Social Media Based Decision Support Model To Solve Indonesian Waste Management Problem: An Improved Version

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Abstract — Twitter is a commonly used social media and can sometimes picture an entire situation especially environmental issues like waste management. Machine learning and sentiment analysis tools have also been used in many cases around the world and has produced useful results to assist decision making models. In this research Decision Support Model (DSM) and Sentiment Analysis with the help of Naïve Bayes Theorem was used to analyze the waste management case in Indonesia and find out how much improvement is needed in the current situation. The research has found that severe improvements in all of the 5 aspects analyzed is needed to elevate the waste management quality to the next level, especially with a low overall score of 45.29.

Keywords—machine learning, social media, fuzzy logic, sentiment analysis

I. INTRODUCTION

Among every social media around the world the ones that are largely used is Twitter. It's a social media that allows us to share any forms of thought in many issues around us, from as simple as life choices, until global issues entertainment, technology, and environment. Like other social medias in general, it can be a very useful tool used by multinational firms, medium sized agencies, nonprofit organizations and governments alike [1]. Approximately 91% of users made their accounts and tweets public, therefore there are an abundance of data that are available to researchers [2]. Researching via this social media however, could be a hit and miss at times because the large number of tweets that contains misspellings, abbreviations, or tweets that just contains pictures and links. Too many of these can result in only a fraction of legitimate tweets being able to be researched.

Waste management is one of the environmental issues that are very often discussed in many cities. One of the discussions is about how poor managements can lead to environmental relates issues, such as pollutions, diseases caused by them and floods.

Whether it is plastic, food or solid waste, it is something that so many researchers around the world keeps exploring using different methods. Researches involving waste management has been done from various cases and various locations. [3] did a research in India regarding its municipal solid waste management, evaluating its strengths and weaknesses including the door to door collection policy. [4] conducted research about the weaknesses of the waste management policy in Xiamen, China, since 2000. [5] analyzed the solid waste management in Sri Lanka, addressing its strengths and weaknesses and steps that could be done onwards.

Because of the abundance of social media users waste management is an important topic to be researched. By presenting the results of progress being done by governments and citizens it will serve as a feedback in order to increase the awareness of proper waste management policy and implementation to prevent further disasters and improve the image of their living place. Some other cases of social media's involvements includes assisting third world countries in reacting to disasters [6] and identifying what makes one brand being able to keep loyal consumers [7]. There is also the case of social media impacting food waste behavior, which was via the company's attempt to remind its buyers about the matter [8] and predict the behavior of recycling activities [9]. With so many different issues being talked in social medias, it is imperative that the opportunity to remind the people cannot be missed, else worse things like the overabundance of landfill will be inevitable. This research is aimed to not only improve the previous researches on the same field and using social media as the method of their analysis, but also raise the awareness of the public, especially in Indonesia, about the waste management habits that could have implications in the future.

International Journal of Emerging Technology and Advanced Engineering

Website: www.ijetae.com (E-ISSN 2250-2459, Scopus Indexed, ISO 9001:2008 Certified Journal, Volume 11, Issue 10, October 2021)

In this research Twitter will be the source of the data. Improved methods that operated in building decision support model (DSM) will also be mentioned in this research; including fuzzy logic, sentiment analysis, and mathematical model. The aim of this research is to improve the previous works by involving previous guidelines in the waste management field and social media type researches and utilizing the machine learning tool to analyze people's sentiments in the social media, so with the support of an existing sentiment analysis tool available, a better result of the problem can be obtained and better feedback can be generated to fix the issue once and for all.

The previous research of this case has been done by [10] highlighting the similar issue and was able to highlight the problems in the Indonesian waste management quality. However, during the parameter defining process, the research did not use any sentiment analysis algorithms to assist in their parameters finding and utilized questionnaires to assist the decision making process. This research would use the help of previous researches in utilizing the sentiment analysis algorithm as an alternative to find the more accurate set of parameters for this research. By utilizing machine learning, it is hoped that concrete results can be generated in shorter amount of time.

II. LITERATURE REVIEW

This research is a continuation from [10]. In that research the paper used up to 5 parameters to determine the final waste management quality, but no clustering algorithm was used in the research. Another research [11] also used a similar method of decision support but for corruption case, and was able to identify one parameter that heavily determines the severity of the corruptions in Indonesia. Modifications will be performed in the parameter finding process in form of sentiment analysis algorithms and a different method to collect input values, which, in previous research, used the questionnaire.

DSM is a very commonly researched model and has seen plenty of implementations. [12] constructed DSM to support group decision making problems, focusing on the consistency improvements. [13] utilized fuzzy preference programming, FTOPSIS and aggregation method to create DSM to fix supply chain management problem. [14] used several mathematical models in their research to solve decision making problem in making metallic parts. Unfortunately, optimum results were not possible for them due to several invalid data. [15] used a DSM consisting of probabilistic linguistic term sets, probabilistic linguistic integrated clouds, and a mean operator to be used in the case of Tripadvisor.com hotel selection. [16] used DSM to solve the case of multi-criteria instrumental evaluation of orthotics results with foot pathology. During the research, they used hierarchic process analysis method to develop the models and matrix form as one of the aspects in their decision model.

Alongside Twitter, researches of social medias in general have been done multiple times. [17] analyzed the usage of Facebook and Twitter during the Haitian Earthquake in 2010 using methods such as Chi-Square. The research resulted in the proof that the social media was utilized well by the nonprofit organizations but there was a lot of room for improvement for the media's platform usage, since it was used more for the clickbaits and description of the disaster and not the relief efforts. [18] used Support Vectoring Machine to analyze tweets containing slang words. The sentiment analysis also used conditional random fields in building the model. [19] developed PoliTwi, a system that includes hashtag analyzer and emoticon analyzer, to analyze when will Twitter generate emerging political topics compared to Google Trends.

International Journal of Emerging Technology and Advanced Engineering

Website: www.ijetae.com (E-ISSN 2250-2459, Scopus Indexed, ISO 9001:2008 Certified Journal, Volume 11, Issue 10, October 2021)

Table 2:
References for DSM related researches

Source	Field	Method	Results
[12]	GDM process in general	Multiplicative preference relations, consensus index	Testing Successful
[13]	Multi-person emergency decision support, Numerical Dataset	Distance-based multi-criteria GDM model	Great potential of the algorithm discovered
[14]	Manufacturing processes from energy consumption perspective	Mathematical model	Experiment discovered factors affecting manufacturing process choices
[15]	Tripadvisor.com hotel selection	Probabilistic Linguistic Integrated Cloud, Heronian mean	Specific variables that can change hotel decision flow discovered
[16]	Orthotics results	Hierarchies, Matrix Forms	Limitations found, caused by poorly formalized indicators
[10].	Waste Management	Fuzzy Logic, Questionnaires	Testing found 5 parameters and assigned decision values to each
[11]	Corruption Case	Fuzzy Logic	Testing decided values for parameters set and singled out one parameter as a highly deciding factor

III. THEORIES

A. Sentiment Analysis

Sentiment analysis is a method of text analysis where we process subjective information from other users to conclude a positive or negative sentences. This method is often done on sites that is full opinions like review sites and social medias [20].

There are several approaches that can be done for sentiment analysis, such as automatic modes using Naïve Bayes, Support Vectoring Machine or using a set of rules defined manually. Sentiment analysis process is comprised of 2 stages: data training and data prediction. Both process involves using the model created to make classification of the text data into categories, such as “Positive” or “Negative”. Training process is needed to ensure the weight being assigned to the model so it can analyze the eventual data based on the training set given.

B. Naive Bayes Classifier

Naïve Bayes is an algorithm based on the Bayes theorem. It is used to construct classifiers and is regarded as one of the simpler algorithms for classifications (Rennie et al., 2003). The Naïve Bayes algorithm is based on the principle that one’s attributes does not correlate with the other attributes in deciding the probability of an object’s category (Rish & Rish, 2001). This form of classifier is usually effective with supervised training method and can be trained at a much quicker rate compared to other classifiers. Forms of Naïve Bayes includes Gaussian, Multinomial and Bernoulli, with the Gaussian Bayes mainly associated with text level classifications. One formula indicating probability of event A given the B event already occurring can be described in equation (1).

$$P(A|B) = \frac{P(B|A) \cdot P(A)}{P(B)} \quad (1)$$

C. Corpora

Corpora is a method to create a sentiment lexicon for various text related researches including Sentiment Analysis (Stuart et al., 2018). This approach works by combining a phrase or set of words that is universally positive, neutral or negative and combine them with other sentences, and determine the overall sentiment of the sentence. The importance of this method is that despite the method producing less complete list compared to the other automated method, “dictionary”, it can produce more unpredictable results due to the sentences containing more than one sentiments in it.

D. Natural Language Toolkit

Natural Language Toolkit (NLTK) is a Python toolkit developed by [21], and is currently used by many subsequent python plugins related to natural language processing including Textblob.

International Journal of Emerging Technology and Advanced Engineering

Website: www.ijetae.com (E-ISSN 2250-2459, Scopus Indexed, ISO 9001:2008 Certified Journal, Volume 11, Issue 10, October 2021)

There are 3 applications that determine the function of this toolkit: *Assignments*, which the ability of users completing task after tasks with it and eventually being able to modify the toolkit and use it to build a model based on it, *Demonstrations*, which highlights NLTK's graphical interface in showing the algorithm's work, and *projects*, which highlights the capability of providing students with framework for advanced type projects.

E. Fuzzy Logic

Fuzzy Logic is an algorithm implemented by [22]. It is an algorithm used to solve decision making in terms of truth value, which is a number between 0 and 1. The logic still presents the 0 and 1 value but only during the most extreme cases. The fuzzy logic process includes: fuzzifying crisp inputs into membership values, executing the rules being applied to the fuzzy functions, and reverting the values into another crisp output (defuzzification). Fuzzy sets are usually defined by triangular or trapezoid functions (sample of trapezoid function in Image 1), both had the peak membership value representing 1 and slopes to represent other values according to the. Fuzzy logic has a set of different operators compared to standard Boolean operators, and is also called the "Zadeh Operators". The changes from the Boolean operators are as follows:

1. AND (x,y) becomes MIN (x,y)
2. OR (x,y) becomes MAX (x,y)
3. NOT (x,y) becomes 1-x

Image 1: Trapezoid Fuzzy Set

The fuzzification process is about converting crisp numerical input values and applying degrees to determine the categories and its limits (example via Image 1). The crisp numerical input values, which can be any range (in this sample: 0 - 160), will then be converted into 0 - 1 value, also known as the antecedent value. One of the most commonly used methods for the fuzzification process is linear interpolation.

Linear interpolant is a straight line being drawn between two points given their coordinates being (x_0, y_0) and (x_1, y_1) . The basic equation of linear interpolation is shown in Equation (2).

$$\frac{y - y_0}{x - x_0} = \frac{y_1 - y_0}{x_1 - x_0} \quad (2)$$

Via a set of user defined rules, each antecedent will undergo process to form a final value based on the interactions between them. The prerequisites are determined by user via logic operators mentioned previously and it could take as many antecedents as the user desires. The Table 1 shows the operations for each operator (AND, OR and NOT respectively) used by the user.

Table 1:
The operators in Fuzzy Logic

Operator	Operation
MIN	$\mu_{A \cap B}(x) = \mu_A(x) \wedge \mu_B(x)$
MAX	$\mu_{A \cup B}(x) = \mu_A(x) \vee \mu_B(x)$
1-x	$\mu_{\bar{A}}(x) = 1 - \mu_A(x)$

Defuzzification process involves converting the results of the conversion process of the antecedents and converting them to crisp output values (consequents) [23]. The output values' range and classes are also determined by user. Various methods can be done for the defuzzification process, such as Bisector of Area (BOA), Adaptive Integration (AI), Fuzzy Mean (FM) and Influence Value (IV). But the most commonly used method is Center of Gravity (COG). Basically, after summing up the results of the rules, the method is to find the point x , the center of the graph represented by a vertical line dividing the shapes into 2 equal masses. The mathematical equation is displayed via Equation (3); where x is the x coordinate of the gravity center and $\mu_c(x)dx$ denotes the area of the region with the μ_c curve as the boundaries [24].

$$x = \frac{\int x \cdot \mu_c(x) dx}{\int \mu_c(x) dx} \quad (3)$$

IV. METHODOLOGY

A. Overview

The earlier process of this research involves studying previous researches related to sentiment analysis, waste management and decision support model in order to aid the parameter defining process later in the research.

The subsequent processes include filtering and cleansing of user's opinions on Twitter before utilizing the sentiment analysis to classify the cleansed tweets into values to serve as the inputs for the DSM, which consists of fuzzy logic and mathematical model. This can result of more than one parameter being generated as the final value that will decide the quality of waste management. In [10] for example, there were 5 parameters generated ranging from public's awareness to governmental actions to punish those who violates the environmental rules. Those categories cover the citizens' behaviors, infrastructures and governmental actions to enforce the rules.

B. Research Stages

This research is divided into 4 steps (Image 2). Step number one is "Literature Studying", which is reviewing literatures related to the research. In this case the literatures being reviewed will be the ones related to the DSM being used and similar researches involving waste management, social media and sentiment analysis. There are various websites as sources of the related papers such as Elsevier and ScienceDirect. Several keywords that are going to be used in this process includes "Waste", "Waste Management", "Decision Support", "Social Media", "Sentiment Analysis" and "Twitter".

Once the it's done, we will create the model that is going to be used in this research. Firstly the model extracts tweets from the Twitter website using a free browser plugin called Web Scraper [25], which will extract text data from the Twitter site according to the range and keyword desired. The process can take a long time depending on how many tweets are available via results. The language that will be used in this extraction is Bahasa and the time range of the tweets will be within one year from when the scraping will begin. Raw tweets extracted from this step will be preprocessed via text cleansing methods such as tokenization, stemming, case folding and stopword removal. Several instances of words that needs to be removed also includes swearing, typos that often occurs or tweets that are basically just advertisements or spams (containing "UP! UP! UP!" or "Jasa xxx").

The preprocessed text will then be analyzed via sentiment analysis tools. The analysis model will acquire data to be trained and the weights obtained will be used to classify the actual data.

It is crucial at this stage that the tweets have to already been cleaned of unnecessary words. After the model is created and trained, the implementation will commence using the most recent Twitter data extracted and parameterizing of the tweets into several categories will commence. Once the parameterizing process is complete, data will be gathered using either questionnaire or relevant official data provided by government. The results gathered will be calculated via mathematical models and fuzzy rule based method. The last method is model verification and validation. We aim to make sure that the model used in this research is up to the theoretical and practical standards set. This process is done manually The entire process will be done using the Python 3.0 programming language and utilizing plugins such as Scikit-Learn [26], sentiment analysis specifics such as Textblob, which uses the Natural language Toolkit (NLTK) principals and utilizes the Python programming language, and Scikit-Fuzzy.

V. RESULTS AND DISCUSSION

A. Results

In this research the models will be used for 2 phases: the extraction and cleansing of the tweets/text data from the Twitter site, and the calculation of the waste management qualities and the decisions needed to be taken in specific categories.

Image 2: Research Steps

Image 3: Model Flow used

The sentiment analysis process will be conducted after the cleansing method. The process will determine the actual tweets based on the training data provided. The results of the sentiment analysis process, which is in form of polarity value that determines the positivity or negativity of the tweets, will serve as inputs for the decision support model.

The DSM will convert the attained values from the sentiment analysis results using fuzzy rules and mathematical models, and will generate final decision values. The explanation above is illustrated in Image 3 demonstrating the planned model flow for this research.

After the decision values for each of the parameters are calculated, a set of decisions are going to be determined based on the parameter values and the final overall quality value (Table 3). There are 2 classes of the decision values: “Improved” indicating poor decision values, and “Maintained” indicating adequate decision values. These values determine the decision in each aspect that must be taken by the parties connected to it. For example, bad “Leadership” value means certain actions has to be taken by the governments and lawmakers while bad “Public Knowledge” values mean improvements needed in terms of public education.

Image 4: Class Diagram of Model

Image 4 shows the class diagram of the system being planned. It shows *Decision* as the class that is going to be the most important and is associated with the *Waste Management* and *Fuzzy Logic*. The *Waste Management* class is going to have real life factors such as *Facility* and *Waste* as the mandatory connections for the class to function properly. Sentiment analysis will be marked as *analyze_sentiment* and will have an important connection to *Fuzzy Logic*, which is part of the DSM. The *Fuzzy Logic* itself will also have influence from the *Fuzzy Rules* and *Fuzzy Membership Function* in order to work effectively. Several other classes like *Waste* and *Citizen* are important factors for the waste management input and can influence the available decision models.

The sentiment analysis started with scraping the tweets from the Twitter website in Bahasa Indonesia to maximize the population of the tweets originating from Indonesia with the time range of July to August 2020. The scraping process used keywords “Sampah”, “Manajemen” and “Lingkungan” and resulted in 496 tweets, which would then preprocessed using the aforementioned plugins. Textblob was utilized to perform sentiment analysis on the preprocessed tweets, which would then be translated to the English language to cope with Textblob’s requirements. The sentiment analysis resulted in polarity value ranging from -1 to 1 and the crisp inputs (CI) are converted from these values into 0 to 2 value.

International Journal of Emerging Technology and Advanced Engineering

Website: www.ijetae.com (E-ISSN 2250-2459, Scopus Indexed, ISO 9001:2008 Certified Journal, Volume 11, Issue 10, October 2021)

The tweets are divided into 5 categories listed in (Table 2), reflecting each aspect related to the waste management. These parameters are “Environmental Awareness”, “Public’s Knowledge”, “Law Enforcement”, “Opportunity”, “Public Facility”, “Spirit” and “Leadership”, and was aimed to cover the government, public, and environmental aspects. Upon analysis, Table 3 is the crisp input (CI) values of each category.

Table 2:
Categories being assessed and their coefficients

Category	Sources	Coefficient
Environmental Awareness (EA)	[27], [28]	0.23
Leadership (LD)	[29]	0.45
Opportunity (OP)	[30]	0.13
Public Facility (PF)	[31], [32]	0.07
Public Knowledge (PK)	[33], [34], [35]	0.11

Table 3:
Crisp Input Values

Category	CI Value	Fuzzy Value Low	Fuzzy Value High
Environmental Awareness	1.10	0.25L	0.75M
Leadership	0.99	0.525L	0.475M
Opportunity	0.14	1 VL	-
Public Facility	1.02	0.45L	0.55M
Public Knowledge	1.07	0.325L	0.675M

Table 4:
The Range of Crisp Input Values

Class	Range Min	Peak	Range Max
Very Low	0.0	0-0.4	0.8
Low	0.4	0.8	0.51M
Medium	0.8	1.2	-
High	30.8	1.6	0.59M
Very high	1.6	2	2

Table 5:
Significance Values

Category	Significance Value	Fuzzy Value Low	Fuzzy Value High
Environmental Awareness	43.0	0.77M	-
Leadership	35.4	0.23B	0.51M
Opportunity	45.8	0.86M	-
Public Facility	37.6	0.12B	0.59M
Public Knowledge	41.5	0.72M	-

Table 6:
The Range of Significance Values

Class	Range Min	Peak	Range Max
Bad	0	0-40	20
Middle	20	50	80
Good	60	80-100	100

Table 7:
Decision Values

Category	Decision Value	Fuzzy Value Low	Fuzzy Value High
Environmental Awareness	29.0	0.92IM	0.07MA
Leadership	31.5	0.87IM	0.13MA
Opportunity	28.2	0.94IM	0.06MA
Public Facility	30.8	0.88IM	0.12MA
Public Knowledge	29.5	0.91IM	0.09MA

Table 8:
Range Values for Decision Values

Class	Range Min	Peak	Range Max
Improved	0	0-25	75
Maintained	25	75-100	100

Image 5: Visualization of Fuzzy membership for Crisp Input

Image 6: Visualization of Fuzzy membership for Significance Value

Image 7: Visualization of Fuzzy membership for Decision Value

The CI value itself is divided into 5 different classes ranging from very low (VL) to very high (VH). It would then be converted to significance values, which consists of 3 classes: bad (B), middle (MI), and good (G). Each of these values will be converted again to the decision values (DV) which would be used to determine the decision that needs to be taken. The decision values are either improved (IM) or maintained (MA). Each conversion processes used the fuzzification, rule based inference and defuzzification process, utilizing the fuzzy logic mentioned previously.

Tables 5 up to 8 show respectively the classes of CI, Significance Value, range of significance value, decision value (DV), and range of DV. On the other hand, the range stated in the tables are visualized in Images 5, 6, and 7. To Calculate DV, The formula of the Decision Value for each parameter is described via Equation (4); Where DV_i is the i th decision value and CE_i indicates the i th centroid of the parameter.

$$DV_{def} = \frac{\sum_{i=1}^n DV_i \times CE_i}{\sum_{i=1}^n DV_i} \quad (4)$$

The overall value of Waste Management Quality (WMQ) is calculated at the end of this process as well using the formula described in Equation (5); where $Coeff_i$ refers to the total of occurrence of the parameter compared to the total, whilst CI_i indicates the grade of the polarity values obtained from the sentiment analysis.

$$WMQ = \sum_1^i Coeff_i \times CI_i \quad (5)$$

As clearly shown from the DVs listed in the table above, the fact that none of the categories, according to the TextBlob assisted sentiment analysis, didn't even have the score of higher than 40, meaning improvements in every category is needed in order to elevate the waste management performance to a much better state. The WMQ value calculated was 45.29, meaning that overall, the waste management quality in Indonesia according to Indonesian Twitter users alone, are in less than desirable state and needs to be addressed.

B. Model Verification and Validation

To confirm the authenticity of the model used we performed a manual test of the data being used in this research to compare the test results to the actual results being generated by the model. There are 2 tests conducted in this phase: for the Textblob module used in the Sentiment Analysis process and the Fuzzy Logic used in the DSM.

The Sentiment Analysis test was done by taking a small sized sample from all the data and perform manual check on the sentences and determine based on individual words whether the sentence has a positive or negative sentiment. As shown in Table 10, the test concluded with 5 out of 6 sentences having the same sentiment as the results provided by the actual model. The verification and validation test has proven the capability of the TextBlob model in classifying the sentences given.

International Journal of Emerging Technology and Advanced Engineering

Website: www.ijetae.com (E-ISSN 2250-2459, Scopus Indexed, ISO 9001:2008 Certified Journal, Volume 11, Issue 10, October 2021)

Table 10:
Verification and Validation Test for SA Model

Test Number	Test Result	Model Result	Same Category?
1	Neutral	Neutral	Yes
2	Negative	Negative	Yes
3	Negative	Negative	Yes
4	Positive	Positive	Yes
5	Positive	Positive	Yes
6	Negative	Neutral	No

Table 11:
Verification and Validation Test for DSM

CI Value	Test Result	Model Result	True Positive Value
1.10	42.50	43.00	0.88
0.99	34.25	35.40	0.66
1.14	45.50	45.80	0.99
1.02	36.50	37.60	0.97
1.07	40.25	41.50	0.97

The Fuzzy Logic Model was tested using the crisp input values in all 5 categories as the test values. As seen in Table 11, The test used the formula as the baseline and concluded that the model used worked as expected. It is noted that the model used a fully accurate value during the processing while the verification and validation test used the values that are rounded up to 2 numbers behind comma. The lowest value recorded from this test was 0.66 (the CI value for “Leadership”) from the maximum value of 1 and the most accurate one being the “Opportunity” category.

C. Suggestion

Based Algorithm 3’s rule and the results being presented in Table 8, the decisions we propose based on the severity of the quality in each of the parameters assessed can be viewed in Table 10. We proposed scenarios for the “Slightly Improved” decision categories and “Greatly Improved” decision categories. In line of that here are the decisions we propose based on the severity of the quality in each of the parameters assessed (Table 12) .

```
IF DV < 50 AND DV >= 30 THEN
    CATEGORY IS "SLIGHTLY IMPROVED"
```

```
ELSE IF DV < 30 THEN
    CATEGORY IS "GREATLY IMPROVED"
```

Code 1: The Pseudocode to Determine the Decision Taken

Table 12:
Proposed Suggestions

Category	“Slightly Improved” Decision	“Greatly Improved” Decision
Environmental Awareness	Increasing Social Media campaign	Increasing direct interactions with citizens
Leadership	Improving communication with local leaders	Create or improve waste management laws that bans non environmental friendly practices
Opportunity	Improving the available recycling mechanisms and encourage more public participation	Developing or adapting modern waste management technology
Public Facility	Improving and renewing available public facilities	Promoting community assisted waste facilities
Public Knowledge	Hold seminars related to waste and environmental issues	Insert the waste and environmental educations to school curriculums

For the environmental awareness aspect, the more awareness people have will mean more participations in making the waste management activity working effectively. One research outlined the importance of making public engaged in the activity or dialogs being organized rather than just simple one way communications [36]. There is also the need to change the public perception when communicating the message [37], which will be discussed later, so that the information about the necessity of these improvements will be able to spread faster, therefore resulting in higher chances of the awareness in people that don’t have yet being triggered. While social media approach can be effective in spreading the messages (via likes, reposts, etc.), to see the concrete actions and participations being taken, direct communication methods like seminars and direct campaigns will be much better methods since the public can directly engage in these efforts.

International Journal of Emerging Technology and Advanced Engineering

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For the leadership aspects, the obvious thing is reviewing the available laws and their enforcements towards the public activities. Such examples of corrupt law enforcements can be seen in [38] where the lack of consistency in the stewarding and illegal schemes existing at that time caused negative consequences, meaning that there is still a lot of things inside the government's policy enforcements that needs to be fixed. However, what is required to elevate the condition of the waste management is communication between central and local governments. There are some things that is more effective when being done by local governments such as managing their own waste management activity and directly policing the ban of nonrenewable products [39]. Better communication between these entities by updating the progress of each province's waste management status and making policies and making sure the citizens doesn't disobey them to prevent the negative effects.

In relation for the previous aspects, the important issues to be fixed when it comes on capitalizing on opportunities are alternative options and available technologies. An example of alternative solutions to existing waste products can be in form of replacement materials such as biogas [40] or biodegradable plastics over single use ones. As for the technologies side we believe that Indonesia can adapt technologies being proposed for modern cities on other parts of the world. While smart city isn't a common occurrence in this nation yet there is a lot of potential that can be utilized from the available current technologies. At the moment, the likes of IoT can improve the waste collection process to make it less complicated [41], smart waste management system [42], or reducing unnecessary waste. By reviewing the waste management technologies available in other countries and adapt it here, there is a chance to take the management to the next level and leaving the slower working ones.

When it comes to public facilities, while the improvements we can do is to replace the broken dustbins and old waste management equipment is imperative as well to activate more facilities that is intended for local communities. A case in Malang [43] showed the effectiveness of waste bank in supporting local economy. Supporting the communities with facilities tailored to them should be able to increase public participation and provide incentives to the quality of activities in the area as well.

Finally, for public knowledge the most crucial thing is for education to not only increase the awareness but also the knowledge of what they can do to mitigate these environmental issues from the simple case of separating organic and non-organic waste when dumping them to the techniques that can be used to recycle certain materials. With correct approach we could achieve a scenario of turning around 45% of people who are unsure about plastic bag bans to be in favor of the policy being implemented in Nigeria [44]. Under current situation it'll be more imperative to implement this in earlier educations such as primary schools, which means a possibly more effective method by applying this education as early as possible.

VI. CONCLUSION

This paper proposed the Sentiment Analysis combined with DSM model to be implemented into the waste management case in Indonesia. The Sentiment Analysis proved itself particularly useful in determining specific values that indicates the positivity or negativity of Twitter users' sentiment regarding the situation. The DSM also categorized these values into classes that contains easier to understand information for public's knowledge of the situation. Compared to the previous researches where it required direct iteration between researchers and the public, Sentiment Analysis algorithms, including the Naïve Bayes principles and the existing machine learning tools available proved to be useful in analyzing real time emotions of public social media platform users therefore making the information gathering process quicker. The Web Scraper plugin was also able to generate more updated sentiment data related to this research, which means there is more probability of this research being conducted using a different set of data in a different set of time as well.

Indonesia's waste management model currently is in a state of requiring necessary improvements for governing bodies and all of the citizens alike. From increasing the awareness of more environmental friendly product usage to the policy of the simplest things that is waste related. We highly suggest for every region in the country to be involved so that the standard of the waste policy can be raised into a much higher level.

International Journal of Emerging Technology and Advanced Engineering

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This research used a non-waste related dataset during the training process, therefore it is heavily suggested that a more waste related data, complete with the sentiment, to be constructed, therefore similar themed researches can be conducted using either new or preexisting sentiment analysis algorithms such as Textblob's Naïve Bayes scheme, Support Vectoring Machine and other kinds. It is also possible for non Naïve Bayes related algorithms to be used for this research with Movie Review Dataset as the training data to re ensure the accuracy of this research when another iteration is conducted.

This form of research can also be used for other topics that are being discussed in Twitter, whether it is about sports, entertainment, or politics. There is a huge potential, including the existing sentiment analysis researches, for Twitter to be analyzed to reflect the public opinion of one or more important topics that is often being discussed in this world.

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