

Mining Netizen's Opinion on Sustainable Agriculture: Sentiment Analysis of Twitter Data

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This research aims to measure public sentiment related to sustainable agriculture on the Twitter social media platform. The research method involves the extraction and classification of tweet data using a Python Library called VADER (Valence Aware Dictionary and Sentiment Reasoner). The research utilized tweet data posted in the past one year. The results showed fluctuations and decreases in the number of tweets discussing sustainable agriculture. The location with the most tweet activity around sustainable agriculture was Brussels, Belgium, with 642 tweets during the observation period. Word cloud analysis on keywords showed that in positive sentiments, words such as "food security" and "climate change" dominated the visualization. On the other hand, in negative sentiments, words such as "farmer" and "private farmland" appeared more frequently. Overall, the majority of tweets expressed a positive attitude towards sustainable agriculture, with 68.5% positive sentiment. A total of 22.3% of tweets showed neutral sentiments, with no strong positive or negative tendencies. Only 9.1% of tweets contained negative sentiment, indicating that a small proportion of tweets expressed less favorable views towards sustainable agriculture.

Keywords: Sustainable agriculture; Sentiment; Twitter

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INTRODUCTION

Global food production more than tripled over the last half century during the green revolution (Wang et al., 2022). Agriculture that is able to continuously provide food and other resources to the world's growing population is critical to human existence and human activities. However, there are many issues that threaten agriculture's ability to meet current and future human needs, including climate change; high rates of biodiversity loss; land degradation through soil erosion, compaction, salinization and pollution; depletion and pollution of water resources; rising production costs; the decreasing number of farms and, relatedly, poverty and rural population decline. (Velten et al., 2015). In the face of these challenges, the idea of sustainable agriculture has become prominent since the publication of the Brundtland Report in 1987, along with the general concept of sustainable development (Tait & Morris, 2000). (Tait & Morris, 2000).

According to Lewandowski et al. (1999) sustainable agriculture can be defined as an approach to the management and utilization of agricultural ecosystems. This approach aims to maintain biodiversity, productivity, regeneration capacity, vitality, and the ability of ecosystems to function effectively. The goal is to fulfill crucial ecological, economic, and social needs, both now and in the future. Sustainable agriculture is not only concerned with environmental aspects, but also takes into account social functions at local, national and global levels. This means that agricultural practices must provide ecological and economic benefits without harming other ecosystems. Sauvenier et al. (2005) emphasized that this concept highlights the importance of maintaining agriculture's ability to perform social, environmental and social functions that have a positive impact on current and future generations.

Advances in technology that are based on scientific knowledge and supported by evidence provide new opportunities to address the challenges associated with sustainable agriculture. The application of digital technologies in agriculture can eradicate extreme poverty and hunger amidst a growing population. (Mushi et al., 2022). Wang et al. (2022) proposed that nanotechnology and nanomaterials have the potential to improve the agricultural sector through their nanospecific properties, such as small size, abundant and customizable surface chemical content, high efficiency, and higher level of robustness.

In the agricultural sector, the adoption of digital technologies has contributed significantly to increased profitability, improved product quality, and environmental preservation. (Saiz-Rubio & Rovira-Más, 2020). The development of digital technologies in the agricultural sector involves knowledge from various disciplines, including information science, computer and software engineering, environmental science, remote sensing, geographic positioning systems (GIS), crop and soil science, and global positioning systems (GPS). (Sarker et al., 2019). The implementation of agricultural management systems that utilize modern technologies such as artificial intelligence (AI), sensors, Internet of Things (IoT), satellite imagery for data collection, big data analysis, and machine learning, has contributed to increased productivity and profitability in the sector. (Saiz-Rubio & Rovira-Más, 2020).

Nonetheless, the majority of small and medium-scale farmers face constraints in adopting modern technologies for sustainable agriculture, which goes against the "leave no one behind" principle of the UN Sustainable Development Goals (SDGs) (Mushi et al., 2022). Smallholder farmers have a central role in creating jobs and generating significant incomes globally, while at the same time contributing more than 70% of the world's food needs. (FAO, 2021).

Several studies have highlighted the development of sustainable agricultural practices around the world. As conducted by Gomiero et al. (2011) examined several issues regarding the environmental impact of agricultural practices. Velten et al. (2015) conducted a theoretical systematic analysis of the sustainable agriculture literature, presented a framework for understanding the components of sustainable agriculture, and highlighted ways for stakeholders involved in sustainable agriculture to address the complexity and diversity of the concept in a constructive way.

Other works, by Sarker et al. (2019) explored the potential application of big data for sustainable agricultural management through a digital farming approach. The study also reviews various technologies applied in crop production, crop protection, livestock production, fisheries, post-harvest management, and market development.

Saiz-Rubio & Rovira-Más (2020) Saiz-Rubio & Rovira-Más (2020), conducted a review of the current status of advanced farm management systems by examining each critical step, from data collection in the crop field to variable-level implementation. The goal is for farmers to make optimized decisions to save costs,

protect the environment, and improve the overall way food is produced.

Mushi et al. (2022) identified knowledge gaps of digital technologies for sustainable agriculture in Tanzania. Wang et al. (2022) on the other hand, analyzed the key properties of nanopesticides in controlling agricultural pests, with the aim of increasing crop yields compared to conventional, non-nano-scale pesticides.

In contrast to some previous studies, this research tries to explore public perceptions of sustainable agriculture from primary data taken from Twitter social media. This research aims to identify public sentiments posted through tweets on the Twitter platform related to sustainable agriculture. This research analyzes three sentiment classifications, namely positive, negative, and neutral, with the help of the Python Library. By providing a comprehensive understanding of people's views on sustainable agriculture, including its positive aspects, advantages, potential, and benefits, as well as identifying potential weaknesses and threats associated with negative views on sustainable agriculture, it is hoped that this research will contribute to relevant parties to take appropriate actions to strengthen the sustainable agriculture ecosystem and increase awareness and support for it.

RESEARCH METHOD

This research is a qualitative study with a sentiment analysis approach, also known as opinion mining. This approach aims to automatically evaluate views, feelings, judgments, and attitudes towards a target, such as products and services. (Cambria et al., 2013; Liu & Zhang, 2013; Ravi & Ravi, 2015; Vinodhini & Chandrasekaran, 2012). The main data source of this study was Twitter tweets, which were collected automatically using Twitter's official application programming interface (API). The data collection was conducted in the time span of January to December 2023, resulting in more than 100,000 tweets related to the topic of sustainable agriculture. A web scraping technique was also used to retrieve data from the Twitter website.

Sentiment analysis is the use of natural language processing, text analysis, computational linguistics, and biometrics to regularly identify, extract, quantify, and study affective states and subjective information and data. The sentiment analysis system is divided into 5 (five) stages, namely crawling, pre-processing, word weighting, model building and sentiment classification.

The selection of Twitter as a social media research platform was based on the availability of relatively accessible data. Twitter has unique characteristics in the social media realm with two main features: public messaging and short message length limits. This limit on message length gives it an advantage in conducting faster analysis compared to other social media platforms. In addition, Twitter facilitates research that includes both individual and media analysis in one analytical framework (Vargo et al., 2014).

This research uses Python Library software called VADER (Valence Aware Dictionary and Sentiment Reasoner) to perform sentiment analysis on tweet data related to sustainable agriculture. VADER is a lexicon-based sentiment analysis tool, which has been specially adapted to handle sentiments commonly found in the context of social media. (Liu, 2012). The use of VADER Python in this study focused on two main objectives: first, to classify the sentiment in tweets into three main categories, namely positive, negative, and neutral; second, to identify the most frequently occurring keywords in tweets discussing the topic of sustainable agriculture.

The composite sentiment score, which is calculated from the lexicon scoring by VADER, gives an idea of the overall level of sentiment in each tweet. This score is normalized to range between -1 (strongly negative) to +1 (strongly positive). This approach helps in determining the polarity of the sentiment, i.e. the extent to which the tweet is positive or negative, and also measures the intensity of the emotions expressed (Rusydziana & Marlina, 2020). Emotion intensity is calculated by dividing the sum of the positive, negative and neutral elements, also high positive and negative elements contained in the tweet by a total of 1 (Roe et al., 2021).

In addition, VADER was also used to identify the most significant keywords in tweets related to sustainable agriculture. This analysis provides further insight into the words that appear frequently and can help with a deeper understanding of the focus of conversations on the Twitter platform regarding this topic. By using these sentiment analysis tools, this research seeks to present more comprehensive results regarding people's attitudes and views towards sustainable agriculture. This sentiment analysis method has been adopted in several studies, such as Alamoodi et al. (2021), Hakim et al. (2022), Maulida (2022), Firmansyah (2022), Riani & Rusydziana (2023), Nuraini

(2022), Ocktavia et al., (2023), Maliha (2023), Hassan et al. (2022), and Maulida & Rusydiana (2022).

RESULT AND DISCUSSION

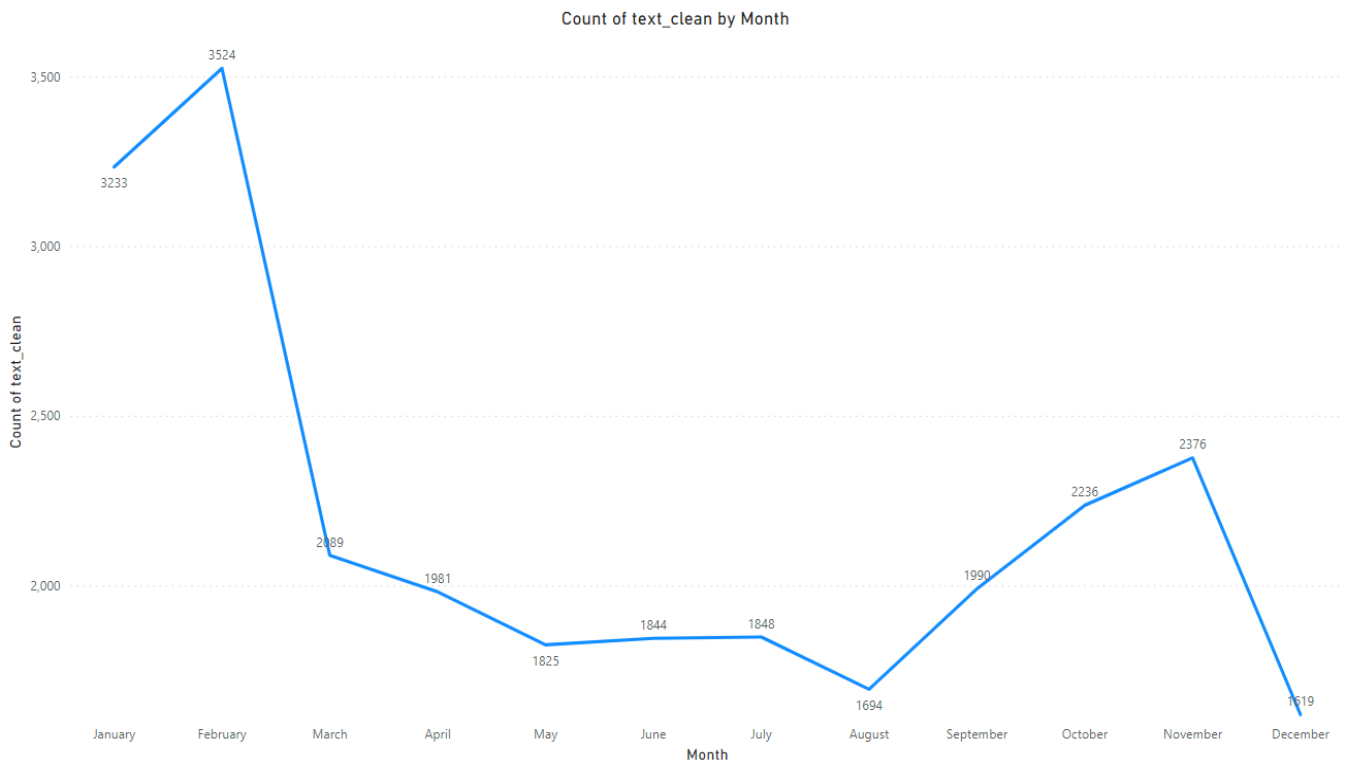


Figure 1. Count of Text Clean by Month

The figure above shows a graph illustrating the development of the number of net tweets about sustainable agriculture by month during the research period. From the graph, it can be seen that the number of net tweets about sustainable agriculture fluctuates and

tends to decrease. As can be seen, the peak number of tweets about sustainable agriculture occurred in February, reaching a maximum of 3524 tweets. After that, there was a significant decline in the following months.

Table 1. Distribution of Data Tweets by Location

No.	Location	Total
1	Brussels, Belgium	642
2	United States	352
3	Washington, DC	331
4	India	306
5	New Delhi, India	252

The data presented above reflects the participation of users from different countries in Twitter conversations about sustainable agriculture. The table above provides an overview of the user locations with the highest number of tweets, illustrating the extent to which this topic is gaining traction in different regions. Brussels, Belgium, tops the list as the location with the most tweet activity around sustainable agriculture, totaling 642 tweets. Second place was taken by the

United States with a total of 352 tweets. Meanwhile, Washington, DC, took third place with 331 tweets. The distribution of tweet data reflects the interest of Twitter users in each region in the topic of sustainable agriculture. This data provides further insight into the geographical distribution of sustainable agriculture conversations on social media Twitter over the period of 2023.

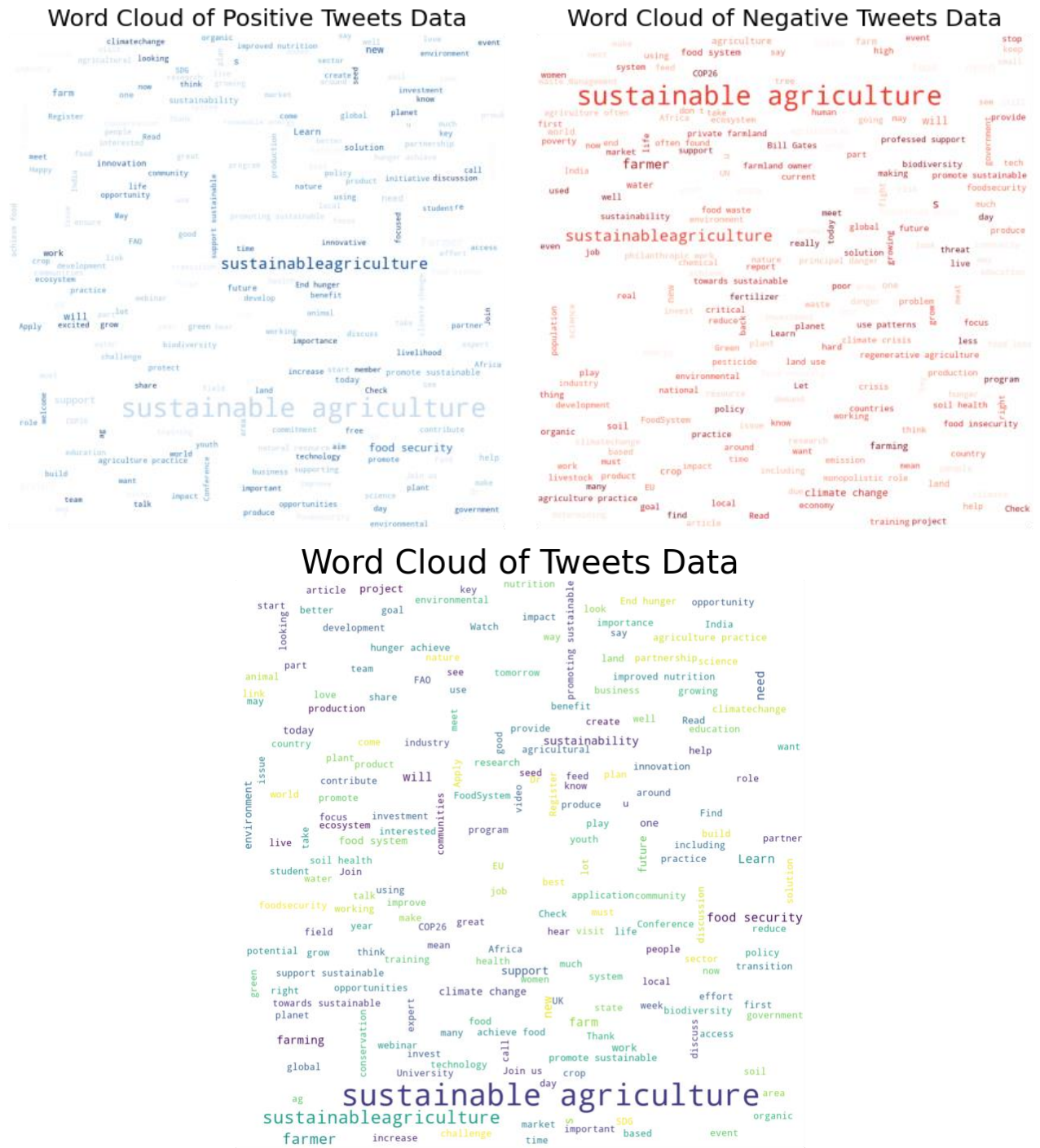


Figure 2. Word Cloud of Tweets Data

The word cloud provides a visual representation of the keywords that frequently appear in tweets related to sustainable agriculture, grouped into three categories: positive, negative and combined. Sustainable agriculture was the most prominent keyword in tweets overall, signaling the significance of this topic in online conversations. In the word cloud, larger word sizes reflect higher frequency of occurrence.

Furthermore, when looking at the word cloud of positive tweets, key words such as "food security" and "climate change" dominate the visualization. This

indicates that when users express positive views on sustainable agriculture, they tend to relate it to important issues such as food security and climate change. This confirms that these aspects are considered positive and relevant in the context of sustainable agriculture.

On the other hand, in the word cloud of negative tweets, key words such as "farmer" and "private farmland" appear more frequently. This illustrates that in a negative context, attention is often focused on issues such as farmer performance and private farmland ownership.

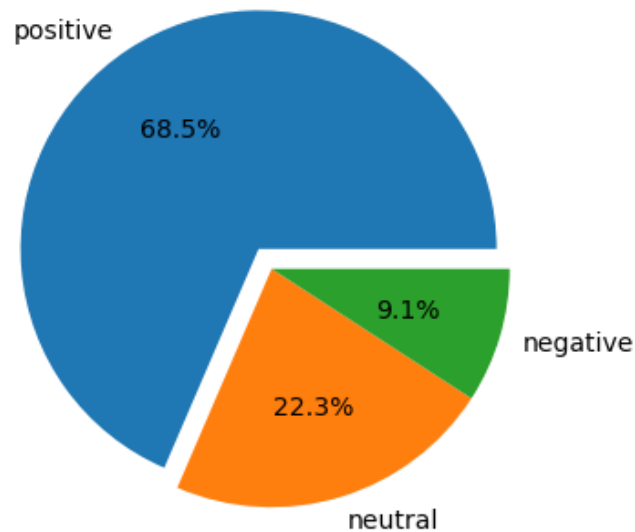


Figure 3. Sentiment Polarity on Tweets Data

Based on the information provided in the pie chart, it can be concluded that the existence of sustainable agriculture generally receives a positive sentiment of 68.5%. This positive sentiment reflects the optimistic views or support expressed by Twitter users regarding the topic of sustainable agriculture. In this context, the majority of the analyzed tweets show a positive attitude towards the concept of sustainable agriculture. Furthermore, there was 22.3% neutral sentiment, indicating that most of the tweets had neutral characteristics without strong positive or negative tendencies. Neutral sentiments can reflect general facts or information without special emphasis on positive or negative values. Meanwhile, the negative sentiment of 9.1% indicates that there is a small proportion of tweets that express views or opinions that are less supportive of sustainable agriculture. This can include criticism, concern, or disapproval of certain aspects of sustainable agriculture. Sentiment determination is based on an analysis of the words used in the tweet text, where the words are ranked in negative, neutral or positive intervals.

This data shows that most Twitter users respond positively to the existence of sustainable agriculture. Therefore, the potential for community acceptance shown by the tendency of positive perceptions must continue to be developed. The development of sustainable agriculture also needs to be supported by systems and education that are in accordance with current conditions so that people can easily understand and implement sustainable agriculture. The tweet data related to sustainable agriculture obtained from Twitter is considered sufficient to represent public sentiment

considering that the Twitter platform is a social media used by many people from various circles to express their opinions on various topics, including the topic of sustainable agriculture.

Discussion

This study aims to investigate community sentiments regarding sustainable agricultural practices. Sustainable agriculture is an approach to agricultural practices that has the main objectives of minimizing negative impacts on the environment, ensuring the economic sustainability of farmers, and improving the social welfare of communities. This approach brings with it a number of issues, both positive and negative, that require special attention.

Sustainable agriculture seeks to address a number of serious issues that have affected food production globally. These include high energy costs, groundwater contamination, soil erosion, declining productivity, fossil resource depletion, low farm incomes, and risks to human health and wildlife habitat. It is important to remember that sustainable agriculture is not a specific strategy, but rather a systems-level approach that seeks to understand the complex interactions within the agricultural ecology (Reganold et al., 2009).

With a focus on these complex interactions, this study will discuss and analyze various aspects of public sentiment regarding sustainable agriculture practices, including responses to positive and negative issues associated with this approach. Analysis of the tweet data (Appendix 1) shows that some countries have shown a serious commitment to sustainable agricultural practices, such as India, which is focusing on crop diversification

and utilization of traditional knowledge. Some countries are also serious about accelerating equitable rural transitions to sustainable agriculture, and are talking about how governments and farmers can work together to achieve sustainable agriculture.

Over the past few decades, sustainable agriculture has achieved widespread attention from both consumers and policy makers for its call to promote farming free from agrochemicals and based on ecological practices, and for its concern for the preservation of biodiversity (Paoletti et al., 2011). Furthermore, through sustainable agricultural practices, farmers' incomes can increase by utilizing minimum and locally available resources. This suggests that sustainable agriculture not only maintains the ability of agriculture to conserve the environment, but also cares for significant social functions for current and future generations (Sauvenier et al., 2011).

As expressed by Gomiero et al. (2011), agriculture should also aim to ensure food security for the community. Food security is defined as a state when "all people, at all times, have physical and economic access to sufficient, safe and nutritious food for a healthy and active life" (FAO, 2022). This notion emphasizes that agriculture should not only serve to meet current food needs, but should also sustainably provide enough food to meet future needs. Therefore, to achieve sustainable food security, we need to pay attention to the balance of the ecosystem, the health of the earth's natural resources, and the well-being of the land.

In the opposite context, negative sentiments were also reflected in a number of tweets related to sustainable agriculture, which are described in more detail in Appendix 3. A number of tweets emphasized the issue of women's participation in science, underlining the important role of women in addressing hunger, reducing poverty and strengthening sustainable agricultural practices. This statement highlights the importance of recognizing and supporting the role of women in science as a crucial element in achieving food security and implementing sustainable agriculture. Additionally, one twitter user criticized the EU's delay in embracing genome editing as a tool to advance sustainable agricultural practices. Such criticism may indicate disapproval of certain policies or attitudes that are perceived to hinder progress in adopting genetic innovations for more sustainable agricultural purposes. On a more general level, criticism is also directed at governments for not being proactive enough in addressing food shortages, saying the world is not ready for innovative and sustainable agriculture.

Looking at the overall negative sentiment contained in the tweets (Appendix 3), it can be concluded that the sentiments voiced are not directed towards the practice of sustainable agriculture itself, but rather towards external elements such as the role of government and other interested parties. This criticism highlights concerns or dissatisfaction with the responses and actions of external entities that are perceived to have a significant impact on the implementation of sustainable agriculture. As such, these negative sentiments do not directly refer to the success or failure of sustainable agriculture practices, but rather the external dynamics that influence them. This illustrates that, while the principles of sustainable agriculture may be well-regarded, implementation challenges may lie in factors outside the direct domain of the practice.

CONCLUSION

This study aims to measure public sentiment related to sustainable agriculture on the social media platform Twitter. The results showed fluctuations and decreases in the number of tweets discussing sustainable agriculture. The location with the most tweet activity around sustainable agriculture was Brussels, Belgium, with 642 tweets during the observation period. Word cloud analysis on keywords showed that in positive sentiments, words such as "food security" and "climate change" dominated the visualization. On the other hand, in negative sentiments, words such as "farmer" and "private farmland" appeared more frequently. Overall, the majority of tweets expressed a positive attitude towards sustainable agriculture, with 68.5% positive sentiment. A total of 22.3% of tweets showed neutral sentiments, while 9.1% showed negative sentiments. These results illustrate that people generally give positive support to the concept of sustainable agriculture, although there is still a small proportion of tweets that express less supportive views. This research provides valuable insights into people's perceptions and responses to sustainable agriculture in cyberspace.

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APPENDIX

Appendix 1. Positive Sentiment Tweets Text

No.	text_clean	vader_label_clean	Retweet Count	Like Count
1	A praiseworthy display of commitment to sustainable agriculture, food security and economic growth. Congratulations to VelliangiriUzhavan FPO on your remarkable performance and to IshaOutreach on your indispensable guidance. -Sg	positive	2996	4452
2	<p>◆ Nutrition ◆ Food security ◆ Climate Change ◆ Sustainable Agriculture ◆ Biodiversity... Pulses help improve all of the above. They are more than just small seeds! This WorldPulsesDay tell us what your favorite pulses are 🐾 LovePulses</p>	positive	401	850
3	MKSP_scheme Mahila Kisaan Shasaktikaran Pariyojana is aimed at empowering women in agriculture. Its objective is to strengthen smallholder agriculture through promotion of sustainable agriculture practices. Kashmir Nayakashmir standwithkashmir Kashmirbleedsgreen TheSkandar	positive	380	402
4	This must be some of that Israeli "sustainable agriculture" that NLinIsrael is so proud to support.	positive	350	703
5	The corporate take-over of farming in India is actively supported by Netafim, an Israeli company that is complicit in the theft of Palestinian land and natural resources. BoycottNetafim SustainableAgriculture Report:	positive	321	474
6	Sustainability, efficiency, and water conservation all play their part in sustainable agriculture. Watch the full interview with seasoned tomato grower Beat Bösiger to learn more:	positive	301	4590
7	Thank you for the solid meeting President EmmanuelMacron FRSabrinadhowre and I are thrilled France is stepping up with a +50% investment in sustainable agriculture through IFAD This investment will boost jobs+other opportunities for youth in Africa OnePlanetSummit GblCtzn	positive	296	2647
8	Bharatiya Prakritik Krishi Paddhati under PKVY is a traditional indigenous practice aimed at promoting Natural Farming. Farmer's income by natural farming increases by using minimum & locally available resources. Let's encourage the National Mission of Sustainable Agriculture!	positive	284	315

9	Today, I signed an executive order to merge the Department of Agriculture and DENR to form a NEW Department of Agriculture and Natural Resources. With this merger, we are fostering sustainable agriculture and conservation that we can pass on to our kids and grandkids. (1/2)	positive	268	2443
10	On this auspicious day of Baba Saheb Bhim Rao Ambedkar Ji's Jayanti... I bow my head in reverence to the great architect of Our Constitution 🙏 Path to Punjab's glory & Sustainable Agriculture is paved by Rights of Dalits & Landless Farm Labor - 36% Dalits own only 2% Land ...	positive	258	2071

Appendix 2. Neutral Sentiment Tweets Text

No.	text_clean	vader_label_clean	Retweet Count	Like Count
1	Today met SadhguruJV in Delhi and discussed "Save the Soils and other issues related to sustainable agriculture future".	neutral	1842	4018
2	Data-powered farming decisions will complement growers' knowledge & judgment and lead to more sustainable agriculture. Read SyngentaGroup's gregmeyersCIO on the start of a new era in agri 🚜 production. 👉	neutral	349	5097
3	We are looking for a team leader in rhizosphere ecology, soil biology, plant-microbe interactions & soil biodiversity. The work contributes to the development of a more sustainable agriculture. It is a permanent research position, Zurich, Switzerland.	neutral	207	236
4	Enabling sustainable agriculture through understanding and enhancement of microbiomes TansleyReview PankajTri29 CMattupalli KellyeEversole PhytoBiomes JanPhytobiomes	neutral	113	246
5	I virtually addressed the UNFCCC Presidency Event: Accelerating a just rural transition to sustainable agriculture and spoke on how Govt & farmers can work in tandem for sustainable agriculture. India is focusing on crop diversification & utilizing traditional knowledge. COP26Glasgow	neutral	111	150
6	"We need to invest in sustainable agriculture infrastructure." Prime Minister ImranKhanPTT's	neutral	109	565

No.	text_clean	vader_label_clean	Retweet Count	Like Count
	Address to the Governing Council of the International Fund For Agricultural Development			
7	G20 Open Forum on Sustainable Agriculture	neutral	101	396
8	Livestock farmers are leading the way toward the future of sustainable agriculture. Climate-smart livestock farming must not be treated as a political football, writes UC Davis Professor GHGGuru.	neutral	72	182
9	Sebastian Vettel says he visited Pedro Diniz's farm prior to the BrazilGP, learning more about sustainable agriculture. Learned about Diniz's post-F1 career when reading a book last year.	neutral	70	919
10	New Postdoc Position in Our Lab: Soil Microbiome Engineering for a Sustainable Agriculture. Deadline to Apply: 10-1-2021. SFranzBender1; grstiftung_ch (scroll down - see 10.12). agroecology microbiome agriculture Soil Sustainability Science	neutral	65	79

Appendix 3. Negative Sentiment Tweets Text

No.	text_clean	vader_label_clean	Retweet Count	Like Count
1	If you want undeniable proof that critical race theory (CRT) is being pushed in Canadian schools, don't take it from me, just listen to Liberal MP Jenica Atwin "We need (Canadian kids) to study engineering, science, sustainable agriculture and critical race theory." CRTinCanada	negative	369	619
2	1. Families in conflict zones need to have ongoing access to food. That's just one reason why we teach sustainable agriculture solutions to ethnic communities throughout Myanmar. Read more: WhatsHappeningInMyanmar	negative	227	192
3	We need more WomenInScience because they are key to... 🤝 Fighting hunger 🤝 Reducing poverty 🤝 Strengthening sustainable agriculture Without women in science, we wouldn't be able to achieve foodsecurity.	negative	220	484

No.	text_clean	vader_label_clean	Retweet Count	Like Count
4	It is inevitable that food shortages will occur more and more frequently in the future. The world is not ready for it - not ready for inventive agriculture, nor sustainable agriculture. This keeps me up at night.	negative	153	500
5	Because jumlas don't yield results! It's imperative that we all stand together for our farmers. They are fighting for us. For our right to food. For our right to a robust economy, for sustainable agriculture, jobs, basic human rights, a progressive nation. आज_भारत_बंद_है	negative	146	109
6	We met w/leaders of peasant struggles today. They are fighting land grabs by agribusiness (producing for Coca-Cola) and working to build a sustainable agriculture centered on food sovereignty. FreeHaiti	negative	137	348
7	ER 🐮 🐷 - sustainable agriculture aims to help provide enough food for all, bring communities out of poverty, and provide an enhanced quality of life for farming families. SDGs Development	negative	125	204
8	Here are some simple ThinkEatSave tips: 1 Adopt a more plant-rich diet 2 Support sustainable agriculture 3 Plant your own garden 4 Reduce food waste 5 Buy local 6 Avoid unnecessary packaging ActNow for FoodSystems:	negative	90	178
9	We need more WomenInScience because they are key to... 🍷 Fighting hunger 🍷 Reducing poverty 🍷 Strengthening sustainable agriculture Without women in science, we wouldn't be able to achieve food security.	negative	87	156
10	Scientists have a crucial role in policy making for more sustainable agriculture. Together with Oana__Dima we elaborate on CurrentBiology on how the EU is lagging behind in embracing gene editing.	negative	71	159