International Journal on Orange Technologies (IJOT)

e-ISSN: 2615-8140
p-ISSN: 2615-7071

Volume: 8 Issue: 1 | January 2026
https://journals.researchparks.org/index.php/IJOT

Article

Data Science-Based Salt Distribution Analysis: Efforts to Map Harvest Absorption for Income Stability of Coastal Farmers

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Abstract Salt distribution is one of the important aspects in the supply chain of the national salt industry. CVWM, as one of the salt distribution companies in Madura, has distribution records from 2017 to 2024 that include information on delivery dates, truck numbers, load tonnage, and salt field origins. This historical data holds great potential to be analyzed using a data science approach, particularly through the exploratory data analysis (EDA) stage. The benefit of this research is to provide insights for the company regarding salt distribution patterns that have occurred over the past eight years, and it is designed to conduct descriptive analysis on salt distribution data. The focus of the analysis is directed at three main aspects, namely annual distribution trends, the contribution of each salt field as a supply source, and seasonal distribution patterns. This research produces data visualizations and descriptive statistical analysis on salt distribution data.

Keywords: Salt Distribution, Data Science, Exploratory Data Analysis, Descriptive Analysis.

Citation: Syahroni, A. W, Ramadhani, N, Zumam, W, Said, B. Data Science-Based Salt Distribution Analysis: Efforts to Map Harvest Absorption for Income Stability of Coastal Farmers. International International Journal on Orange Technologies (IJOT) 2026, 8(1), 13-21

Received: 10th Oct 2025
Revised: 04th Nov 2025
Accepted: 14th Dec 2025
Published: 26th Jan 2026

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1. Introduction

Salt distribution is an important part of the national salt industry supply chain. As one of the strategic commodities, salt is not only used for household consumption, but also as a raw material for the chemical, pharmaceutical, and food industries. CVWM is one of the salt distribution companies in Madura that consistently distributes salt from several main salt stations, namely PPGK Sumenep, Saronggi Sumenep, and Pesalaman II Pamekasan [1], [2], [3].

The company has historical salt distribution data from 2017 to 2024, including information on loading dates, truck numbers, tonnage of loads, and salt origin. This kind of data has great potential to be analyzed using a data science approach, so that it can generate new insights into distribution trends, supply contributions, and seasonal patterns that have not been systematically mapped so far. Not only that, Data Science technology through EDA is present as Orange Technology (technology that cares about humans) to help map distribution patterns.

Research related to salt distribution in Indonesia generally still focuses on aspects of economics, production, and import policies. Data science-based analysis of salt logistics distribution, especially at the company level, is still very limited [4], [5].

The novelty of this study lies in (1) The use of relatively long historical data on salt distribution (2017–2024) from one company, namely CVWM, (2) Exploratory Data Analysis (EDA) approach based on data science to uncover annual trends, salt contributions, and seasonal patterns of salt distribution. (3) This research is designed as an initial stage (baseline study) for continuous research using supervised or unsupervised learning. Thus, this research has a practical contribution to the company as well as an academic contribution in expanding the application of data science in the strategic commodity distribution sector.

This study is designed to conduct a descriptive analysis of CVWM salt distribution data. The focus of the analysis was directed at three main aspects, namely: (1) annual distribution trends, (2) the contribution of each salt as a source of supply, and (3) seasonal patterns of distribution. The Exploratory Data Analysis (EDA) approach was chosen because it was able to provide a comprehensive initial picture of distribution patterns before advanced model development was carried out [6].

The benefit of this research is to provide insight for companies regarding the salt distribution pattern that has occurred over the past eight years, as well as provide a knowledge base that can be used by coastal communities considering the uncertainty of salt harvest absorption that often makes coastal farmers experience economic stress (stress/welfare problems), and is also useful for advanced research based on artificial intelligence with machine learning methods such as supervised Learning (e.g., predicting distribution volume by regression or forecasting) and unsupervised learning (e.g., grouping distribution patterns using clustering).

Thus, this research is expected to be able to make a dual contribution, namely practically supporting managerial decision-making in CVWM, and academically enriching the literature on the application of data science in commodity distribution analysis. In fact, if distribution patterns are well mapped, stakeholders can ensure that farmers' harvests are well absorbed, which ultimately increases the happiness and well-being of coastal communities.

2. Materials and Methods

Exploratory Data Analysis

Exploratory Data Analysis (EDA) is a process that can analyze and display data with the aim of gaining a better understanding of the data. EDA can also be said to be an activity of identifying, investigating, analyzing phenomena or habits that have been carried out based on historical data, EDA will provide very important insights into the characteristics and dynamics of data sets [7], [8], [9]. Thus, Exploratory Data Analysis (EDA) can be said to be an approach to summarizing data by taking its main characteristics and visualizing it with the right representation.

EDA quickly describes the number of rows or columns of the dataset, missing data, data type, and preview. Clean corrupted data, handle missing data, invalid data types, and incorrect values. EDA visualizes the distribution of data using graphs such as bar charts, histograms, boxplots and others. EDA helps analyze datasets to summarize their statistical characteristics by focusing on four main aspects, such as central tendency measures (consisting of means, modes, and medians), spread sizes (consisting of standard deviations and variances), forms of distribution, and outlier presence [10], [11].

The steps in conducting EDA in this study can be seen in the image below.

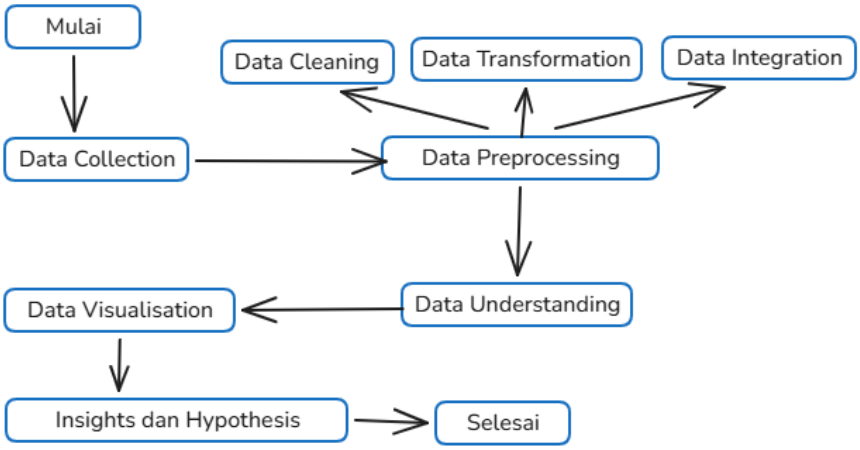

Figure 1. EDA Flowchart

Python

Python was used in this study because Python is easy to learn, has a huge library. The data handling capacity is much higher and is used as an open source programming language. Python has the ability to work with all third-party languages, it can be run on any platform. Python offers a wide range of libraries and some of them use interesting visualization tools. The visualization process can make it easier to create clear reports. The python libraries used in this study include pandas, matplotlib and seaborn. In this study, Python was run using a juptyer lab [10], [12].

Data Collection

Data Collection is a stage of collecting data that will be analyzed before starting to explore patterns, create graphs, or seek insights from the data. Data Collection can also be said to be the first step in EDA, which is a process to obtain data to be analyzed. In this study, data collection was carried out by collecting distribution data from CV records [7], [8]. In the form of an Excel file containing daily distribution records, Period 2017 - 2024. The research team has succeeded in collecting data from 2017 to 2024 in the form of a folder containing excel files.

	A	B	C	D	E	F
1	REKAPITULASI ANGKUTAN GARAM					
2	PENGIRIMAN DARI PEGARAMAN I SUMENEP (PALEBUNAN)					
3	KE PT UNICHEM CANDI INDONESIA - MANYAR - GRESIK					
4	NO.	TANGGAL	NO.POLISI	NETTO	SAT	KETERANGAN
6	1	01-10-2017	M 8679 UA	10.470	kg	
7	2	02-10-2017	M 8674 UV	9.490	kg	
8	3	08-10-2017	M 8679 UA	10.670	kg	
9	4	21-10-2017	M 9246 V	10.290	kg	
10	5	21-10-2017	N 8598 UK	10.070	kg	
11	6	21-10-2017	M 9044 UA	10.540	kg	

Figure 2. Salt delivery data excel format

Data Preprocessing

Data Preprocessing is a stage carried out to ensure the quality of data before it is analyzed, which consists of Data Cleaning, Data Transformation and Data Integration [11].

Data Cleaning involves identifying and addressing missing values, outliers, duplicates, and inconsistencies in the dataset. In this study [13] , such as handling missing data (missing values), standardizing date formats, and removing duplicate data (if any). For missing data, there is none, because this is salt shipment data, duplicate data is also absent, what is done at this stage is to standardize the date format from the date-month-year pattern to date/month/year.

Data Transformation converts the initial unit of data into unit data that corresponds to the calculation data, such as converting tonnage units to numerical format, adding a derivative column of the date format to year, month, day. In this part, the shipment data is changed to data that can be used for the next process, namely by creating the required columns such as date, truck, tonnage and origin, so that from the data that was initially like figure 1 to figure 2 as below.

```
       Tanggal        Truk   Tonase Asal  Tahun  Bulan
0   2017-04-20   M 9270 UA  10180.0  AMB   2017      4
1   2017-04-20   M 8968 UA  10970.0  AMB   2017      4
2   2017-04-22   P 8784 UY  11520.0  AMB   2017      4
3   2017-04-22   N 8598 UK  10550.0  AMB   2017      4
4   2017-04-26   M 9354 UA  11510.0  AMB   2017      4
..         ...         ...      ...  ...    ...    ...
504 2017-12-04   M 8679 UA  11440.0  KLT   2017     12
505 2017-12-05   M 9270 UA  10340.0  KLT   2017     12
506 2017-12-05   M 9110 UA  10290.0  KLT   2017     12
507 2017-12-06  AA 1484 SB  10700.0  KLT   2017     12
508 2017-12-06   S 8582 UU  10730.0  KLT   2017     12

[509 rows x 6 columns]
```

Figure 3. Salt Distribution Data 2017

The tonnage column has a unit of kilograms, while the origin column contains an abbreviation of the origin of the salt which consists of several places. The following is the data on the origin of salt shipments and the abbreviations.

	A	B	C	D	E	F	G	H	I	J	K
1	Data Asal Pengiriman										
2				ADA DI TAHUN							
3	NO	Nama Asal Pengiriman	Singkatan	2017	2018	2019	2020	2021	2022	2023	2024
4	1	AMBET	AMB	ada	ada		ada		ada	ada	ada
5	2	PALEBUNAN	PLB	ada	ada	ada	ada	ada	ada		
6	3	KALIANGET	KLT	ada	ada		ada				
7	4	PPGK	PPGK		ada	ada	ada	ada	ada		ada
8	5	SARONGGI	SRG		ada	ada	ada	ada			
9	6	PEG SAMPANG	SMP		ada	ada					
10	7	PEG II PAMEKASAN	PMK			ada	ada	ada	ada		ada
11	8	Ladang Penjemuran Peg. Pamekasa	LDG	ada							

Figure 4. Data on the origin of salt shipments

Data Integration can be done to combine data from various separate data just like combining data from different years into a single dataset. In this section, the research team has combined data, starting from data per year, to data all years from 2017 to 2024. The results of data integration are as follows

There were 509 lines of salt distribution data in 2017 (509 salt distribution using trucks).

There are 348 lines of salt distribution data in 2018.

There are 976 lines of salt distribution data in 2019.

There are 1632 lines of salt distribution data in 2020.

There are 443 lines of salt distribution data in 2021.

There are 2215 lines of data on salt distribution in 2022.

There are 161 lines of salt distribution data in 2023.

There are 1170 lines of data on salt distribution in 2024.

Salt distribution data from 2017 to 2024 has 7454 lines of data.

Data Understanding and Visualization

Data understanding is a stage in the data analysis process (including Exploratory Data Analysis / EDA) where we study and understand the content of the dataset before conducting a deeper analysis. By doing Data Understanding, we can understand the structure, content, quality, and meaning of data. Data Visualization is the process of connecting information through clear and effective images. Data Visualization performs the appearance of visualizations according to the needs [13], [14], [15].

3. Results and Discussion

Results and Analysis

Considering that the data processed is very large and consists of several years, this article will only be explained for 1 year, namely 2017. The following are the results of this stage on salt distribution data in 2017.

Table 1. Descriptive Statistics of Salt 2017

Statistic	Value
Count	509
Red	11.813,79
Std	3.677,13
Min	8.400
25% (Q1)	10.000
50% (Median)	10.470
75% (Q3)	11.220
Max	24.780
Count	509

The following is an explanation of the descriptive statistics for salt distribution data in 2017

a. Count = 509 means that there are 509 salt shipment data recorded in 2017. This shows a large enough number of observations that the statistical analysis is quite stable and representative.
b. Mean = 11,813.79 kg, The average tonnage value is about 11.8 tons per shipment, that is, in general, each truck transports almost 12 tons of salt. This average provides an overview of the delivery capacity of the year.
c. Standard Deviation (Std) = 3,677.13 kg, Standard deviation indicates how much the tonnage varies between trucks. The value of 3.67 tons is quite large. This means that the tonnage between shipments is quite varied. There are small trucks (± 9 - 11 tons) and some with large loads (>20 tons), so the data is quite spreading. The greater the std value, the more heterogeneous the charge.
d. Min (Minimum) = 8,400 kg, The smallest tonnage recorded is 8.4 tons. This value can point to a smaller size truck, or an underloaded load, or a variation in salt type or demand. But after confirmation, this is a small truck with a load of about 10 tons, but it is not fully filled.
e. Q1 (25%) = 10,000 kg, 25% data has a tonnage below 10 tons. This shows that some trucks (about a quarter) carry a relatively small load on average.
f. Median (50%) = 10,470 kg, Middle value of distribution = 10.47 tons, meaning 50% of trucks transport < 10.47 tons. The other 50% of trucks transport > 10.47 tons. Since the median < mean, it indicates a right-skewed tonnage distribution, usually because there is a very large tonnage value (payload > 20 tons).
g. Q3 (75%) = 11,220 kg, 75% shipment has < tonnage of 11.22 tons. This indicates the values that are common in the field, the range of 10–11 tons is the most frequent load.
h. Max (Maximum) = 24,780 kg, Highest tonnage reaches 24.78 tons. This value is well above the median, an indication that there are large-capacity trucks, or that there are special deliveries, or that this tonnage is a high outlier. This large tonnage caused the average to increase from 10.47 tons (median) to 11.81 tons.

So that interpretation can be carried out for the distribution of salt data in 2017, namely the tonnage data in 2017 consists of 509 observations with an average of 11.81 tons per shipment. The tonnage tends to vary quite a bit as indicated by the standard deviation value of 3.67 tons. The distribution of the data shows a right-skewed tendency, where most shipments are in the range of 10–11 tonnes, but there are some shipments with very high tonnage of up to 24.78 tonnes. The minimum tonnage value was recorded at 8.4 tonnes, while the median of 10.47 tonnes illustrated that half of the shipments were under the load. Overall, this pattern shows a combination of low-capacity trucks and high-capacity trucks used throughout 2017.

The visual of the 2017 Salt Distribution Tonnage Trend can be seen in the image below.

Figure 5. Salt Distribution Tonnage Trends 2017

The visual of the total tonnage of salt distribution in 2017 based on the origin of salt shipment can be seen in the image below.

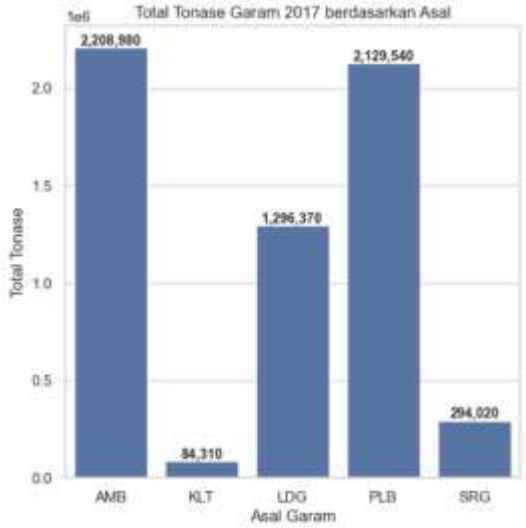

Figure 6. Total Tonnage of Salt Distribution 2017 Based on Salt Shipment Origin

The visuals of the 5 trucks with the highest total tonnage in 2017 are below.

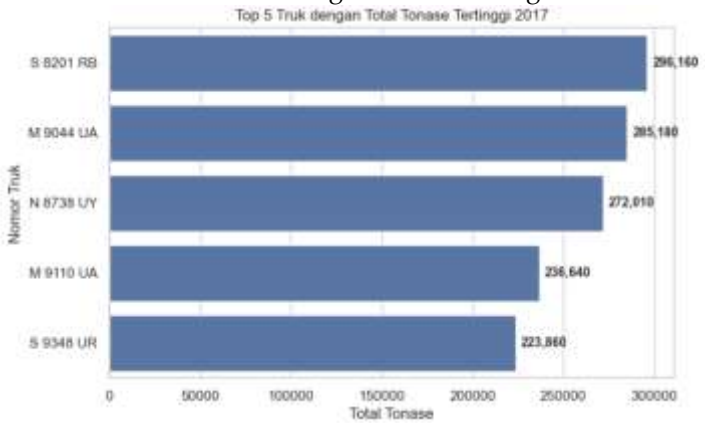

Figure 7. Top 5 Trucks with the Highest Total Tonnage of 2017

The visuals of the seasonal pattern can be seen below:

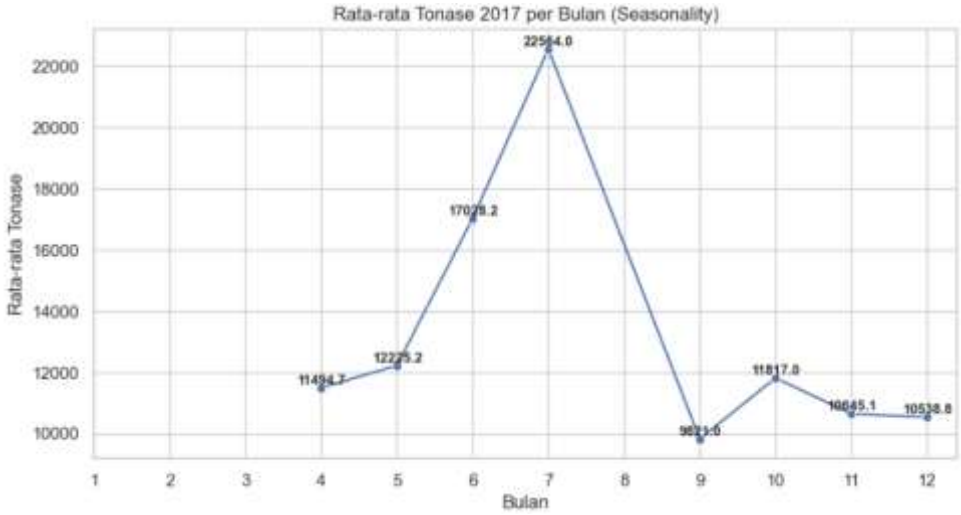

Figure 8. Seasonal Patterns 2017

The seasonal pattern in 2017, for example, peaked in July, the uptake surge in July is a crucial period for the welfare of coastal farmers. A smart and mapped distribution system this month will prevent stockpiling at the farmer level, thereby maintaining price stability and their mental well-being from the threat of losses.

The visuals of the 10 trucks with the highest delivery frequency in 2017 are below.

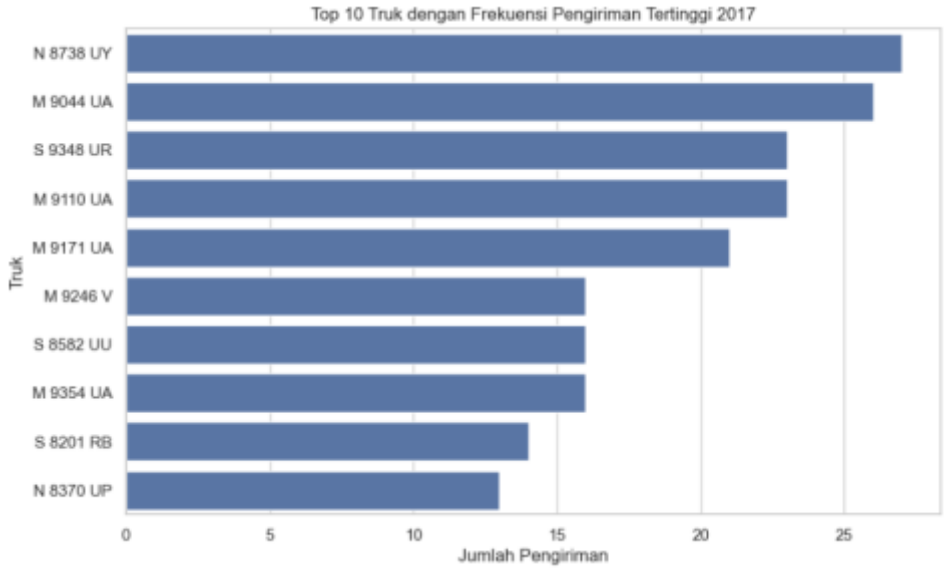

Figure 9. Top 10 trucks with the highest delivery frequency of 2017

4. Conclusion

Conclusion

Based on the results and discussion in this study, it is concluded that the Exploratory Data Analysis (EDA) method can provide a descriptive analysis of salt distribution data such as the number of shipments per year, the smallest and largest capacity of salt delivery trucks, variations of truck types (small or large trucks). Not only that, this method can also provide visualization of salt distribution such as visualization for monthly shipment tonnage trends, visualization of total salt distribution tonnage based on the origin of salt shipments, visualization of trucks with the highest total tonnage, visualization of seasonal patterns (average monthly tonnage in one year) so that you can know in which month the most shipments are made, and visualization of trucks with the highest delivery frequency.

Using this method, researchers can also find out the imbalanced data and outliers of the existing salt delivery distribution. But not only that, the insights from this data are not only useful for corporate logistics, but also as a digital intervention tool to maintain the sustainability of the livelihoods of coastal farming communities.

Acknowledgments

We would like to thank the research team, students and lecturers who have supported the process of writing this scientific article, as well as the University of Madura who have provided support both in the form of material and non-material so that this research was successfully implemented.

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