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Sentiment Analysis of Mandatory Halal Certification Policy on Twitter Using the Naive Bayes and K-Nearest Neighbors Algorithm

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ABSTRACT

Twitter become a platform for Indonesians to express views on various issues, including the mandatory halal certification policy regulated by Law Number 33 of 2014 on Halal Product Assurance. The first phase of this certification runs from October 17, 2019, to October 17, 2024, covering: (1) food and beverages; (2) raw materials, food additives, and auxiliary materials; and (3) slaughter products and services. This research analyzes public sentiment on Twitter towards this policy using the Naive Bayes and KNN algorithm. Analysis of 536 tweets revealed 307 neutral (57.3%), 145 positive (27.1%), and 84 negative sentiments (15.7%). The findings highlight public support and criticism of the policy. The model Naïve Bayes showed an accuracy of 82.7% and KNN 81.62%, demonstrating its effectiveness in classifying new sentiments. This research aids the government's decision-making process in evaluating the mandatory halal certification policy, ensuring it aligns with public needs and is well-received by Indonesians.

Keywords: *Mandatory Halal Certification, Naive Bayes Algorithm, Sentiment Analysis, Twitter*

1 Introduction

Information and communication technology advancements have made social media a primary platform for public interaction, expression of opinions, and public discourse [1]. One popular platform frequently used to express public views on various issues, including government policies, is Twitter [2]. Currently, a hot topic being discussed by the Indonesian public is the mandatory halal certification policy [3]. This policy is crucial for Indonesia's predominantly Muslim population, as halal certification ensures that products consumed and used are by Islamic law [4] prohibiting the use of substances such as pork and alcohol [5]. This affects not

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only religious beliefs but also the lifestyle of the Muslim community, known as the "halal lifestyle," which is increasingly developing in Indonesia [6]. Halal products symbolize trust and safety for Muslim consumers, ensuring that the products have undergone processes compliant with Islamic law [7].

Halal certification is essential for consumer health and safety [8]. Halal products must be free from prohibited substances and processed cleanly and healthily. Additionally, halal certification can enhance the competitiveness of local products in the global market [9]. This is because halal products have a broad market not only in Indonesia but also in countries with predominantly Muslim populations. Thus, halal certification can also improve the quality and standards of Indonesian products, enabling them to compete in the international market. Halal certification is regulated by Law No. 33 of 2014 concerning Halal Product Assurance [10] Article 4 of the law states that products entering, circulating, and trading within Indonesia must be halal certified. The mandatory halal certification is being implemented in stages, starting from October 17, 2019, to October 17, 2024 [11] covering three categories: (1) food and beverage products; (2) raw materials, food additives, and auxiliary materials for food and beverage products; and (3) slaughtered products and slaughter services. This policy was issued in response to the growing demand for halal products [12] and to protect Muslim consumers from products that do not comply with Islamic law [13].

In Indonesia, Halal Product Assurance (JPH) is implemented by the Halal Product Assurance Organizing Agency (BPJPH) under the Ministry of Religious Affairs. BPJPH has made various efforts to support the implementation of mandatory halal certification [14]. Some programs launched include the mandatory halal campaign in 1,000 locations and the #WajibHalalOktober2024 movement held in 34 provinces in Indonesia. Additionally, the Free Halal Certification Program (SEHATI) was launched to assist Micro, Small, and Medium Enterprises (MSMEs) in the food and beverage sector with specific criteria for obtaining halal certification for free [15]. These government programs aim to encourage and increase awareness among more MSMEs and the public to register their products for halal certification [16]. However, many MSMEs and individuals still need to register their products for certification [17] due to a lack of information and the perception that the process is complicated and time-consuming [18]. Products without halal certification tend to be less favored by Muslim consumers [19] which can result in decreased competitiveness and narrower market opportunities [20]. This underscores the importance of halal certification as a critical factor in marketing strategies and business development, particularly in Indonesia [21].

As the implementation of mandatory halal certification approaches, the government must understand public responses to the policy. The diversity of public perspectives on a topic can provide valuable data to support decision-making processes [22]. Social media, such as Twitter, serves as a platform for the public to express their opinions on the policy. Sentiment analysis can offer valuable insights into public perceptions of the mandatory halal certification policy and assist the government in formulating more effective and responsive strategies to meet public needs.

This study aims to analyze Indonesian public sentiment towards the mandatory halal certification policy expressed on Twitter using the Naive Bayes and K-Nearest Neighbors (KNN) algorithms. The scope of this research is limited to tweets containing keywords related to mandatory halal certification, collected over a specific period using the Twitter API. Only tweets in Indonesian will be used, and sentiment analysis will focus on positive, negative, and neutral sentiments. Naive Bayes was chosen for its simplicity and effectiveness in handling data with independent features, while KNN was selected due to its proximity-based approach for classifying data [23]. This study also aims to compare the performance of Naive Bayes and KNN in determining the best model for sentiment classification. The results are expected to provide a better understanding of public sentiment towards the mandatory halal certification policy in Indonesia and serve as an evaluation tool for the government.

2 Materials and methods

2.1 Materials

The data source used in this study is Twitter, obtained through the Twitter API. The dataset consists of Indonesian-language tweets with the keywords "*wajib sertifikasi halal*" from January 1, 2021 to May 20, 2024. A total of 654 data tweets were collected, with 536 data points ready for further processing after removing duplicates. The dataset was then cleaned of unnecessary characters to ensure data quality. In this study, the dataset does not include user demographic information, such as age, gender, or location, as these details were not collected during data retrieval. As a result, the findings from Twitter users cannot be generalized to the broader population, and there may be specific user demographics that could potentially influence the sentiment analysis. This limitation is inherent to social media data, where demographic information is often unavailable unless explicitly provided by users. This study uses Python and is executed on the Google Colab platform. Several Python libraries are used in this research, including numpy for numerical operations, sastrawi for Indonesian stemming, nltk for text processing, tokenization, and stopword management, matplotlib and seaborn for data visualization, smote for oversampling imbalanced sentiments in dataset, and scikit-learn for Naive Bayes, KNN algorithm implementation and model evaluation.

2.2 Methods

The methods in this study are depicted in Figure 1, illustrating the steps in the sentiment analysis process using the Naive Bayes and KNN algorithm. The process is conducted systematically, from data collection to model evaluation, with each step playing a crucial role in ensuring the accuracy and effectiveness of the sentiment analysis.

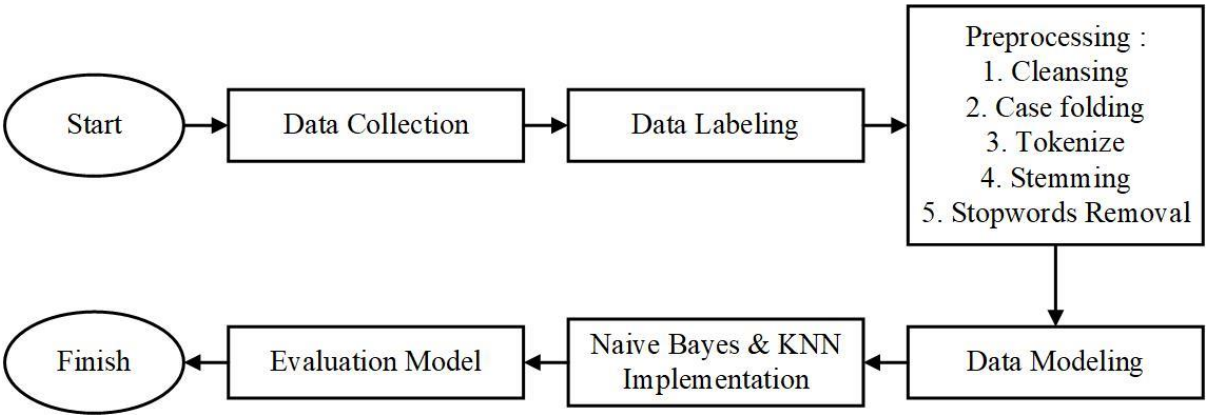

Fig. 1 Research methodology

The study begins with data collection from Twitter, gathering public opinions about the mandatory halal certification policy. Dataset will manually be labeled by three researchers based on positive, neutral, or negative sentiments. The labeled data undergoes pre-processing, including cleansing, case folding, tokenizing, stemming, and stopword removal. Indonesian stemming is the step to converts affixed Indonesian words into their root forms by removing prefixes, suffixes, infixes, or circumfixes, such as "*me-*", "*di-*", or "*-kan*."

The next step is data modeling, where an oversampling technique is carried out first to handle class imbalance in the dataset and then splitting the data into training and testing sets with an 80:20 ratio. The Naive Bayes and KNN algorithm are implemented for text classification.

Naive Bayes is a probabilistic classification method based on Bayes' Theorem, which estimates class probabilities by assuming that the features used in classification are conditionally independent of each other [24]. Although this independence assumption is rarely satisfied in practice, Naive Bayes often yields satisfactory results across various applications, particularly in text analysis and document classification. The fundamental formula of Bayes' Theorem can be expressed as follows equation 1.

$$P(C|X) = \frac{P(X|C)\,.\,P(C)}{P(X)} \quad (1)$$

where *P(C/X)* represents the probability of class *C* given features *X*, *P(X/C)* denotes the probability of features *X* given class *C*, *P(C)* is the prior probability of class *C*, and *P(X)* is the probability of features *X*. In the context of sentiment analysis, Naive Bayes is employed to classify texts into positive, negative, or neutral categories based on the words present within the text.

K-Nearest Neighbors (KNN) is a non-parametric classification algorithm that relies on distance measurement between data points. KNN operates by identifying the *k* nearest neighbors of the data point to be classified and determining the class based on the majority class of these neighbors [25]. KNN does not require assumptions regarding data distribution and is frequently utilized in various applications, including pattern recognition and sentiment analysis. The commonly used distance measure in KNN is the Euclidean distance, defined as follows equation 2.

$$d = \sqrt{\sum_{i=1}^{k}(x_i - y_i)^2} \quad (2)$$

where d represents the distance between two points, and x_i and y_i are the feature values of the two points being compared. In sentiment analysis, KNN is used to classify texts by comparing words in new texts to those in pre-categorized texts.

The resulting model is then evaluated to assess its performance and accuracy using a confusion matrix to determine accuracy, precision, recall, and F1-score for each sentiment. The process concludes by analyzing the results and drawing conclusions based on the findings.

3 Results and discussion

3.1 Results

Data Collection

The first step in this phase is collecting public opinion data which discusses the mandatory halal certification policy on Twitter. This collected data forms the basis for the sentiment analysis process. Researchers also added parameters such as keywords, date range, and text language during data collection to enhance data relevance and achieve accurate analysis results. A total of 536 data were obtained, with Table 1 showing examples of public opinion variations used in this study.

Table 1. Variations in public opinion

No	Tweet
1	🤣🤣🤣🤣🤣🤣 lucu banget. Pemerintah ngebuat kebijakan wajib sertifikasi halal ????? kok ngurusnya susah dan bertele tele banget ya
2	Koperasi dan UKM Jakbar Beri bimbingan teknis tentang wajib sertifikasi halal ke 600 UKM https://umkm.kompas.com/read/2024/06/07/175848283/sudin-koperasi-dan-ukm-jakbar-beri-bimtek-sertifikasi-halal-ke-600-ukm#subhidarajat #digitalmarketing
3	Saya bangga dengan kekayaan kuliner halal Indonesia! saya mendukung program wajib sertifikasi halal untuk desa wisata yang lebih maju dan mendunia. #WajibHalalOktober2024 #WHO2024 #3000DesaWisata
4	RT@areumdamwoo dulu itu kebijakan wajib sertifikasi halal itu sifatnya sukarela, nah sekarang wajib. Tapi kalau prosesnya lama & si pendamping tidak responsif ya sama aja bohong, malah kasihan ke pelaku usahanya. kemarin juga sempat ketemu sama pelaku usaha yang tidak diurusi sama pendampingnya, ada juga yang cuman didata lalu tidak tahu kelanjutannya.
5	Tingkatkan Daya Saing Global, Telkom Dukung Program Wajib Sertifikasi Halal 497 UMKM Binaan https://koranbumn.com/tingkatkan-daya-saing-global-telkom-dukung-sertifikasi-halal-497-umkm-binaan/ @TelkomIndonesia @Telkomsel @KemenBUMN @Synergy_Telkom @TelkomCare @telkomsat @KemenBUMN @KemenkopUKM

Data Labeling

Data Labeling is a stage for marking or labeling data and categorizing it based on positive, neutral, or negative sentiment. This process was conducted manually by three researchers. Each researcher was responsible for reviewing and classifying the tweets according to the sentiment they conveyed. The labeling was carried out using a majority voting system, where the label agreed upon by at least two researchers was assigned as the final label. In cases of

disagreement among the three researchers, discussions were held to reach a consensus. Manual labeling was chosen to ensure data accuracy and validity, offering greater precision in interpreting the cultural nuances of the Indonesian language, while involving multiple researchers enhanced the reliability of sentiment classification through consensus, resulting in higher-quality data for improved model performance. Table 2 shows tweets that have undergone the data labeling process.

Table 2. Data Labeling results on dataset

No	Tweet	Sentiment
1	🤣🤣🤣🤣🤣🤣 lucu banget. Pemerintah ngebuat kebijakan wajib sertifikasi halal ????? kok ngurusnya susah dan bertele tele banget ya	Negative
2	Koperasi dan UKM Jakbar Beri bimbingan teknis tentang wajib sertifikasi halal ke 600 UKM https://umkm.kompas.com/read/2024/06/07/175848283/sudin-koperasi-dan-ukm-jakbar-beri-bimtek-sertifikasi-halal-ke-600-ukm#subhidarajat #digitalmarketing	Neutral
3	Saya bangga dengan kekayaan kuliner halal Indonesia! saya mendukung program wajib sertifikasi halal untuk desa wisata yang lebih maju dan mendunia. #WajibHalalOktober2024 #WHO2024 #3000DesaWisata	Positive
4	RT@areumdamwoo dulu itu kebijakan wajib sertifikasi halal itu sifatnya sukarela, nah sekarang wajib. Tapi kalau prosesnya lama & si pendamping tidak responsif ya sama aja bohong, malah kasihan ke pelaku usahanya. kemarin juga sempat ketemu sama pelaku usaha yang tidak diurusi sama pendampingnya, ada juga yang cuman didata lalu tidak tahu kelanjutannya.	Negative
5	Tingkatkan Daya Saing Global, Telkom Dukung Program Wajib Sertifikasi Halal 497 UMKM Binaan https://koranbumn.com/tingkatkan-daya-saing-global-telkom-dukung-sertifikasi-halal-497-umkm-binaan/ @TelkomIndonesia @Telkomsel @KemenBUMN @Synergy_Telkom @TelkomCare @telkomsat @KemenBUMN @KemenkopUKM	Positive

The researcher also created a visualization of the bar chart diagram shown in Figure 2 to display the total sentiment from the results of the data labeling process on the dataset.

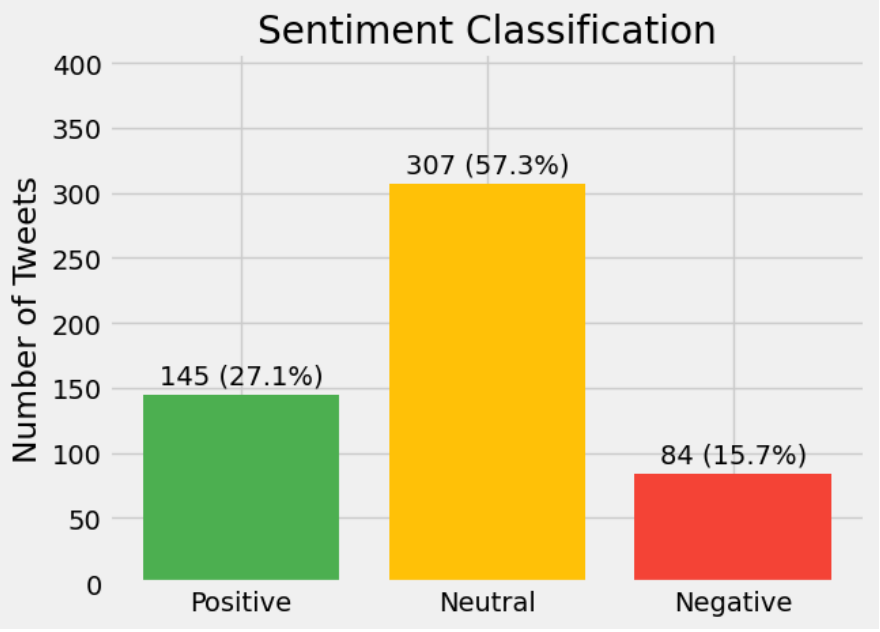

Fig. 2 Sentiment classification diagram

Figure 2 above shows that out of a total dataset of 536 tweets, 145 (27.1%) were classified as positive sentiment, 307 (57.3%) as neutral sentiment, and 84 (15.7%) as negative sentiment.

Pre-processing

This stage consists of several sub-processes to clean and prepare the data before analysis. This step is crucial to reduce data complexity and improve the quality of the information produced. The pre-processing stages include:

a. Cleansing

Cleansing is the step to removing irrelevant elements or those that do not add value to the dataset, such as emojis, web links (URLs), non-alphanumeric symbols, retweets (RT), etc. The main goal of this process is to reduce noise in the data, ensuring that the processed data only contains relevant and essential information. Table 3 shows tweets after the cleansing process.

Table 3. Cleansing results on dataset

No	Before	After
1	🤣🤣🤣🤣🤣🤣 lucu banget. Pemerintah ngebuat kebijakan wajib sertifikasi halal ????? kok ngurusnya susah dan bertele tele banget ya	lucu banget Pemerintah ngebuat kebijakan wajib sertifikasi halal kok ngurusnya susah dan bertele tele banget ya
2	Koperasi dan UKM Jakbar Beri bimbingan teknis tentang wajib sertifikasi halal ke 600 UKM https://umkm.kompas.com/read/2024/06/07/175848283/sudin-koperasi-dan-ukm-jakbar-beri-bimtek-sertifikasi-halal-ke-600-ukm#subhidarajat #digitalmarketing	Koperasi dan UKM Jakbar Beri bimbingan teknis tentang wajib sertifikasi halal ke UKM
3	Saya bangga dengan kekayaan kuliner halal Indonesia! saya mendukung program wajib sertifikasi halal untuk desa wisata yang lebih maju dan mendunia. #WajibHalalOktober2024 #WHO2024 #3000DesaWisata	Saya bangga dengan kekayaan kuliner halal Indonesia saya mendukung program wajib sertifikasi halal untuk desa wisata yang lebih maju dan mendunia
4	RT@areumdamwoo dulu itu kebijakan wajib sertifikasi halal itu sifatnya sukarela, nah sekarang wajib. Tapi kalau prosesnya lama & si pendamping tidak responsif ya sama aja bohong, malah kasihan ke pelaku usahanya. kemarin juga sempat ketemu sama pelaku usaha yang tidak diurusi sama pendampingnya, ada juga yang cuman didata lalu tidak tahu kelanjutannya.	dulu itu kebijakan wajib sertifikasi halal itu sifatnya sukarela nah sekarang wajib Tapi kalau prosesnya lama si pendamping tidak responsif ya sama aja bohong malah kasihan ke pelaku usahanya kemarin juga sempat ketemu sama pelaku usaha yang tidak diurusi sama pendampingnya ada juga yang cuman didata lalu tidak tahu kelanjutannya
5	Tingkatkan Daya Saing Global, Telkom Dukung Program Wajib Sertifikasi Halal 497 UMKM Binaan https://koranbumn.com/tingkatkan-daya-saing-global-telkom-dukung-sertifikasi-halal-497-umkm-binaan/ @TelkomIndonesia @Telkomsel @KemenBUMN @Synergy_Telkom @TelkomCare @telkomsat @KemenBUMN @KemenkopUKM	Tingkatkan Daya Saing Global Telkom Dukung Program Wajib Sertifikasi Halal UMKM Binaan

b. Case Folding

Case folding is the step to converting all text characters to lowercase. This is done to create consistency in the data and prevent information duplication due to differences in uppercase and lowercase letters. Table 4 shows tweets after the case folding process.

Table 4. Case folding results on dataset

No	Before	After
1	lucu banget Pemerintah ngebuat kebijakan wajib sertifikasi halal kok ngurusnya susah dan bertele tele banget ya	lucu banget pemerintah ngebuat kebijakan wajib sertifikasi halal kok ngurusnya susah dan bertele tele banget ya
2	Koperasi dan UKM Jakbar Beri bimbingan teknis tentang wajib sertifikasi halal ke UKM	koperasi dan ukm jakbar beri bimbingan teknis tentang wajib sertifikasi halal ke ukm
3	Saya bangga dengan kekayaan kuliner halal Indonesia saya mendukung program wajib sertifikasi halal untuk desa wisata yang lebih maju dan mendunia	saya bangga dengan kekayaan kuliner halal indonesia saya mendukung program wajib sertifikasi halal untuk desa wisata yang lebih maju dan mendunia
4	dulu itu kebijakan wajib sertifikasi halal itu sifatnya sukarela nah sekarang wajib Tapi kalau prosesnya lama si pendamping tidak responsif ya sama aja bohong malah kasihan ke pelaku usahanya kemarin juga sempat ketemu sama pelaku usaha yang tidak diurusi sama pendampingnya ada juga yang cuman didata lalu tidak tahu kelanjutannya	dulu itu kebijakan wajib sertifikasi halal itu sifatnya sukarela nah sekarang wajib tapi kalau prosesnya lama si pendamping tidak responsif ya sama aja bohong malah kasihan ke pelaku usahanya kemarin juga sempat ketemu sama pelaku usaha yang tidak diurusi sama pendampingnya ada juga yang cuman didata lalu tidak tahu kelanjutannya
5	Tingkatkan Daya Saing Global Telkom Dukung Program Wajib Sertifikasi Halal UMKM Binaan	tingkatkan daya saing global telkom dukung program wajib sertifikasi halal umkm binaan

c. Tokenize

Tokenize is the step to breaking a sentence into words or tokens. This stage aims to facilitate analysis at the word level, such as identifying keywords and understanding words that carry specific emotions or expressions. Table 5 shows tweets after the tokenization process.

Table 5. Tokenization results on dataset

No	Before	After
1	lucu banget pemerintah ngebuat kebijakan wajib sertifikasi halal kok ngurusnya susah dan bertele tele banget ya	lucu, banget, pemerintah, ngebuat, kebijakan, wajib, sertifikasi, halal, kok, ngurusnya, susah, dan, bertele, tele, banget, ya
2	koperasi dan ukm jakbar beri bimbingan teknis tentang wajib sertifikasi halal ke ukm	koperasi, dan, ukm, jakbar, beri, bimbingan, teknis, tentang, wajib, sertifikasi, halal, ke, ukm
3	saya bangga dengan kekayaan kuliner halal indonesia saya mendukung program wajib sertifikasi halal untuk desa wisata yang lebih maju dan mendunia	saya, bangga, dengan, kekayaan, kuliner, halal, indonesia, saya, mendukung, program, wajib, sertifikasi, halal, untuk, desa, wisata, yang, lebih, maju, dan, mendunia
4	dulu itu kebijakan wajib sertifikasi halal itu sifatnya sukarela nah sekarang wajib tapi kalau prosesnya lama si pendamping tidak	dulu, itu, kebijakan, wajib, sertifikasi, halal, itu, sifatnya, sukarela, nah, sekarang, wajib, tapi, kalau, prosesnya, lama, si, pendamping,

	responsif ya sama aja bohong malah kasihan ke pelaku usahanya kemarin juga sempat ketemu sama pelaku usaha yang tidak diurusi sama pendampingnya ada juga yang cuman didata lalu tidak tahu kelanjutannya	tidak, responsif, ya, sama, aja, bohong, malah, kasihan, ke, pelaku, usahanya, kemarin, juga, sempat, ketemu, sama, pelaku, usaha, yang, tidak, diurusi, sama, pendampingnya, ada, juga, yang, cuman, didata, lalu, tidak, tahu, kelanjutannya
5	tingkatkan daya saing global telkom dukung program wajib sertifikasi halal umkm binaan	tingkatkan, daya, saing, global, telkom, dukung, program, wajib, sertifikasi, halal, umkm, binaan

d. Stemming

Stemming is the step to converting words to their root forms by removing affixes. This stage aims to simplify and unify word forms with the same basic meaning and reduce the complexity of text data. Table 6 shows tweets after the stemming process.

Table 6. Stemming results on dataset

No	Before	After
1	lucu, banget, pemerintah, ngebuat, kebijakan, wajib, sertifikasi, halal, kok, ngurusnya, susah, dan, bertele, tele, banget, ya	lucu, banget, perintah, buat, bijak, wajib, sertifikasi, halal, kok, urus, susah, dan, tele, tele, banget, ya
2	koperasi, dan, ukm, jakbar, beri, bimbingan, teknis, tentang, wajib, sertifikasi, halal, ke, ukm	koperasi, dan, ukm, jakbar, beri, bimbing, teknis, tentang, wajib, sertifikasi, halal, ke, ukm
3	saya, bangga, dengan, kekayaan, kuliner, halal, indonesia, saya, mendukung, program, wajib, sertifikasi, halal, untuk, desa, wisata, yang, lebih, maju, dan, mendunia	saya, bangga, dengan, kaya, kuliner, halal, indonesia, saya, dukung, program, wajib, sertifikasi, halal, untuk, desa, wisata, yang, lebih, maju, dan, dunia
4	dulu, itu, kebijakan, wajib, sertifikasi, halal, itu, sifatnya, sukarela, nah, sekarang, wajib, tapi, kalau, prosesnya, lama, si, pendamping, tidak, responsif, ya, sama, aja, bohong, malah, kasihan, ke, pelaku, usahanya, kemarin, juga, sempat, ketemu, sama, pelaku, usaha, yang, tidak, diurusi, sama, pendampingnya, ada, juga, yang, cuman, didata, lalu, tidak, tahu, kelanjutannya	dulu, itu, bijak, wajib, sertifikasi, halal, itu, sifat, rela, nah, sekarang, wajib, tapi, kalau, proses, lama, si, damping, tidak, responsif, ya, sama, aja, bohong, malah, kasihan, ke, pelaku, usaha, kemarin, juga, sempat, temu, sama, pelaku, usaha, yang, tidak, urus, sama, damping, ada, juga, yang, cuma, data, lalu, tidak, tahu, lanjut
5	tingkatkan, daya, saing, global, telkom, dukung, program, wajib, sertifikasi, halal, umkm, binaan	tingkat, daya, saing, global, telkom, dukung, program, wajib, sertifikasi, halal, umkm, bina

e. Stopwords Removal

Stopwords removal is the step to removing common words frequently appearing in the text but not providing significant sentiment-related information, such as conjunctions, pronouns, and other irrelevant words to the halal certification topic. This stage aims to reduce data dimensions and focus the analysis on the most informative words. Table 7 shows tweets after the stopwords removal process.

Table 7. Stopwords removal results on dataset

No	Before	After
1	lucu, banget, perintah, buat, bijak, wajib, sertifikasi, halal, kok, urus, susah, dan, tele, tele, banget, ya	lucu perintah buat bijak wajib sertifikasi halal urus susah tele tele
2	koperasi, dan, ukm, jakbar, beri, bimbing, teknis, tentang, wajib, sertifikasi, halal, ke, ukm	koperasi ukm jakbar beri bimbing teknis wajib sertifikasi halal ukm
3	saya, bangga, dengan, kaya, kuliner, halal, indonesia, saya, dukung, program, wajib, sertifikasi, halal, untuk, desa, wisata, yang, lebih, maju, dan, dunia	bangga kaya kuliner halal indonesia dukung program wajib sertifikasi halal desa wisata maju dunia
4	dulu, itu, bijak, wajib, sertifikasi, halal, itu, sifat, rela, nah, sekarang, wajib, tapi, kalau, proses, lama, si, damping, tidak, responsif, ya, sama, aja, bohong, malah, kasihan, ke, pelaku, usaha, kemarin, juga, sempat, temu, sama, pelaku, usaha, yang, tidak, urus, sama, damping, ada, juga, yang, cuma, data, lalu, tidak, tahu, lanjut	bijak wajib sertifikasi halal rela sekarang wajib proses lama damping tidak responsif bohong kasihan pelaku usaha kemarin temu pelaku usaha tidak urus damping data tidak tahu lanjut
5	tingkat, daya, saing, global, telkom, dukung, program, wajib, sertifikasi, halal, umkm, bina	tingkat daya saing global telkom dukung program wajib sertifikasi halal umkm bina

The researcher also created data visualizations, as shown in Figure 3, to illustrate the frequency of word occurrences in the database as a word cloud.

Fig. 3 Word cloud visualization

The word cloud visualization aims to display words frequently appearing in discussions about the mandatory halal certification policy. More prominent words indicate a higher frequency of the most common words in the dataset, such as “halal”, "wajib", "sertifikasi", "produk", "makan", "minum", "usaha", "umkm". These words highlight the main topics in the discussion

related to the policy. The high frequency of words like "halal" and "sertifikasi" emphasizes the main focus on the policy and how the Indonesian public perceives it. Words like "usaha", "produk", "makanan", "minuman", and "UMKM" show special attention to the policy's impact on the business sector, especially MSMEs facing challenges in meeting halal certification requirements.

Data Modeling

Data modeling is the stage for creating a statistical model that can later be used to predict new data labels based on previously labeled data, which is implemented using the Naive Bayes algorithm. Before the modeling process, the researchers applied an oversampling technique to address class imbalance in the dataset. Specifically, the Synthetic Minority Over-sampling Technique (SMOTE), implemented through the SMOTE library, was used to balance the number of minority sentiment categories to match the majority. SMOTE generates synthetic samples for the minority class by interpolating between existing data points, ensuring the model can learn equally from both majority and minority classes. This balancing is crucial to enhance the model's ability to detect sentiment accurately, particularly in categories with fewer data points.

After applying oversampling, the dataset was divided into two parts: training data and testing data. The ratio used in this research is 80:20, with 80% of the data used to train the model and the remaining 20% used to test it. This division ensures the model learns from most of the data and is tested on unseen data, providing a more accurate indication of the model's performance in determining sentiment for new data.

Naive Bayes & KNN Implementation

Stages for building a sentiment classification model using the Naive Bayes and KNN algorithm from the data modeling results that have been created. The implementation of these algorithms allows for a comparative evaluation of their performance in sentiment prediction. The Naive Bayes algorithm uses the training data to train the model by calculating the frequency of words in each sentiment class and using this information to predict the sentiment of the testing data entries based on the model. On the other hand, KNN algorithm classifies new data points based on their proximity to labeled examples in the training data. It measures the distance between data points, typically using Euclidean distance, and classifies a data point according to the majority sentiment of *k* nearest neighbors. By implementing both algorithms, the performance of the models in predicting sentiment can be evaluated, facilitating a comparison of their accuracy and effectiveness in classifying new data.

Model Evaluation

The final stage in this process is the model evaluation to ensure the built model can provide accurate predictions. This stage uses a confusion matrix to assess the algorithm's accuracy and calculates precision, recall, and F1-score for each sentiment using the following equations (Equations 3-6).

$$Accuracy = \frac{(TP_{negative} + TP_{positive} + TP_{netral})}{(Total\ Cases)} \quad (3)$$

$$Precision = \frac{(TP)}{(TP+FP)} \quad (4)$$

$$Recall = \frac{(TP)}{(TP+FN)} \quad (5)$$

$$F1\ score = 2\ x\ \frac{(Precision\ x\ Recall)}{(Precision + Recall)} \quad (6)$$

Figure 4 below shows the confusion matrix visualization for the 536 data tweets divided into test and train datasets and implemented using the Naive Bayes algorithm.

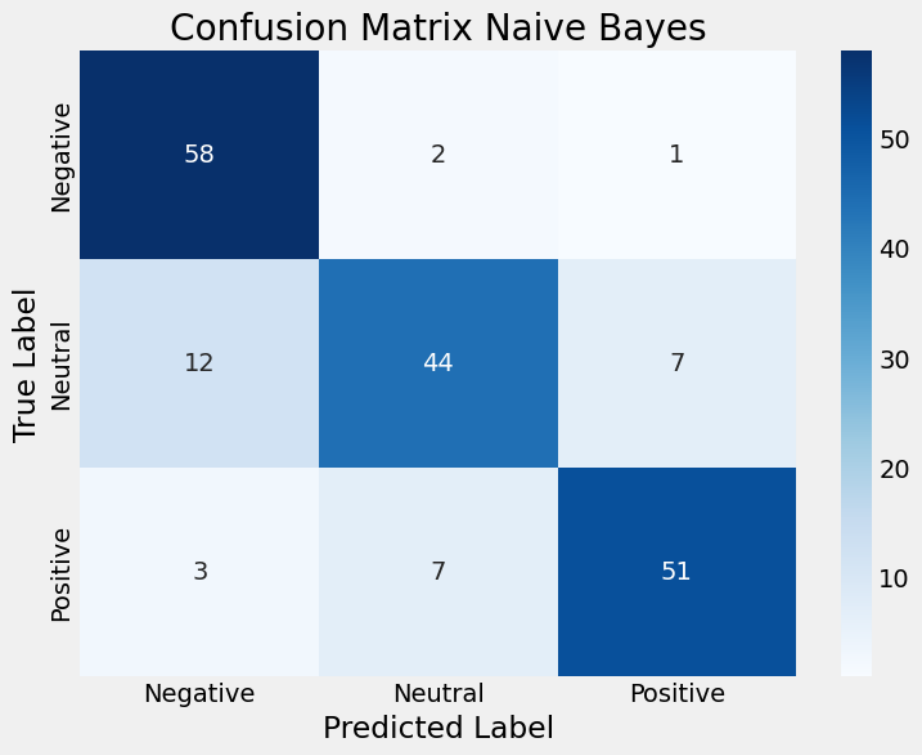

Fig. 4 Confusion matrix of naive bayes

Based on the confusion matrix in Figure 4, the performance of the Naive Bayes algorithm in classifying sentiment into three different categories (positive, neutral, and negative) is as follows:

- Positive Category: There are 51 True Positive cases where the model correctly predicts a particular sample is positive. However, there are 3 Positive cases predicted as Negative and 7 Positive cases predicted as Neutral.
- Neutral Category: There are 44 True Neutral cases where the model correctly predicts that a particular sample is neutral. However, there are 12 Neutral cases predicted as Negative, and 7 Neutral cases as Positive.
- Negative Category: There are 58 True Negative cases where the model correctly predicts a particular sample is negative. However, 2 Negative cases are predicted as Neutral, and 1 Negative case is predicted as Positive.

The next step is to calculate the accuracy and the values of recall, precision, and F1-score for each sentiment in the Naive Bayes algorithm from the confusion matrix values in Figure 4 as follows:

Accuracy of Naive Bayes:

$TP_{positive} = 51$

$TP_{neutral} = 44$

$TP_{negative} = 58$

$Total\ Cases = 58 + 2 + 1 + 12 + 44 + 7 + 3 + 7 + 51$

$Total\ Cases = 185$

$Accuracy = \frac{51+ 44+58}{185}$

$Accuracy = \ 0.82702\ or\ 82.7\%$

Sentiment Positive of Naive Bayes:

$TP_{positive} = 105$

$FP_{positive} = 1 + 7$

$FP_{positive} = 8$

$FN_{positive} = 3 + 7$

$FN_{positive} = 10$

$Precision_{positive} = \frac{(TP_{positive})}{(TP_{positive}+FP_{positive})}$

$Precision_{positive} = \frac{51}{51+8}$

$Precision_{positive} = \ 0.8644\ or\ 86.44\%$

$Recall_{positive} = \frac{(TP_{positive})}{(TP_{positive}+FN_{positive})}$

$Recall_{positive} = \frac{51}{51+10}$

$Recall_{positive} = \ 0.83606\ or\ 83.61\%$

$F1\ score_{positive} = \ 2\ x \frac{(Precision_{positive}\ x\ Recall_{positive})}{(Precision_{positive} + Recall_{positive})}$

$F1\ score_{positive} = \ 2\ x \frac{(0.86440\ x\ 0.83606)}{(0.86440 + 0.83606)}$

$F1\ score_{positive} = 0.85\ or\ 85\%$

Sentiment Neutral of Naive Bayes:

$TP_{neutral} = 44$

$FP_{neutral} = 2 + 7$

$FP_{neutral} = 9$

$FN_{neutral} = 12 + 7$

$FN_{neutral} = 19$

$Precision_{neutral} = \frac{(TP_{neutral})}{(TP_{neutral}+FP_{neutral})}$

$Precision_{neutral} = \frac{44}{44+9}$

$Precision_{neutral} = 0.83018 \; or \; 83.02\%$

$Recall_{neutral} = \frac{(TP_{neutral})}{(TP_{neutral}+FN_{neutral})}$

$Recall_{neutral} = \frac{44}{44+19}$

$Recall_{neutral} = 0.69841 \; or \; 69.84\%$

$F1\ score_{neutral} = 2\ x \frac{(Precision_{neutral}\ x\ Recall_{neutral})}{(Precision_{neutral} + Recall_{neutral})}$

$F1\ score_{neutral} = 2\ x \frac{(0.83018\ x\ 0.69841)}{(0.83018 + 0.69841)}$

$F1\ score_{neutral} = 0.75862 \; or \; 75.86\%$

Sentiment Negative of Naive Bayes:

$TP_{negative} = 58$

$FP_{negative} = 12 + 3$

$FP_{negative} = 15$

$FN_{negative} = 2 + 1$

$FN_{negative} = 3$

$Precision_{negative} = \frac{(TP_{negative})}{(TP_{negative}+FP_{negative})}$

$Precision_{negative} = \frac{58}{58+15}$

$Precision_{negative} = 0.79452 \; or \; 79.45\%$

$Recall_{negative} = \frac{(TP_{negative})}{(TP_{negative}+FN_{negative})}$

$Recall_{negative} = \frac{58}{58+3}$

$Recall_{negative} = 0.95082 \; or \; 95.08\%$

$F1\ score_{negative} = 2\ x \frac{(Precision_{negative}\ x\ Recall_{negative})}{(Precision_{negative} + Recall_{negative})}$

$F1\ score_{negative} = 2\ x \frac{(0.79452\ x\ 0.95082)}{(0.79452 + 0.95082)}$

$F1\ score_{negative} = 0.86567 \; or \; 86.57\%$

Figure 5 below shows the confusion matrix visualization for the 536 data tweets divided into test and train datasets and implemented using the KNN algorithm.

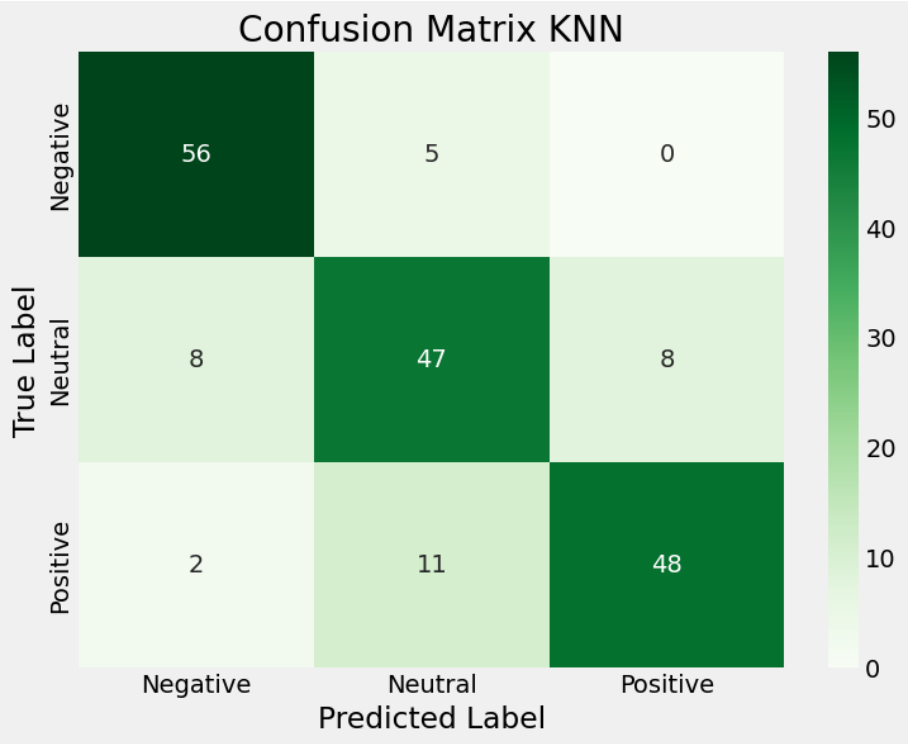

Fig. 5 Confusion matrix of KNN

Based on the confusion matrix in Figure 4, the performance of the KNN algorithm in classifying sentiment into three different categories (positive, neutral, and negative) is as follows:

- Positive Category: There are 48 True Positive cases where the model correctly predicts a particular sample is positive. However, there are 2 Positive cases predicted as Negative and 11 Positive cases predicted as Neutral.
- Neutral Category: There are 47 True Neutral cases where the model correctly predicts that a particular sample is neutral. However, there are 8 Neutral cases predicted as Negative, and 8 Neutral cases as Positive.
- Negative Category: There are 56 True Negative cases where the model correctly predicts a particular sample is negative. However, 5 Negative cases are predicted as Neutral, and no Negative case is predicted as Positive.

The next step is to calculate the accuracy and the values of recall, precision, and F1-score for each sentiment in the KNN algorithm from the confusion matrix values in Figure 5 as follows:

Accuracy of KNN:

$TP_{positive} = 48$

$TP_{neutral} = 47$

$TP_{negative} = 56$

$Total\ Cases = 56 + 5 + 0 + 8 + 47 + 8 + 2 + 11 + 48$

$Total\ Cases = 185$

$Accuracy = \frac{48+47+56}{428}$

$Accuracy = 0.81621\ or\ 81.62\%$

Sentiment Positive of KNN:

$TP_{positive} = 48$

$FP_{positive} = 0 + 8$

$FP_{positive} = 8$

$FN_{positive} = 2 + 11$

$FN_{positive} = 13$

$Precision_{positive} = \frac{(TP_{positive})}{(TP_{positive}+FP_{positive})}$

$Precision_{positive} = \frac{48}{48+8}$

$Precision_{positive} = 0.85714\ or\ 85.71\%$

$Recall_{positive} = \frac{(TP_{positive})}{(TP_{positive}+FN_{positive})}$

$Recall_{positive} = \frac{48}{48+13}$

$Recall_{positive} = 0.78688\ or\ 78.68\%$

$F1\ score_{positive} = 2\ x\ \frac{(Precision_{positive}\ x\ Recall_{positive})}{(Precision_{positive} + Recall_{positive})}$

$F1\ score_{positive} = 2\ x\ \frac{(0.85714\ x\ 0.78688)}{(0.85714 + 0.78688)}$

$F1\ score_{positive} = 0.82051\ or\ 82.05\%$

Sentiment Neutral of KNN:

$TP_{neutral} = 47$

$FP_{neutral} = 5 + 11$

$FP_{neutral} = 16$

$FN_{neutral} = 8 + 8$

$FN_{neutral} = 16$

$Precision_{neutral} = \frac{(TP_{neutral})}{(TP_{neutral}+FP_{neutral})}$

$Precision_{neutral} = \frac{47}{47+16}$

$Precision_{neutral} = 0.74603\ or\ 74.6\%$

$Recall_{neutral} = \frac{(TP_{neutral})}{(TP_{neutral}+FN_{neutral})}$

$$Recall_{neutral} = \frac{47}{47+16}$$

$$Recall_{neutral} = 0.74603 \; or \; 74.6\%$$

$$F1\ score_{neutral} = 2\ x \frac{(Precision_{neutral}\ x\ Recall_{neutral})}{(Precision_{neutral} + Recall_{neutral})}$$

$$F1\ score_{neutral} = 2\ x \frac{(0.74603\ \ x\ 0.74603\ )}{(0.74603\ \ +\ 0.74603\ )}$$

$$F1\ score_{neutral} = 0.74603 \; or \; 74.6\%$$

Sentiment Negative of KNN:

$$TP_{negative} = 56$$

$$FP_{negative} = 8 + 2$$

$$FP_{negative} = 10$$

$$FN_{negative} = 5 + 0$$

$$FN_{negative} = 5$$

$$Precision_{negative} = \frac{(TP_{negative})}{(TP_{negative}+FP_{negative})}$$

$$Precision_{negative} = \frac{56}{56+10}$$

$$Precision_{negative} = 0.84848 \; or \; 84.85\%$$

$$Recall_{negative} = \frac{(TP_{negative})}{(TP_{negative}+FN_{negative})}$$

$$Recall_{negative} = \frac{56}{56+5}$$

$$Recall_{negative} = 0.91803 \; or \; 91.8\%$$

$$F1\ score_{negative} = 2\ x \frac{(Precision_{negative}\ x\ Recall_{negative})}{(Precision_{negative} + Recall_{negative})}$$

$$F1\ score_{negative} = 2\ x \frac{(0.84848\ x\ 0.91803)}{(0.84848 + 0.91803)}$$

$$F1\ score_{negative} = 0.88189 \; or \; 88.19\%$$

The researcher provides a comparative analysis in Table 8 to clarify the evaluation outcomes of the Naive Bayes and KNN algorithms. This table serves to highlight the differences and similarities in performance between the two models, offering a comprehensive understanding of their respective evaluation results.

Table 8. Comparative evaluation of naive bayes and knn algorithm performance

Metrix	Naive Bayes	KNN
Accuracy	82.7%	81.62%
Precision (Positive)	86.44%	85.71%
Precision (Neutral)	83.02%	74.6%
Precision (Negative)	79.45%	84.85%
Recall (Positive)	83.61	78.68%

Recall (Neutral)	69.84%	74.6%
Recall (Negative)	95.08%	91.8%
F1-Score (Positive)	85%	82.05%
F1-Score (Neutral)	75.86%	74.6%
F1-Score (Negative)	86.57%	88.19%

Table 8 presents a comparative performance analysis between the Naive Bayes and K-Nearest Neighbors (KNN) algorithms applied to sentiment analysis of public opinions on the mandatory halal certification policy on Twitter. The models were evaluated using several metrics, including accuracy, precision, recall, and F1-Score, across three sentiment categories: positive, neutral, and negative. In terms of accuracy, the Naive Bayes model slightly outperforms KNN, achieving 82.7% compared to 81.62% for KNN. This indicates that, overall, Naive Bayes has a marginally better capacity to correctly classify tweets. However, the difference between the two models is relatively small, suggesting both algorithms are closely competitive in terms of overall accuracy.

Regarding precision, which measures the proportion of correct positive predictions made by the model, Naive Bayes shows superior performance for the positive and neutral sentiment categories, with precision values of 86.44% and 83.02% respectively. In contrast, KNN achieves slightly lower precision for positive sentiment at 85.71% and significantly lower precision for neutral sentiment at 74.6%. For the negative sentiment category, however, KNN exhibits better precision, recording 84.85%, while Naive Bayes attains only 79.45%. This suggests that KNN is more effective at accurately identifying tweets with negative sentiment.

When examining recall, which reflects the model's ability to correctly identify all relevant instances of a sentiment, Naive Bayes again outperforms KNN in the positive and negative sentiment categories. Naive Bayes achieves a recall of 83.61% for positive sentiment and an impressive 95.08% for negative sentiment, compared to KNN's recall values of 78.68% and 91.8% for positive and negative sentiments, respectively. For neutral sentiment, KNN slightly surpasses Naive Bayes, with recall values of 74.6% versus 69.84%. This indicates that KNN is marginally more effective at identifying neutral sentiment tweets, while Naive Bayes is more proficient at capturing positive and negative sentiment tweets.

Finally, the F1-Score, which provides a balance between precision and recall, indicates that Naive Bayes performs better in classifying positive and neutral sentiments. The F1-Score for positive sentiment is 85% for Naive Bayes, compared to 82.05% for KNN, and for neutral sentiment, Naive Bayes records 75.86%, while KNN reaches 74.6%. Conversely, for negative sentiment, KNN achieves a higher F1-Score of 88.19%, outperforming Naive Bayes at 86.57%. This suggests that while Naive Bayes is generally more effective in identifying positive and neutral sentiments, KNN demonstrates greater accuracy in classifying negative sentiment tweets.

In conclusion, Naive Bayes exhibits overall superior performance in detecting positive and neutral sentiments, whereas KNN is more effective at recognizing negative sentiments. Although the overall accuracy of both models is relatively similar, Naive Bayes marginally outperforms KNN in terms of overall classification efficiency.

3.2 Discussion

The sentiment analysis application on the mandatory halal certification policy on Twitter shows various responses from the Indonesian public. Of the 536 tweets analyzed, the majority were neutral, with 307 tweets (57.3%). This indicates that many users provide information or descriptive opinions without clearly supporting or opposing the policy, such as information about the timing of the halal certification socialization, delays in the halal certificate, etc. There was positive sentiment in 145 tweets (27.1%), indicating significant support for the mandatory halal certification policy. This finding suggests that several Twitter users view this policy as an essential and beneficial step in ensuring the halal status of products consumed by the Indonesian public. Words such as "halal", "wajib", "sertifikasi", "usaha", "produk", "makanan", "minuman", and "UMKM" that appear in the word cloud visualization support this finding and show that discussions often and also pointed out that discussions often focus on the importance of halal certification for various products and its impact on MSMEs. Negative sentiment accounts for 84 tweets (15.7%), which, although relatively low compared to other sentiments, remains essential to note. One of the most prominent issues is the perceived complexity of the halal certification registration process, with users reporting difficulties in understanding how to navigate the SIHALAL platform. Many users expressed frustration over the lack of clear guidance or assistance, particularly regarding how to locate or contact the assigned certification facilitators. Furthermore, some users noted that facilitators were unresponsive, exacerbating the delays in the registration process. Another critical concern raised was the lengthy and uncertain time frame for halal certificate issuance. Numerous business owners expressed frustration over the absence of clear timelines or estimated dates for certificate approval, leaving them in a state of uncertainty. Such delays could significantly disrupt business operations, especially for MSMEs. These findings highlight the need for improvements in the system, including the provision of simpler, clearer tutorials for using the SIHALAL platform, the implementation of a facilitator rating or reporting system, and the addition of features that offer estimated certification time frames to businesses. Despite the relatively lower percentage of negative sentiment, these concerns are crucial to address, as they directly impact the effectiveness and public perception of the halal certification policy, particularly among businesses. By addressing these issues through policy improvements, the user experience can be enhanced, and broader public support for the certification process can be strengthened.

4. Conclusion

This study shows that the mandatory halal certification policy received a neutral response with 307 tweets (57.3%), a positive response with 145 tweets (27.1%), and a negative response with 84 tweets (15.7%). The developed sentiment analysis model can help automatically identify new data or public opinions on Twitter regarding the halal certification policy. Implementing this model is expected to increase the speed and accuracy of identifying public sentiment and provide deeper insights into public perceptions of the policy. This research can support the decision-making process by BPJPH at the Ministry of Religious Affairs in responding to public aspirations and concerns, as well as formulating more effective policies in line with public needs and desires, thereby enhancing the acceptance and success of the policy's implementation.

For further research, comparing the Naive Bayes and KNN algorithm with other classification algorithms, such as Support Vector Machine (SVM) or Decision Tree, is recommended to achieve higher accuracy and effectiveness in sentiment classification. Additionally, data sources should not be limited to Twitter but should also include Facebook, Instagram, or other platforms to provide a more diverse and accurate sentiment analysis. A larger dataset is also expected to improve model accuracy and benefit future research. The Naive Bayes and KNN algorithm's high performance demonstrates the developed model's reliability in classifying sentiment, which can be further enhanced to detect sentiment more accurately. This model has great potential for application and development in future sentiment analysis automation and can significantly benefit the monitoring and understanding of public opinion more effectively, supporting better decision-making processes by relevant parties.

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