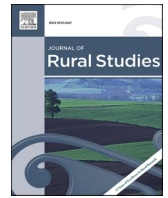


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Natural language processing of social network data for the evaluation of agricultural and rural policies

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ABSTRACT

Global sustainable development challenges affect the agricultural sector, and many innovations aimed at addressing these challenges have been introduced in the agri-food sector. In this complex context, new agricultural policies are being implemented in Europe. Their success depends on their potential to adapt to new realities, responding to the opinions and demands of the European population. Given the rapid rise of social media as an important part of people's daily lives, public administrations have introduced digitalization and communication strategies through social media sites. Social media can provide policymakers with large amounts of data on user opinions. Given the value of social media as a rich source of data on public views and opinions, the aim of this paper is twofold: (i) to use natural language processing (NLP) to identify the events that have led to negative or positive opinion about European Common Agricultural Policy (CAP) reform and (ii) to evaluate the ability of NLP to study users' opinions on Twitter/X. The findings show that issues such as Brexit, the European Green Deal, the role of CAP in the environment, livestock farming, food safety, and illegal practices and corruption in the distribution of CAP funds have crucial implications for the design and application of the new CAP. Moreover, the study also suggests that NLP techniques can provide opportunities to integrate agricultural policies and instruments in the agri-food sector by assessing society's opinions. Sentiment analysis, even considering its limitations, could support sound and inclusive policymaking approaches anticipating public opinion in cases of risk of social unrest.

1. Introduction

European agriculture faces multiple global challenges. Human activity will soon lead to an increase in the Earth's temperature of at least 1.5 °C (IPCC Intergovernmental Panel on Climate Change et al., 2022). This rise will in turn result in more extreme weather and climate events in regions such as Southern Europe. In such regions, periods of drought and heat waves will reach critical tolerance thresholds for biodiversity, human health, and agriculture. In addition, the conflict between Russia and Ukraine has exacerbated the energy crisis and caused a general rise in prices that threatens food security in Europe and jeopardizes farmers' income. This scenario has heightened social tensions in the rural world. In this context of uncertainty, new agricultural policies in Europe, mostly included in the post-2020 Common Agricultural Policy (CAP), must adapt to address these new realities (Kirylyuk-Dryjska et al., 2020; Moraleda, 2022). European policymakers must consider the needs of

producers and consumers alike. However, how can public organizations learn about the opinions and demands of the mass public in a rapid and inexpensive way?

Social media have become an effective source of information on citizens. They offer a window to the opinions of citizens, who express themselves freely on these sites (Batinca and Treleven, 2015). Social media have been growing in importance in people's daily lives for more than a decade, becoming a "social, political, economic, and technological phenomenon that is modifying the way we relate to each other" (Criado and Rojas, 2013, p. 7). These online platforms have reached a critical mass of millions of users, who share their opinions, complaints, and information about their daily lives with followers anywhere, anytime. All they need is a smartphone and an Internet connection. Meanwhile, public administrations have undergone a profound transformation in terms of digitalization and communication in social media over the last two decades (Criado and Rojas, 2013). They now rely on

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social media to disseminate their strategies, commitments, and messages through their profiles and other communication channels. Similarly, technology allows public entities to collect valuable data from social networks so that they can improve evaluation and decision making in public policies (e.g., CAP) through data analytics.

Natural language processing (NLP) is one such data analytics tool. Although some NLP techniques such as sentiment analysis have been employed in many fields such as tourism, finance, politics, and health (Bermeo-Almeida et al., 2019), their use in agri-food research remains unexplored. To date, few studies have used NLP to analyze different areas of the food industry (Recuero-Virto and Valilla-Arróspide, 2022) such as consumer experience, delivery, and food safety. The use of these techniques can provide small and large farmers with insights from user-generated content (UGC) on networks such as Twitter/X. These insights can be linked to consumer opinion about products bought in supermarkets or local markets, as well as about products' origin and method of production. The findings of NLP analysis suggest that social media could be used for prospective analyses in agricultural public policies (Ramos-Sandoval and Beltran, 2021). Social media can contribute to the design of new agri-food policies that are more in line with the needs and values of today's society. Therefore, NLP methodologies could provide important insights to support policymaking (Patel and Patel, 2020), forecasting, trend analysis, and the co-creation of policies. Moreover, public opinion could be considered through these methodologies, anticipating future cases of social upheaval that challenge policymakers, such as the upheaval of German and French farmers in the winter of 2023–2024.

According to Swinnen (2018), agricultural policy based on political economy theories considers consumers, producers, and taxpayers as the primary agents for analyzing policy incentives, impacts, and outcomes. Nevertheless, more agents may participate in and influence agricultural policymaking. Agricultural policy is still dominated by the interests of political forces in all world countries. Interest groups are encouraged by institutions to apply their political power according to their preferences (Anderson et al., 2013). The European Commission (2017) classified agricultural stakeholders into two main groups: individual and organizational participants. Individual participants can be farmers or other citizens. In turn, organizations include private companies; public authorities; trade, business, or professional associations; non-governmental groups (NGOs), platforms, or networks; research and academia; and others. Similarly, the European Food Safety Authority (EFSA, 2023) groups stakeholders (i.e., third parties with an interest in the food sector) into seven categories: consumers, environmental and health NGOs and advocacy groups, farmers and primary producers, business and food industry, distributors and serving food (wholesalers, retailers, hotels, restaurants and caterers, HORECA), practitioners' associations, and academia.

Considering the complexity of agricultural decision-making and the variety of interests and outcomes that affect future decisions, this study explores a more democratic approach in the context of agricultural policy that helps to monitor policy developments by enhancing ways of assessing public opinion. According to Criado et al. (2013), social media in government settings impacts democratic practices, generating information flows and innovative activities. Therefore, social media may foster democratic deliberation and shape public opinion (Gayo-Avello, 2015). Social media platforms such as Facebook and Twitter/X can reinforce the local public sphere while encouraging participation that bridge the divide between residents as consumers and citizens (Ellison and Hardey, 2014), including minorities and marginalized groups (Lee et al., 2018). In this context, social media may not only provide a more democratic approach but it can also be used to identify emerging agricultural issues and target efforts and resources directly to the influenced areas (Zipper, 2018). Nevertheless, although social media enhances the sharing of views, opinions, and communicative behavior, relying on it as the only source of information can lead to stagnant political knowledge acquisition since not all the population is represented (Lee et al., 2018).

This may highlight the potential of social media in agricultural policy-making as a complement to other instruments.

Agricultural policy is not only the result of lobbying patterns and heterogeneous political interests (Malang and Holzinger, 2020) but also of well-established reform processes, at least within the European Union. Currently, data related to agriculture, the CAP, and European citizens are collected through the Eurobarometer. The Eurobarometer consists of surveys gathering information on public opinion on agriculture, rural areas, and forestry (European Commission, 2024). Our study drives citizen opinion through real-time data obtained from Twitter/X,¹ which could complement the traditional basis of agricultural policy design. The CAP and the needs and preferences of European citizens are more effectively aligned by understanding and assessing public sentiment (European Commission, 2024). Nevertheless, it is paramount to note that information and posts on Twitter/X do not necessarily represent citizen opinion. Only some individuals use this social media or use it more frequently. Moreover, opinions are expressed in complex ways. Users may not post directly reflecting their thoughts or feelings. Each user may use language differently or employ the platform for different reasons or with different purposes. Therefore, when applying NLP techniques and sentiment analysis to policymaking, it may be relevant to consider that individuals' social media use could widely differ.

The literature has not yet discussed sentiment analysis (or opinion mining) and its usefulness in aligning agricultural public policies with the interests and needs that citizens express on social media. This paper presents an application of the NLP methodology of unsupervised learning to analyze user opinions on Twitter/X, one of the most popular social media sites. The analysis was conducted when the social network was called Twitter. Now, it is referred to as X. Specifically, the analysis focused on tweets/posts (from here, we will refer to tweets as posts) about the agri-food topics that have generated the most debate in the last five years, particularly the reactions of citizens to the European CAP. Events that have triggered reactions in the form of positive and negative posts were detected. The reliability of this method versus human verification was also assessed. This paper evaluates the feasibility of using language models of this kind as a fast and reliable source of information to help develop sociopolitical agri-food initiatives in line with the sentiment of the majority of the population. The findings show that this methodology could complement other instruments used to develop agricultural and rural policies. It can thus open the door for a transformation in the agricultural sector by considering the opinions of the population. However, as previously stated, not all individuals use social media to express their opinions, nor do they use them with the same frequency, in the same manner, for the same purpose, or share content on the same topics. Therefore, social media and NLP techniques could be used for policymaking in the agri-food sector but considering that social media do not always reflect the diversity of people's feelings and thoughts and, when they do, they tend to do so in a complex manner.

This paper is divided into several sections. Section 2 presents a brief theoretical framework on the CAP and social media as sources of information on agricultural policies. Section 3 explains the methodology applied in the sentiment analysis. Section 4 describes the case and the findings of the NLP analysis. Finally, conclusions, limitations, and future research possibilities are presented in Section 5.

2. Theoretical framework

2.1. Agri-food policy

Agriculture is one of the human activities with the greatest impact on citizens (Moraleda, 2022). The population is rapidly growing, and climate change and human activity are jeopardizing the availability of the planet's resources. Therefore, advances in agri-food are important to

¹ Twitter/X is a registered brand ®.

ensure sustainable food production on a global scale. Innovations such as cultured (or synthetic) meat, transgenic organisms, and a return to more sustainable production systems and local supply chains may contribute to making industry and society sustainable.

In recent years, there have been major changes in the global dynamics of food systems (Ramos-Sandoval and Beltran, 2021). Innovations are central to economic and social progress, so understanding the position of consumers and producers is important (Siegrist and Hartmann, 2020). Their support is crucial to ensure that technological innovations are successful. In addition, the agri-food industry must evaluate whether a new technology will be accepted or rejected by the public before applying and commercializing it (Cifci et al., 2020). The same is true of public institutions when launching strategic plans that shape new agricultural production systems. For example, some technologies such as genetically modified organisms (GMOs) and food irradiation have received widespread negative criticism (Vázquez-Salat and Houdebine, 2013).

The agri-food industry must exploit all available sources of information and analysis to understand consumer thinking. Developing technologies and implementing socially accepted strategies based on the needs and values of today's society will engage the population in the progress of change (Kemp, 2013). Similarly, knowing the population's opinions can help clarify how companies, public administrations, and universities should provide information to citizens. This insight can also help when developing information campaigns and communication and marketing strategies that show consumers all the benefits of these innovations to society and explain how they contribute to solving challenges such as supply, food security, and even climate change (Tao et al., 2020). The analysis of UGC on the Internet, and, more specifically, on social media may be important in the development of new technologies and innovations in the agri-food sector (Recuero-Virto and Valilla-Arróspide, 2022), as well as the promotion of new agri-food strategies and policies with majority support among the public.

In recent decades, European agriculture has been shaped by the CAP. Since it was first implemented in 1962, the CAP has undergone successive changes, which have always accompanied emerging socioeconomic needs and changes within the European and global landscape (De Castro et al., 2020). Moreover, it has been shaped by the demands of European consumers, especially in terms of environmental protection, food safety, and animal welfare. In 2023, the new post-2020 CAP will come into force. This new policy introduces several modifications to the previous plan. It takes a greener approach in response to social pressure to adopt a more environmentally responsible position (Horák, 2022). These changes mainly relate to strengthening the role of agriculture in the environment and climate change, as well as aligning the expected outcomes with the standards imposed by the Sustainable Development Goals (SDGs) of the United Nations 2030 Agenda (Matthews, 2020). The new CAP comes into force at a time of upheaval. It was delayed during the SARS-CoV-2 pandemic, but it must now deal with the energy and price crisis that has affected European farmers and consumers since the outbreak of the war between Russia and Ukraine (Consejo Europeo, 2021; Martínez Arroyo, 2021; Maté, 2022). The latest reform follows the same lines as in recent years in that it is based on direct payments linked to achieving environmental and climate objectives (Petsakos et al., 2022). In the last decade, the literature on the impact of CAP measures and reforms on European agricultural activity has grown. The commitment to environmental measures has had major effects on other key elements, such as the competitiveness of the European primary sector (De Castro et al., 2020). Therefore, discussing the possible ramifications of new approaches is important.

According to some authors (e.g., Nandwani and Nwosisi, 2016; Gamate et al., 2023), there is a process of agri-food transformation where new trends towards a more sustainable system (i.e., trends towards organic farming, direct sale markets, new forms of nutrition ...) coexist with some political resistance driven from lobbying groups. Political resistance means some producers may refuse to join those

sustainable trends (Johnson, 2006). In this context, NLP techniques and sentiment analysis can be used for policymakers to better design and inform agri-food policies, considering consumers' perspectives within a framework of co-creation and co-evaluation. Mazzucato (2022) argues that the concept of stakeholder value is being redirected to include sustainability and inclusive goals. Value should be created and shared collectively because firms and private institutions need citizens, associations, governments, and other individuals to be successful (Mazzucato, 2018). Society contributes to economic growth collectively, implying that the rewards from this process should be shared and fairly distributed between private and public agents. Producers, consumers, regulators, investors, managers, and workers co-create value (Mazzucato, 2022). This logic applied to the agri-food system highlights the importance of all agricultural agents when establishing changes and policies because sustainable agricultural value is only created collectively.

2.2. Using social media as a source of data for agricultural policy analysis

Social media have become a way for people to share ideas, thoughts, and information virtually (Susmitha and Pranitha, 2022). They are tools of communication that have grown in popularity in recent years (Criado and Rojas, 2013). According to Kaplan and Haenlein (2010, p. 61), the term "social media" or "social network" refers to any online platform "whereby content and applications are no longer created and published by individuals, but instead are continuously modified by all users in a participatory and collaborative fashion." In other words, social media are Internet-based applications that allow the creation and sharing of UGC.

According to Antypas et al. (2022), 48% of Europeans use social media every day or almost every day. In recent years, these tools have led to thematic networks of users that generate valuable knowledge for organizations to learn about users' interests and use this information to shape their actions (Criado and Rojas, 2013). Social media provide huge volumes of text data, images, videos, sounds, and geolocations. Together, this accumulated data is known as social media big data (Stieglitz et al., 2018). Analysis of this data can provide Internet users with valuable information about the latest trends, problems, needs, and influential actors in a given place and time. Companies and public organizations can thus identify risks and opportunities in social media communication and draw useful conclusions to support their decision making.

Social media have given public institutions a non-intermediated multidirectional communication channel with citizens that provides an almost instantaneous response (Rojas-Martín and Criado, 2015). The presence of public administrations on social media brings them closer to citizens' demands and contributes to citizens' involvement in public decisions (Agostino, 2013). In addition to helping communication, public organizations can use social media analytics (SMA) to help policymakers design public policies and services in line with the desires of society expressed through posts. SMA encompasses all processes needed to extract knowledge from social media. It refers to collecting a large set of UGC data for a specific period on a specific topic and analyzing it quantitatively (Stieglitz et al., 2018).

Antypas et al. (2022) studied why and how social media have become so influential in Western policymaking. On social media, users debate current issues and the future actions of policymakers, discuss consequences, express skepticism, anger, and general satisfaction, and propose changes (Stieglitz et al., 2018). For example, SMA can be used to identify the factors that influence electoral participation (Johannessen and Følstad, 2014). By applying SMA, governments and political parties can obtain insight to develop political strategies for elections (Vaccari et al., 2013). The possibilities of SMA have encouraged the participation of public figures and political parties in social media such as Twitter/X. Using Twitter/X, policymakers express their opinions, discuss current issues, and promote their political agenda to influence voter behavior

(Antypas et al., 2022). Conversely, social media also allow users to follow policymakers and interact with them, increasing citizens' interest in political discussion.

A number of recent studies have classified posts according to their sentiment (negative, neutral, or positive) to investigate the popularity of political candidates and determine the voting intention of users (Stieglitz et al., 2018). Such techniques are known as sentiment analysis or opinion mining. They have been used in several countries to test for correlation between the sentiment in a set of social media posts and electoral results. Stieglitz et al. (2018) argued that sentiment affects the dissemination of messages in social media. Supposedly, messages with a higher emotional content tend to be shared more quickly than messages with a neutral tone. Antypas et al. (2022) studied the idea of sentiment and opinion in their study of the relationship between the sentiment of political posts and their virality. They collected a large set of recent posts from members of parliament in Greece, Spain, and the United Kingdom. Their results indicate a strong relationship between the emotional tone of political posts and their level of public interest. According to their findings, negative posts are more viral than those conveying positive sentiment.

Virality is the speed and quantity of diffusion of specific media content (Stieglitz and Dang-Xuan, 2013), usually related to rapid popularity rises (Kim, 2018). However, virality is not objective. Social media users do not necessarily behave legitimately or neutrally. Their behavior is usually influenced by emotional and psychological factors (Tsugawa and Ohsaki, 2017). Moreover, virality can spread misinformation, affecting issues such as politics, public health, or economic change (Chen et al., 2023). This suggests that not all information or data that goes viral need to be true. Low-quality information can also go viral quickly due to a large amount of available information and limited attention (Qiu et al., 2017). Polarized debates are created where the position or opinion adopted by social media users is not always supported by evidence.

Viral posts or comments have the potential to influence voting patterns, public demonstrations, government perceptions, politicians' behavior, xenophobia, and political polarization (Zhuravskaya et al., 2020). Moreover, it becomes paramount to consider the possibility of false information when policymaking relies on information on social media. Being unable to detect false information and, make decisions and promote official strategies and programs based on this information can undermine credibility and institutional legitimacy and destabilize governments and political parties (Bennett and Livingston, 2018). That is why disinformation that emerges from technologies (e.g., artificial intelligence, social media, and the Internet) calls for the highest levels of accountability and examination. In this way, policy could be built on ensured democratic and ethical values (Landon-Murray et al., 2019). An in-depth analysis of societal sentiment is essential to identify uninformed or manipulated opinions. Salvatore et al. (2021) claim that it is crucial to assess social media data quality for policymaking by combining qualitative and quantitative analyses. Therefore, policy decisions can draw on the current and actual context based on the most objective and unbiased information possible.

Social media provide more than just insights into public opinion about political figures. Recuero-Virto and Valilla-Arróspide (2022) found that agri-food innovations are supported by society despite a somehow apparent negative sentiment of Twitter/X emerged in users toward innovative-related topics such as genetics or biotechnology (i.e., changes related to genetics, engineering, biotechnology, and pest). This insight could help companies and public administrations design educational and outreach campaigns to address consumer reticence and formulate public policies to respond to the prevailing public opinion. The study also revealed the issues on which users adopt a majority neutral sentiment or attitude. Examples include hunger and the depletion of the planet's resources. This early detection of user indifference toward crucial issues could lead to a rapid response to change user perceptions and make users accept the proposed strategies or

innovations. Mahon et al. (2023) applied sentiment analysis to study consumers' opinions on animal farming through an online survey. Similarly, other authors studied the connection of agriculture with the expansion of new technologies. Ancín et al. (2022) analyzed how the stakeholders of the agri-food sector perceived digital transformation. Pindado and Barrena (2021) employed Twitter/X as an information tool for investigating social attitudes towards new food trends across regions.

Twitter/X seems to have become the leading social media site for politicians and citizens to share their views on sociopolitical issues (Antypas et al., 2022). It has one of the largest numbers of users of any social media site, with around 500 million posts a day (Araujo Britto Sass et al., 2020). It is therefore an excellent platform for public communication since it is considered the most widely accessible social media platform (Riley and Robertson, 2021). The variety of topics covered on Twitter/X makes it a virtually unlimited source of data for analysis on any topic.

Nevertheless, social media data implies ethical and legal issues (Ahmed et al., 2017). According to Zimmer and Proferes (2014), privacy threats exist due to the lack of knowledge of the public nature of users' social media activity. For instance, the study conducted by Fiesler and Proferes (2018) shows that most social media users are unaware that their public posts are used for research purposes. Particularly, Twitter/X's terms of service indicate that third parties can use posts, giving legal consent when accepting these terms (Williams et al., 2017). Other issues deal with intellectual property and ownership (Taylor and Pagliari, 2018), confidentiality, informed consent (Golder et al., 2017), security, and transparency, among others (White and Boatwright, 2020). In this study, although Twitter/X users' approval was not requested, public opinions were aggregated to reflect sentiment categories. Thus, the privacy was guaranteed. Moreover, this study was conducted months after the users' opinions were published on the network. The individual findings, in the cases where the origin could be tracked, are also not shared with third parties.

3. Method and data

3.1. Natural language processing (NLP)

The rise of UGC in social media and the interest in exploiting this data creates difficulties in capturing, examining, and translating written content because published information is scattered, fuzzy, and unstructured (Alsaeedi and Khan, 2019). NLP is a field of computer science, artificial intelligence, and linguistics that is oriented towards the understanding of human language statements or words by computers (Srivastava et al., 2022). SMA techniques (including sentiment analysis and opinion mining) have gained considerable acceptance within academic research groups (Stieglitz et al., 2018). However, in this emerging field, there are still no standardized performance criteria for researchers to apply in applications of SMA. A key feature of SMA is its applicability to any research field where relevant information can be mined from social media. Notable examples include politics, sociology, marketing, advertising, psychology, and economics. According to Stieglitz (2018), a relatively similar process is implemented in all cases. The process consists of data discovery, data collection, data preparation, and data analysis. Therefore, further study and discussion of general models and approaches to SMA is important so that these models can be used to study issues related to agricultural policy and the agri-food sector.

Sentiment analysis extracts opinions, sentiments, attitudes, emotions, and points of view on a topic of interest from a text and then classifies them as positive, negative, or neutral depending on their context (Patel and Patel, 2020). Sentiment analysis relies on NLP, text mining, and computational linguistics to identify, extract, assess, and analyze a text's subjective information and emotional states and thus determine the author's attitude or sentiment on a particular issue (Alsaeedi and Khan, 2019). In particular, NLP implies understanding the representation or meaning of a sentence or language piece and studying

some characteristics of that meaning (Mahon et al., 2023). Existing opinion analysis techniques often attempt to identify words, phrases, or patterns that reflect a point of view (Valsamidis et al., 2013). However, this process is complex because the context, and not only the presence of keywords, matters. Companies have widely employed sentiment analysis to detect customer preferences and attitudes toward their brands, products, and services (Antypas et al., 2022). Nevertheless, sentiment analysis is valuable not only in commercial settings but also in socio-political areas such as public perceptions of the COVID-19 pandemic (Barkur and Vibha, 2020), gender stereotypes (Bhaskaran and Bhalla-mudi, 2019), and voter assessments of political representatives (Antypas et al., 2022). Therefore, NLP technology can be applied not only to solve problems but also to generate knowledge.

Feldman (2013) described the sentiment analysis process in several steps. The source document (in PDF, HTML, XML, Word, or otherwise) is called the corpus. It is converted into text and pre-processed (or cleaned) using linguistic tools such as derivation, tokenization, tagging, entity extraction, and relation extraction. The system then uses lexicons and linguistic resources to classify the pre-processed document based on sentiment annotations. These annotations can be made at the document level, the individual sentence level, or the syntagma level, as explained later. These annotations shape the output of the system. They can be presented to the user through visualization tools. The existing methods for sentiment analysis fall into three categories: (i) manual annotation method, (ii) supervised learning method or machine learning (ML), and (iii) unsupervised learning or lexicon-based methods. The difference between supervised and unsupervised learning relies on the training process required when labeling and preparing for the training set. Therefore, unsupervised learning requires less effort and is less time-consuming (Jung and Lee, 2019). Fig. 1 shows the sentiment analysis process when applying SMA.

3.2. Data

This paper presents an application of unsupervised learning to texts on agri-food policy. A large volume of Twitter/X data was analyzed to extract users' sentiment and attitudes. The validated function and lexicon were used to extract information from a large sample of posts. The aim was to test the usefulness of this method when processing large

data sets without prior manual filtering.

The chosen topic was the CAP at a time when a new reform had not yet entered into force. This timing may have led to social media conversations on the evaluation of the performance of previous policies and proposals for improvement for the future CAP for the period 2023 to 2027. Posts published from 2017 to 2022 were studied. They provided insight into the evolution of user sentiment in favor of or against the CAP over time. Destabilizing events in Europe have had an impact on user opinions in recent years. Examples include the COVID-19 pandemic, Brexit, and the recent war in Ukraine. English has the largest data and resources for NLP techniques. Likewise, lexicon, benchmarks, and ML models available for sentiment analysis are mostly developed in English, limiting research in other languages (Rodríguez-Ibáñez et al., 2021). However, selecting one language or another will ultimately depend on the requirements or subject matter of the study in question. The language considered was English because it is regarded as the international language despite excluding the other languages of the European Union. Table 1 summarizes the main features of the case.

The analysis procedure had three phases: data selection, data pre-processing, and data testing. The keywords for data selection were "Common Agricultural Policy". Although the abbreviation CAP would have returned a larger number of posts, the word "cap" has different meanings. Therefore, thousands of unrelated posts would have been returned by including "cap" as a keyword. The period of study was January 1, 2017, to May 31, 2022. A retweet/repost (from here, we will refer to retweets as reposts) may indicate that a user agrees with what another user has published and has decided to share it with followers. The person who reposts a post probably shares the same sentiment or attitude on the topic. Therefore, including reposts can provide a more

Table 1
Main characteristics of the CAP case study.

| CHARACTERISTICS | |
|-----------------|---------------|
| Methodology | Lexicon-based |
| Language | English |
| Number of posts | 73,850 |
| Period | 2017 to 2022 |
| Geolocation | No |

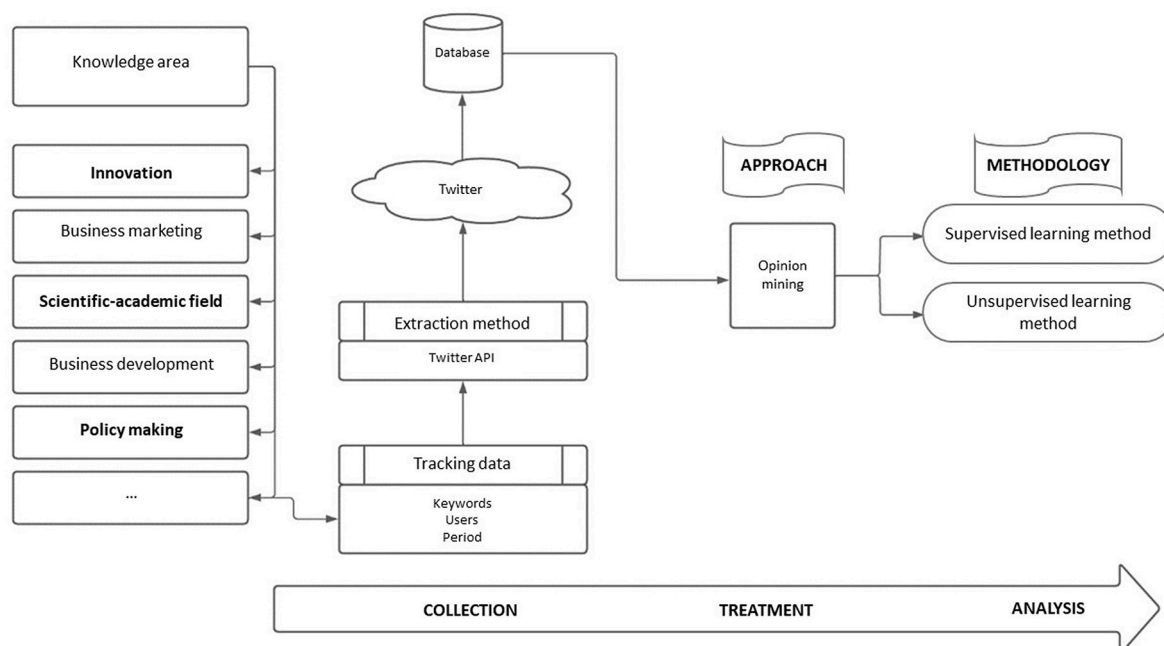


Fig. 1. SMA applied to sentiment analysis or opinion mining Source: Authors based on Stieglitz et al. (2018) and Stieglitz and Dang-Xuan (2013).

accurate view of reality. However, if reposts are included, any error in post classification is repeated for each re post, which can distort the results. This study excludes reposts to minimize the possible errors. They were only considered when analyzing the match between the most reposted topics and the cluster topics found in the paper’s findings.

A custom function was used for data pre-processing. Although this custom function was less optimized than other R packages, it enabled selection of each cleaning step to adapt it to the type of text being analyzed, namely a set of posts. Given the aim of examining the sentiment conveyed in the posts, text elements (capitalization, URLs, punctuation marks, single or control characters, numbers, graphics, etc.) were removed. In the testing phase, the posts were analyzed (52% neutral, 28.2% positive, and 19.6% negative). In total, 20,789 positive and 14,441 negative posts were found. The high number of neutral posts may be due to the presence of publications from the media and other organizations that report on the CAP objectively. Also, EU announcements and webinars or events on this topic tend to spread rapidly within networks.

4. Results: the CAP

4.1. Evolution over time

Attitudes and opinions are volatile and change over time (Patel and Patel, 2020). These changes can be monitored to determine which events trigger changes in individuals’ opinions or attitudes toward a topic and how general thinking evolves over time. The temporal distribution of posts over more than five years (2017–2022) was analyzed according to the sentiment category (positive or negative). Fig. 2 shows this distribution.

There was similar activity for both categories. When positive posts increased, negative posts also increased. Over the period, the number of positive posts was higher than the number of negative ones. However, this response did not always occur when the number of negative posts increased substantially. For example, in July and August 2017, a large share of CAP posts was related to Brexit. A year after the Brexit referendum, there was uncertainty about the next steps in terms of the UK’s agricultural policy. This uncertainty was reflected in users’ posts, which were divided between those expressing concern for the consequences of Brexit for UK farmers and those defending their departure to stop

supposedly ineffective financing measures.

In March and April 2019, many Twitter/X users were unsure about some of the new CAP measures because the European Parliament’s agriculture committee approved a series of proposals for the post-2020 CAP reform in early April. In November 2019, the CAP was widely questioned following the publication of a *NY Times* article. This article identified practices that could lead to land concentration and subsidies for oligarchs in Hungary and other Central and Eastern European countries (Gebrekidan et al., 2019), as well as by the Mafia in Italy (Roberts, 2018). The article triggered comments questioning the CAP’s benefits and calling for structural reform. In October 2019, the number of positive and negative posts rapidly increased in response to the debate in the European Parliament on the CAP and the vote on its approval (Sottile, 2020). Most criticisms mentioned the lack of ambition in climate and environmental protection. Specifically, a post by Greta Thunberg criticizing the vote as “disastrous” for climate, biodiversity, and sustainable agriculture received more than 1800 reposts.

4.2. Opinion analysis of original posts

The next analysis looked at changes in the distribution of different sentiment categories when only the original posts were considered (excluding reposts). Although including reposts provides a closer reflection of reality, excluding reposts minimizes possible errors attributable to the calculation model. The percentage of neutral posts increased by more than 10%. The proportion of negative publications only slightly increased, while positive publications grew by almost 10%. If the proportion of positive posts increased after considering only the original posts, they tended to be less reposted than negative ones.

4.3. Word frequency

Analysis of the word frequency of posts was also conducted. The most mentioned words in posts categorized as positive and negative were extracted to identify the topics that citizens associated with the CAP, the policy benefits detected by the users, and the problems attributed to the CAP. Only words mentioned at least four times were included. The keywords used during data collection (“Common Agricultural Policy”) and stop words and other zero-value words were removed. COVID-19 was not a frequently mentioned topic, despite

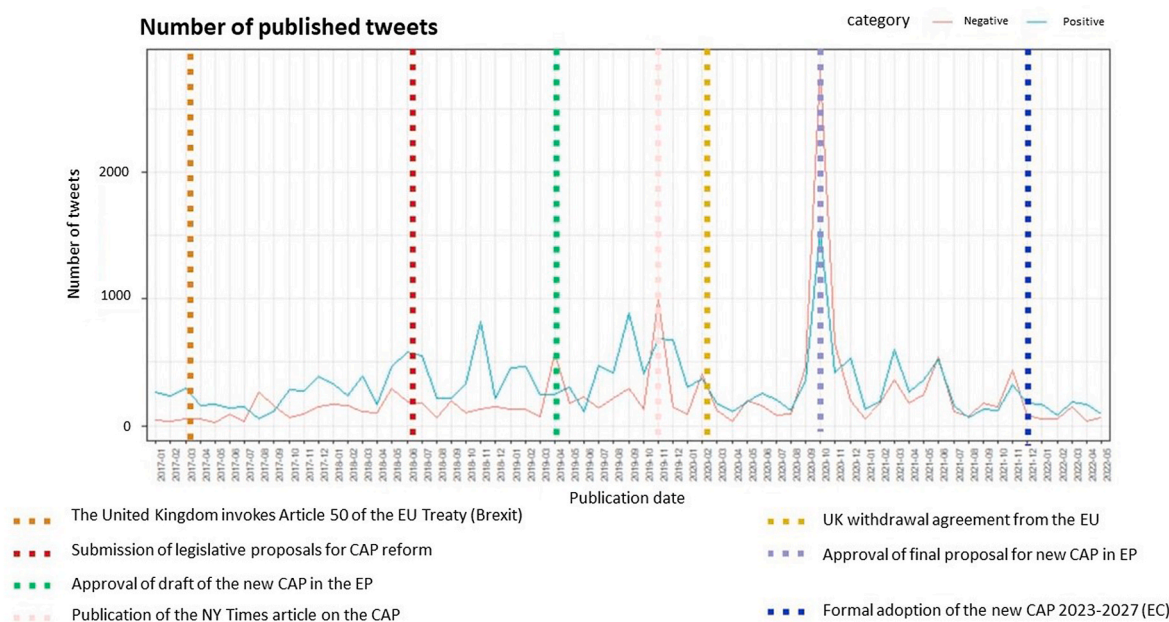


Fig. 2. Number of posts by sentiment category over time.

having caused a more than two-year delay in the approval of the new CAP reform.

The findings for positive posts were inconclusive. The main topic was Brexit, which was also the most mentioned topic over the last five years. The word “reform” was used in posts referring to the actions and proposals for the future reform of the CAP post-2020. However, learning about users’ opinions on more specific aspects of the CAP (e.g., the scope of measures, eco-schemes, and the ability of member states to adapt proposals to specific national conditions) was difficult with only this information. Many of the topics in the most mentioned negative posts were the same as those in the other category (e.g., “Brexit”, “new”, and “parliament”). Nevertheless, some new words appeared. For example, Greta Thunberg was cited as an important climate activist, and Nigel Farage was cited as one of the foremost British politicians in favor of the UK’s exit from the EU. Users used stronger adverbs and adjectives than in positive sentiment posts (e.g., “disastrous”, “barbaric”, and “massively”).

Many of these words did not provide insight into users’ positive or negative sentiments or attitudes about the CAP. Hence, it was impossible to draw clear conclusions. Analyzing words by clusters according to the topic they referred to was helpful to identify the benefits that users associated with the CAP. The 30 most frequently mentioned words in positive and negative posts were selected and grouped by topic (see Fig. 3). Some words were difficult to group into a single cluster (e.g., “parliament”, “new”, and “animal”).

Fig. 3 shows that the topic of Brexit attracted the most attention in relation to the CAP. This interest is perhaps justified by the fact that most posts were in English. The number of posts from users in the United Kingdom was proportionally higher than the number from users from other countries. However, the UK’s exit from the EU is pivotal for the future of the CAP, given that the UK was the third biggest contributor to the EU budget. Only Germany and France provided more (EAE Business School, 2019). This aspect concerns Europeans, suggesting that it must be addressed by member countries in terms of both the overall CAP budget and the inclusion of contingency plans for companies in the sector.

The second most mentioned topic was the environment and the

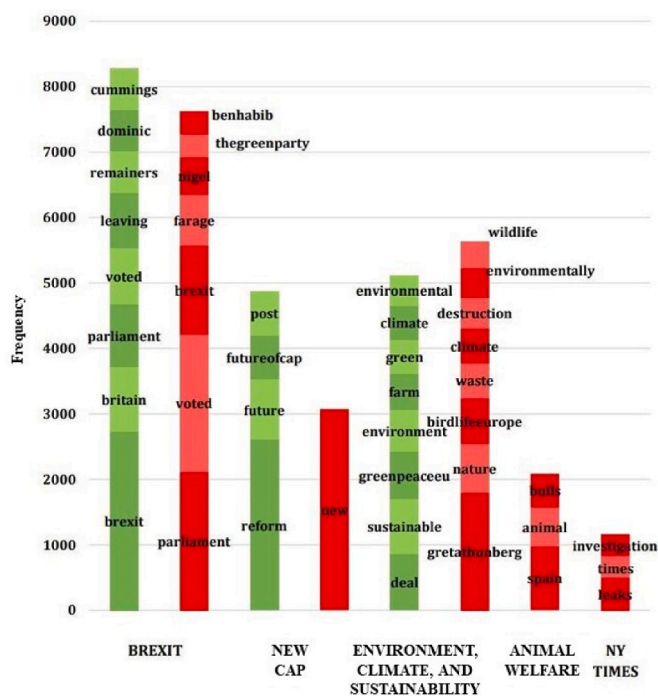


Fig. 3. Grouping of the most used words in positive and negative posts by topic.

climate crisis. Surprisingly, negative posts outnumbered positive ones. Accordingly, Twitter/X users seemed to perceive the environmental and sustainability measures included in the CAP as unambitious. One of the most mentioned concepts in positive posts was the Green Deal. The Green Deal is a set of initiatives aimed at making Europe the first continent to achieve climate neutrality by 2050. This plan could set the roadmap for future CAP post-2020 reform measures on the climate and environmental sustainability.

The structure of the new CAP attracted considerable interest on Twitter/X. Users commented on good results or stressed weaknesses in the new reform. Interest in this issue was also shown by the number of hashtags on the new CAP for 2023 to 2027, such as #FutureOfCAP, #CAPreform, and #CAPStrategicPlan, as well as critical hashtags such as #VotheThisCAPDown and #WithdrawTheCAP.

On the topic of animal welfare, the allocation of CAP funds for the breeding of fighting bulls was widely criticized. This issue is still awaiting the vote of the European Council after the European Parliament approved an amendment in the framework of the CAP reform in 2020. This amendment vetoes the allocation of coupled payments for the breeding of fighting bulls. Finally, the publication of the *NY Times* article on the allocation of CAP funds to beneficiaries suspected of carrying out opaque land transfers and land grabbing operations was one of the most important issues.

4.4. Most reposted topics

Analysis of the topics covered by the positive and negative posts with the most reposts was performed. This analysis assessed whether the topics in these highly reposted posts matched the topics of the clusters. It also determined whether positive or negative sentiment posts were reposted the most. Table A1 in Appendix I shows the positive and negative posts with the most reposts. Negative posts were reposted up to 10 times more than positive posts, even though the total number of positive posts was higher. This finding is consistent with the study of Antypas et al. (2022), who reported a strong relationship between sentiment and the popularity of political posts. They found that posts classified negatively were more viral than those that conveyed a positive sentiment. These results show that the topics that received the most interest could have implications in designing and implementing the new CAP. The topics of Brexit, environmental commitments, the Green Deal, food safety, cattle farming, and corruption and illegal practices in the distribution of CAP funds are all important.

5. Conclusions

This paper discusses the usefulness of NLP methods as a way of quickly collecting large sets of data on user sentiment or opinion on social media, in this case Twitter/X. The analysis examined the agri-food sector and, more specifically, the CAP. The findings show that NLP techniques contribute to assessing old policies and promoting and shaping new policy initiatives. These techniques can also help identify the reasons why citizens support or oppose issues, such as policies, production models, or farming practices. Accepting the limitations of Twitter/X data, and according to Ahmed et al. (2017), the social network can be used to monitor political and other social events in real time because this platform is a communication channel among different economic agents (Simon et al., 2014).

Our proposal does not neglect that policy design and process are complex, leading to continuous interactions between institutional and economic factors. Policymaking emerges from a transaction or exchange in which different interest groups or individuals are involved. These interest groups have specific preferences and behaviors that result in specific agricultural policy decisions (García-Álvarez-Coque, 1991). Therefore, it becomes paramount to note that using societal information and opinions (in the present research gathered through NLP techniques) to monitor policy decisions can be a complementary tool that provides a

broader view, encompassing a wider range of agents affected by agricultural policy. For example, [Tudela-Marco et al. \(2017\)](#) argue that consumer and industry pressures influence national food policies when establishing norms and standards. We cannot underestimate that social media shapes political opinion ([Barnes et al., 2023](#)), while political opinion can also affect societal sentiment toward some topics. In this sense, NLP techniques applied to agricultural policy could create a relational policy-sentiment approach. This relational approach reflects that as well as policies influence societal sentiment, society's opinion can influence policymakers, modulating their decision choices, and not independently of the sentiment of society and lobbying groups.

The CAP has always moved, sometimes slowly, according to new socioeconomic demands, as well as to changes in the European or global policy settings. Brexit remains a major concern for Europeans. It is a delicate issue that should be addressed in the new CAP to support farmers' standard of living and prevent further rises in product prices, which have been affected by the war in Ukraine. Brexit will influence the future budget and finances of each member state. It will also require plans to contain the crisis and protect European exports in the face of new customs regulations.

The CAP has been criticized for its lack of ambition in terms of the environment and the European Green Deal. For example, despite the aspirations of the new eco-schemes, their adoption by farmers is voluntary, and neither European farmers nor the European market can guarantee an orientation towards specific environmental outcomes ([Martino and Muenzel, 2018](#)). Moreover, each member state can decide which voluntary payments to adopt and what the eligibility criteria for obtaining them should be ([Petsakos et al., 2022](#)). Social movements, farmers' unions, and political parties at the European Parliament have urged the European Commission to adopt greener, but at the same time, practical proposals because they regard the new CAP as incapable of meeting the aims of the Green Deal and 2030 Agenda in time. However, the CAP has also increased citizens' awareness of food safety and has helped ensure the quality and safety of products, as well as affordable prices for consumers. Supporting and protecting farmers' incomes is also a positive aspect of the CAP. The new strategic dialogue, announced by the European Commission in September 2023 ([von der Leyen, 2023](#)), will probably call for a more inclusive reflection on the future CAP, involving all kinds of stakeholders of the food system.

Anticipating the state of opinion in cases of risk of social unrest through sentiment analysis tools could support inclusive and sound policymaking approaches. Therefore, NLP techniques are also useful for alerting sentiments on very specific cases. Another example which summarizes the conflicting views of the European integration process is the management of bullfighting livestock. Some users have expressed concern for the CAP's support for it. They questioned whether European funds should be used to finance bullfighting, while others argued that it is a Spanish tradition that should be preserved. In this study, the majority supported the removal of these funds. Other specific aspects refer to remaining suspicions of corruption and illegal practices in the distribution of CAP funds that must be eliminated. Such efforts are only possible if the methods for applying and allocating funds are improved. Another specific CAP feature is the implementation of the farmer's field notebook as a key instrument for good practices for land management. In many countries (such as Spain), it is not digitized. The digitization and automation of these processes are important steps to reduce the number of infringements.

SMA is still a relatively new research area. The process of collecting, processing, and analyzing social media data is complex. Data from social media sites can be useful for researchers in a range of fields given the interdisciplinary nature of SMA ([Stieglitz et al., 2018](#)). This paper highlights the need for further research into the application of these disciplines in sectors other than information and communication technology (ICT), where researchers are unfamiliar with computational methods that can enable the automated discovery, collection, and preparation of large volumes of social media data. The findings show the

usefulness of NLP for sentiment analysis in relation to the CAP. There are opportunities in the agricultural public sector to integrate social media data science and analytics to enhance assessment methods and influence policy. Moreover, social media can help provide a more complete picture of European citizens' views of agricultural policy in Europe. Therefore, analyzing social media users' sentiment and opinions on the CAP to evaluate the results of agricultural policy and propose new measures can ensure effective and successful agricultural policies and initiatives.

This paper is not without limitations. For example, farmers themselves leave few comments on social media. Other fields where there is little opinion include farmers' working conditions and prices. This situation probably indicates that farmers are not present on social media and lack support networks on these sites or organizations that generate debate on the issues that concern them. Therefore, social media is not widespread in all geographic areas and social groups ([Bos and Owen, 2016](#)). Whereas consumers have been widely represented on Twitter/X, producers' opinions are almost unknown. Therefore, this method would not be the most appropriate to cover farmers' opinions. Moreover, firms or large corporations such as Twitter/X have objectives that do not necessarily consider informing policymakers. When corporative databases are used for research, some comments or information may be known or accessed. Similarly, the techniques used in this study have technical, linguistic, legal, and even ethical limitations. These limitations are accentuated in areas such as agriculture, where the use of these tools is limited and there is room for improvement. Other limitations relate to the period of analysis and the sole use of certain specific learning language models.

As future research lines, applying other learning language models (based on machine learning or neural networks) and comparing the performance of each with respect to lexicon-based methods could validate the use of each technique in different fields for different purposes. Examining longer periods or comparing opinions according to users' gender could also be useful. However, this information is only available in the profiles of users who choose to make it public. Another interesting variable is users' country of residence. However, the number of geo-located posts is scarce, so the sample might be too small to study. In addition, automatic data mining could be extended to new topics, keywords, hashtags, languages, and even social media sites. A final reflection for the future refers to exploring the opportunities of combining the analysis of images, audio-visual elements, and even the great advances in artificial intelligence (AI) with sentiment analysis to complement our methodology. These research avenues could give a more accurate picture of users' profiles in favor of or against a particular issue.

CRediT authorship contribution statement

Alba Gutiérrez Domínguez: Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Norat Roig-Tierno:** Supervision, Software, Methodology, Formal analysis, Data curation. **Nuria Chaparro-Banegas:** Writing – review & editing, Visualization, Investigation, Conceptualization. **José María García Álvarez-Coque:** Writing – review & editing, Validation, Supervision, Formal analysis.

Declaration of competing interest

None.

Data availability

Data will be made available on request.

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Appendix A. Results. Case 2: CAP

Table A1

Publications with the most reposts classified by sentiment and topic

| Date | Post | Reposts | Topic |
|--------------------|--|---------|--|
| 25/10/2020 | This week the European Parliament voted for a new 7yr Common Agricultural Policy (CAP) that will be disastrous for climate, biodiversity and sustainable farming. But it's not over yet. Sign the open letter demanding the @EU_Commission to #WithdrawTheCAP http://WithdrawTheCAP.org | 1769 | Environment, climate, and sustainability |
| October 20, 2020 | The European Parliament has voted against any meaningful reform of the EU's common agricultural policy #CAP They have signed a death sentence for small farms, nature and the climate #FutureofCAP #CAPPreform | 712* | New CAP |
| September 10, 2019 | Dominic Cummings had a go at Remainers saying we were all rich elite. This is where he lives. His father-in-law lives in a castle & receives EU funding from the Common Agricultural Policy. https://theredroar.com/2019/08/revealed-anti-elite-dominic-cummings-lives-in-1-6-million-islington-townhouse/ | 625* | Brexit |
| September 20, 2020 | In Spain they enjoy setting bulls on fire & to torture them in barbaric arenas. Spain is a EU member since 1986. 34 years the EU has failed to put an end to this torture. Even worse EU budgets have been going to support this under Common Agricultural Policy. | 478 | Bullfighting |
| December 20, 2018 | "The biggest waste of EU resources is Nigel Farage's salary" | 471 | Brexit |
| June 25, 2021 | This pro-extinction policy will hit Europe's wildlife with extreme violence. Read our press release for more #WithdrawTheCAP #EUGreenDeal #CAPPreform https://birdlife.org/europe-and-central-asia/news/press-release-bad-CAP-Deal-kill-nature 25June2021 | 360 | Environment, climate, and sustainability |
| November 07, 2019 | Why is @TheGreenParty pro EU when the single most environmentally damaging policy in Europe is the Common Agricultural Policy? It costs a fortune, enables farmers to grow things we could buy more cost effectively elsewhere and uses land which should be used for reforestation. | 349 | Environment, climate, and sustainability |
| October 18, 2020 | 1) for the last 60 years, we've been funding a campaign to exterminate Europe's wildlife. Through the EU's Common Agricultural Policy (CAP), hundreds of billions of euros of public money have been funnelled into destroying wildlife-rich meadows, woods, wetlands and rivers. | 333 | Environment, climate, and sustainability |
| November 04, 2019 | New York Times investigation finds the EU's common agricultural policy "is deliberately opaque, grossly undermines the EU's environmental goals and is warped by corruption and self-dealing", fuelling "Mafia-style land grabs". https://nytimes.com/2019/11/03/world/europe/eu-farm-subsidy-hungary.html | 307 | NY Times investigation |
| November 10, 2019 | 7. The EU's Common Agricultural Policy supports farmers, ensures food security and delivers reasonable prices to consumers. https://instituteofgovernment.org.uk/explainers/common-agricultural-policy | 161 | Food security, fair prices |
| June 01, 2018 | Presenting a modernised & simplified Common Agricultural Policy for the future of food & farming in Europe: http://europa.eu/!wn47yD | 111 | New CAP |
| |  | | |
| November 29, 2017 | Targeted, Flexible, Effective #FutureofCAP @PhilHoganEU The Future of Food & Farming – a flexible, fair & sustainable Common Agricultural Policy: http://europa.eu/!Nh37NV #FutureofCAP | 86 | New CAP |
| April 09, 2021 | Week 32 of my #ClimateStrike for #FridaysForFuture My sign says (in Finnish): Better Agricultural Policy! I am asking for the CAP (Common Agricultural Policy) to be good for the small farmers, the climate and biodiversity. | 80 | Environment, climate, and sustainability |
| April 08, 2019 | We are prepared to support European farmers in a possible "no-deal" Brexit scenario. Our Common Agricultural Policy has existing tools that can be activated in the event of market disturbances to #Prepare4Brexit. Learn more https://europa.eu/!Uu97Vj | 73 | Brexit |

Note: *Some positive sentiment posts were found to be wrongly categorized. A review of some of the miscategorized posts showed that errors in the categorization were mainly due to references (positive or negative) within the post to topics other than the CAP. Specifically, many posts supporting Brexit referred to the advantages of leaving the CAP for the UK. By introducing these positive opinions, the model mistakenly classified the post as being in support of the CAP, when in fact it was a negative post supporting the exit of the UK.

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