A Study on the Productivity of Salt Farming on Madura Island, Indonesia

Elys Fauziyah[1,*], *Dwi* Ratna Hidayati[1], and *Ika* Fatmawati[2]

[1]Agribusiness, Faculty of Agriculture, Trunojoyo University, Bangkalan, Indonesia
[2]Agribusiness, Faculty of Agriculture, Wiraraja University, Sumenep, Indonesia

Abstract. Salt is a strategic commodity in the Indonesian economy, with consistent growth in both import volume and number. However, the inability of domestic production to fulfil existing demand is caused by low productivity, which is also affected by farmers on Madura Island. Therefore, this study aims to analyze the determinant factors of salt production, the level of technical efficiency, and the socio-economic factors that cause technical inefficiency. The samples involved 120 people as determined by multistage sampling in 3 regencies on Madura Island, namely Sampang, Pamekasan, and Sumenep. Meanwhile, the parameters were analyzed using the Translog Frontier Stochastic Production Function model and multiple linear regression. The results showed that land and geomembrane influenced salt production, as well as most farmers have not produced efficiently due to the causing factors such as age, number of family members, secondary income, geomembrane, and bozem ownership.

1 Introduction

In Indonesia, salt is one of the strategic commodities with high economic value due to its functions as a provider of household consumption needs and industrial raw materials. Based on the data from Lokadata [1], the need for salt in the country has significantly increased over the past five years (Figure 1). However, this opportunity has not been optimally used to increase salt commodities' production and economy. According to the Ministry of Maritime Affairs and Fisheries, the amount of salt production, which is 1.3 million tons, has not yet fulfilled the demand and is far from the targeted 3.1 million tons planned in 2021[2]. This has led to an increase in the number of salt imports. Within 5 years, there has been an increase in the number of salt imports by 26.35%, from 3,532,887 tons in 2016 to 4,464,670 tons in 2020 [3].

One of the salts farmings location that significantly contributes to Indonesian salt production is Madura Island. This island is part of East Java Province, which contributed 782,738 tons out of 2,349,629 tons of total salt production in 2018. Madura Island contributed around 645,533 tons or approximately 82.47 percent, which mostly came from people's salt farming. Although the island has a fairly large salt supplier, farmers still face various problems, such as low productivity. Based on the data from the Ministry of

[*] Corresponding author: fauziyah@trunojoyo.ac.id

Maritime Affairs and Fisheries , the productivity of salt farming on Madura Island is still far from other salt-producing areas [4]. For example, in West Nusa Tenggara, which is capable of producing salt with a productivity level of 134.81 tons per hectare. Meanwhile, in three key regencies of salt producer areas on Madura Island, namely Sampang, Pamekasan, and Sumenep, salt productivity was 3.23, 9.94, and 12.21 tons per hectare, respectively.

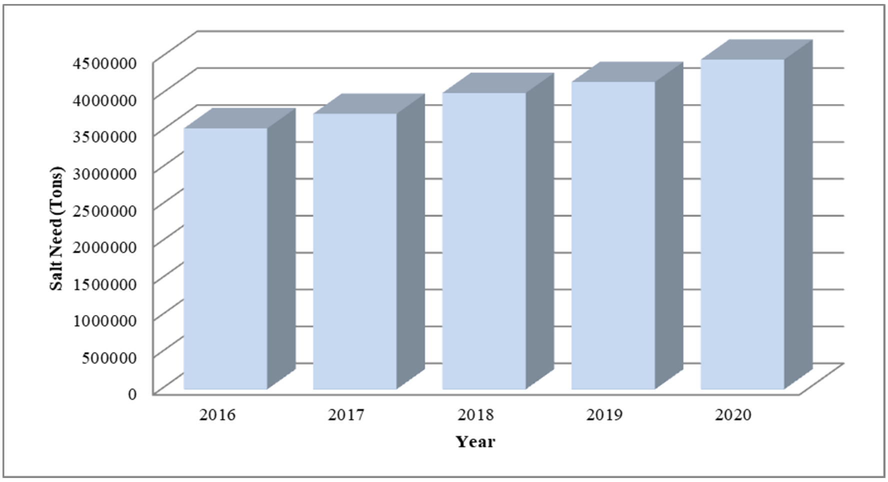

Fig. 1. The trend of Increasing Salt Demand in Indonesia

The problem of productivity in farming is often attributed to the use of resources in the activity and the socio-economic conditions of the farming determinants. Some studies on the problem of the relationship between the level of productivity and the use of resources stated that land resources, seeds, labor, fertilizers, and socio-economic factors (such as experience, education, frequency of extension visits) affected farming productivity [5-10]. Similarly, productivity problems are usually identified with technical inefficiency problems. According to some scholars the low productivity is caused by inefficient of business determinants [11-16]. In this regard, this study aims to analyze the determinant factors of salt production, the level of technical efficiency, and the socio-economic factors that cause technical inefficiency.

2 Material and method

Production is a technical relationship between output and the number of inputs that are used. Theoretically, the level of production of producers is highly dependent on the level of input used, therefore, the relationship between output and input is often called the production function, which is used for prediction [7]. One form of a production function that is widely used to explore the relationship between output and input is the Translog production function. This function was introduced by Christensen [8] with the formula as stated in Equation (1) below.

$$\ln y = \ln \alpha + \beta 1 \ln x1 + \beta 2 \ln x2 + (1/2)\, \gamma\, (\ln x1 \ln x2) + 1/2\, \phi_1 (\ln x1)^2 + 1/2\, \phi_2 (\ln x2)^2 \quad (1)$$

Where Q is the amount of production, K is the stock of capital, L is labor, and M is the amount of material input.

In its development, several studies developed the concept of production function based on production inefficiency, which is currently known as Stochastic Frontier Analysis (SFA). Meanwhile, the general form of SFA is shown in Equation (2).

$$Yi = \exp(Xi\beta + \varepsilon i) = \exp(Xi\beta + Vi - Ui), \varepsilon = Vi - Ui, i = 1 \dots . N \quad (2)$$

The composition of the error term in SFA production consists of technical inefficiency (Ui) and risk (Vi). SFA was introduced by Aigner [9], which formulated and estimated the stochastic frontier production function and described the disturbance term characteristics. The concept has been further developed in several studies, such as by Schmidt & Knox Lovell [10] which developed the use of the frontier production function as the duality of the cost function and used it to determine the allocative efficiency value. Green [11] also investigated the use of maximum likelihood estimation to calculate the frontier production function, while Jondrow et al. [12] conducted a disturbance term U and stated that it showed technical inefficiency and random factors. Other studies [23-25], aimed at the empirical work that addresses the use of a stochastic frontier production function and in agricultural cases using panel and cross-section data [14].

The use of the stochastic frontier production function has been widely applied in various empirical studies to assess the level of technical efficiency. However, most of the studies used the production function of Cobb Douglass, in the salted fish business, which explains most of these product entrepreneurs have not been efficient [15]. A study on maize farming stated that most farmers are inefficient in their production [16] & [17]. Another empirical study of SFA used the translog production function applied the function to predict the technical efficiency of maize in Zambia [18]. These studies showed that most of the farmers in the study area are not yet technically efficient. However, it is inversely proportional to the result of Addison et al [19] in rice farming in Ghana, where the average level of technical efficiency for rice farmers is very high at 0.899.

The study location was determined purposively on Madura Island over three regencies, namely Sampang, Pamekasan, and Sumenep. The island is one of the centres of salt production that significantly contributes to the national salt supply. Meanwhile, the sample was determined using the multistage sampling method with a total of 120 salt farmers, where the distribution of area is shown in Table 1 below.

Table 1. Number and Distribution of Samples

Regency	Sub-district	Selected Village	Sample (people)
Sampang	Sreseh	Marparan	20
		Disanah	20
Pamekasan	Galis	Lembung	10
		Polagan	10
		Konang	10
		Pandan	10
Sumenep	Kalianget	Karanganyar	15
		Kertasada	10
		Pinggir Papas	15

The study was analyzed using primary data taken through interviews with salt farmers using a structured questionnaire and observation process. The types of data used include the amount of salt production (quintal), salt area (hectare), percentage of crystallization land area, number of labor (HOK/Working People Day), and geomembranes (square meter).

Meanwhile, the method used for analysis is the stochastic frontier translog production function (SFA) to analyze the factors affecting production and efficiency levels. SFA model is selected because of the method's ability to classify error terms into two, namely technical inefficiency and random factors outside the model. Furthermore, the socio-economic factors assumed to be the cause of technical inefficiency are analyzed using multiple linear regression, and the model used is shown in Equation 3 below.

$$\begin{aligned} Log\ prodgr = {} & \beta0.logC + \beta1.logllgr + \beta2.logllkr + \beta3.logtkgr + \beta4.loggmgr \\ & + \beta5.0.5.logllgr^2 + \beta6.0.5.logllkr^2 + \beta7.0.5.logtkgr^2 \\ & + \beta8.0.5.logX4gmgr^2 + \beta9.logllgrlogllkr + \beta10.logllgrlogtkgr \\ & + \beta11.logllgrloggmgr + \beta12.logllkrlogtkgr \\ & + \beta13.logllkrloggmgr + \beta14.logtkgrloggmgr + log(vi - ui) \end{aligned} \quad (3)$$

The calculation of the elasticity value is carried out using the following formula,

$$epi = \frac{\partial logYi}{\partial logXi} \quad (4)$$

As an illustration, the calculation of the land elasticity value is as follows.

$$epllgr = \frac{\partial logprodgr}{\partial logllgr} = \beta1 + \beta5logllgr + \beta9logllkr + \beta10logtkgr + \beta11loggmgr \quad (5)$$

The technical efficiency value is determined using Equation 5 below.

$$TE = \frac{Yi}{Yi*} = \frac{f(x;\beta)e^{vi-ui}}{f(xi;\beta)e^{vi}} = e^{-ui} \quad (6)$$

It is recommended to estimate the function using maximum likelihood estimation with frontier 4.1 software.
Meanwhile, the prediction model for socio-economic factors that affect technical inefficiency can be seen in Equation 6.

$$iet = b0 + b1umr + b2pnd + b3jak + b4pglm + b5pps + b6dpg + b7dpb + e \quad (7)$$

Description
prog gr : salt production per season in tons
llgr : salt land area (hectare)
llkr : percentage of crystallization land area
tkgr : labor used in salt farming (HOK)
gmgr : geomembranes used by salt farmers (square meters)
iet : technical inefficiency level
umr : salt farmer age (years old)
pnd : salt farmer formal education (years)
jak : number of family members (person)
pglm : salt farmer experience (years)
pps : income from salt farmer's side job (million rupiahs)
dpg : dummy of geomembrane use (D=1 if using; D=0 if not using)
dpb : dummy of bozem ownership
(D=1 if it has bozeem; D=0 if it does not have bozem)

3 Results and Discussion

Madura Island, which is known as a salt Island, has made a significant contribution to the supply of national salt and the sector has become an important source of the economy in the three regencies in the region. However, salt farming productivity is one of the main obstacles to its development. Therefore, this study examines the causes of low productivity, using 120 salt farmers as respondents. Based on the initial analysis, the characteristics of the farmers on Madura Island are described in Table 2 below.

Table 2. Characteristics of Salt Farmers on Madura Island

Characteristics	Average	Unit
Total productivity	60.11	Tons/hectare
Percentage of land used for salt crystallization per hectare	20	Percent
Labor use per hectare	3468.1	HOK
Geomembrane use per hectare	605	Square meter
Salt farmer age	49	Year old
Salt farmer formal education	6	Year (SD)
Number of salt farmer's family members	5	Person
Salt farmer experience	21	Year
Total income from side jobs	1250971	Rupiah/month
Percentage of salt farmers using geomembrane	88	Percent
Percentage of salt farmers who own bozem	23	Percent

The average salt production per hectare on Madura Island is still below the national average salt productivity (70 tons/hectare). The main resources used in salt farming include 1) land for crystallization, 2) geomembrane plastic, and 3) labor. In this study, these three resources are used in the stochastic frontier translog production function model, and the analysis results are shown in Table 3. The use of the model is in line with the available data, which is indicated by the loglikelihood function value in the OLS estimation. This is smaller than the value in the MLE estimation, while the LR value is greater than the palm code table (8.273).

The analysis results showed that two resources, namely land and geomembrane plastic affect salt production. The land has an elasticity value of -1.921, which indicates that when the land area for salt farming is increased by 1 percent, the production is decreased by 1.921 percent. On Madura Island, the land use for salt farming is categorized into two scales, namely less than 1 hectare and more than 1 hectare. The data in the field showed that groups of salt farmers with less than 1 hectare of land produce more salt than those with land of more than 1 hectare. The number of farmers who manage land more than or equal to 1 hectare is approximately 66.67 percent, and the average salt production per hectare is 48.4 tons. Meanwhile, 33.33 percent of salt farmers manage less than 1 hectare with the production of 67.31 tons per hectare, which indicates that they are more productive than those with more than 1 hectare of land. This occurred because farmers with land less than 1 hectare produced more intensive and provided more labor than those with more than 1 hectare. This result is not in line with some finding, where the land area has a positive effect on production [18], [20], [19].

The second resource that influences salt production is the use of a geomembrane, with an elasticity value of 0.228 in this model. This showed that the increased use of geomembrane by 1 percent would increase salt production by 0.228 percent. Based on the data, the number of farmers who use geomembrane is approximately 88 percent. The average salt production for groups of salt farmers using geomembrane is higher (82.9 tons per hectare) than those who do not use the technology (78.9 tons per hectare). This is in line with the study by Effendy et al. [21] and Arwiyah et al. [22], which stated that the use of geomembrane by salt farmers in Madura provides better salt productivity, with a higher NaCl content compared to those who do not use the technology. The results of this study support salt research in Thailand. His research states that salt farmers who use geomembrane technology are more efficient than traditional salt farmers [23].

Table 3. The Stochastic Frontier Translog Production Function Model for Salt Farming on Madura Island

Variable	Coefficient	Standard Error	t ratio
Constant	5.360	1.677	3.198
Salt land area	2.072	0.834	2.485*
Crystallization land area	-0.429	0.689	-0.623
Labor	-0.824	0.695	-1.186
Geomembrane	-0.248	0.111	-2.247*
Salt land area-Salt land area	-0.048	0.121	-0.398
Crystallization land area-Crystallization land area	-0.086	0.087	-0.992
Labor-Labor	0.129	0.081	1.582
Geomembrane-Geomembrane	-0.002	0.006	-0.303
Salt land area-Crystallization land area	0.860	0.396	2.173
Salt land area-Labor	-0.548	0.322	-1.702
Salt land area-Geomembrane	0.034	0.037	0.923
Crystallization land area-Labor	0.139	0.263	0.529
Crystallization land area-Geomembrane	-0.057	0.041	-1.407
Labor-Geomembrane	0.086	0.036	2.421
Log-likelihood function in OLS	-72.11		
Log-likelihood function in MLE	-66.09		
LR	12.03		
Gamma	0.900	0.052	16.99*
Land area elasticity	-1.921		
Geomembrane elasticity	0.228		
Smallest technical efficiency level	0.118		
Greatest technical efficiency level	0.932		
Average technical efficiency level	0.752		
Highest technical efficiency	0.909		
Lowest technical efficiency	0,483		

Description: *significant at α=5%

Based on the results, most people's salt farming is not technically efficient. A total of 60.83 percent of respondents, or 73 farmers, have an efficiency between 0.118 to 0.800. Meanwhile, the remaining 39.17 percent could produce salt efficiently, with a value between 0.810 to 0.932. By referring to the highest efficiency number, there is still an opportunity to increase salt production with a potential of 53.13 percent for the lowest technical efficiency. This is in line with salt study in Guinea and Ghana [32-34], and previous studies [35-38], which revealed that many traditional farmers in Indonesia still have limitations in achieving high production efficiency. However, this is different from the condition of wheat farmers in the Punjab Region, India, who produced with a high level of technical efficiency [26], and cowpea farmers in Nigeria [27].

Previous study also stated that farmers are still unable to produce with a high level of technical efficiency because of several factors such as education, transportation costs, land area, year, and positive impact of a region [26]. According to Heriqbaldi et al. [28], land size, income, and funding sources are the causes of low technical efficiency. Other factors that can be a source of inefficiency are participation in social groups, the distance between the farmer's house and the extension office, agricultural extension activities, access to credit and use of technology [29], [30], [31], [32]. Table 4 shows the analysis result of the factors causing technical inefficiency in this study.

Table 4. The Effect of Salt Farmers' Socio-Economic Factors on the Level of Technical Inefficiency

Variable	Coefficient	Significance
Constant	0.305	0.000
Salt farmer age	0.002	0.089**
Salt farmer formal education	0.003	0.519
Number of family members	-0.016	0.090**
Salt farmer experience	0.000	0.730
Income from side jobs	-0.002	0.100**
Dummy of geomembrane	-0.083	0.041*
Dummy of bozem	-0.060	0.042*

Description : ** significant at α = 10%, * significant at α = 5%

Socio-economic conditions that are assumed to influence the level of technical inefficiency are the age of salt farmers, the number of family members, income from side jobs, dummy of geomembrane and bozem. When the age of the farmer increases, the level of technical inefficiency also rises. Based on the results, the average age of salt farmers on Madura Island is 49 years, but the productive age category of between 19-45 years old is only around 44.16%; meanwhile, the rest are over 45 to 74 years old. This is in line with the results of research on small farmers in Ethiopia [33]. However, family members have a role in salt-farming activities. Most salt farmers use labor from family members, especially males, for production activities. Therefore, based on the analysis results, the number of family members influenced inefficiency, indicating the greater the number, the smaller the level of technical inefficiency. This is in line with salt production in Guinea [24]. This is presumably because more people tend to help salt farmers in carrying out production activities, thereby optimizing farming productivity. Another factor that reduces the level of inefficiency is income from side jobs, this is because when farmer has a side job, part of the income is allocated for salt production activities, such as paying labor wages, repairing windmills, buying and repairing rakes, and buying geomembranes. Subsequently, the use of geomembranes by salt farmers contributes to a decrease in the level of technical inefficiency. In Line with salt research in Phetcaburi [23]. Currently, most salt farmers on Madura Island use geomembrane technology which increases the amount of production. The difference in production between farmers that use and do not use geomembrane ranges around 6 tons per hectare. Another factor predicted to affect the level of technical efficiency is bozem ownership. In salt production, bozem has a function as the first pond used to accommodate seawater with a concentration of 2-3 oBe and deposit organic material. On Madura Island, only 23 percent of salt farmers own bozem. Based on the analysis results, farmers who have bozem tend to produce more efficiently than others without bozem.

4 Conclusion

Madura Island is one of the key producers of salt in Indonesia, which has an issue with production inefficiency. Based on the analysis results, the resources that affect salt

https://doi.org/10.1051/e3sconf/202344402027

production are land and geomembrane. The land has a negative effect, while a geomembrane has a positive effect. In general, salt farmers are not yet technically efficient, while the socio-economic factors that affect the level of technical inefficiency include age, number of family members, income from side jobs, geomembrane use, and bozem ownership.

Acknowledgements. Thanks are expressed to the Chancellor of UTM, who has provided research funding to the author in 2023. We hope that this research can contribute to the development of local Madurese commodities and the welfare of salt farmers on the island.

References

1. Lokadata, Beritagar.Id 1 (2020)
2. V. B. Kusnandar, *Indonesia Masih Impor Komoditas Pangan, Ini Daftarnya* (2022)
3. V. A. Dihni, *Indonesia Impor Garam Senilai Rp1,5 Triliun Pada 2021* (2022)
4. H. Rasidi, Mata Madura (2021)
5. N. M. Aung, (2011)
6. S. C. Kumbhakar, Am. J. Agric. Econ. **84**, 8 (2002)
7. D. L. Debertin, *Agricultural Production Economics* (Macmillan Publishing Company, new York, 1986)
8. L. R. Christensen, D. W. Jorgenson, and L. J. Lau, Rev. Econ. Stat. **55**, 28 (1973)
9. D. Aigner, C. A. K. Lovell, and P. Schmidt, J. Econom. **6**, 21 (1977)
10. P. Schmidt and C. A. Knox Lovell, J. Econom. **9**, 343 (1979)
11. William H. Greene, **13**, 27 (1980)
12. J. Jondrow, C. A. Knox Lovell, I. S. Materov, and P. Schmidt, J. Econom. **19**, 233 (1982)
13. G. E. Battese and T. J. Coelli, J. Econom. **38**, 387 (1988)
14. S. C. Kumbhakar, Agric. Econ. **10**, 143 (1994)
15. H. A. Sutanto and S. Imaningati, J. Econ. Policy **7**, 73 (2014)
16. I. Suprapti, D. H. Darwanto, J. H. Mulyo, and L. R. Waluyati, J. Econ. Sustain. Dev. **7**, 154 (2016)
17. Y. T. Bahta, H. Jordaan, and G. Sabastain, Agric. **10**, (2020)
18. S. Chiona, T. Kalinda, and G. Tembo, J. Agric. Sci. **6**, 108 (2014)
19. M. Addison, K. Ohene-Yankyera, and E. Fredua-Antoh, J. Food Secur. **4**, 27 (2016)
20. M. A. Maryanto, K. Sukiyono, and B. Sigit Priyono, Agrar. J. Agribus. Rural Dev. Res. **4**, 1 (2018)
21. M. Zainuri, M. Effendy, F. F. Muchsoni, Hafiluddin, A. Budianto, and M. Syaiful, UTMPress 134 (2020)
22. Arwiyah, M. Zainuri, and M. Efendy, J. Kelaut. **8**, 1 (2015)
23. R. Tansuchat, Agric. **13**, (2023)
24. B. S. Balde, H. Kobayashi, M. Nohmi, A. Ishida, I. Matsumura, M. Esham, and E. Tolno, Am. J. Appl. Sci. **11**, 1310 (2014)
25. L. Akhilomen, G. Bivan, S. Rahman, and S. Sanni, Am. J. Exp. Agric. **5**, 267 (2015)
26. M. A. Shahzad, A. Razzaq, M. Aslam, M. F. Gulzar, M. A. ur R. Naseer, and N. Nisar, J. Agric. Stud. **7**, 115 (2019)
27. O. Egbetokun, B. T. Omonona, and A. A.T., Econ. Anal. Policy **40**, (2010)
28. U. Heriqbaldi, R. Purwono, T. Haryanto, and M. R. Primanthi, Asian Soc. Sci. **11**, 91 (2015)
29. S. Islam, S. Mitra, and M. A. Khan, J. Agric. Food Res. **12**, 100581 (2023)
30. R. Qu, Y. Wu, J. Chen, G. D. Jones, W. Li, S. Jin, Q. Chang, Y. Cao, G. Yang, Z. Li, and L. J. Frewer, Sustainability **12**, 8194 (2020)

31. P. Miriti, D. J. Otieno, E. Chimoita, E. Bikketi, E. Njuguna, and C. O. Ojiewo, Heliyon **7**, e05845 (2021)
32. C. A. Obianefo, J. N. Ng'ombe, A. Mzyece, B. Masasi, N. J. Obiekwe, and O. O. Anumudu, Agric. **11**, 1 (2021)
33. A. Tenaye, Economies **8**, 1 (2020)