How to Cite
Suryanti, T., Setyono, P., & Ramelan, A. H. (2024). Data mining based on dynamic waste information system in Surakarta City. *International Journal of Life Sciences & Earth Sciences, 7*(1), 18-32. https://doi.org/10.21744/ijle.v7n1.2291

Data Mining Based on Dynamic Waste Information System in Surakarta City

Tri Suryanti
Master of Environmental Science, Sekolah Pascasarjana Universitas Sebelas Maret, Surakarta, Indonesia
Corresponding author email: trisuryanti@student.uns.ac.id

Prabang Setyono
Master of Environmental Science Lecturer, Sekolah Pascasarjana Universitas Sebelas Maret, Surakarta, Indonesia
Email: prabangsetyono@staff.uns.ac.id

Ari Handono Ramelan
Master of Environmental Science Lecturer, Sekolah Pascasarjana Universitas Sebelas Maret, Surakarta, Indonesia
Email: aramelan@mipa.uns.ac.id

Abstract*---*The waste problem is a problem for all parties because the negative impacts caused by waste are very diverse. Increase in waste volume caused by community activities. Research related to waste management that utilizes information technology and data mining is currently still widely open. It is hoped that the use of this technology can support decision-making in sustainable development. As a complement to this research, it also reveals that the public's perception of waste management regarding waste volume is a negative perception, which shows that the more people know about information about waste management, it has an impact on reducing waste volume. On the other hand, the positive perception shows that there is less Information about waste management has an impact on increasing the volume of waste. Both the results of the data mining process and public perception are in agreement. It is hoped that this suitability can be used as support for decision-making regarding waste management to maintain the sustainability of abiotic, biotic and cultural factors.
Keywords*---*data mining, information systems, public perception, waste management, waste volume.

Introduction

Identification of problems related to waste management in Surakarta City is the focus of this research. One of the main problems faced is the increase in waste volume that occurs from time to time due to population growth and increased economic activity (Barrientos & Gómez, 2020). The increase in waste volume becomes a burden on the waste management system and causes negative impacts on the environment such as soil, air and water pollution. In addition, the lack of an adequate information system in waste management is a serious obstacle in identifying patterns, trends and solutions to existing waste problems (Abdi, 2021; Aini et al., 2021; Kurniawan & Santoso, 2020; Kakesing et al., 2022; Mahyudin & Mahyudin, 2016; Septiani et al., 2019).

Environmental quality refers to the condition of the natural environment which includes air, water, soil, flora, fauna and other factors that influence life. Good quality supports healthy living while poor quality causes problems. Efforts to maintain and improve environmental quality are a priority in efforts to preserve the environment and sustainable development (Liao et al., 2012; Peña-Ayala, 2014).

Sustainability refers to the ability of a process to continue over a long time without compromising the future, which includes the use of resources, biological protection, waste reduction, equitable access to resources, and the development of environmentally friendly technologies (Anastasia & Azis, 2020; Carr et al., 2007; DLH, 2022; Gusti et al., 2015; Hapsari, 2015; Lubis, 2007; Mahyudin & Mahyudin, 2016; Pranolo et al., 2020). The city of Surakarta

ISSN 2632-9425
Submitted: 27 May 2024 |Revised: 18 June 2024 | Accepted: 09 July 2024

as a trading center has the potential to produce waste. Based on the data obtained, the volume of Surakarta city waste from 2017 to 2013 is shown in Figure 1 and Table 1.

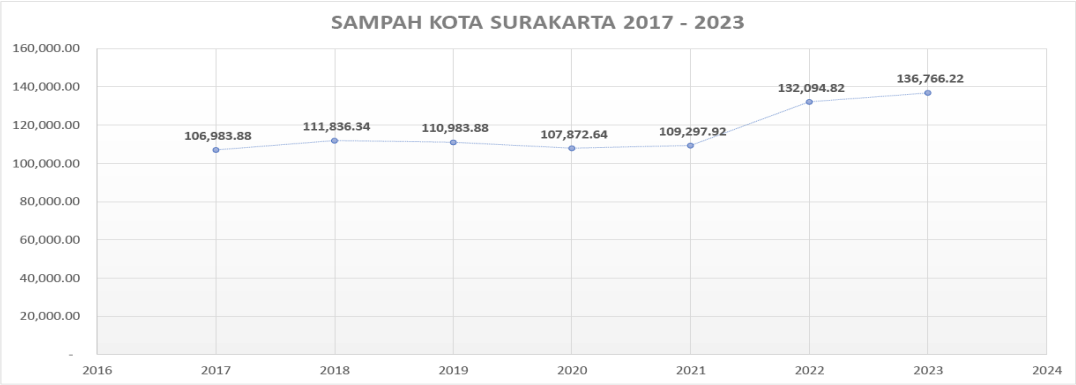

Figure 1. Waste data

Based on Figure 1. shows the trend of increasing waste in the city of Surakarta every year. Table 1. shows the trend of the difference between increasing and decreasing every year in Surakarta city waste.

Table 1
Waste Data 2017 – 2023

Year	Volume (tons)
2017	106,278.86
2018	111,836.34
2019	110,983.88
2020	107,872.64
2021	109,297.92
2022	132,094,817
2023	136,766.22

Increase in waste volume So the problem is serious and requires the right strategy to overcome it. Identify the practicality of urban communities, namely the widespread use of single-use tools (single-*use only*). which has the potential to become waste (Giusti, 2009).

Population growth and consumption of goods in the city of Surakarta have become a major concern in the context of sustainable waste management. According to data from the Central Statistics Agency (BPS) (Surakarta, 2023c, 2023e, 2023d, 2023b, 2023a), the population of the city of Surakarta continues to experience a significant increase from year to year.

The increase in population has a direct impact on increased consumption of goods and services. The Surakarta City Environmental Service (DLH, 2021) shows that the volume of waste produced is also increasing along with population growth and consumption of goods.

Table 2
Population of Surakarta City

Subdistrict	Number of Population (People)			
	2020	2021	2022	2023
Laweyan	88,524	88,578	88,617	104,086
Serengan	47,778	47,853	47,921	54,848
Kliwon Market	78,517	78,565	78,600	88,676
Jebres	138,775	138,859	138,921	151.117
Banjarsari	168,770	168,873	168,949	188,919
Total	522,364	522,728	523,008	587,646

Economic activity refers to any type of activity carried out by individuals, companies, or governments aimed at producing goods and services, as well as carrying out their exchange or distribution in the market. Economic activities include various things, such as production, distribution, consumption, investment, and trade (Dodi et al., 2015).

Pollution refers to the entry of substances that are detrimental to the natural environment, whether in the form of air, water or soil. Pollution originates from various sources, including waste industry, emissions vehicle motorized, waste agriculture, waste domestic, and others (Mikhina & Trifalenkov, 2018). Environmental pollution has a detrimental impact on natural ecosystems and human health. Efforts to reduce environmental pollution include better waste management, the use of environmentally friendly technology, strict environmental regulations, and public awareness of the importance of protecting the environment. This step aims to minimize negative impacts and maintain ecosystem balance for sustainability (Hasibuan, 2016).

Information systems are a form of utilization of information technology that is designed to have specific functions starting from collecting, storing, managing, analyzing and presenting information related to the environment. The aim is to assist in monitoring, modelling and decision-making (Muthoharoh et al., 2022). The information system developed in this research can carry out data mining which aims to segment data to recognize patterns (Han, 2006; Hariyanto, 2016; Iswardani & Riadi, 2016; Jogiyanto, 2001).

Literature reviews

This research provides an important contribution to identifying new challenges and opportunities in efforts to improve sustainable and technology-based waste management in the City of Surakarta because currently, the complexity of the environmental science discipline demands a creative and bold research approach to achieve a deeper understanding and utilization of resources. which exists (Koivisto & Hamari, 2019; Gunasekaran & Ngai, 2004).

Several studies have highlighted the importance of utilizing information technology in waste handling, specifically related to data mining techniques in grouping computer network traffic (Iswardani & Riadi, 2016). Data mining in self-isolation areas (Iswardani et al., 2021). The extensive implementation of data mining and the flexibility of using information technology, in this case, information systems, brings an understanding that waste management must focus on sustainable governance (Ical & Mane, 2022; Mahyudin & Mahyudin, 2016; Nisaa, 2020).

Methods

The qualitative and quantitative research used by the author is *questionnaire-based research and data warehouse* computer laboratory experiments. The results of *questionnaire* processing are combined with the results of *data warehouse* computer laboratory experiments.

Population Representatives of Surakarta city residents of various types were determined as the population in a *questionnaire-based study* that asked questions related to the causes and effects of the increase in waste. Sample Waste of Surakarta City volume data from 2017 to 2013 was obtained from the Surakarta City Environmental Service in tons. The calculation of waste volume is obtained from weighing Surakarta city waste that goes to the landfill.

Relationship determination is an attempt to determine the existence of a relationship between two or more factors. The results of responses from respondents are used as the main indicator and Surakarta city waste volume data as a supporting indicator. This research provides a series of questions through an online Google Form survey which is distributed online to representatives of various types of respondents (Ioannidis & Koutsoyiannis, 2020).

Data mining is a data processing technique that aims to discover knowledge from data collected over time. The results of using data mining techniques can be used as decision support because the results of using data mining techniques can be in the form of segmentation (*clustering*), class (*classification*), rule set *(association)*, to data description.

Data analysis (*Likert)* a measuring instrument that uses five levels of accuracy in measuring the highest level of approval is denoted by the number 5 (five) to the highest level of rejection approval is denoted by the number 1 (one). An example of using a Likert scale is shown in Table 3.

Table 3
Likert Scale

Scale	Information
5	Strongly Agree (SS)
4	Somewhat Agree (US)
3	Agree (S)
2	Disagree (TS)
1	Strongly Disagree (STS)

The notation or symbols 5 (highest) and 1 (lowest) are used to determine a person's response to a problem based on their ability to understand. This ability is used as the basis for determining whether positive or negative sentiment is selected.

Slovin
Determining the sample from a population in this study uses the Slovin equation shown in Equation 3.1

$$n = \frac{N}{1 + Ne^2}$$

Information :
n = minimum sample
N = population sample
e = percentage of tolerance limits (*Margin of Error (MoE*))

Clustering

Clustering is a technique for dividing data based on *centroid distance*. The *unsupervised learning* technique works by comparing data with *centroids* and forcing (CRISP-DM) the data into a segment (cluster). Clustering works to produce data segmentation (*clusters*) based on the level of similarity of the data based on distance (Dhanachandra et al., 2015). This algorithm does not require (*unsupervised*) user inference to produce *clusters*. Clustering stage see Figure 2 as follows:

```
1. Inisialisasi: Tentukan nilai K sebagai jumlah cluster yang diinginkan;
2. Pilih K data dari dataset sebagai centroid;
3. Alokasikan semua data ke centroid terdekat dengan metrik jarak yang telah
   ditetapkan;
4. Hitung kembali centroid C berdasarkan data yang mengikuti masing-masing
   cluster;
5. Ulangi langkah 3 dan 4 hingga kondisi konvergen tercapai (tidak ada data yang
```

Figure 1Clusters

Utilizing these cluster results is useful for describing data more easily and/or useful as decision support.

System development

The information system developed in this research is an information system that can extract data using *clustering techniques*. The development of data mining-based information systems refers to the waterfall model of *the Software Development Life Cycles which* is presented in Figure 3.

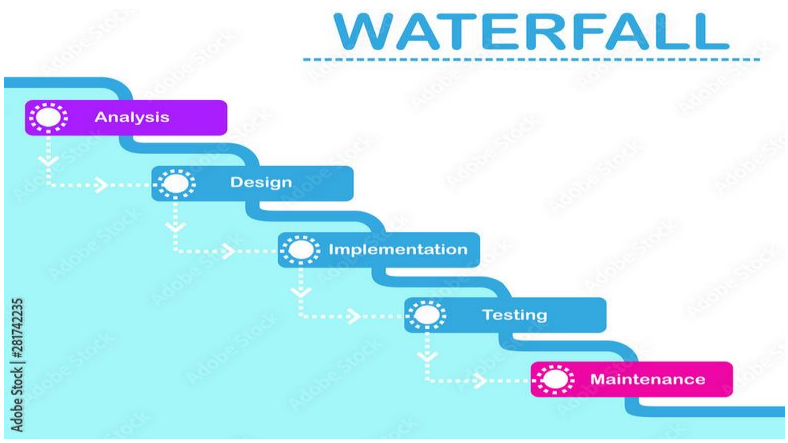

Figure 3. Waterfall model

This system development model has 5 (five) stages with an explanation of each stage as follows:
Needs Analysis
This stage aims to carry out an inventory of system requirements starting from database requirements, interfaces, and main and additional functions.
System planning
This stage produces a conceptual system design from the interface, database and system functions being developed.
Implementation
This stage is the main system development process which involves writing code for building the database, main and additional function interfaces (*clustering*).
Testing
The testing stage is testing the main and additional functions (*clustering*).
Maintenance
Treatment process system information.
Database design
A database is a series of tables that are connected to make data management easier. Data management in this database is achieved by compiling tables that represent the basic data needed in developing the Surakarta city waste data mining information system which is presented in Table 4 and Table 5.

Table 4
Sources

Fields	Type	Key
ID	BigInt	PK
Source	Char	

Table 5
Waste

Fields	Type	Key
ID	BigInt	PK
Source	BigInt	FK
Volume		

The relationship between source and waste tables is explained by the data obtained, namely data on waste producers and their weights waste generated on the range time.

Information Systems Integration and Clustering Scheme

Integration is a technique for combining the process of a series of heterogeneous objects used in research activities. The integration process is presented in Figure 4.

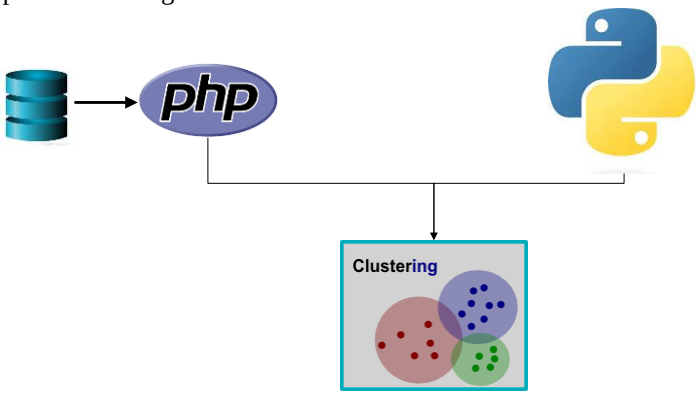

Figure 4. Integration

The data stored in the database is processed by two translator scripts to produce output in the form of Surakarta City waste *clusters* based on producers and volumes produced during a certain period.

Data interpretation

The final result of the research is a conclusion obtained from data interpretation based on data that has been processed. This interpretation is important to present because it reveals the fact that there is a relationship between waste volume and abiotic, biotic and cultural factors and/or the importance of a tool in decision-making in a large-scale organization.

Results

The data mining-based dynamic waste information system development stage uses a waterfall framework which involves 6 (six) stages. The waterfall stage is shown in Figure 3. Explanation of every stage of development of dynamic information system based on data mining as follows:

Analysis

Data Requirements Analysis

The data used in this research is data on the volume of Surakarta city waste from 2017 to 2023 that was entered (weighed and recorded) at the landfill. Garbage data is shown in Table 6. This data is a compilation of waste data compiled from the Surakarta city area. The aim of using this data is to segment the largest waste-producing sources in the Surakarta city area.

Table 6
Waste Volume

Year	Volume (tons)
2017	106,278.86
2018	111,836.34
2019	110,983.88
2020	107,872.64
2021	109,297.92
2022	132,094,817
2023	136,766.22

System Requirements Analysis
The Dynamic Waste information system was developed using 3 (three) modules, namely:

Producer
Master data for waste sources

Rubbish
Waste volume data related to waste sources

Clusters
The main segmentation processor with the *K-Means algorithm* .
Design and Implementation

The design and implementation stages are divided into:

Database design
The dynamic waste information system only uses 2 (two) related tables shown in Figure 5.

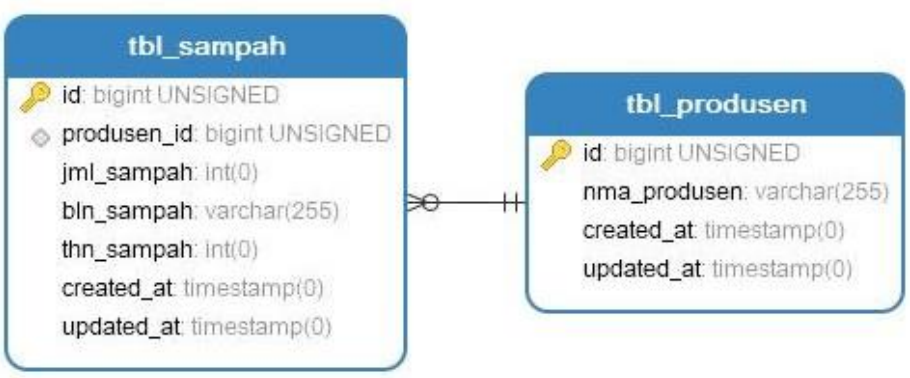

Figure 5. Table Relations

This relationship functions so that waste volume data is connected to waste producers to facilitate the waste data segmentation process.

Master Manufacturer interface design
The producer master functions as a reference for the waste volume data shown in Figure 6.

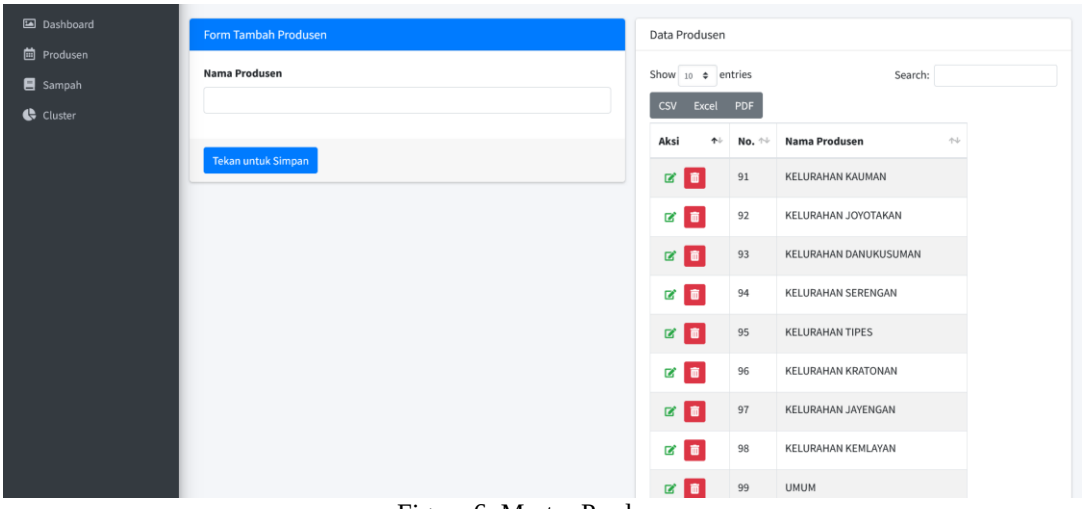

Figure 6. Master Producers

In the master producer, the functional functions used are the operations of creating records, displaying records, updating records and deleting records.

Volume interface design

The waste module shown in Figure 7 is used to enter waste volume data based on waste producer references. function involves the process of creating records, displaying records, and deleting records only.

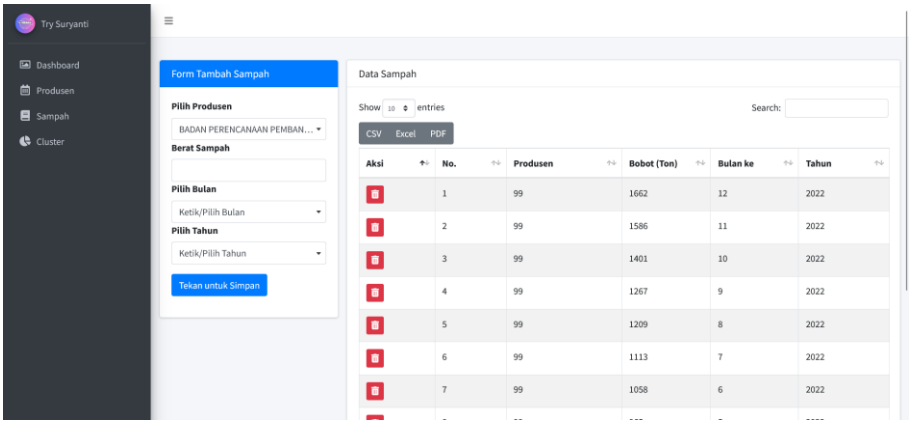

Figure 7. Waste Volume Modules

Integration design

The integration design for segmentation is shown in Figure 8.

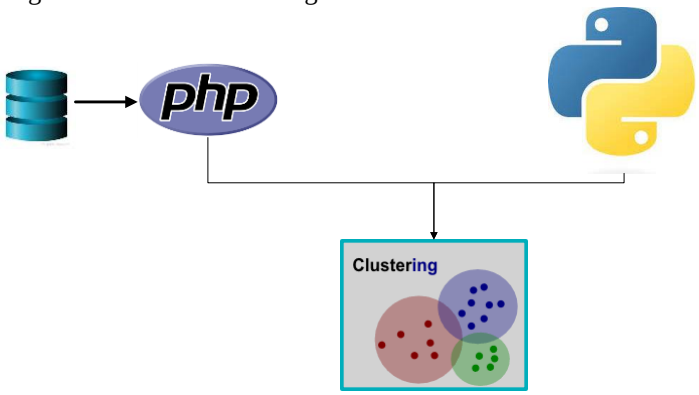

Figure 8. Segmentation Scheme

Testing

Testing of a data mining-based dynamic waste information system that has been carried out has resulted in the segmentation of waste data into 3 clusters. The segmentation results are shown in Figure 9.

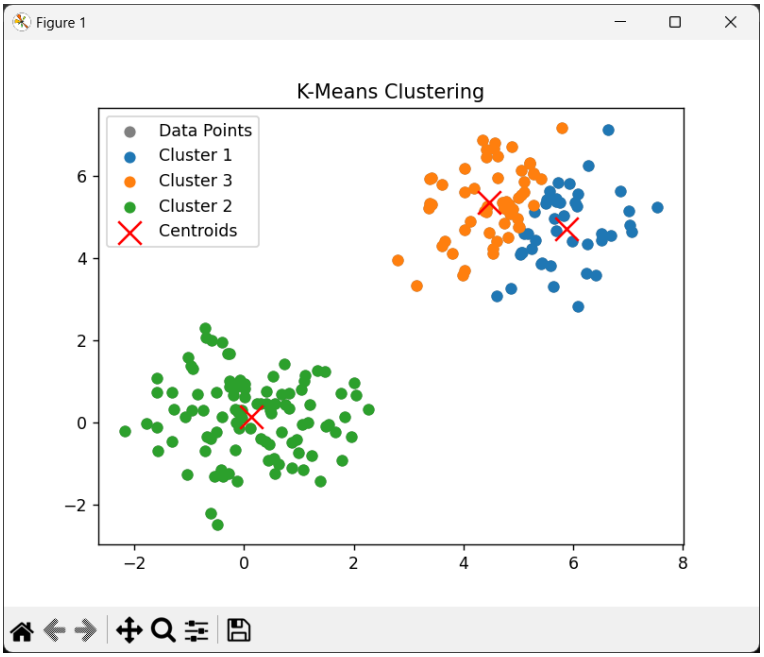

Figure 9. Segmentation Rubbish

The segmentation results show that waste producers with the largest volume are gathered with data that has a level of data similarity (in green) and waste producers with segments middle and segment each small colored orange and blue.

Maintenance

This research aims to segment waste volume data based on waste producing sources. The research objectives that have been achieved eliminate the *maintenance process*.

Perception of Waste Management

Population

This research describes the characteristics of respondents' perceptions of the community in waste management regarding the volume of waste in the city of Surakarta as follows:

Based on Respondents Gender

Table 7
Sex Respondent

Gender	Amount
Man	117
Woman	45
Total	162

Based on the Respondent's Age

Table 8
Age Respondent

Age	Amount
11 - 20	1
21 - 30	30
31 - 40	34
41 - 50	63
51 - 60	33
61 - 70	1
Total	162

Based on Respondents Job

Table 9
Work Respondent

Age	Amount
Laborer	24
Housewife	11
Employee Private	90
Civil servants	30
Doesn't work	4
TNI/ Polri	3
Total	162

Based on Education Level

Tabel 10
Education

Level of education	Amount
D1	1
D3	10
D4/S1	31
S2	5
Elementary School/ Equivalent	8
SMA/SMK equivalent	88
Middle School/ Equivalent	19
Total	162

Sample Determination

This research seeks to reveal the perception that current waste management has a relationship with increasing waste volumes. To do this, the author distributed questionnaire instruments in the city of Surakarta. 164 respondents answered and returned the questionnaire instrument using equation 3.1, obtaining a sample of 117 respondents from a total of 164 respondents with *a Margin of Error* (*MOE*) of 5%.

Validity test

Testing validity in study This aims to ensure that the answers given by respondents are valid. The results of the validity test are shown in Appendix 2 which shows the output *of* the correlation value between the item scores and the total score. This value will be compared with the rtable value, rtable is looked for at a significance of 0.05 with (*n*) 23, then we get an r-table of 0.413. With so, everyone question declared valid.

Reliability Test

Reliability testing in this research aims to ensure that the answers given by respondents are consistently valid at different testing times. The validity test results are shown in Figure 10.

Reliability Statistics

Cronbach's Alpha	N of Items
.864	23

Figure 10. Reliability Test Results

From the output table above is known There is *N of Items* there are 23 items with Cronbach's Alpha value is 0.864, because Cronbach's Alpha value 0.864 > 0.60, then as base taking decision in the reliability test above, it can concluded all question items questionnaire is reliable.

Relationship between community perceptions in waste management and waste volume

This research aims to answer the relationship between public perception in waste management and increasing waste volume. Testing has been carried out by analyzing using the *Spearman rank* correlation statistical test. *The Spearman rank* correlation test is used after knowing the two variables are in Ordinal form. Analysis of the relationship between public perception and an increase or decrease in waste volume is shown in Figure 11 and Table 11.

Correlations

			Total	Volume Sampah Harian
Spearman's rho	Total	Correlation Coefficient	1.000	-.598**
		Sig. (2-tailed)	.	.000
		N	117	117
	Volume Sampah Harian	Correlation Coefficient	-.598**	1.000
		Sig. (2-tailed)	.000	.
		N	117	117

**. Correlation is significant at the 0.01 level (2-tailed).

Figure 11. Connection perception and waste volume

Table 11
Spearman rank correlation tests

Variable	Significant (*p*)	Correlation (*r*)
Community Perceptions in Waste Management with Waste Volume	0,000	- 0.598

Based on calculation correlation *Spearman's rank* in Table 10 is between variable Internal Community Perception Management Rubbish with Trash Volume obtained mark coefficient correlation of -0.598 with significance of 0.000, from results the obtained significance of 0.000 < 0.05 (more small) then hypothesis researcher can accepted. These results can concluded that there is significant relationship between variable Internal Community Perception Management Rubbish with Trash Volume. The correlation coefficient shows the strength and direction of the relationship between the two variables. The correlation coefficient figure is -0.598 which shows that the level of relationship or correlation between Community Perceptions in Waste Management and Waste Volume is included in the level of a strong relationship. A negative coefficient number indicates a negative relationship, namely if the public's perception of waste management increases, then the volume of waste will decrease. On the other hand, if public perception of waste management falls, then the volume of waste will rise (Guerrero et al., 2013).

Analysis community perception in management rubbish on waste volume

First Premise:
Do you follow the habit of sorting waste at home?
On the first premise question, the average respondent answered 3 or medium. This shows that the level of public awareness in waste management, especially waste sorting, has been followed by the average respondent.
Premise Second :
Do you recycle repeat rubbish ? If yes, how often?
On the second premise question, the average respondent answered 2 or rarely. This shows that the level of public awareness in waste management, especially waste recycling, is still low.
Third Premise
Does the habit of sorting waste at home help reduce the volume of waste you throw away?

On the third premise question, the average respondent answered 4 or decreased a lot. This shows that the level of public knowledge in waste management, especially waste sorting, is quite high.
Fourth Premise
re-usable shopping bags or bring your own shopping bags when shopping?
On the fourth premise question, the average respondent answered 1 or never. This shows that the level of public awareness in waste management, especially the use of *re-usable goods* , such as shopping bags, is very low.
Premise Fifth
How much important for you to buy friendly products environment ?
On the fifth premise question, the average respondent answered 4 or agreed never. This shows that the level of public awareness regarding waste management, especially the importance of buying environmentally friendly products, is quite high.
Sixth Premise
Do you reduce your consumption of single-use products, such as plastic bottles or food packaging?
On the sixth premise question, the average respondent answered 4 or agreed never. This shows that the level of public awareness in waste management, especially reducing consumption of single-use products, is quite high.
Analysis of *Abiotic, Biotic and Culture* Factors (Culture)
Based on answer as many as 164 respondents of the 23 questions on the instrument questionnaire . Samples used in study This based on determination sample with equation 3.1. as many as 117 respondents showing .
Negative coefficient number
Public perception of waste management increases, then the volume of waste will decrease.
Positive coefficient number
Public perception of waste management decreases, then waste volume will increase.
Analysis of public perceptions in waste management regarding waste volume based on the premises provided shows variations in awareness and waste management practices among respondents. Following is analysis detailed from every connected premises with factor abiotic , biotic , and culture (*culture*):
First Premise:
Habit of Sorting Waste at Home
Public awareness in sorting waste at home is at a moderate level.
Abiotic Factors
The availability of facilities for sorting waste, such as separate bins for organic and non-organic, may have an influence. If infrastructure This available with OK , society more tend For sort rubbish .
Biotic Factors
Awareness community local and influence social from neighbor or environment around can influence habit sort rubbish.
Cultural Factors
Traditions and values encouraging culture management good trash , like religious teachings or custom customs , yes increase awareness and practice sort rubbish .
Premise Second:
Recycling Repeat Rubbish
Abiotic Factors:
Access to facility cycle Efficient and affordable rework is essential. Nothingness facility This can become inhibitor main.
Biotic Factors:
Participation in community programs that focus on cycles repeat can increase frequency recycle repeat rubbish.
Cultural Factors:
Education and campaign awareness that focuses on its importance cycle repeat Can increase practice This. In some cultures, recycling is not yet a common norm.
Third Premise:
Influence Sorting Rubbish on Waste Volume
Abiotic Factors:
Effectiveness system collection and processing supporting trash sorting Garbage is very influential results This.
Biotic Factors:
Support from member family and environment around in activity sort rubbish can increase its effectiveness.
Cultural Factors:
Culture that teaches importance management rubbish and waste answer environment tend see more results Good in reduction in waste volume.

Fourth Premise: Use of Re-usable Grocery Bags
Abiotic Factors:
The availability of reusable bags in stores and affordable prices can influence this habit.
Biotic Factors:
Social influence from friends and family who use reusable items can motivate individuals to adopt this habit.
Cultural Factors:
A culture that places less emphasis on the importance of using reusable goods and is more inclined towards using single-use products is the main obstacle.
Premise Fifth: Importance Buy Environmentally Friendly Products
Abiotic Factors:
Availability product friendly easy environment accessible and affordable influence decision purchase.
Biotic Factors:
Influence friends and a supportive community purchase product friendly environment Can strengthen decision This.
Cultural Factors:
Emphasizing cultural values is not quite enough answer to the environment and sustainability can push purchasing friendly environment.
Sixth Premise:
Reducing the Consumption of Single-Use Products
Abiotic Factors:
Alternative more products friendly environment, like water bottle that can be filled repeat, you have to available and affordable.
Biotic Factors:
Examples from people around who have switched from product very used to more products sustainable can motivate change in behavior .
Cultural Factors:
The culture that teaches subtraction of waste and sustainability will see level more awareness tall in reducing the consumption of product very use.

Conclusion

A dynamic waste information system based on data mining can be used to carry out segmentation using the K-means clustering algorithm which produces segmentation of large waste producers, segmentation of medium waste producers and segmentation of small waste producers (Jain, 2010). Waste volume relationship with factors abiotic, biotic and cultural. Habit sort trash, do cycle repeat, reduce use plastic, using product friendly environment can influence factor sustainability abiotics, *biotics* and *cultures.* The increasing level of public perception shows the potential for reducing waste volume.

References

Abdi, H. (2021). Sanitary Landfill is a Waste Management System, Here's the Explanation. Hot.Liputan6.Com.

Adistya, R., & Muslim, M. A. (2016). Deteksi dan klasifikasi kendaraan menggunakan algoritma backpropagation dan sobel. *Journal of Mechanical Engineering and Mechatronics*, *1*(02).

Aini, N. N., Kurniasari, I., Putri, M. N., & Ngazizah, N. (2021). Waste Management through the Anggrek Asri Waste Bank in Borokulon, Banyurip, Purworejo. Academia.

Anasstasia, T. T., & Azis, M. M. (2020). Life cycle assessment (LCA) kegiatan bank sampah di pedesaan (Bank Sampah Asoka Berseri, Desa Sokosari, Tuban). *Jurnal Pengelolaan Lingkungan Berkelanjutan (Journal of Environmental Sustainability Management)*, 537-551.

Barrientos, N. E. G., & Gómez, R. F. (2020). Didactic material for preparation observation and estimation content on subject recreational activities in nature. *International Journal of Life Sciences & Earth Sciences*, *3*(1), 15-19. https://doi.org/10.31295/ijle.v3n1.140

Carr, E. R., Wingard, P. M., Yorty, S. C., Thompson, M. C., Jensen, N. K., & Roberson, J. (2007). Applying DPSIR to sustainable development. *International journal of sustainable development & world ecology*, *14*(6), 543-555.

Dhanachandra, N., Manglem, K., & Chanu, Y. J. (2015). Image segmentation using K-means clustering algorithm and subtractive clustering algorithm. *Procedia Computer Science*, *54*, 764-771. https://doi.org/10.1016/j.procs.2015.06.090

DLH. (2021). Surakarta City Waste Data 2017-2021.
DLH. (2022). Surakarta City Environmental Quality Index.
Dodi, N., Syafii, & Raharjo, S. (2015). Feasibility Study Study of the Construction of a Waste Power Plant (Pltsa) in Padang City (Study Study at Padang City Cold Water Landfill). *ITP Electrical Engineering Journal*, *4*(2), 24–33.
Giusti, L. (2009). A review of waste management practices and their impact on human health. *Waste management*, *29*(8), 2227-2239. https://doi.org/10.1016/j.wasman.2009.03.028
Guerrero, L. A., Maas, G., & Hogland, W. (2013). Solid waste management challenges for cities in developing countries. *Waste management*, *33*(1), 220-232. https://doi.org/10.1016/j.wasman.2012.09.008
Gunasekaran, A., & Ngai, E. W. (2004). Information systems in supply chain integration and management. *European journal of operational research*, *159*(2), 269-295. https://doi.org/10.1016/j.ejor.2003.08.016
Gusti, A., Isyandi, B., Bahri, S., & Afandi, D. (2015). Faktor determinan intensi perilaku pengelolaan sampah berkelanjutan pada siswa sekolah dasar. *Jurnal Kesehatan Masyarakat Andalas*, *9*(2), 65-72.
Han, J. (2006). Data Mining: Concepts and Techniques Second Edition. Elsevier.
Hapsari, D. (2015). Kajian Kualitas Air Sumur Gali dan Perilaku Masyarakat di Sekitar Pabrik Semen Kelurahan Karangtalun Kecamatan Cilacap Utara Kabupaten Cilacap. *Jurnal Sains & Teknologi Lingkungan*, *7*(1), 18-28.
Hariyanto, S. (2016). Management Information System. Management Information System.
Hasibuan, R. (2016). An Analysis of Impact of Household Waste/Waste on Environmental Pollution. *Journal of Advocacy Science*, *4*(1), 51.
Ical, I., & Mane, A. (2022). Kesadaran Lingkungan Dalam Pengelolaan Sampah Di Pantai Nirwana Kota Baubau. *Jurnal Green Growth Dan Manajemen Lingkungan*, *11*(2), 85-97.
Ioannidis, R., & Koutsoyiannis, D. (2020). A review of land use, visibility and public perception of renewable energy in the context of landscape impact. *Applied Energy*, *276*, 115367. https://doi.org/10.1016/j.apenergy.2020.115367
Iswardani, A., & Riadi, I. (2016). Denial Of Service Log Analysis Using Density K-Means Method. *Journal of Theoretical & Applied Information Technology*, *83*(2)), 299–302.
Iswardani, A., Rochmadi, T., Sudibyo, N. A., Wicaksana, T. G., & Barabas, C. (2021). Clustering Rumah Isolasi Di Kota Surakarta. *Electro Luceat*, *7*(2), 118-131.
Jain, A. K. (2010). Data clustering: 50 years beyond K-means. *Pattern recognition letters*, *31*(8), 651-666. https://doi.org/10.1016/j.patrec.2009.09.011
Jogiyanto, H. M. (2001). Information System Design Analysis. *YogyaNarta: Andi Offset*.
Kakesing, S. S., Rares, J., & Londa, V. (2022). Manajemen Pengelolaan Sampah Dinas Lingkungan Hidup dan Pertanahan Kabupaten Sitaro. *Jurnal Administrasi Publik*, *8*(2), 115-125.
Koivisto, J., & Hamari, J. (2019). The rise of motivational information systems: A review of gamification research. *International journal of information management*, *45*, 191-210. https://doi.org/10.1016/j.ijinfomgt.2018.10.013
Kurniawan, D. A., & Santoso, A. Z. (2020). Pengelolaan sampah di daerah sepatan kabupaten tangerang. *ADI Pengabdian Kepada Masyarakat*, *1*(1), 31-36.
Liao, S. H., Chu, P. H., & Hsiao, P. Y. (2012). Data mining techniques and applications–A decade review from 2000 to 2011. *Expert systems with applications*, *39*(12), 11303-11311. https://doi.org/10.1016/j.eswa.2012.02.063
Lubis, A. (2007). Renewable energy in sustainable development. *Journal of Environmental Engineering*, *8*(2), 156-163.
Mahyudin, R., & Mahyudin, R.P. (2016). Sustainable Waste Managemen Strategy. *EnviroScienteae, 10* (1).
Mikhina, E. K., & Trifalenkov, V. I. (2018). Text clustering as graph community detection. *Procedia computer science*, *123*, 271-277. https://doi.org/10.1016/j.procs.2018.01.042
Muthoharoh, B. L., Yuriah, S., Gustiani, R., Agustina, Y. R., Indrawati, I., & Mufdlilah, M. (2022). Efficacy of early initiation of breastfeeding (EIB) for preventing hypothermia in newborns. *Journal of Health Technology Assessment in Midwifery*, *5*(2), 82-95.
Nisaa, A. F. (2020). Kebijakan Pengelolaan sampah Plastik di indonesia: Studi Kasus kota Surabaya. *Jurnal Purifikasi*, *20*(1), 15-27.
Peña-Ayala, A. (2014). Educational data mining: A survey and a data mining-based analysis of recent works. *Expert systems with applications*, *41*(4), 1432-1462. https://doi.org/10.1016/j.eswa.2013.08.042
Pranolo, S. H., Setyono, P., & Fauzi, M. A. (2020). Life cycle analysis of palm kernel shell gasification for supplying heat to an asphalt mixing plant. *Waste Disposal & Sustainable Energy*, *2*(1), 55-63.
Septiani, B. A., Arianie, D. M., Risman, V. F. A. A., Handayani, W., & Kawuryan, I. S. S. (2019). Pengelolaan sampah plastik di Salatiga: praktik dan tantangan. *Jurnal Ilmu Lingkungan*, *17*(1), 90-99.
Surakarta, B. (2023a). Banjarsari District in Figures 2023. BPS Surakarta.

Surakarta, B. (2023b). Jebres District in Figures 2023. BPS Surakarta.
Surakarta, B. (2023c). Laweyan District in Figures 2023. BPS Surakarta.
Surakarta, B. (2023d). Pasar Kliwon District in Figures 2023. BPS Surakarta.
Surakarta, B. (2023e). Serengan District in Figures 2023. BPS Surakarta.