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## Interpolation Methods of Spatial Distribution Salt Price During Scarcity Period in Malang Raya Using Geographic Information System



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### ABSTRACT

In mid-2017, people in Malang Raya experienced salt scarcity. This situation did not only happen in Malang Raya but also in almost all parts of Indonesia. This study was aimed to determine the distribution pattern of fine salt and crude salt in Malang Raya areas during the salt scarcity. The analysis was carried out by employing a *Geographic Information System* (GIS) based interpolation. The best interpolation result for fine salt was using the ordinary kriging method with a J-Bessel semivariogram. Meanwhile, the best interpolation method for crude salt was using the inverse distance weighting method. The results of this study revealed some effects of salt scarcity on salt prices. The shortage of salt in Malang Raya caused an increase of exceptional salt prices in almost all areas of Malang Raya, especially in the Northern and Southern part of Malang Regency. However, the result was different for crude salt. The production of crude salt decreased, and the stock was also limited. The demand for crude salt was low; thus, the price of crude salt did not rise sharply in all Malang Raya areas.

**Key words:** GIS, Interpolation, Salt Price, Spatial Analysis

### 1. INTRODUCTION

Salt (NaCl) is a kind of mineral that has a salty taste. Salt is commonly used as a kitchen spice. There are two types of salt sold in Indonesian markets; those are fine salt (table salt) and crude salt. The price of crude salt tends to be cheaper than fine salt. Salt belongs to the major commodities in Indonesia. Salt is one of the ingredients that is mostly needed in every Indonesian cuisine. In addition, salt is also required in various industrial sectors. One sector of the marine industry in Indonesia that significantly needs salt is the salted fish industry [1].

Although Indonesia is a maritime country which has wide sea areas, Indonesia is currently importing salt with a value of more than IDR 1 Trillion every year. More than 70% of Indonesian salt is produced in Java using a traditional way. Salt production in Indonesia yields a purity of the salt product (NaCl) of 90% on average. Some salt industries are currently starting to increase their salt product

(NaCl) purity to 98.4% by modifying the adjustment of seawater concentrations [2]. In 2017, salt scarcity occurred in all regions in Indonesia, including Malang Raya (consisting of Malang city, Malang regency, and Batu city). This scarcity made the price of salt rose sharply. Secretary-General of the Association of Salt Farmer of Indonesia (APGRI) said that salt scarcity was caused by salt harvest failure in 2016 [3]. The harvest failure was due to weather factors; rain frequently fell during the dry season due to the La Nina phenomenon. Harvest failure in the salt industry at that time reached 106,000 tons on the national scale. Indonesia was not the only country that experienced salt scarcity that caused many industries to make a loss. Ghana was a country that also experienced a salt crisis. Ghana was only capable of producing about 10% of the salt production potential in the country. This was due to a lack of land, investment, and advanced technology [4].

At the seller level in Malang Raya, many salt sellers were out of stock. According to Muhamad Sulkan, a salt seller in Malang city's main market, the scarcity started to happen in early July 2017. Fine salt and crude salt could not be found in the market. The seller has been a seller since ten years ago, and that was his first time experiencing the vacuum of salt stock [5]. Another seller pointed out that even though the price of salt was high, salt was still a high-demand product for buyers whose majority was dominated by food sellers [6].

The Head of Department of Industry and Commerce of Malang, Wahyu Setianto, confirmed that there was salt scarcity in Malang. Scarcity occurred after the Eid al-Fitr holiday and almost occurred in all markets in Malang. The Head of Department of Industry and Commerce of Malang thought that it is a strange phenomenon considering that Indonesia is surrounded by sea salt [7].

Referring to the explanation given above, the researchers conducted an investigation related to the scarcity of salt and its effects on the price of salt in Malang. It was intended to answer the following questions: Did salt scarcity happen in all areas in Malang Raya? Where was the area which had salt stock? What was the price? Thus, the results of this research were expected to answer the conditions related to the

scarcity of salt and salt prices in Malang Raya as well as provide input related to the phenomenon of salt scarcity.

**2.MATERIALS AND METHODS**

The following were some steps in conducting this research:

**2.1. Data Collection**

The process of data collection was done by collecting data from the Department of Industry and Commerce of East Java. Department of Industry and Commerce had routine activities to monitor salt prices in markets in East Java. Some markets for research that were always monitored by the Department of Industry and Commerce of East Java can be seen in Table 1.

**Table 1:** List of Markets for Research

No	Area	Market
1	Batu City	Batu Main Market
2	Batu City	Gentengan Market
3	Batu City	Songgoriti Market
4	Batu City	Selecta Market
5	Malang City	Blimbing Market
6	Malang City	Tawangmangu Market
8	Malang City	Oro-Oro Dowo Market
9	Malang City	Klojen Market
10	Malang City	Madyopuro Market
11	Malang Regency	Lawang Market
12	Malang Regency	Singosari Market
13	Malang Regency	Karangploso Market
14	Malang Regency	Kepanjen Market
15	Malang Regency	Turen Market
16	Blitar Regency	Wlingi Market
17	Pasuruan Regency	Sukorejo Market
18	Kediri Regency	Pamenang Market
19	Lumajang Regency	Pasirian Market
20	Mojokerto Regency	Mojosari Market
21	Jombang Regency	Ploso Market

The salt price data were the results of the survey on July 25, 2017, during the salt scarcity period. Not only in Malang, but the researchers also took the data of salt prices in some markets in areas adjacent to Malang Raya such as Blitar, Pasuruan, Kediri, Lumajang, Mojokerto, and Jombang.

**2.2. Analysis**

After the data obtained, the next step was data analysis. The researchers employed interpolation analysis which aimed to get a prediction of salt price in Malang Raya. The data were in the form of a map so that the results would be easier to be explained.

The interpolation analysis was performed by using ArcGIS software. In ArcGIS, there were many interpolation methods available including Inverse Distance Weighting, Global Polynomial Interpolation, Radial Basis Functions, Local Polynomial Interpolation which were categorized as

deterministic methods. There was also interpolation kriging method which was categorized as geostatistics method [8].

Since there were several access methods, the researchers needed to make some comparisons in order to get the best interpolation results among all methods. Gong et al. conducted a study aimed at comparing the accuracy of a Kriging interpolation method with Inverse Distance Weighting. They used correlation to find interpolation results with the best method. The result of their study revealed that the Inverse Distance Weighting result was better than Kriging [9]. Meanwhile, Bhunia et al. who compared 5 GIS-based interpolation methods such as Inverse Distance Weighting (IDW), Local Polynomial Interpolation (LPI), Radial Basis Function (RBF), Ordinary Kriging (OK) [10] and Empirical Bayes Kriging (EBK) suggested employing RMSE to find out the best interpolation results [11]. In this research, RMSE was used as a tool to reveal the best interpolation method in estimating salt price in Malang Raya.

**2.3. Interview**

Besides spatial analysis, the researchers also conducted an interview that was intended to get deeper information about salt scarcity. By conducting a direct interview with the seller, the researchers expected to get additional information that was useful for the current research [12].

**3.RESULTS AND DISCUSSION**

The result of data collection from Department of Industry and Commerce of East Java regarding the salt prices can be seen in Table 2.

**Table 2 :** Salt Prices in Malang Raya in July 25, 2017

Area	Market	Crude Salt Price	Fine Salt Price
		25-7-2017	25-7-2017
Batu City	Batu Main Market	IDR 1,200	
Batu City	Gentengan Market	IDR 1,000	IDR 6,000
Batu City	Songgoriti Market		
Batu City	Selecta Market	IDR 1,500	
Malang City	Blimbing Market	IDR 800	IDR 5,000
Malang City	Tawangmangu Market		
Malang City	Oro-Oro Dowo Market	IDR 700	IDR 5,000
Malang City	Klojen Market		
Malang City	Madyopuro Market	IDR 1,500	IDR 4,000
Malang Regency	Lawang Market	IDR 1,000	IDR 7,000
Malang Regency	Singosari Market	IDR 1,000	IDR 7,000
Malang Regency	Karangploso Market	IDR 1,750	IDR 6,000
Malang Regency	Kepanjen Market	IDR 1,000	IDR 7,000
Malang Regency	Turen Market	IDR 1,000	IDR 7,000

Area	Market	Crude Salt Price	Fine Salt Price
		25-7-2017	25-7-2017
Blitar Regency	Wlingi Market	IDR 1,000	IDR 10,000
Pasuruan Regency	Sukorejo Market	IDR 1,000	IDR 8,000
Kediri Regency	Pamenang Market	IDR 750	IDR 4,500
Lumajang Regency	Pasirian Market	IDR 500	IDR 6,000
Mojokerto Regency	Mojosari Market	IDR 6,000	IDR 13,000
Jombang Regency	Ploso Market	IDR 1,000	IDR 6,000

There were some markets that had no salt stock, including Batu Main Market, Songgoriti Market, Selecta Market, and Tawangmangu Market. Furthermore, crude salt did not exist only in Songgoriti Market and Blimbing. The lowest price of crude salt was in Pasirian market in Lumajang regency, regency adjacent to Malang city. The price of crude salt in Lumajang regency was IDR 500. Meanwhile, in Mojosari market, the price of crude salt was IDR 6,000, which was 12 times higher. Then, the lowest price of fine salt was in Madyopuro market in Malang. In contrast, the highest fine salt price was in Mojosari market in Mojokerto.

The data in Table 2 were analyzed with several methods of interpolation. In order to find the best result, the researchers used RMSE value, and the results can be seen in Tables 3 and 4.

**Table 3 :** RMSE Interpolation Method for Soft Salt

Interpolation Method	RMSE
Inverse Distance Weighting	2,305.934
Global Polynomial Interpolation	3,032.501
Radial Basic Functions	2,346.807
Local Polynomial Interpolation	2,408.753
Ordinary Kriging (Semivariogram J-Bessel)	2,161.940
Empirical Bayesian Kriging	2,201.037

The best interpolation method for fine salt was using Ordinary Kriging with Semivariogram J-Bessel. The RMSE value obtained from that method was 2,161.940.

**Table 4 :** RMSE Interpolation Method for Crude Salt

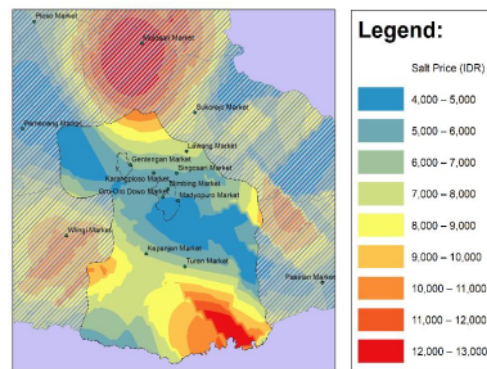
Interpolation Method	RMSE
Inverse Distance Weighting	1,267.7465
Global Polynomial Interpolation	1,462.098
Radial Basic Functions	1,330.591
Local Polynomial Interpolation	1,504.276
Ordinary Kriging (Semivariogram Rational Quadratic)	1,398.063
Empirical Bayesian Kriging	1,469.614

Meanwhile, the best interpolation method for crude salt was using Inverse Distance Weighting. The RMSE value obtained from that method was 1,267.7465.

**Table 5 :** Ordinary Kriging (Semivariogram J-Bessel) for Soft Salt Price

Nugget	100,530.2
Range	0.5455588
Partial Sill	5,310,534
Anisotropy	False
Lag Size	0.06
Number of Lags	12
Sector type	4 Sectors With 45 <sup>o</sup> offset

In ordinary kriging interpolation for fine salt price, the nugget value from J-Bessel Semivariogram was 100,530.2 with range of 0.5455588 and partial sill of 5,310,534. In that case, the researchers used isotropy with 4 sector type and 45<sup>o</sup> offset. The result of interpolation ordinary kriging can be seen in Figure 1.



**Figure 1 :** Result Interpolation Ordinary Kriging Method (Semivariogram J-Besse) for Fine Salt Price

From Figure 1, it can be seen that the fine salt price in Southern Malang city (Sukun and Gondang Legi Sub-district) was the lowest. Based on the field observation, people in that area were still easy to get fine salt so that there was only a slight salt price increase. Batu and northern areas of Malang city had a similar condition. The salt prices in that area ranged between IDR 5,000-6,000. According to a seller in the Blimbing market, most sellers in Malang and Batu city bought fine salt from Southern Malang district. Thus the salt stock in Southern Malang district was limited earlier than in Malang and Batu City. Limited stock of fine salt in Southern Malang district caused the price of fine salt in that area tended to be more expensive. If the production of salt was still not stable, then the fine salt prices in Malang and Batu City would become more expensive. Although the salt stock was limited, the demand for fine salt rose dramatically due to consumers' panic reaction. That case caused the price of fine salt to increase. The highest salt price reached IDR 13,000 in Mojokerto regency.

Meanwhile, for crude salt interpolation by Inverse Distance Weighting method formed regression function  $y = -0.0111x + 1147.0311$ . The results of crude salt interpolation using Inverse Distance Weighting method can be seen in Figure 2.

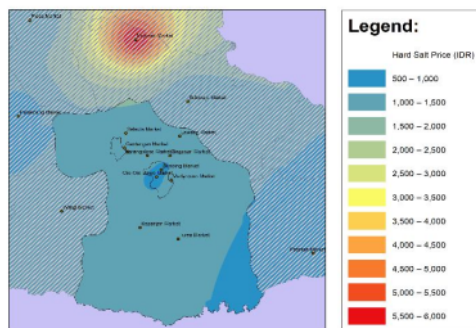


Figure 2 : Result Interpolation Inverse Distance Weighting for Crude Salt Price

Based on Figure 2, it can be seen that the price for crude salt in Malang Raya was relatively stable. Less production of crude salt due to the low demand for crude salt contributed to that phenomenon. A salt consumer in Malang city said that she preferred to buy fine salt rather than crude salt, although it was more difficult to get. Another consumer said that they were afraid to use crude salt because it was turbid and less tasty [13]. A seller in Blimbing market in Malang city said that there were not many people who bought crude salt. Most of the consumers tended to choose fine salt, although it was expensive.

#### 4.CONCLUSION

Salt scarcity in Malang Raya caused an effect of salt price increase in almost all areas of Malang Raya, especially in Northern and Southern Malang regency because sellers in Batu and Malang city bought the salt stock from those areas. Meanwhile, the salt prices in Malang and Batu city only increased slightly, especially in the southern part of Malang, due to the limited stock availability. The researchers feared that if there was still any problem in fine salt production, salt scarcity would last longer. In the near future, the fine salt price in Malang City and Batu City might also increase, and the price might be similar to the price in Southern and Northern Malang Regency. On the other hand, the result was different for crude salt. Although the production of crude salt decreased and the stock was also limited, the low-demand of crude salt made a slight increase in crude salt price in Malang Raya.

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