

## Sentiment Analysis in Agriculture

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### Abstract

Sentiment analysis is currently the most actively researched topic in the field of natural language processing, however, despite it being such a powerful tool, it is not very widely used in the agrarian sector. This research focuses on the discovery and analysis of scientific literature related to Sentiment analysis in agriculture, to provide an overview of how and where Sentiment analysis is used in the agrarian sector and which methods are most commonly used. This article also discusses which applications of Sentiment analysis yield the most benefits and suggests a direction for future research.

### Keywords

Sentiment analysis, agriculture, opinion mining, natural language processing, text mining.

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### Introduction

The goal of this research is to discover and analyze literature focused on the application of Sentiment analysis in agriculture, to map the current state of research, and ultimately, to suggest a direction for future research conducted on this topic. The first part of the article is covering the background of the observed topic and asserting its importance, as well as acknowledging the previous work of other researchers. Afterward, the focus shifts towards a definition of a methodology for the discovery of information sources, their analysis and evaluation. Following that, the article communicates the results of the analysis and then finally concludes with an evaluation of research done on the observed topic and suggestions for future work. The research is purely focused on the analysis of literature, which is dealing with the application of sentiment analysis agriculture and farming. Applications of sentiment analysis in fields closely related to agriculture, such as food quality and food production, are not covered in this research.

#### ICT and agriculture

The introduction of ICT in the agrarian sector has a tremendous transformational character throughout the whole industry and leads to increased agricultural efficiency and reduced environmental impact, which in turn increases the food quality. (Heege, 2013). This is hardly surprising,

considering that agriculture has always been highly dependent on precise information and efficient communication (McNamara et al., 2011). Also, in addition to improvement in farming efficiency and empowerment of farmers, increased adoption of ICT in agriculture brings new ways to collect valuable data, which may be then used for further research (Daum, 2018) as well as improvement of the management processes using information technologies (Muhammad et al., 2019). ICT usage in communications at all stages of manufacturing and commerce in agrarian sector, like other types of economic activity, leads to increase of effectiveness, measured by value added and connected economic indicators (Bilan et al., 2019). Beyond that, digital technology also dramatically increases the quality of life in rural regions for individuals and enterprises (Shaibu et al., 2018; Toomsalu et al., 2019), being in many cases one of the crucial factors of the rural communities' development (Kostiukevych et al., 2020). Clearly, there is potential in exploring new ways of integrating ICT into agriculture, but it is necessary to point out that farmers are hesitant adopters (Pierpaoli et al., 2013), and therefore the benefits of such new methods must be proven and explained thoroughly (Chukwunonso, 2012).

#### Sentiment analysis and opinion mining

Since the web changed from "read-only" to "read-write", its enthusiastic users started to create a base

of collective knowledge through social networks, blogs, wikis, online communities, and other types of web media. Meanwhile, engineers and computer scientists started to apply text classification methods, such as opinion mining and Sentiment analysis on the user-produced content (Cambria et al., 2013). Sentiment analysis is described as a discipline focused on the analysis of people's opinions, sentiments, evaluations, appraisals, attitudes, and emotions towards products, services, organizations, and other entities with methods of natural language processing (Liu, 2012). The term "sentiment analysis" was first used by (Nasukawa and Yi, 2003) and the term "opinion mining" was introduced by (Dave et al., 2003) and both of them are being used interchangeably by academics (Saber and Saad, 2017).

Sentiment classifiers use human-generated text (words, phrases, or whole documents) as an input and determine the sentiment polarity of the given document to be either positive or negative. Modern sentiment classifiers are able to distinguish neutral sentiment as well. Sentiment analysis is mainly used in the fields of marketing, sociology, and politics (D'Andrea et al., 2015).

Currently used approaches of Sentiment analysis can be categorized into the following three groups (Sharma et al., 2019):

- **Lexicon based approach** determines sentiment from the semantic orientation of words and phrases. This approach requires a dictionary, containing a selection of words with their positive and negative sentiment values (Jurek et al., 2015). This makes the approach more difficult to implement in the environment of less spoken languages, where such dictionaries are not yet widely available.
- **Machine learning approach** applies machine learning algorithms such as Naïve Bayes, Maximum Entropy, etc., to determine sentiment through linguistic features. Both supervised and unsupervised methods can be used, although supervised learning is preferred, given that a sufficient quantity of labeled input documents is available (Wala et al., 2014).
- **Hybrid approach** combines the lexicon-based approach and machine learning approach for increased performance (Ahmad et al., 2017).

## Related work

A similar paper titled "A survey of the applications of text mining for agriculture" exists (Drury and Roche, 2019) however, it is focused broadly on reviewing applications of data collection and text mining methods in agriculture in general. A small section of the mentioned paper is dedicated to Sentiment analysis in agriculture; however, the topic is covered quite briefly and only a few examples are provided. This research on the other hand focuses specifically on applications of Sentiment analysis in agriculture and aims to review all available literature related to this topic.

## Materials and methods

This research is going to apply methods of conventional literature review, similar to those in (Drury and Roche, 2019), however, it is going to cover a significantly larger volume of topic-specific literature. Unlike in (Drury and Roche, 2019), the reviewed publications are not going to be discussed in depth individually, but instead, their methodologies will be extracted in a standardized way proposed by the author, and the following discussion is going to focus on the state of research in the topic as a whole.

The first step is going to be finding a sufficient quantity of relevant literature for the topic of Sentiment analysis in agriculture. Once the list of publications is compiled, then all of the listed publications are going to be reviewed and grouped by proposed approaches, objects of analysis and dates of publication, to determine the current state of research in Sentiment analysis in agriculture. Publications are going to be reviewed from the oldest to the newest, to maintain continuity.

Finally, a synthesis of information obtained from the reviewed publications is going to be used in making suggestions for further research.

## Methodology of discovering literature

The literature is going to be searched for via Scopus and Google Scholar databases. Boolean search operators are going to be used to search for specific as possible.

- Scopus database query: TITLE-ABS-KEY ("sentiment analysis" OR "opinion mining") AND agriculture);
- Google Scholar query #1: "sentiment analysis" AND agriculture;

- Google Scholar query #2: “opinion mining” AND agriculture.

Google Scholar, unfortunately, does not support brackets, therefore “sentiment analysis” and “opinion mining” have to be queried separately. Results of all the queries are going to be filtered manually according to the criteria defined by the author in Table 1, in order to exclude irrelevant literature.

Requirements for literature	
Date of publication:	2010-2020
Type of publication:	Scientific article, Book, Thesis, Conference proceedings, Project report
SJIF:	Any or N/A
Topic:	Application of sentiment analysis/opinion mining and agriculture

Source: own

Table 1: Requirements for publications compiled by the author, in order to exclude irrelevant literature.

### Methodology for literature review and analysis

Individual articles are going to be reviewed thoroughly, to extract methods and approaches used by researchers working on Sentiment analysis in agriculture. Firstly, a set of characteristics for the description of methodology in Sentiment analysis research should be defined. According to a consensus amongst researchers in the field, the process of Sentiment analysis consists of the following steps:

- Obtainment of input data;
- Pre-processing of input data;
- Application of Sentiment analysis model;
- Model evaluation.

These methods used, to accomplish these steps, are going to be extracted from the reviewed articles and are going to serve as a base set of characteristics for evaluating applications of Sentiment analysis in agriculture. In addition to this, the language of input data and results of the model evaluation will be extracted from the articles as well. Therefore, the final set of characteristics, which will be used to describe each of the articles is going to look as follows:

- Input data [Type and source of the input data.];
- Input language [Original language(s) of the input data.];
- Pre-processing [Methods used for data pre-processing, if mentioned.];

- SA algorithm [Algorithm, model, or tool used to perform the actual sentiment analysis.];
- Model Evaluation [Methods used for model evaluation, if mentioned.];
- Model Accuracy [If provided.].

Note: It was originally intended to include whether the authors of the peer-reviewed articles considered their research to be successful or not, but this was omitted because it was shown that all authors considered their research to be successful and worthy of further development.

Therefore, it was decided, that only purely methodologic information will be included in the results.

### Methodology for the state of research determination

Quantitative and qualitative methods are going to be combined, to describe the current state of research. Firstly, statistical analysis will be used to determine the distribution of reviewed articles per year of publication, applied approach of sentiment analysis, and object of study. Synthesis of results combined with a qualitative evaluation of the results will then be used in conclusion, to describe the current state of research and to suggest the direction for future work.

### Results and discussions

A total of eleven publications has been found via the proposed methodology of literature discovery and are now listed in Table 2.

Figure 1 shows a trend of increase in publications on the topic of Sentiment analysis in agriculture over the past few years. The most productive so far was the year 2018 with a total of 5 publications on the topic.

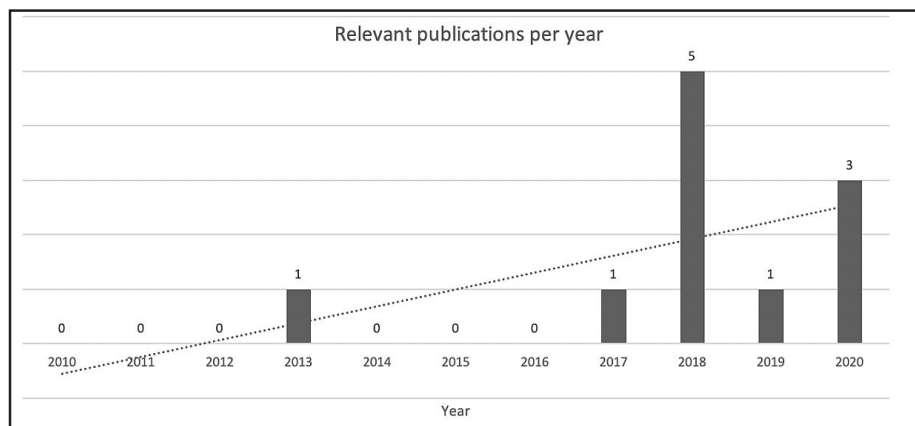
As shown in Figure 2, machine learning is the most commonly used approach to Sentiment analysis in agriculture, while the lexicon-based approach only appears in the form of NRC Sentiment analysis library for R, and hybrid approaches are ignored completely. All of the publications focus on the three following objects of analysis:

- The sentiment of farmers towards agriculture;
- The sentiment of the general public towards agriculture;
- The sentiment of mainstream media towards agriculture.

Year	SJIF	Paper title	Journal/publication type	Author
2020	3.84	Drivers and challenges of precision agriculture: a social media perspective	Precision Agriculture	(Ofori and El-Gayar, 2020)
2020	2.825	A novel text-based framework for forecasting agricultural futures using massive online news headlines	International Journal of Forecasting	(Li et al., 2020)
2020	0.53	Twitter Users Opinion Classification of Smart Farming in Indonesia	IOP Conference Series: Materials Science and Engineering	(Salim et al., 2020)
2019	N/A	Sentiment Analysis of English-Punjabi Code-Mixed Social Media Content for Agriculture Domain	[Conference Proceedings]	(Singh et al., 2019)
2018	6.94	Sentiment Analysis Through Tweets For “Doubling Farmers’ Income” In India	Asian Journal of Science and Technology	(Hooda et al., 2018)
2018	N/A	A Framework for Sentiment Analysis Based Recommender System for Agriculture Using Deep Learning Approach	[Book chapter]	(Nimirthi et al., 2018)
2018	0.57	Sentiment analysis in social networks for agricultural pests	Advances in Intelligent Systems and Computing	(Bermeo-Almeida et al., 2018)
2018	0.57	Sentiment Analysis through Recent Tweets for "Agriculture" in India	Advances in Intelligent Systems and Computing	(Hooda and Hooda, 2018)
2018	N/A	Sentiment Analysis of Recent Tweets for Agriculture from BRICS Countries	[Thesis]	(Hooda, 2018)
2017	N/A	Predicting State-Level Agricultural Sentiment with Tweets from Farming Communities	[University Project]	(Dunmon et al., 2017)
2013	N/A	A Framework for Opinion Mining in Blogs for Agriculture	Procedia Technology [Journal discontinued]	(Valsamidis et al., 2013)

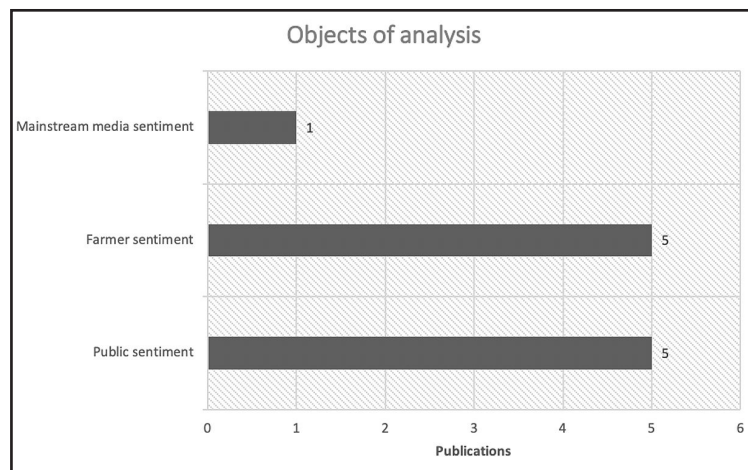
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Table 2: Result of literature discovery after application of requirements defined in Table 1.



Source: own

Figure 1: Publications related to sentiment analysis in agriculture per year.



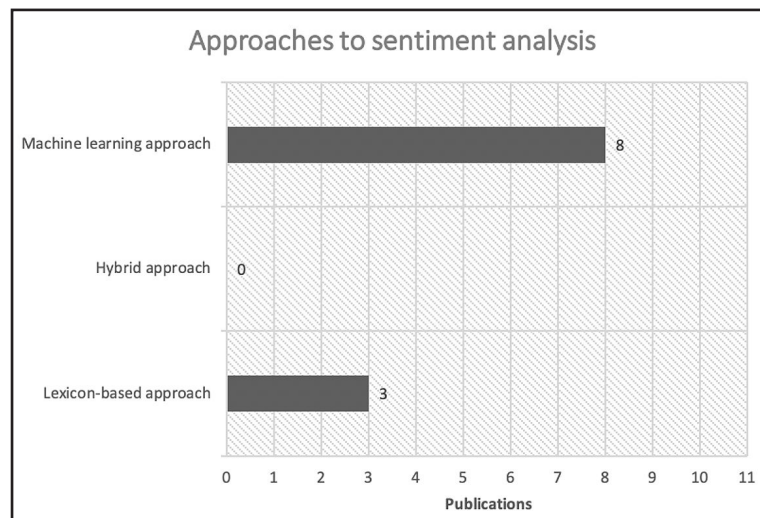
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Figure 2: Listing and occurrences of objects of analysis in the reviewed literature, based on input data source.

As shown in Figure 3, most of the research is evenly distributed between the first two of the fore-mentioned objects of analysis. The sentiment of mainstream media (more specifically headlines) is only analyzed in (Li et al., 2020). Nine out of eleven publications are working with input text in the English language, except for (Li et al., 2020), where the input text is Chinese and (Singh et al., 2019), where English is mixed with Punjabi dialect. The most commonly used algorithm for Sentiment analysis in agriculture is Naive Bayes, which also seems to be the most accurate algorithm used by researchers. Only four out of eleven researchers performed a model evaluation, therefore it is difficult to determine how accurate is Sentiment analysis in agriculture.

Although some of the reviewed research seems to be intended as a proof of concept for the application of Sentiment analysis in agriculture rather than to an application by itself (Valsamidis et al. 2013) (Nimirthi et al., 2018)

(Bermeo-Almeida et al., 2018), there are also cases of research, where it has been integrated into complex prediction models (Li et al., 2020) (Dunnmon et al., 2017) or used as a powerful tool for assessment of public opinion on important topics, concerning the adoption of modern technologies and agrarian politics (Hooda et al., 2020)(Ofori and El-Gayar, 2020) (Salim et al., 2020). All authors of the reviewed literature seem to be convinced that Sentiment analysis has its use in agrarian research, but (Bermeo-Almeida et al., 2018) and (Dunnmon et al., 2017) point out that accuracy in ternary sentiment classification, which includes neutral sentiment is still significantly lower than in binary sentiment analysis, where only positive and negative sentiments are considered. For this reason, these two authors encourage further research to be focused on the improvement of accuracy in ternary sentiment classification. More detailed information available in Tables 3 to 13.



Source: own

Figure 3: Occurrences of approaches to sentiment analysis in methodologies of reviewed literature.

Input data	Posts from agriculture web blog ran by the authors
Input language	English
Pre-processing	Removal of symbols, URLs and emoticons + TF.IDF transformation
SA algorithm	Naive Bayes (binary classification)
Model evaluation	None mentioned
Model accuracy	N/A

Source: own

Table 3: Paper analysis – A Framework for Opinion Mining in Blogs for Agriculture.



Input data	Tweets referring to agriculture, location and weather
Input language	English
Pre-processing	Own built automatic pre-processor
SA algorithm	CNN, RNN (binary and ternary classification)
Model evaluation	Accuracy testing, IQR, Confusion matrix
Model accuracy	Up to 80 % for binary and up to 63 % for ternary

Source: own

Table 4: Paper analysis – Predicting State-Level Agricultural Sentiment with Tweets from Farming Communities.

Input data	Tweets referring to agriculture
Input language	English
Pre-processing	Removal of numbers, symbols, white spaces, URLs and emoticons
SA algorithm	Unspecified Lexicon-Based approach (NRC sentiment library in R)
Model evaluation	None mentioned
Model accuracy	N/A

Source: own

Table 5: Paper analysis – Sentiment Analysis of Recent Tweets for Agriculture from BRICS Countries.

Input data	Tweets referring to agriculture.
Input language	English
Pre-processing	Removal of numbers, symbols, white spaces, URLs and emoticons
SA algorithm	Unspecified Lexicon-Based approach (NRC sentiment library in R)
Model evaluation	None mentioned
Model accuracy	N/A

Source: own

Table 6: Paper analysis – Sentiment Analysis through Recent Tweets for "Agriculture" in India.

Input data	Tweets and Facebook posts referring to agricultural pests
Input language	English
Pre-processing	Removal of spec. characters, expansion of abbreviations, spellcheck
SA algorithm	Unspecified machine learning approach. (NLU software)
Model evaluation	Accuracy testing, Recall, F-Measure
Model accuracy	77.43 %

Source: own

Table 7: Paper analysis – Sentiment analysis in social networks for agricultural pests.

Input data	Tweets referring to agriculture
Input language	English
Pre-processing	Removal of numbers, symbols, white spaces, URLs and emoticons
SA algorithm	CNN
Model evaluation	None mentioned
Model accuracy	N/A

Source: own

Table 8: Paper analysis – A Framework for Sentiment Analysis Based Recommender System for Agriculture Using Deep Learning Approach.

Input data	Tweets referring to doubling income of farmers
Input language	English
Pre-processing	Removal of numbers, symbols, white spaces, URLs and emoticons
SA algorithm	Unspecified Lexicon-Based approach (NRC sentiment library in R)
Model evaluation	None mentioned
Model accuracy	N/A

Source: own

Table 9: Paper analysis – Sentiment Analysis Through Tweets For “Doubling Farmers’ Income” In India.

Input data	Facebook, Twitter and Youtube Comments referring to agriculture
Input language	Mixed language (English and Punjabi)
Pre-processing	Removal of numbers, symbols, white spaces, URLs and emoticons
SA algorithm	SVM, Naive Bayes
Model evaluation	Accuracy testing
Model accuracy	85 %(SVM), 85.6 % (Naive Bayes)

Source: own

Table 10: Paper analysis – Sentiment Analysis of English-Punjabi Code-Mixed Social Media Content for Agriculture Domain.

Input data	Tweets referring to agriculture and smart farming
Input language	English
Pre-processing	Tokenization, Case folding, Stemming, Removal of stopwords
SA algorithm	Naive Bayes (binary classification)
Model evaluation	Accuracy testing, Confusion matrix, Recall, F1, AUC
Model accuracy	90 %

Source: own

Table 11: Paper analysis – Twitter Users Opinion Classification of Smart Farming in Indonesia.

Input data	Headlines of online news specialized in agricultural futures
Input language	Chinese
Pre-processing	None mentioned
SA algorithm	Bi-LTSM
Model evaluation	None mentioned
Model accuracy	N/A

Source: own

Table 12: Paper analysis – A novel text-based framework for forecasting agricultural futures using massive online news headlines.

Input data	Posts from Twitter, Reddit and other internet forums referring to PA
Input language	English
Pre-processing	None mentioned
SA algorithm	Unspecified machine learning approach (Buzz Monitor)
Model evaluation	None mentioned
Model accuracy	N/A

Source: own

Table 13: Paper analysis - Drivers and challenges of precision agriculture: a social media perspective.

## Conclusion

The topic of Sentiment analysis in agriculture is not being researched very actively, which is obvious from the relative lack of literature compared to other fields of application of sentiment analysis. The topic has been slowly getting more attention since 2018 and the quantity of publications is rising fast since then.

The most common applications for Sentiment analysis in agriculture according to the reviewed literature are the determination of farmers' attitude towards events, policies and adoption of new technology, increasing the accuracy of prediction models by introducing sentiment-based variables and determining public attitude towards agriculture and its state in particular countries.

Machine learning approach to Sentiment analysis is dominating in the agrarian sector with the naive Bayes algorithm being the most commonly used method. Lexicon-based approaches are significantly less utilized and hybrid approaches have not been used at all.

On several occasions, the authors of the reviewed publications stated that more research should be directed to improving the accuracy of ternary

sentiment analysis with the inclusion of neutral sentiment.

In summary, it has been proven that methods of Sentiment analysis have application in agriculture, and it would be a good idea to adopt them more widely especially for analyzing public opinion on topics related to the Agrarian sector. However, as shown by the reviewed literature, the methods of Sentiment analysis are most effective when enhancing or working in combination with other approaches, therefore it might be wise to focus future research on integrating Sentiment analysis into existing processes, rather than inventing stand-alone applications. Finally, it would be suitable to extend this research on applications of sentiment analysis in closely related fields, such as food quality and food production.

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