centered on the consumption of and the need for hydration. However, sustaining the environment, the state of personal and public health, and the economy are visible throughout the online discussions. The prominence of the terms sustainability further implies that the online discussions of bottled drinking water are connecting to larger discussions of the environment. This finding is consistent with previous research that has documented an increased coupling of consumer issues with sustainability online. From a management perspective, the findings demonstrate that companies marketing bottled drinking water should utilize sustained availability and environmentally responsible practices.

3.3 Sentiment Analysis

To understand public sentiment regarding bottled drinking water on X/Twitter, we conducted a sentiment analysis of 714 posts. The posts were classified as positive, neutral, or negative. This analysis captures a perspective on digitally constructed dialogues with respect to bottled drinking water.

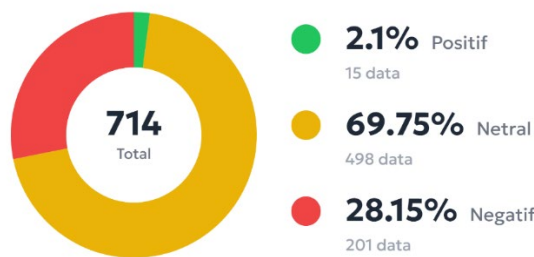


Fig. 4. Analysis of X/Twitter Discussion on Bottled Drinking Water

Fig. 4. In Figure 4, the distribution of sentiments reveals the largest datasets as neutral sentiments with 498 conversations (69.75%). Negative sentiments prevail in this group, encompassing two hundred one conversations (28.15%). Conversely, only fifteen conversations (2.10%) exhibit positive sentiments. The prevailing neutral sentiment indicates that the conversations pertaining to bottled drinking water were pri-

marily experiential and informational, focusing on the practice of daily consumption, and devoid of the emotional component.

Many of the conversations used bottled drinking water as an example to illustrate staying hydrated, making purchasing decisions, availability of products, and personal drinking habits. A lot of these conversations were descriptive so that they likely contributed to neutral sentiment being the prevailing category in the dataset. This trend mirrors the positioning of bottled drinking water as an ordinary consumer item that is referenced in everyday discussions and does not evoke strong sentiments.

While neutral sentiment prevailed, there was a substantial amount of negative sentiment. Critical comments discussed the environment, plastic, microplastics, cost, and other issues related to sustainability. The prevalence of these comments shows that the audience is beginning to notice the more extensive impacts of bottled drinking water on the environment. Some users connected drinking bottled drinking water to issues of sustainability and conscious consumption, instead of thinking about the functionality of the product.

Occurrences of positive sentiment in the data set were few and far between. The small percentage of positive sentiment may be attributed to the pragmatic perspective associated with the consumption of bottled drinking water. Instead of this form of water being perceived as something worthy of creating a positive serial emotional attachment, it may instead be associated with a utility. When instances of positive sentiment do appear in the data, they are most frequently attributed to the convenience and accessibility.

The combined distribution of sentiments illustrates that digital public discourse has mostly normalized the practice of consuming bottled drinking water. Sampled conversations centered on the everyday experience of consuming bottled water and sharing information on its use, however, including critical discussions on the environmental and economic issues related to bottled water. The findings are consistent with those of earlier studies, whereby utilitarian products, compared to products associated with lifestyle and hedonic consumption, have primarily neutral discourse in social media. The findings, therefore, suggest that in digital public discourse, the practice of consuming bottled water, beyond fulfilling everyday needs, is increasingly influenced by the concern for sustainability.

3.4 Text Network Analysis

To understand the framework of public discourse regarding the consumption of bottled drinking water, this study utilized Text Network Analysis (TNA) to examine the relationships of keywords found in conversation threads on X/Twitter. A network is formed from the patterns of word co-occurrence. In the network structure, the nodes represent keywords and the links represent the keywords that co-occurred the most. This method has proven useful to the extent that it can identify the main themes of discussions and at the same time can address how different concepts are related within the larger discourse.

The interpretation of thematic clusters was not based solely on keyword frequency. Instead, the text network was constructed from word co-occurrence relationships, and

the resulting clusters were interpreted by considering the semantic context of representative conversations associated with the co-occurring terms. Consequently, thematic labels such as pricing, packaging, sustainability, and microplastic concerns represent conceptually related discussion topics emerging from the public discourse rather than isolated high-frequency keywords.

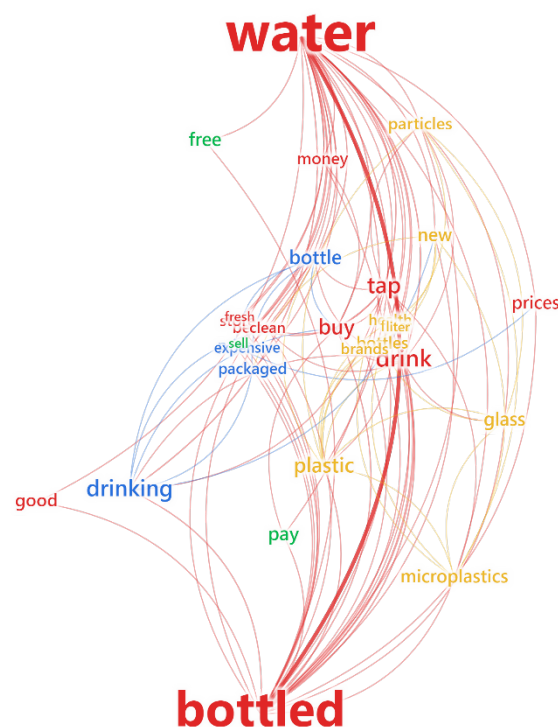


Fig. 5. Text network analysis of X/Twitter conversations related to bottled drinking water

According to Figure 5, water and bottled assumed the most significant position in the network. Both nodes were associated with many surrounding key nodes, influenced each other's position substantially, and were of high importance in organizing the discussion structure. Both nodes were of high importance since the discussion in X/Twitter was focused on the role of water/bottled water in daily hydration and consumption.

Several frequently co-occurring keywords, including drink, drinking, bottle, and buy, were clustered around the central nodes. Rather than indicating direct conceptual relationships, these co-occurrence patterns reflect terms that consistently appeared together across public conversations. By examining the contextual meaning of representative discussions associated with these terms, the cluster was interpreted as repre-

senting practical consumer-oriented discussions concerning bottled drinking water, including purchasing decisions, product use, and everyday consumption experiences. These findings indicate that routine consumption remains one of the dominant themes within online discussions.

Another prominent cluster consisted of the keywords plastic, microplastic, and glass. These terms frequently co-occurred within the same conversations and were interpreted by examining the contextual content of representative posts. The cluster primarily reflects discussions concerning packaging materials, environmental sustainability, and potential health implications associated with bottled drinking water. Accordingly, the environmental cluster indicates that public discourse extends beyond product consumption to include broader sustainability-related concerns.

Various elements related to economy were represented in the network with the use of the terms prices, money, and pay. Their presence indicates that consumers are likely to consider economic factors when they discuss drinking bottled water. Beyond the convenience and accessibility, users also consider the pricing and the value of the product, indicating the importance of the economic factor when thinking of consumer behavior.

The network overall shows that conversations around bottled water are mainly shaped by the factors of behavior regarding consumption, sustainability, and economics. Even though the main topics continued to be about product usage and hydration, issues concerning the environment and finances were given considerable space within the conversations. The findings are consistent with earlier research suggesting that online interactions often center around related subcommunities that have formed through joint efforts and the exchange of pertinent information [32]. With respect to bottled water, the majority of online discussions are integrating the traditional narratives about bottled water consumption with more expansive considerations of the environmental and health implications, along with the conscious consumerism. This demonstrates the intricate and multilayered nature of online discussions regarding bottled water.

3.5 Emotion Analysis

The subsequent segment regards the sentiment analysis undertaken to evaluate the emotional sentiment in public discussions regarding bottled drinking water on X/Twitter. Unlike sentiment analysis which categorize opinions as positive, natural, or negative, emotion analysis focuses on identifying specific emotional expression with the discussions. In this study, five emotions categorized were analyzed with happy, sadness, anger, fear, and love.

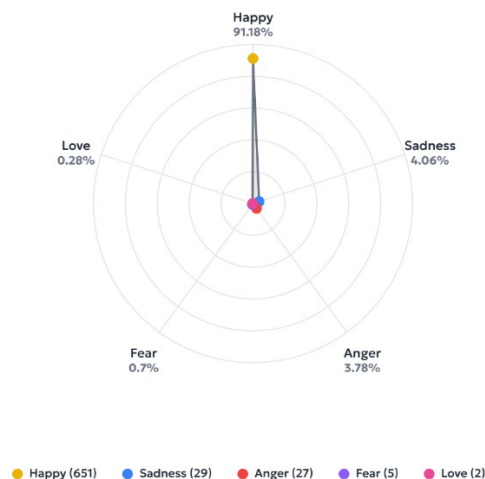


Fig. 6. Emotion Analysis of bottled drinking water conversations on X/Twitter

Figure 6 shows that the majority of conversation were classified under the happy category accounting for 651 conversation or (91.18%). This dominance shows that bottled drinking water was generally discuss and the context of every consumption or rather than controversial or emotionally sensitive issues. Many conversations refer to routine activities such as purchasing, drinking, and accessing bottled water, which may explain why positive emotional expressions appeared more frequently than other emotional categories.

The second largest category was sadness, representing 29 conversations which is (4.06%). Even the proportion was relatively small this discussion reflects concern related to environmental issues, plastic waste, microplastic contamination, as well other sustainability related topics. Sadness-related expressions suggest that some users linked bottled drinking water to various environmental issues and their possible outcomes.

Twenty-seven conversations (3.78%) were classified as anger. Compared to sadness, these conversations showed more intense disapproval and frustration. Discussions in this category were commonly associated with issues such as the lack of environmental responsibility, the use of unnecessary packaging, the unjust pricing of products, and the adverse effects associated with the consumption of bottled drinking water. Although this theme was not as prominent, the presence of anger indicated that this particular discourse was able to elicit stronger responses from the public regarding certain issues.

Fear and love appeared infrequently during analysis comprising 5 (0.28%) conversations, respectively. The miniscule percentage of fear suggests that discussing bottled drinking water does not evoke anxiety. Likewise, the small percentage of conversations where love was expressed suggests that consumers do not develop emotional

bonds with the brand of bottled drinking water, viewing it instead as a rational consumption choice.

Generally speaking, Emotional Distribution indicates that discussions regarding bottled drinking water are predominantly derived from the experience of using the product. The discussions predominantly describe the use of the product in everyday use and describe the product's environmental effects within the emotional response. These findings corroborate the results of the text network analysis, which illustrated the relationship of bottled drinking water to consumption and to packaged materials and to environmental issues, and to consumers. Considering the findings, the results show that in the digital discussion of bottled drinking water, product use and concern for sustainability are closely interrelated.

3.6 Social Network Analysis

The following analysis focuses on Social Network Analysis (SNA), which is a method used to assess user interactions within public postings on X/Twitter regarding bottled water. This network is based on mention interactions, with each account represented as a unique node, and connections reflecting communications between users. This form of social media interaction enables understanding of dominant users, behavior of users within a network, and the general pattern of communication associated with a discussion network.

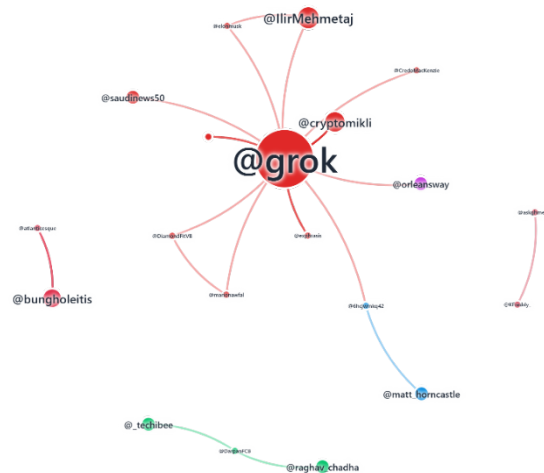


Fig. 7. Analysis of Drinking Water Marketing via Social Network Analysis

The interpretation of the communication network was supported by several network metrics generated by the SocialX platform. These included network density, modularity, number of connections, cluster distribution, degree centrality (represented by node size), betweenness centrality, and harmonic centrality. Collectively, these

metrics were used to describe the overall network structure, identify influential actors, and evaluate the extent to which conversations were interconnected or dispersed across multiple discussion groups.

Consistent with these network metrics, Figure 7 illustrates a communication network characterized by one dominant central actor connected to several smaller discussion communities. The network consisted of 319 connections, 131 clusters, a network density of 0.3%, and a modularity value of 0.95. The low network density indicates that only a small proportion of potential connections were formed among users, whereas the high modularity value suggests that conversations were organized into multiple relatively independent communities. Consequently, interactions were concentrated around several influential accounts rather than being evenly distributed across the entire network.

The central hub did not signal an integrated network. There were several smaller clusters beyond the central interactions. These clusters formed conversational communities with weak ties to the dominant network core. Three of these clusters are centered on @bungholeitis, @raghav_chadha, and @matt_horncastle. These clusters demonstrate that the discussions on bottled drinking water occurred in several different discussion locations rather than in a single unified community.

The presence of a central hub and several peripheral clusters showcases the ways users engage with the different levels of the network. Some users only engaged through the dominant central cluster, while others engaged in the smaller clusters that were more focused on particular and localized conversations. This is the dominant framework of social media platforms, where the distribution of information occurs simultaneously and across interconnected and loosely bounded networks.

From an influence perspective, information diffusion was characterized by a handful of highly visible actors that drew the most interactions. Engagement in online communications has similarly been shown to gravitate towards the most visible, active, and audience-rich users. In the meantime, the presence of several peripheral clusters indicates that the communication remained dispersed across several communities, not wholly reliant on one information source.

Based on these descriptors, the network is partially centralized, and moderately fragmented. While the more influential accounts, like @grok, were important for driving the interactions and information flows, smaller communication groups were also relevant to the overall communication flow. Complementary to discussions around the contents of engagement flows, the structure of the interactions captured in the current study aligns with previous work indicating that communication around bottled drinking water connects with discussions on consumption, environmental sustainability, and concerns. Similar network structures have also been described in computational social media research, indicating that the online communication phenomena emerge from the interactions among influential central nodes and distributed communities of active users [35]. These results show that both primary and secondary community members shape the messaging surrounding bottled drinking water. Therefore, the structure can be described as both centralized and fragmented.

3.7 Trend Analysis

The subsequent phase of the analysis focuses on trend analysis and explores the evolution of discussions on X/Twitter concerning biodegradable bottled water from January through May 2026. By observing differences in the levels of engagement over the months, this analysis captures the shift in the level of public interest towards this topic over the duration of the study.

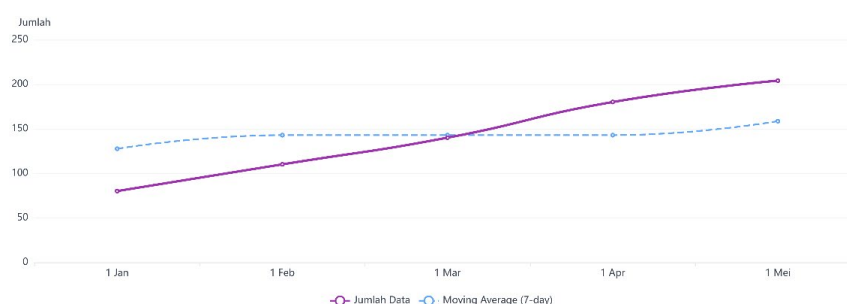


Fig. 8. Trend Analysis of X/Twitter Conversations About Bottled Drinking Water

As illustrated in Figure 8, conversation frequency increased continuously from January to May 2026. The increase in discussion from approximately 80 to more than 200 postings in January and May, respectively, signifies an overall increase in user participation. The moving average also takes an upward trend, indicating that this user participation increase was not due to a rapid increase in user participation over a short period. Rather, it was due to a consistent user participation increase.

An increase in the volume of discussions indicates that drinking bottled water became a more prominent discussion topic in online forums during the observed period. Many discussions dealt with issues of daily consumption and hydration, but some forum posts also dealt with the issues of packaging, sustainability, price and issues relating to the consumer. The introduction of these issues may have resulted in greater public participation in discussion forums in the following months.

Monthly activity levels fluctuated, yet the overall trend for the duration of the study remained positive.. Such fluctuation is common in social media environment where discussion intensity can change according to public interest, ongoing events, and the circulation information among users. Despite this variation, the continued growth and conversation volume suggests that interest in bottled drinking water remain active over several months rather than being concerted within a single time.

Even monthly activity levels had a lot of variations, The overall trend remained positive throughout the study period. Such fluctuations are common in social media environments, where discussion intensity can change according to public interest, ongoing events, and the circulation of information among users. Despite these variations, the continued growth and conversation volumes suggested that interest in bottle drinking water active over several months rather than being concentrated within a single period.

The increasing trend exhibited in this analysis corroborates with the outcome of the sentiment, emotion, and network analyses. As the number of discussions increases, conversations focus not just on the use and access of the products discussed, but also on many environmental and sustainability issues. What this shows is that there are many useable and practical consumption considerations, as well as many social and environmental concerns, and sustainability issues, that make the case for and justify the use of bottled drinking water.

Based on the evidence, the use of bottled drinking water was sustained and increased during the documented periods of digital public discourse. The uninterrupted increase in conversations in the public sphere on this topic is an indication of its sustained interest and public engagement, and is an example of why this type of analysis and research is useful and applicable for understanding the evolution of the dynamics of consumer interest and change in the nature of the discourse and public engagement.

Recent studies in the social media sphere that incorporate computation have documented the same type of time-related behavior [17]. In this case, the continuous increase in conversations and discussions indicates that progress and development of public discourse on the subject of bottled drinking water is relevant and timely. It also indicates that the nature of public discourse and consumer interest should be observed continuously, as it is subject to change.

3.8 Zero-Shot Classification

To analyze the discourse concerning bottled drinking water on X/Twitter, we uncovered larger trends pertaining to public perception through the application of zero-shot classification. Compared to conventional supervised classification, zero-shot classification offers the capability to classify text on the fly, without a training set consisting of bespoke label definitions. This makes the method particularly advantageous for the assessment of unstructured social media data. Using one of the transformer-based language models, the discourses were classified into three perception categories, namely, positive, neutral, and negative.

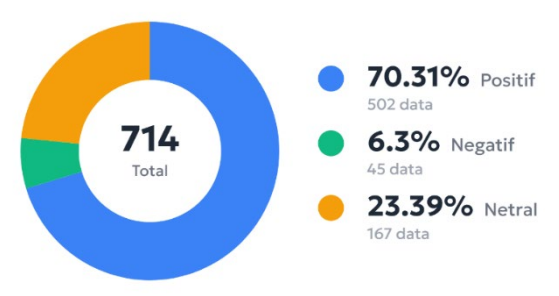


Fig. 9. Analysis of X/Twitter Bottled Drinking Water Conversations via Zero-Shot Classification

Based on the classification outcomes, positive perceptions comprised 502 conversations (70.31%), thus being the largest segment of the dataset. Unlike the sentiment analysis, which measures the emotional polarity expressed in individual posts, the zero-shot classification identifies broader perception categories based on semantic context. Therefore, the predominance of the positive category in the zero-shot classification should be interpreted as indicating an overall favorable semantic orientation toward bottled drinking water rather than a predominance of explicitly positive emotional sentiment..

Neutral perceptions accounted for 167 conversations (23.39%). These conversations tended to be either informational or descriptive. They referred to products, described consumption experiences, and reported observations of facts. The dominant presence of neutral classifications indicates that most consumers perceive bottled water as a standard and mediocre consumption practice. It is, therefore, unsurprising that most do not express strong opinions regarding bottled water.

Negative perceptions were expressed in 45 conversations (6.30%), representing the smallest category in the dataset. Although small, the conversations expressed perceptions that continue to form aspects of the dominant discourse. Concerns that were expressed in conversations with negative perceptions included sustainability, plastic waste, pricing and packaging, and microplastics. The persistence of these concerns demonstrates that, at a minimum, some consumers reflect on the environmental implications of bottled water when critiquing it in online conversations.

The classification pattern indicates that bottled drinking water is popularly accepted as a standard consumer good. The presence of both neutral and negative categories shows that the classification system is capable of communicating beyond notions of product utility. Throughout the classification, the presence of environmental and sustainability issues articulated a concern beyond the classification of bottled water. The findings of the classification reflect the sentiment and emotion analyses and the network analysis, as all these analyses reflect the interaction of consumption and the sustainability discourse. In a more general sense, the classification provided an opportunity to demonstrate that the public communication patterns and discourse orientations in large communication networks can be captured with the classification of NLP.

4 Conclusion

This study examined public discourse on X/Twitter regarding bottled water using an innovative, multidimensional, computational social media analysis framework. This combines NLP, sentiment analysis, emotion analysis, text network analysis, social network analysis, trend analysis, and zero-shot classification. Based on 714 public discussions collected between January and May 2026, this study examined the discourse around bottled water in contemporary digital communication channels.

Results showed that discourse surrounding bottled drinking water is shaped by practical consumption experiences and broader sustainability-related issues during the study period. Most discussions were characterized by neutral sentiment, indicating

that public conversations were predominantly informational and descriptive rather than explicitly favorable or unfavorable. Positive sentiment represented only a small proportion of the dataset, whereas negative sentiment primarily reflected concerns regarding environmental sustainability, plastic waste, pricing, and potential health issues associated with bottled drinking water. Participants mainly exchanged information and shared everyday consumption experiences, while sustainability-related concerns emerged as recurring topics within the broader digital discourse. Consistent with the emotion analysis, the dominant emotional category was happy, suggesting that bottled drinking water was generally discussed within the context of routine consumption rather than emotionally charged situations. Nevertheless, discussions also highlighted environmental responsibility, packaging, waste generation, and pricing, indicating that sustainability considerations increasingly accompany everyday conversations about bottled drinking water.

The themes that emerged from the text network analysis capture the multiple dimensions of the discourse. The sentiment of discussions was related to the consumption of water, and the interrelated themes of bottled and plastic water, microplastics, and consumption.

At the network level, communication demonstrated a decentralized structure whereby information flowed amongst numerous participants as opposed to being funneled through a single dominant participant. This indicates that the formation of discourse in digital environments is reliant on a multitude of participants and various ways of interacting.

The overall upward trend in conversation volume across the study period demonstrates a heightened interest by social media users in the topics surrounding the social and environmental issues of bottled water. Further to this, the zero-shot classification results indicate that the other social media users' comments and posts on the issue reflect a positive evaluation of bottled water. The other users the authors identified as participants in the discussions brought up issues of sustainability. These related issues reflect the limits of the authors' study and express the need for the integration of NLP and network approaches to study the structure and content of digital public discourse.

The authors of this study extend their findings in the field of digital social communication beyond the academic boundaries and address participants in the new digital economy, especially business, policy, and social sustainability communicative stakeholders. Social and environmental issues of bottled water shape public discourse. The findings of this study may inform how stakeholders in the economy and social sustainability communicators may align their strategies to respond to what the authors identify as the evolving public demands and preferences.

Several constraints must be considered in light of the findings. First, the research focused on only X/Twitter, and therefore may not account for everything happening on other social media platforms. Second, the focus was restricted to the period of January to May 2026, which limits the findings to an even shorter period of public discourse. Future research may include cross-platform data, extended periods of observation, and increased volumes of social media data. The integration of more advanced machine learning techniques may also provide additional insights into the

evolution of sustainability-related consumer discourse and communication dynamics within digital environments.

References

1. R. Husain, A. Ahmad, and B. M. Khan, "The impact of brand equity, status consumption, and brand trust on purchase intention of luxury brands," *Cogent Business and Management*, vol. 9, no. 1, 2022, doi: 10.1080/23311975.2022.2034234.
2. G. Aydin, "Thresholds of Sustainability: Necessary and Sufficient Conditions for Green Buying behavior," *Sustainability (Switzerland)*, vol. 17, no. 11, Jun. 2025, doi: 10.3390/su17114965.
3. C. Chen, D. Li, J. Qian, and Z. Li, "The Impact of Green Purchase Intention on Compensatory Consumption: The Regulatory Role of Pro-Environmental Behavior," *Sustainability (Switzerland)*, vol. 16, no. 18, Sep. 2024, doi: 10.3390/su16188183.
4. M. Simanjuntak, N. L. Nafila, L. N. Yuliati, I. R. Johan, M. Najib, and M. F. Sabri, "Environmental Care Attitudes and Intention to Purchase Green Products: Impact of Environmental Knowledge, Word of Mouth, and Green Marketing," *Sustainability (Switzerland)*, vol. 15, no. 6, Mar. 2023, doi: 10.3390/su15065445.
5. Cindy Mutia Annur, "Inilah Negara Penghasil Sampah Terbesar Dunia, Ada Indonesia?," *Databoks*, Jakarta, Jul. 05, 2023. Accessed: May 16, 2026. [Online]. Available: <https://databoks.katadata.co.id/infografik/2023/07/05/inilah-negara-penghasil-sampah-terbesar-dunia-ada-indonesia>
6. Gamma Shafina, "10 Besar negara dengan buangan sampah plastik ke laut terbanyak pada 2021," *GoodStats*, Aug. 2023, Accessed: Aug. 09, 2026. [Online]. Available: <https://data.goodstats.id/statistic/indonesia-masuk-10-besar-negara-dengan-buangan-sampah-plastik-ke-laut-terbanyak-pada-2021-Wz1MV>
7. Robin Hicks, "B Corp-certified bottled water brand Aqua tops audit of Indonesia's biggest plastic polluters," *Eco-Business*. Accessed: Feb. 20, 2026. [Online]. Available: <https://www.eco-business.com/news/b-corp-certified-bottled-water-brand-aqua-tops-audit-of-indonesias-biggest-plastic-polluters/>
8. S. Rahman *et al.*, "Prevalence and health risks of microplastics in bottled water and beverages: A food safety concern," *Journal of Hazardous Materials: Plastics*, vol. 2, p. 100024, Feb. 2026, doi: 10.1016/j.hazmp.2025.100024.
9. P. S. Borah, C. S. K. Dogbe, and N. Marwa, "Generation Z's green purchase behavior: Do green consumer knowledge, consumer social responsibility, green advertising, and green consumer trust matter for sustainable development?," *Bus. Strategy Environ.*, vol. 33, no. 5, pp. 4530–4546, Jul. 2024, doi: 10.1002/bse.3714.
10. M. Cui, Y. Li, and S. Wang, "Environmental Knowledge and Green Purchase Intention and Behavior in China: The Mediating Role of Moral Obligation," *Sustainability (Switzerland)*, vol. 16, no. 14, Jul. 2024, doi: 10.3390/su16146263.
11. F. De Canio, E. Martinelli, and E. Endrighi, "Enhancing consumers' pro-environmental purchase intentions: the moderating role of environmental concern," *International Journal of Retail and Distribution Management*, vol. 49, no. 9, pp. 1312–1329, 2020, doi: 10.1108/IJRDM-08-2020-0301.
12. Y. Gulzar, N. Eksili, K. Koksai, P. Celik Caylak, M. S. Mir, and A. B. Soomro, "Who Is Buying Green Products? The Roles of Sustainability Consciousness, Environmental Attitude, and Ecotourism Experience in Green Purchasing Intention at Tourism Destinations," *Sustainability (Switzerland)*, vol. 16, no. 18, Sep. 2024, doi: 10.3390/su16187875.

13. E. Iliopoulou, E. Koronaki, A. Vlachvei, and O. Notta, "From Knowledge to Action: The Power of Green Communication and Social Media Engagement in Sustainable Food Consumption," *Sustainability (Switzerland)*, vol. 16, no. 21, Nov. 2024, doi: 10.3390/su16219202.
14. Z. Yu, S. Rosbi, and M. H. Amlus, "Mechanisms of Media Persuasion and Positive Internet Word-of-Mouth Driving Green Purchasing Behavior: Evidence from China," *Sustainability (Switzerland)*, vol. 16, no. 15, Aug. 2024, doi: 10.3390/su16156521.
15. A. I. Gunawan, R. Hurriyati, L. A. Wibowo, and H. Monoarfa, "Consumers in responsible consumption: what leads to sustainable behavior?," *Urbanization, Sustainability and Society*, vol. 2, no. 1, pp. 259–283, Dec. 2025, doi: <https://doi.org/10.1108/uss-09-2024-0056>.
16. D. Naaman, F. Yeşilada, and I. Aghaei, "A Moderated Mediation Analysis of Lebanon's Food Consumers' Green Purchasing Intentions: A Path Towards Sustainability," *Sustainability (Switzerland)*, vol. 17, no. 4, Feb. 2025, doi: 10.3390/su17041714.
17. X. Liu, T. H. Kim, and M. J. Lee, "The Impact of Green Perceived Value Through Green New Products on Purchase Intention: Brand Attitudes, Brand Trust, and Digital Customer Engagement," *Sustainability (Switzerland)*, vol. 17, no. 9, May 2025, doi: 10.3390/su17094106.
18. Z. Song, M. Hu, M. Leng, and S. Zhu, "Exploring the Effects of Low-Carbon Labels on Purchase Intentions for Green Agricultural Products," *Sustainability (Switzerland)*, vol. 16, no. 17, Sep. 2024, doi: 10.3390/su16177313.
19. L. J. Camacho, M. Banks, S. Sookhai, and E. Concepción, "Redimensioning the theory of planned behavior on workplace energy saving intention The mediating role of environmental knowledge and organizational culture.," *Sustainability (Switzerland)*, Apr. 2025, doi: <https://doi.org/10.3390/su17083574>.
20. Y. Feng, Y. Feng, and Z. Liu, "The Impact Mechanism of Government Environmental Regulation and Green Consumer Orientation (GCO) on Green Purchase Intention: A Case Study of Zespri," *Sustainability (Switzerland)*, vol. 17, no. 6, Mar. 2025, doi: 10.3390/su17062575.
21. S. Qi, M. Niu, and Z. Guan, "Promoting Pro-Environmental Behavior Among University Students Through Sustainability Education and Institutional Support: A Mediated Moderation Model," *Sustainability (Switzerland)*, vol. 17, no. 22, Nov. 2025, doi: 10.3390/su172210069.
22. J. Shen and H. Zhang, "From Values to Policy Understanding: Linking Pro-Environmental Worldviews, Self-Efficacy, and Climate Risk Perceptions to Sustainability Policy in China," *Sustainability (Switzerland)*, vol. 17, no. 22, Nov. 2025, doi: 10.3390/su172210002.
23. V. K. Laheri, W. M. Lim, P. K. Arya, and S. Kumar, "A multidimensional lens of environmental consciousness: towards an environmentally conscious theory of planned behavior," *Journal of Consumer Marketing*, vol. 41, no. 3, pp. 281–297, Apr. 2024, doi: 10.1108/JCM-03-2023-5875.
24. A. Al Mamun, M. Yang, N. Hayat, J. Gao, and Q. Yang, "The nexus of environmental values, beliefs, norms and green consumption intention," *Humanit. Soc. Sci. Commun.*, vol. 12, no. 1, Dec. 2025, doi: 10.1057/s41599-025-04979-6.
25. P. Kotyza *et al.*, "The predictive power of environmental concern, perceived behavioral control and social norms in shaping pro-environmental intentions: a multicountry study," *Front. Ecol. Evol.*, vol. 12, 2024, doi: 10.3389/fevo.2024.1289139.
26. M. Petrescu, I. Oncioiu, M. H. Hojda, D. A. Mândricel, and M. C. Uzlău, "Dual-Process Neurocognitive Pathways Bridging the Intention–Behaviour Gap in Sustainable Consumer Decisions," *Sustainability (Switzerland)*, vol. 17, no. 22, Nov. 2025, doi: 10.3390/su172210141.

27. X. Sun, Z. Tian, J. Wang, and W. Su, "The Impact of Environmental Commitment on Green Purchase Behavior in China," *Int. J. Environ. Res. Public Health*, vol. 19, no. 14, Jul. 2022, doi: 10.3390/ijerph19148644.
28. H. Tian and X. Liu, "Pro-Environmental Behavior Research: Theoretical Progress and Future Directions," Jun. 01, 2022, *MDPI*. doi: 10.3390/ijerph19116721.
29. M. Arvidsson, P. Hedström, B. F. Jarvis, and M. Keuschnigg, "On the Intersection of Analytical Sociology and Computational Social Science."
30. H. Liu, M. F. S. D. C. B. M. F. De Costa, M. A. Imran Bin Yasin, and Q. Ruan, "A study on how social media influences on impulsive buying," *Expert Syst.*, vol. 42, no. 1, Jan. 2025, doi: 10.1111/exsy.13448.
31. N. L. P. E. Mertaningrum, I. G. A. K. Giantari, N. W. Ekawati, and P. Y. Setiawan, "Price discount, influencer and impulsive buying: When emotions overpower logic on social media," *Edelweiss Applied Science and Technology*, vol. 9, no. 7, pp. 1960–1971, Jul. 2025, doi: 10.55214/2576-8484.v9i7.9058.
32. W. A. Jasim, R. A. Hussein, B. M. Basheer, H. A. A. Algashamy, and O. Turovsky, "Advanced Network Analysis Techniques for Social Media Study: Unveiling Patterns and Influences in Digital Communities," *Journal of Ecohumanism*, vol. 3, no. 5, pp. 353–364, Jun. 2024, doi: 10.62754/joe.v3i5.3911.
33. P. K. K. G. Arpita, "Preprocessing Steps for Opinion Mining on Tweets. In Proceedings of International Conference on Artificial Intelligence and Applications ,” *Springer Singapore*, pp. 333–444, Nov. 2020.
34. Shatakshi Brijpuriya and M. Rajalakshmi, "Deployment of Sentiment Analysis of Tweets Using Various Classifiers. In Artificial Intelligence and Evolutionary Computations in Engineering Systems,” *Springer Nature Singapore*, pp. 167–178, Apr. 2022.
35. Mamatha N, Sunitha S.S, and Shivakumar M D, "Graph theory and its role in social network analysis,” *World Journal of Advanced Research and Reviews*, vol. 21, no. 2, pp. 2088–2093, Feb. 2024, doi: 10.30574/wjarr.2024.21.2.0249.
36. Rosário, A. T., and J. C. Dias, "The Role of Digital Marketing in Shaping Sustainable Consumption: Insights from a Systematic Literature Review," *Sustainability*, vol. 17, no. 17, Art. 7784, 2025. <https://doi.org/10.3390/su17177784>.