Increased Efficiency of Production of Madura People's Salt with the Analytic Network Process (ANP) Method and Data Envelopment Analysis (DEA) Approach

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## ABSTRACT

Madura Island is one of the largest people's salt producing areas and has a lot of scattered areas, especially the people's salt that is in every coastal area. The problem is that the production of salt by the people of Madura is not able to carry out the maximum production process, and the output of salt can't be fully absorbed by the market due to the quality of the salt. People still do not meet the criteria, in addition to the existence of the governmental policy of importing salt to meet the national salt supply. Imported salt has a quality that is considered sufficient. Moreover, a more affordable price than local salt is one of the drivers of salt import activity, moreover, salt import activities are not one solution that can be justified and still need a sustainable study. The investigation aims to determine the level of efficiency and optimize the production of people's salt, in particular in Sumenep district, which is one of the largest salt-producing areas. The research begins with determining the factors that influence the efficiency of the production of Madura people's salt using the Analytic Network Process (ANP) method, then determines the level of production efficiency using the Data Envelopment Analysis method (DEA). The efficiency of salt production among the Madura people, especially in Sumenep district, is 80.66%. Factors leading to inefficiency include fields and supporting technology. Improvement proposals to improve the efficiency of people's salt production include periodic inspection of the geomembranes, construction of intensive crystallization houses during the rainy season, improving the layout of the pitch, which is less effective at the time of irrigation, and the application of a roll material handling tool to assist the process of transferring the salt that has been harvested to a silo or a temporary storage warehouse.

**Keywords: Efficiency, ANP, DEA**

# INTRODUCTION

The Indonesia is an island country with a vast area of water larger than the mainland, which consists of 17,508 islands and a coastline length of 95,191 km. Indonesia has a sea area of approximately 5,176,800 km2, making Indonesia the maritime country with the largest commodity of marine resources, one of which is salt. National salt needs are managed to meet the needs of consumers, the food industry, the "C.A.P." industry, oil drilling, and other needs. National salt needs tend to increase each year as the population and industry grow, but local salt commodities are not able to make optimal use, so local salt production can't meet national salt needs. Plus, with the area of fertilization becoming more and more limited because of the number of fertilized land transferred to function while the opening of new fertilized land requires a fairly high cost, this will have an impact on national production. (KKP, 2020).

As an island state with the largest commodity of marine resources, every region in Indonesia has the potential to develop salt production, but there are only a few areas known as major salt producers, including the island of Madura. Madura Island is one of the largest salt-producing regions due to the characteristics of the island, which make it ideal for producing salt in topographic conditions with low slopes and high sun intensity. (Kemenperin, 2018).

The problem of importing salt in Indonesia began with the accumulation of imported salt from Australia, India, New Zealand, and China. As a result of the accumulation of imported salt, the price of people's salt produced by local Indonesian salt farmers tends to decline because the output of the production of folk salt can't be absorbed evenly and can't compete with the salt of people imported both in terms of price and quality. The efforts of the people's salt in the face of competition against the commodities of imported salt are demanded to be able to carry out production in a state of high efficiency, both in terms of physical efficiency and price efficiency (price or allocative efficiency). (KKP, 2021).

People's salt as one of the fairly important commodities of trade in recent years has become a strategic issue in the national economy. It is, among other things, related to the fact that salt imports are increasing every year. The government, through the Ministry of Maritime Affairs and Fisheries, is making every effort to suppress salt imports by forming and implementing the National Salt Swasembada program through the construction of the Salt Economic Zone (KEG), with the objective of implementation in the years 2020-2024. One of the objectives and functions of the development of the salt economic zone is to reduce the salt import rate by optimizing the production of people's salt through an approach from the top to the bottom, in particular by optimizing the amount of salt production that exists on the island of Madura. The production of people's salt in the Sumenep district is still average using traditional and simple methods. The success of the salt farmers' production depends heavily on the natural conditions, especially on the intensity of the weather and the environment around them, as in the rainy season, where the salt farmer maximizes his production in certain months of the rainy season. The district of Sumenep has the largest people's farmland that produces people's salt to meet a variety of needs, including households and industrial needs. The quality of the people's salt, which is unable to compete, makes the process of absorption of folk salt in the market uneven; the instability of salt prices, the relatively traditional production process, and the competition of salt commodities between the regions are some of the many problems of the production of people's salt. Additionally, the income from salt farmers is still relatively low, as the salt farmer is only able to produce salt in certain months, while the farmers' income is not proportionate to the needs to be met while the salt farmer is not producing, especially during the rainy season. In addition, the low income of salt farmers is also due to the instability of the sale value of people's salt compared to the sale price of imported salt. With this level of productivity, it is still relatively difficult to meet the needs of the market for salt. With the need for the supply of salt still scarce, it must be one of the opportunities for salt farmers to increase their productiveness in making salt production more efficiently in order to scrape the income of the salt farmer society so that the economic well-being of the salty farmers can be realized.

# LITERATURE REVIEW AND HYPOTHESIS

Hoiriyah (2020) state that, salt is one of the supplementary food requirements as well as a source of electrolytes for the human body. Salt is also a solid matter of white color and crystalline shape that has a content of NaCl compounds of >80% and a sequence of other compounds such as CaSO4, MgSO4, MgCl2, and others. In general, folk salts are grouped into three types, namely:

1. K-1 Salts are salts of the highest quality, suitable for both industrial and consumer use, with the following composition:

• NaCl: 97.46%

• CaCl2: 0.723%

• CaSO4: 0.409%

• MgSO4: 0.04%

• H2O: 0.63%

• Impurities: 0.65%

1. K-2 salts are salts that have a color below K-1 salts, where this type of salt has to be reduced from the levels of various substances in order to be able to meet the standard as an industrial raw material.
2. K-3 salt is the lowest quality salt produced from folk salt. Salt of this type has a ratio of between 88 and 90%. This salt is said to have a low quality because it is mixed with soil, so the color is brown.

Erliana (2020) state that, efficiency is one of the tools for balancing outputs and inputs. Efficiency focuses on how a resource is capable of producing an output. Efficiency is also referred to as the savings in the use of resources in an organization's activities, where the efficiency is in the usability. The method used in measuring efficiency is a frontier approach that is divided into two:

1. The parametric frontier approach is an approach that has a model to establish the presence of certain conditions on the population parameters that are the source of research. Parametric frontier approaches can be measured with statistical tests using the stochastic frontier analysis (SFA) and distribution-free analysis (DFA) methods.
2. A non-parametric frontier approach is an approach that does not impose specific conditions on the population parameters of the sample. (DEA).

 Data Envelopment Analysis (DEA) is a non-parametric method used to calculate the engineering efficiency of the entire unit. The DEA model is used as a tool in evaluating the performance of an activity on Decision Making Unit (DMU) data that is included in the ratio between input and output that has been weighed. (efficiency score). This is a step-by-step implementation of the Data Envelopment Analysis (DEA) method.

1. Identify the decision-making unit (DMU) or unit to carry out the observation or research.
2. Identify the input and output of the decision-making unit. (DMU).
3. Calculate the efficiency of each decision-making unit (DMU) to obtain the target input and output required for optimal performance. The method of performing this efficiency calculation is to perform mathematical programming, then complete the linear programming with a simplex method.

Darmawan (2018) state that, the Analytic Network Process (ANP) is a comprehensive analytical framework available to make decisions as well as analyze decisions. ANP allows an analyst to include all the factors and criteria, whether tangible or not, in relation to the best decision-making. ANP allows for dependency and feedback between elements in clusters (inner dependencies) and inter-clusters (outer dependencies). ANP uses the system of pairwise comparisons to measure the weight of structural components and to determine the alternative ranking of the best choice to be made. The ANP model has three parts of decision, namely:

1. Strategic criteria in terms of which decisions are evaluated according to (merit) Benefits, Opportunities, Costs, and Risk (BOCR)
2. Control criteria and possibly control subcriteria.
3. a decision network to determine alternative decision priorities.

## RESEARCH AND METHOD

Research activities in an attempt to improve the efficiency of the production of salt in Madura are carried out in Sumenep district. The selection of such a location is due to having sufficient land covered, but the output of production and the quality of the salt produced are still below maximum. The primary data is obtained by conducting an interview with the owner or salt farmer directly. Secondary data are obtained from the history of people's salt production as well as the data assigned as the processing of ANP data obtained by using a questionnaire distributed to each salt farmer. The step taken in this phase is to conduct an interview and then determine the factors that influence the performance of the salt production that exists in the salt enterprise. The utility data is the labor force or population of salt farmers in Sumenep district, the number of working hours, wages, farmland, and supporting technology used to support all processes of people's salt production. Total production data is historical data on salt production outputs from each district in Sumenep district.

Data processing is done using the Analytic Network Process (ANP) and Data Envelopment Analysis methods. (DEA). After obtaining data from the questionnaires distributed to some salt entrepreneurs or salt farmers, the geometric averages of each aspect of the criteria are determined. It's just that it processes the results of the questionnaire using the Super Decisions software to figure out the weight of each criterion. The next step is the determination of the DecisionMaking Unit (DMU). At this stage, we will analyze the efficiency, where DMU is the salt-producing area. Next is the definition of the input and output; here, the input data is the data factor affecting the production efficiency. While output is the aspect that affects the production of the salt, which in this study is the data output of salt production**.** The input data consists of the labor force, working hours, wages, farmland, and supporting technology. However, before being used as an input, it was previously calculated with the weight of the ANP calculations, whereas the output data is the data of the salt production. The next step is to determine the DEA model, where the determination of the model used first is by looking at the available data. The approach used is DEA with the BCC model using assumptions (VRS). Then calculate the efficiency of each DMU using the Baxia Frontier software. The first step is to enter the DMU data to find out the input and output of the software. The models used are orientation output, return to scale variable, and DEA (multi-stage). Once the DMU is known to be inefficient based on the calculations that have been made, the next step is to carry out analysis to find out the causes and consequences and give suggestions for improvement.

# RESULT AND DISCUSSION

# A. Data processing carried out

# After data processing, here are the factors that influence the efficiency of the production of Madura people's salt.

# Criteria Determination

Table 1. Criteria



  Table 1 contains a number of criteria on several factors that influence the efficiency of the production of people's salt madura, including labor force factors, number of hours of work, wages, parking ground, and supporting technology in the production process. The first step in the processing of this data is to perform a criterion-to-criterion grinding with the Analytic Network Process (ANP) method using the Super Decisions software. Here are the stages in the weighing of the criteria that affect the effectiveness of the production of people's salt madura.

# ANP model for production efficiency criteria



Figure 1. ANP Model

# ANP modeling using Super Decisions Software

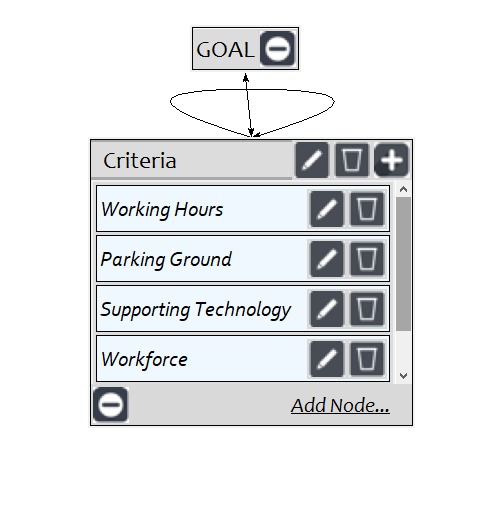


Figure 2. ANP model using software

# Comparison of pairs of criteria

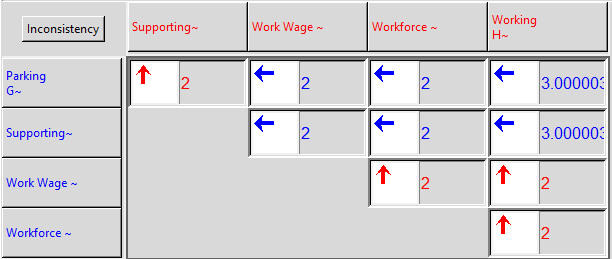


Figure 3. Comparison of pairs of criteria

Table 2. Weighting of comparison criteria

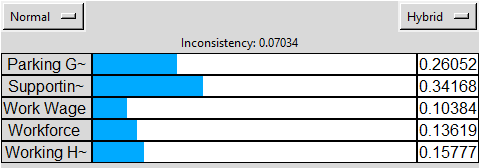
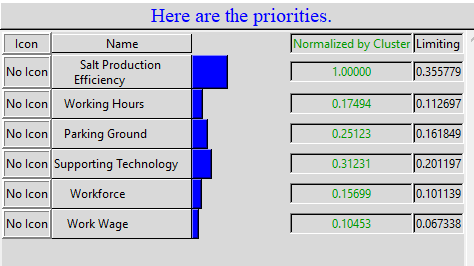


Table 2 is the weighting value obtained from the comparison of criteria. The supporting criteria are 0.20549 times more influential than the labor criteria. Further on Table 3, the output of the results of the comparison between criteria, where the supporting technology criteria has the highest value of 0.34168, can be seen by looking at the consistency index in the table, where a consistance is considered to have a consistent value if the value CR < 0.1. The processing of this data obtained a value of 0.07034, which can be concluded that the respondents are consistent in assessing.

# Weighing

Here is the weighting result for each criterion to be used as the multiplication of input values in the DEA method.

Table 3. Priorities of factors the efficiency



 Once the determination of the factors affecting the efficiency of the production of salt people madura through the weighing criteria of the ANP method is completed, the next step is to perform data processing with the DEA method. The first step to be taken is to make a determination decision-making unit (DMU), where DMU is a unit that will be analyzed for performance later.

In this study, each district or area that has a people's salt production land in Sumenep district is measured as a DMU. There are 10 areas measured in this study.

Next is a grouping between the input components, DMUs, and outputs used to measure the efficiency of the production of Madura people's salt.



Figure 4. Grouping the input components, DMUs, and outputs

After performing data processing using the Banxia Frontier Analysis software, this is the result of the measurement of the efficiency of the production of people's salt madura.

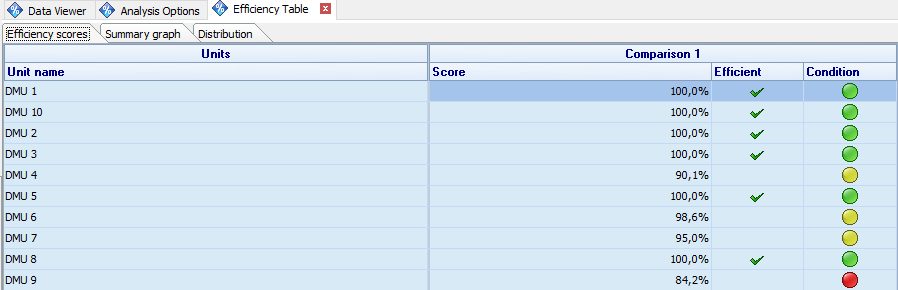


Figure 5. Efficiency Calculation

Figure 5 shows the results of the determination of the effectiveness value of the production of madura folk salt with the DEA approach of the BBC model that assumes the CRV output orientation. The measurement of the efficiency condition is indicated by the presence of traffic light indicators, where there are three ranges: the green range with an efficiency value of 100%, which shows the DMU has been perfectly efficient; the amber range with an effectiveness value of 90–99%, which indicates that the DMU is already efficient but not perfect because there is a potential improvement that needs to be done to achieve perfect efficiency; and the red range with a value of 0-89.99%, which indicates a DMU that is not ifisien or cannot reach the expected level of efficiency. There are 10 DMUs in the decision-making unit at this investigation, where the data processing results obtained 6 DMU that have reached the level of efficiency values and 4 DMU that have not achieved efficient values (inefficient). (Sapeken). So the efficiency of the production produced by the process of producing the salt of the people of Madura is 80.66%.

# Factors affecting production efficiency

After doing the efficiency measurement on the process of salt production, people found that there are several DMUs that are inefficient because there are a number of factors that influence them, among them supporting technology and soil grinding that have a significant impact, and there are potential improvements that need to be enhanced to achieve perfect efficiency values.

# CONCLUSSION

The factors that influence the efficiency of the production of salt in Madura are, among them, the labor force, hours of work, wages, supporting technology, and land cultivation. This study found several factors that affect the level of production efficiency of salt people in Madura significantly, namely, the technology of cultivation and soil cultivation, so that the rate of efficiency of production of salt folk in Madura, especially in Sumenep district, is 80.66%. There are some DMUs or areas that are still not at their maximum in carrying out the salt production process, so the process of salt population maturation is still declared inefficient because there are still many aspects that need to be improved and developed according to the influential factors in order to subsequently be able to optimize the production process of salt population maturation. Recommendations and improvement proposals to improve the efficiency of people's salt production are to apply the use of geomembranes from the juvenile plates to the salt crystallization plates, as well as to conduct periodic inspections and treatments on the structure of the geomember to support the salt production process better, which can also improve the quality of the salt. Combine the people's salt production process with appropriate technology for the use of domestic supports such as crystallization houses during the rainy season, suction pumps for the hydration of seawater, and roll material handling to move or transport the salt harvest to the silo part or temporary storage place, as well as performing design improvements to the people's salt fields that are deemed less efficient against the hydrogenation of sea water during the production process.

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