The Eurasia Proceedings of Science, Technology, Engineering & Mathematics (EPSTEM)
ISSN: 2602-3199

The Eurasia Proceedings of Science, Technology, Engineering & Mathematics (EPSTEM), 2023

Volume 23, Pages 253-261

ICRETS 2023: International Conference on Research in Engineering, Technology and Science

Embracing Green Choices: Sentiment Analysis of Sustainable Consumption

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Abstract: Currently, resource scarcity and climate change are among the main global problems. Governments are actively seeking regenerative solutions so that humans and nature can co-exist in harmony in the face of ecological destruction and resource limitations. One of these solutions is green consumption. Making greener consumption decisions is necessary for society to become sustainable. If sustainable consumption is to be promoted, public perception must shift, and achieving this shift will be simpler if society's shift toward green consumption is understood. This research aims to explore the sentiment and attitudes towards sustainable consumption on YouTube, a popular online platform with a vast pool of user-generated content. We employ a combination of data mining techniques and sentiment analysis to process and analyze a large dataset of YouTube videos and comments related to sustainable consumption topics. The data collection includes videos from various categories, such as reviews of eco-friendly products, vlogs of sustainable living, and informative content on environmentally responsible practices. The study focusses on understanding user engagement, sentiment polarity, and the factors influencing positive or negative attitudes toward sustainable consumption. In this way, the attitude of society toward green consumption and the role of social networks in public opinion can be understood. Overall, the study shows how data mining techniques and social networks have the potential to help with the shift to more sustainable growth paths.

Keywords: Sustainability, Green consumption, Sentiment analysis, Data mining, Social media

Introduction

Individuals and businesses are seeking ways to adopt eco-friendly practices and make greener choices with growing awareness about the impact of human activities on the planet. The shift towards sustainable consumption is driven by both ethical considerations and by the realization that our consumption patterns can directly contribute to environmental degradation or restoration. That is, the shift towards sustainable consumption is happening because we now understand more clearly how our actions affect the well-being of the planet. We humans can now see the harmful consequences of unsustainable practices like using too many resources, causing pollution, cutting down forests, and emitting greenhouse gases. As people become more aware of the impact of their daily choices on the environment, they are reconsidering their consumption habits and actively looking for more environmentally friendly options.

Ethics are playing a crucial part in encouraging the transition towards sustainable consumption (Tomsa et al., 2021; Suphasomboon & Vassanadumrongdee, 2022). Increasingly, individuals are recognizing the moral responsibility to safeguard and maintain the environment for the well-being of future generations. We have come to understand that our current consumption patterns are causing significant harm. We are depleting finite resources, putting biodiversity at risk, and worsening climate change. This realization has sparked a strong sense of responsibility to act and minimize harm while promoting environmental stewardship. Additionally, we now recognize that our choices as consumers directly impact the environment, which has created a pressing need to adopt sustainable practices. We feel an urgent drive to embrace eco-friendly alternatives and contribute to the restoration of our planet. By choosing environmentally friendly products, minimizing waste, and endorsing sustainable production methods, both individuals and organizations can play an active role in promoting positive environmental outcomes. This understanding empowers consumers to make well-informed decisions that align with their values and actively engage in the collective endeavor to tackle urgent environmental issues.

The shift towards sustainable consumption goes beyond individual efforts and also encompasses organizations in different sectors (Kong et al., 2002; Hobson, 2004; Charter et al., 2017; Bocken, 2017). Businesses are recognizing the importance of sustainable practices in ensuring their long-term success and competitiveness. Consumers are increasingly showing a strong inclination towards environmentally responsible products and services, prompting companies to incorporate sustainability into their fundamental strategies. This acknowledgement of the business value of sustainability further propels the adoption of greener alternatives, as organizations grasp the advantages of aligning their operations with environmental and social considerations. In summary it can be said that the shift towards sustainable consumption is driven by both ethical concerns and the recognition that our consumption choices directly affect the environment. With the awareness of the interconnectedness between our actions and the planet's well-being, individuals and organizations should be encouraged to actively seek environmentally friendly alternatives and adopt greener choices. By encouraging sustainable consumption, we can work together towards a better connection between human actions and the Earth, creating a more sustainable and resilient future.

The purpose of this research is to examine the sentiments and attitudes surrounding sustainable consumption on YouTube, utilizing data mining techniques and sentiment analysis. By analyzing a vast dataset comprising YouTube videos and comments related to sustainable consumption, including various categories like eco-friendly product reviews, sustainable living vlogs, and informative content promoting responsible practices, the study aims to gain valuable insights into user engagement, sentiment polarity, and the factors influencing positive or negative perspectives towards sustainable consumption. Through understanding societal attitudes towards green consumption and recognizing the impact of social networks on shaping public opinion, this research contributes to our knowledge of how data mining techniques and social networks can facilitate the transition to more sustainable growth paths.

Literature Review

Most of the literature-based study on sustainability has used a group of participants and questionnaires on various aspects. Biswas (2016) conducted a study with the technology acceptance model theory to evaluate the effect of social media use on green consumption. In his study, data was collected through a questionnaire survey and for analysis binary logistic regression analysis, one-way MANOVA and factor analysis were used. As a result of the study, it has been observed that social media has a positive effect on consumer green choice behavior.

Hui and Khan (2021) while investigating the effect of social exclusion on green consumption intention, with data collected through online surveys, expanded the theory of planned behavior (TPB) by taking green self-identity into account. Structural equation modeling (SEM) technique was used to test the model presented in the study.

Wang (2021) collected data with a questionnaire survey consisting of 3 main parts, to investigate the effect of consumers' green cognition on green consumption behavior. Those 3 main parts consisted of the participant’s green consumption behavior in everyday life, level of green cognition and personal information such as the age, gender, occupation and monthly disposable income. 110 valid questionnaires were collected from the surveys. The study's findings indicate that consumer understanding of green consumption and their perspectives on environmental issues are key to helping consumers become aware of green consumption and adopt green behaviors.

Sarac (2022) conducted a study on the sustainable consumption levels of gender and cultural tourists. In his study, he used data collected from questionnaires answered by 449 participants. As a result, it has been observed that the level of sustainable consumption varies according to gender. The results were also gathered under four dimensions as "environmental awareness, non-need purchasing, savings and reusability" according to the answers given by cultural tourists who have high sustainable consumption levels.

There are different market segmentation approaches such as demographic segmentation approach, which groups the market with demographic information including consumer's age, gender, race, religion, education and so on; psychographic segmentation, which groups the market with information like consumer's personal qualities, beliefs, behaviors, expectations and similar, and behavioral segmentation, which groups according to consumer's real behavior, reaction to the product and the use (Huseynov & Yıldırım, 2019).

Bedard and Tolmie (2018) found a positive correlation between social media and online interpersonal influence on green purchasing intentions in the millennial generation. In addition, it has been revealed that individuality has no effect on green purchasing, but masculinity weakens the relationship.

Although there are green consumption studies using machine learning with the development of technology, the numbers are not very high. Jain et al. (2020) developed a framework to describe the elements of green purchase intentions and social media usage, interpersonal influence and E-WOM used as exogenous variables in the research. As a result, it has been seen that the biggest factor on purchasing is social media.

Tang et al. (2020) developed a model to determine the green consumption behaviors and prominent features of college students. The estimation method is based on the one of the simplest classification approaches K-Nearest Neighbor (KNN) model with OBLFA_GWO, a swarm intelligence method. The data were collected through 2020 questionnaires distributed to 9 different universities.

Materials and Methods

This section outlines the integrated framework employed for data collection, data cleaning/preprocessing, and text mining approaches for analysis. The schematic framework shown in Figure 1 illustrates the methodological architecture. The first stage involved is data acquisition. For this study, YouTube was selected as the primary data source. Videos and associated comments related to sustainable consumption were collected using the YouTube Data API.

In the second stage, the text data (video comments and descriptions) obtained from YouTube were preprocessed for the final analysis. This step involved cleaning the data by removing non-essential elements such as URLs and non-alphanumeric characters and preparing the text for analysis through techniques such as tokenization and lemmatization. More detailed information on the data collection and preprocessing stages can be found in the section ‘Data collection and preprocessing’.
The third stage involved is data analysis. A variety of text mining techniques were employed for this purpose, including:

1. Topic Modelling: This was used to identify latent topics in the text data.
2. Semantic Network Analysis: This method visualized the semantic relationships between words in the corpus.
3. Sentiment Analysis: This was used to identify emotions and feelings expressed in the comments, providing information on public opinion on sustainable consumption.

Through this three-stage methodology, the study aimed to achieve a comprehensive understanding of sentiments and attitudes toward sustainable consumption on YouTube.

Data Collection and Pre-Processing

In recent years, social networking sites (SNS) such as Facebook, Twitter, MySpace, FriendFeed, and GooglePlus have transformed global communication. These SNS platforms generate vast real-time data for researchers in fields such as linguistics, sociology, behavioral sciences, health, and psychology. YouTube is one of the most popular platforms today, hosting millions of videos and serving billions of users. Most conversations on YouTube, particularly comments on videos, are publicly available and easily accessible through YouTube's Application Programming Interface (API). Therefore, YouTube was chosen as the data source for this study.

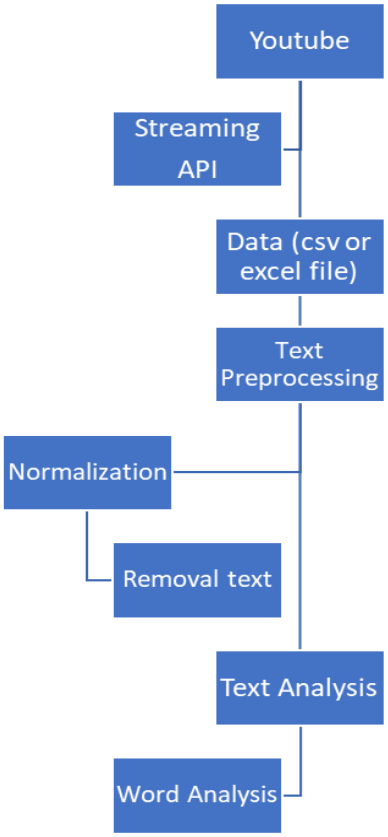

Figure 1. A proposed framework of the text data analysis method.

The Python programming language, particularly its libraries for data manipulation and analysis (Pandas, NumPy) and for web scraping and API interaction (Requests, BeautifulSoup), was used for data collection and preprocessing. The video metadata and comments related to "sustainable consumption" were extracted using the YouTube Data API. We collected data from videos posted between 1 December 2021 and 30 December 2022, resulting in a raw data set of 39,678 comments. After removing duplicates, 26,425 unique comments remained for analysis.

YouTube data, like most user-generated content, is often unstructured and noisy; therefore, it was pre-processed before the main analyses. The Python libraries NLTK (Natural Language Toolkit) and spaCy were used for this purpose. These libraries helped improve the quality of our corpus by removing irrelevant content that did not contribute to the meaning of the text, such as numbers, URLs, punctuation, stop words, and excessive whitespace. This text cleaning process facilitated more accurate subsequent analysis of the data.

Text Mining Approaches

Topic Modelling

For this study, we used Latent Dirichlet Allocation (LDA)-based topic modelling, a generative probabilistic model based on a three-level hierarchical Bayesian model. This method has been employed across various fields and has demonstrated superior performance among several topic modelling algorithms, offering proven reliability.

In Python, the LDA implementation was achieved using the 'gensim' library, which provides tools for topic modelling. LDA is an unsupervised learning algorithm that uncovers latent topics based on patterns of word co-occurrences within the corpus. The fundamental principle behind LDA modelling is that each document (in this case, each comment) from a set of D documents is a mixture of K latent topics. Moreover, each topic is a multinomial distribution of words from a vocabulary of W words.

Here, φk (for all k = 1, . . . , K) is the probabilistic distribution over words for each latent topic, and θd (for all d = 1, . . . , M) is the distribution per document topic. In this context, M represents the number of comments and N represents the number of words in the vocabulary.

α and β are Dirichlet parameters where α represents per-document topic distributions, and β represents per-topic word distribution. For each comment d in the corpus, the words are generated in a two-stage process. In the first stage, a distribution is randomly chosen. Based on this distribution, a topic is randomly selected for each word in the comment. This approach allows us to extract meaningful topics from the YouTube comments and to understand the main themes in the discussions about sustainable consumption.

Semantic Network Analysis

Semantic Network Analysis is a subfield of Natural Language Processing (NLP) and Machine Learning that constructs structures to approximate concepts within a large corpus. This analysis creates an interactive visual system that depicts the semantic networks of words in the corpus. Each word is represented by a node in the network structure, and the edges signify semantic connections between words.

For this study, we used the Python library network for creating and analyzing the semantic network, and community for community detection in the network. We implemented the Louvain Community Detection Algorithm (LCDA) to identify semantic clusters. This method aims to maximize a modularity score for each cluster, where the modularity quantifies the quality of the assignment to clusters. The algorithm evaluates how much more densely connected the nodes are within a cluster compared to connections in a random network.

The Louvain algorithm's primary inspiration is to optimize modularity, a scale that measures the relative density of edges within the network. This value can range from -0.5 to 1. The modularity function gauges the strength of division of a network into clusters. By applying this method to YouTube comments, we can better understand the semantic relationships between the words used in discussions about sustainable consumption.

Sentiment Analysis

Sentiment Analysis (SA) is a computational linguistics technique that is used to identify and extract sentiment associated with a piece of text data. It is a subset of Natural Language Processing (NLP) that analyses subjective information such as opinions and emotions expressed in text.

There are two primary methods for conducting SA: lexicon-based and corpus-based. For this study, we used the lexicon-based method. Numerous lexicons are available to perform sentiment analysis, such as SentiWordNet, General Inquirer, Q-WordNet, Lexicon of Subjectivity Clues, LIWC dictionary, and Sentiment-based Lexicon.

We chose to use the NRC Emotion Lexicon, also known as EmoLex, because of its ability to classify emotions into eight basic categories: anger, fear, sadness, anticipation, disgust, joy, surprise, and trust, in addition to identifying positive and negative sentiments in the data.

To implement sentiment analysis, we used Python's NLTK (Natural Language Toolkit) library, which has an interface to the NRC EmoLex. This allowed us to extract and analyse the sentiments expressed in YouTube comments on sustainable consumption, providing valuable insights into public opinion on the topic.

Results and Discussion

LDA Model

Prior to performing LDA topic modelling, we executed perplexity and coherence tests to evaluate our model's quality. Perplexity is a measure of the overall quality of the model. It gauges how well the model can describe a document based on a generative process learnt from the set of topics. However, topic coherence captures the optimal number of topics by measuring the degree of semantic similarity between high-scoring words within the topic, thereby yielding human-interpretable topics.

Table 1 presents perplexity scores for keywords ranging from 1 to 50. A lower perplexity score indicates that the probability distribution is more effective in predicting the document. The optimal keywords are determined based on perplexity validation, where the score reaches the lowest point before rising again. To compute perplexity and coherence scores in Python, we used the 'gensim' library's built-in functions. This provided us with a systematic and quantitative way to evaluate our keyword models and choose the best one for further analysis.

Table 1. Perplexity values for different keywords.

Key words	Validation Perplexity	Key words	Validation Perplexity	Key words	Validation Perplexity	Key words	Validation Perplexity	Key words	Validation Perplexity
1	290.4	2	285.7	3	281.3	4	276.9	5	272.5
6	268.1	7	263.7	8	259.3	9	254.9	10	250.5
11	246.1	12	241.7	13	237.3	14	232.9	15	228.5
16	279.5	17	282.3	18	280.4	19	278.7	20	277.6
21	275.9	22	273.5	23	271.7	24	269.4	25	267.8
26	265.2	27	263.5	28	261.9	29	260.3	30	258.6
31	256.9	32	255.3	33	253.6	34	251.9	35	250.3
36	248.6	37	246.9	38	245.3	39	243.6	40	241.9
41	240.3	42	238.6	43	236.9	44	235.3	45	233.6
46	231.9	47	230.3	48	228.6	49	226.9	50	225.3

It is observed that validation perplexity generally decreases as keyword numbers increase, which is an expected outcome in the topic modelling process. This trend indicates that the model's ability to predict or understand the text data improves as more keywords are considered. For example, the validation perplexity for Keyword 1 is highest at 290.4, indicating a relatively poor fit of the model. However, as we progress to Keyword 50, the perplexity value decreases to 225.3, indicating a better fitting model. However, there are some anomalies to this trend. For example, the perplexity value increases slightly between keywords 15 and 16, and again between keywords 16 and 17. These minor inconsistencies could be due to the specific content and context of the keywords and how they interact with the rest of the text data. Overall, these results suggest that increasing the number of keywords aids the model in capturing the semantic richness of the YouTube comments data, thus enhancing the overall topic modelling performance. However, it is also crucial to monitor for potential overfitting, where the model starts to capture noise instead of the underlying semantic structures as the keyword count increases. Therefore, the choice of the number of keywords should be carefully considered based on both the perplexity values and the interpretability of the resulting topics.

In Table 2, the terms are grouped into several categories, indicating the multifaceted nature of sustainable consumption. These categories include Environment, Consumerism, Lifestyle, Development, Energy, Production, Waste Management, and others. Terms such as "green consumption", "green product", "green industry", and "green development" reflect the prominence of the "green" branding in sustainable consumption. This could indicate a marketing trend towards promoting products and services as environmentally friendly. The terms "Consumer behavior", "Consumption behavior", and "Online consumer behavior" suggest that understanding consumer attitudes and behaviors is crucial for promoting sustainable consumption. This implies the importance of psychological and sociological approaches in studying sustainable consumption. The presence of terms such as "Gen y", “social media", and "Online consumer behavior" points to the role of younger generations and digital platforms in driving sustainable consumption. The terms “recycle”, “recycling”, “reusability”, “virtual water", and "Water footprint" highlight the importance of waste management and water conservation in sustainable consumption. The presence of the terms “balance of trade", “energy consumption", "Energy efficiency", and “green infrastructure" show that sustainable consumption also intersects with broader economic and infrastructural concerns. The terms "Environmental Awareness”, "Environmental concern", "Pro-environmental Behavior”, and "Pro-environment" reflect the significance of public awareness and attitudes toward the environment in promoting sustainable consumption.

We used the TextBlob library for sentiment analysis within the Python environment. Initially, we loaded the text data (YouTube comments), tokenized each word to form a list, and applied the TextBlob sentiment polarity method. This method computes sentiment scores based on comparison with a built-in lexicon, returning a polarity score ranging from -1 (negative sentiment) to +1 (positive sentiment). According to our sentimental results (Figure 2), people exhibit mixed sentiments (i.e. positive and negative) toward sustainable consumption. However, positivity appears to be more prominent in our results, possibly due to the presence of high positive emotions (anticipation, joy, and trust).

Some phrases associated with positive sentiments include abundance, health, opportunity, mindful, delicious, confident, prefer, recovery, protection, etc. Conversely, phrases associated with negative sentiments include 'toxic', 'junk', 'waste', 'degradable', 'irresponsible', 'guilty', 'loss', etc. The sentiment polarity and subjectivity scores assigned by TextBlob provided a comprehensive understanding of the overall sentiment toward sustainable consumption on the YouTube platform

Table 2. Keywords with key terms.

Keyword ID	Term	Label
1	Balance of trade	Economy
2	Clean production	Production
3	Consumer behavior	Consumerism
4	Consumption	Lifestyle
5	Consumption behavior	Consumerism
6	Consumption environment	Environment
7	Ecological behavior	Environment
8	Ecological product	Production
9	Ecology	Environment
10	Ecotourism	Tourism
11	Energy consumption	Energy
12	Energy efficiency	Energy
13	Enviroment	Environment
14	Enviromental concern	Environment
15	Enviromental consensus	Environment
16	Enviromental ethics	Ethics
17	Enviromental management	Management
18	Environmental awareness	Environment
19	Environmental concern	Environment
20	Environmental problem	Environment
21	Environmentally friendly	Lifestyle
22	Gen y	Demographics
23	Go green	Lifestyle
24	Green attitude	Lifestyle
25	Green building	Construction
26	Green cognition	Psychology
27	Green consumerism	Consumerism
28	Green consumption	Lifestyle
29	Green consumption beh	Consumerism
30	Green development	Development
31	Green food products	Food
32	Green industry	Industry
33	Green infrastructure	Infrastructure
34	Green marketing	Marketing
35	Green product	Production
36	Green purchase	Consumerism
37	Green purchase intentions	Consumerism
38	Green self id	Identity
39	Online consumer behavior	Consumerism
40	Planned behavior theory	Psychology
41	Practice SDG	Development
42	Pro environmental behavior	Environment
43	Pro-enviroment	Environment
44	Purchase motives	Consumerism
45	Recycle	Waste Management
46	Recycling	Waste Management
47	Reusability	Waste Management
48	Social consumption	Sociology
49	Social media	Media
50	Sustainability	Environment

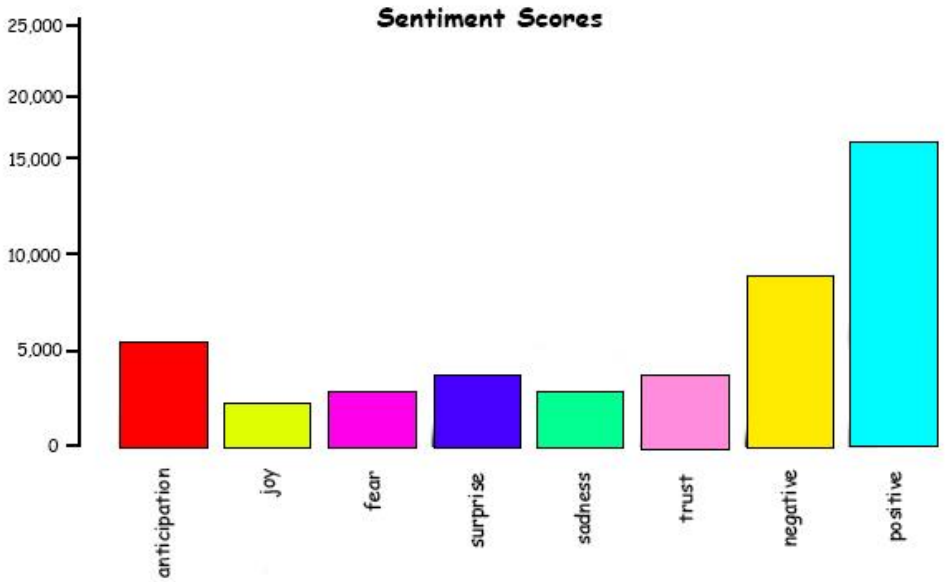

Figure 2. Sentiment towards sustainable consumption.

Conclusion

This article analyzed recent video comments on sustainable consumption posted on YouTube. The main strength of this study lies in its novel findings, obtained through advanced text mining approaches, such as Latent Dirichlet Allocation (LDA) for topic modelling and the Louvain Algorithm for semantic network analysis. One of the significant contributions of this work is the use of social media data, specifically from YouTube, as opposed to the conventional method of obtaining data from interviews and questionnaire-based surveys. Every day, millions of comments are posted on YouTube that contain unbiased and rich opinions. Therefore, YouTube is an excellent source of data for researchers to better understand public behaviors, opinions, and sentiments. Traditional methods such as interviews often introduce bias / subjectivity, as the interviewer's preconceived response, idea or opinion could affect the responses of interviewees. In contrast, people freely express their unbiased views on social media platforms such as YouTube. This study employed the Python programming language, known for its powerful libraries for data processing and analysis. The use of Python opened up a range of analytical possibilities, making it easier to handle large data sets, apply advanced text mining techniques, and present the findings in a visually appealing manner. In general, the application of these methods to YouTube data offers valuable insight into public sentiment about sustainable consumption, providing a more nuanced understanding of the topic than traditional survey methods could achieve. This study underscores the potential of using social media data in conjunction with robust data analysis tools like Python for research in various fields.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in EPSTEM journal belongs to the authors.

Acknowledgements or Notes

* This article was presented as an oral presentation at the International Conference on Research in Engineering, Technology and Science (www.icrets.net) held in Budapest/Hungary on July 06-09, 2023.

* This study is one of the preliminary outputs of the project numbered 2022-A-113-07 funded by Research Fund of Gebze Technical University.

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To cite this article:

Cubukcu-Cerasi, C., Balcioglu, Y.S., Kilic, A. & Huseynov, F. (2023). Embracing green choices: Sentiment analysis of sustainable consumption. *The Eurasia Proceedings of Science, Technology, Engineering & Mathematics (EPSTEM), 23,* 253-261.