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Impact of Application of Geoisolator in Saltworks Business in East Java Province: A Propensity-Score Matching Approach

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Abstract – High quantity and high quality of salt are needed by the industrial sector in Indonesia, but the salt that is produced by farmers still has low quality. The application of geoisolator can increase the quantity and quality of salt produced by farmers. This study aims to analyze the impact of the application of geoisolator on productivity, selling prices, income, fixed costs, and variable costs of saltworks business in East Java Province. The study was conducted at the salt production center in Madura. The farmer survey was conducted in August-September 2018. Retrieval of respondents amounted to 190 respondents consisting of 131 geoisolator farmers and 59 traditional farmers. This study estimates the impact of applying a geoisolator using the Propensity Score Matching (PSM) technique. The results show that the application of geoisolator had an impact on increasing productivity, selling prices, income, and fixed costs, but lowering the variable costs of saltworks business. The government needs to provide investment credit for the purchase of geoisolator so that the goal of increasing production, competitiveness, and welfare of salt farmers can be achieved.

Keywords – Salt Production, Income, Price, Fixed Cost, Salt.

I. INTRODUCTION

World salt production in 2017 is 288 million tons (USGS 2019) and more than one-third of the total salt produced comes from seawater evaporation. About 60 percent of the total world salt production is consumed by the chemical industry as raw materials and supporting materials (Sedivy 2009). Large industries in Indonesia in 2017 used 2.1 million tons of industrial salt (Kementerian Perindustrian 2018).

National salt production in 2017 amounted to 1.02 million tons so that the total national salt needs are only fulfilled around 40 percent (KKP 2013). Increased production can be done by developing and adopting technology (Coelli et al. 2005). This shows that to overcome the problems related to meeting the needs of national salt can be done by using the technology currently available, namely the application of geoisolator. The term geoisolator or waterproof plastic mat as per Law of the Republic of Indonesia Number 7 of 2016 concerning Protection and Empowerment of Fishermen, Fisheries, and Salt Farmers. While internationally it is better known as high-density polyethylene (HDPE) or geomembrane.

The initiation of the application of geoisolator at the end of 2010 and starting in 2011 carried out a national program for the Empowerment of People's Salt Enterprises (PUGaR) to improve the welfare of salt farmers through the launching of the National Salt Self-Sufficiency (Suhelmi et al. 2013). Geoisolator is applied by installing a crystallization pool with a waterproof plastic (geoisolator) so that the salt produced is not exposed to the soil. Traditional saltworks are converted into semi-intensive ones consisting of seawater reservoirs, evaporation ponds, concentration pools, pre-crystallization ponds, and crystallization ponds (BPPP Tegal 2017). The advantages of geoisolator are that they are resistant to ultraviolet rays and chemicals Scheirs (2009), prevent shrinkage of seawater which is a raw material for salt, and accelerate the process of crystallization (Efendy et al. 2014; Suhendra 2016).

The application of geoisolator in the salt production process can help farmers to increase their salt production and quality. In addition to salt production that has increased, the resulting salt is equivalent to the quality I so that it will get a higher price. Salts that are produced by farmers using a base in crystallization ponds are of higher quality because there are fewer contaminants (Balde et al. 2013). Salt produced with a waterproof plastic base in crystallization ponds costs 37.5 percent higher than traditional ones because of better quality so that the difference in sales value reaches 30 million rupiahs (Susanto et al. 2015).

Salt prices fluctuate very high when approaching the big harvest and at the end of the season the price is lower than the price determined by the Directorate General of Foreign Trade Regulation No. 02 / DAGLU / PER / 5/2011. This happened simultaneously with the entry of imported salt into Indonesia (Ihsannudin 2011). When the price of salt rises, the price is above the standard set by the regulation. Fluctuations in salt prices affect the income earned by farmers.

Despite all these positive developments regarding the application of geoisolator, empirical evidence on their impact in Indonesia is still limited. This study mainly considers the determinants of the application of geoisolator and analyzes their impact on saltworks business.

II. Research Method

The data used to analyze the impact of applying a geoisolator on a saltworks business is primary data collected using a questionnaire. Information collected in the form of farmer characteristics, land, salt production, and income. Data collection was conducted in August-September 2018. This research was conducted in 4 districts, Sampang, Pamekasan, and Sumenep Regencies which are salt-producing centers, and Bangkalan District which is a buffer zone in East Java Province. Site selection is done deliberately with consideration in the area of geoisolator application.

The sampling method is done by using the purposive sampling method for geoisolator farmers, while the sampling for traditional farmers is done by the snowball sampling method. The sample of farmers in this study amounted to 190 respondents, 131 geoisolator farmers, and 59 traditional farmers.

Analysis of the impact of the application of geoisolator on saltworks was estimated using the Propensity Score Matching (PSM) technique. It is the most commonly used technique to identify the effects of treatment correctly because it ensures that, although treated and control groups are different, these differences can be taken into account to reduce selection bias. This allows the control group to be used to construct counterfactuals for the treated group (Heinrich et al. 2010).

PSM analysis procedure refers to Baker (2000) and Harris & Horst (2016) with the following stages.

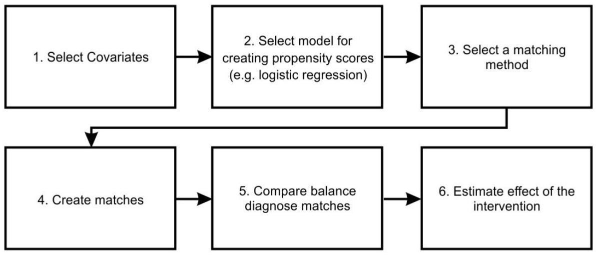

Figure 1. Steps were taken in PSM

First, determine the variables (covariates) that will be used in the model. These variables serve as predictors in the decision to apply the geoisolator. **Second**, choosing a model to make the value of propensity, in this study researchers used logistic regression. The choice of the logistic regression model is used only to create a counterweight or propensity value. When making propensity values through logistic regression, researchers only calculate the probability that the farmer decides to apply geoisolator as binary forms of 0 and 1, the farmer regression that applies a geoisolator or treated group called a geoisolator farmer is given a value of 1 and that does not apply or the control group is called Traditional farmers are given a value of 0. The general form of the logistic regression model is written as follows (Hosmer et al. 2013).

In this study, the factors that are suspected to influence the application of geoisolator consist of the age of the head of the family, the length of education of the head of the family, experience, number of family members, crystallization ponds, facilities pool, dummy farmer group membership, and counseling dummy.

Third and fourth, after calculating the value of propensity, the next step is to choose a matching method and make a match. After obtaining a propensity score, the observations of the geoisolator and traditional farmers based on propensity scores were matched using the Nearest Neighbor (NN) matching. NN is one alternative to overcome the limitations of poor matching quality (Stuart 2010). NN matching is a matching method based on the closest propensity value. The traditional farmer propensity value can be paired several times if the propensity value gives the closest match with some geoisolator farmers.

Fifth, compare balance. After a matching is done, it is necessary to assess the quality of matching to ensure the traditional group of farmers has a distribution of propensity values that is similar to the group of geoisolator farmers. The purpose of the propensity value is as a counterweight, so the variables must be balanced. If the variables are not balanced, then the model will be wrong specifications, and study conclusions may be biased. Matching is usually assessed by comparing in a balanced manner ie matching the characteristics between geoisolator farmers and traditional farmers by matching propensity values. Individuals whose propensity values are outside the range will be excluded from the covariate (Caliendo & Kopeinig 2005).

Sixth, estimating the effect of treatment by comparing ponds between geoisolator and traditional farmers. Outcome variables must be compared between groups only after matching and evaluating the quality of the balance between the two groups. If the aim is to estimate the effect of treatment on a geoisolator farmer, then the average treatment effect on the treated (ATT) can be easily estimated. Calculate ATT with the following equation:

$$P_i = \mathrm{Ln}\frac{P_i}{1-P_i} = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_i x_i$$

Where ATT is the difference in the impact of the application of geoisolator between the geoisolator farmer group (Yi (1)) and the traditional farmer group (Yi (0)). Areas, where geoisolator and traditional farmers overlap in the distribution of propensity values, are called common support areas. If several units in the geoisolator group have a combination of characteristics that cannot be matched with units in a traditional group, therefore, the impact cannot be estimated accurately. Qualitatively different individuals were excluded from the analysis.

III. Result and Discussion

3.1 Characteristics of Saltworks Business

Table 1 presents the average difference test of geoisolator and traditional saltworks business characteristics. The average difference test results showed that geoisolator and traditional saltworks businesses differed significantly on the productivity, income, and fixed costs of the saltworks business.

Table 1. Productivity, income, fixed costs and variable costs of saltworks business in 2017

Variable	Mean		Difference	t-test	
	Geoisolator	Traditional		t-stat	Sig
Productivity (ton/ ha)	98.46	58.34	40.12	7.92	***
Selling price (Million Rp/ton)	1.26	1.05	0.21	13.77	***
Income (Million Rp/ ha)	84.83	36.89	47.94	9.57	***
Fixed Cost (Million Rp/ ha)	19.39	15.62	3.77	6.62	***
Variable Cost (Million Rp/ ha)	20.36	23.34	-2.97	- 0.92	

*Significant at $p < 0.10$, ** Significant at $p < 0.05$, *** Significant at $p < 0.01$

Source: Estimated from survey data

Average different test results related to productivity, selling prices, income, fixed costs, and variable costs of saltworks between geoisolator and traditional farmers are presented in Table 1. The result shows that the productivity, selling price, income and fixed costs of a saltworks business have a positive and significant average difference between adopters and non-adopters. Geoisolator farmers have an average productivity of 68.77% higher than the average productivity of traditional farmers. Geoisolator farmers have an average selling price of crude salt which is 20% higher than the average selling price of traditional salt farmers. Geoisolator farmers have a higher average income of 129.95% than the average income of traditional salt farmers. The fixed costs incurred by geoisolator farmers are 24.13% higher than the average fixed costs incurred by traditional salt farmers. The results of this study are due to selection bias obtained from the characteristics of farmers observed, and these results do not have a causal interpretation. To get results that have meaning and have a causal interpretation, the researchers used PSM.

3.2 Factors Affecting Farmers Decision to apply geoisolator

The logistic regression model is used to estimate the factors that influence the salt farmer's decision to apply a geoisolator. The model was validated using Pearson's goodness of fit test. The results of testing the goodness of the model using the Pearson test obtained the probability value of the chi2 statistical test of 0.85 is greater than $\alpha = 0.05$, meaning that the logistic regression model is feasible to use in predictions. The ability of the model to predict correctly was 71.05%. The results of the estimation of the factors that influence the salt farmer's decision to apply a geoisolator are presented in Table 2. Parameter testing is carried out simultaneously and partially. Simultaneous testing uses the likelihood ratio test. The test results obtained the chi-square LR value of 47.77 with an estimated log-likelihood value of -93.8239 and Prob> chi2 of 0.0000, so it can be concluded that the overall model is statistically significant. From this test, it is implied that the variables selected in this analysis have an overall significant effect on the application of geoisolator in the study area. The results of partial testing using the Wald test showed that the farmer's decision to apply a geoisolator was influenced by the number of family members, facility ponds, salt farmers' group membership, and extension access.

Based on the results of logistic regression analysis, we found that the adoption of geoisolator technology would be higher in farmers who had fewer family members, a wider pool of facilities, were members of the group of farmers, and had extension access. The logistic regression results will be used to estimate the value of propensity.

Table 2. Logistic Regression Results for Estimating Geoisolator and Traditional Farmers' Propensity Scores

Variable	Coefficient		S.E	P > | z |	Marginal Effect
Farmers'Age	-0.0297		0.0231	0.197	-0.0054
Farmers' Education	-0.0852		0.0702	0.225	-0.0154
Experience	-0.0078		0.0223	0.725	-0.0014
The number of family members	-0.3441	**	0.1640	0.036	-0.0624
The size of the Crystallization pond	-2.2331		4.1281	0.589	-0.4048
The size of Facilities pond	0.9829	*	0.5179	0.058	0.1781
Group Membership (dummy)	1.3153	***	0.4153	0.002	0.2655
Extension Access (dummy)	1.9791	***	0.7940	0.013	0.2649
Constant	2.1986		1.3853	0.112	
Log-likelihood	-93.8239				
Pearson's (Prob > chi2)	0.8517		LR chi2		47.77
Correctly Classified	0.7105		Prob > chi2		0.0000

*Significant at $p < 0.10$, ** Significant at $p < 0.05$, *** Significant at $p < 0.01$

Source: Estimated from survey data

3.3 Impact of Geoisolator Application on Saltworks Business

In this section, we first discuss the variables that are used to implement the decision-making such as age geoisolator head of the family, head of the family education, experience, number of family members, crystallization pond, pond facilities, dummy farmers group membership, and dummy extension access. The second step in choosing a model used to estimate the value of propensity is to use logistic regression (Table 2), calculate propensity values, and determine the distribution of propensity values (Figure 1). The main results of this study are then discussed in terms of the impact of the geoisolator application on saltworks (Table 4). The logistic regression results that were used to estimate propensity scores (Table 2) show that the number of family members, the size of pond facilities, group membership, and extension access influence the application of geoisolator. While the farmers' age, farmers' education, farmers' experience, and the size of the crystallization pond did not significantly influence.

The third and fourth step is to determine the matching method and do the matching. The matching method that was used to match the observed values of geoisolator and traditional groups used the Nearest Neighbor (NN) matching and then tested using covariate imbalance testing (Table 3).

Furthermore, matching propensity values obtained from matching 190 farmer samples consisting of 131 geoisolator farmers and 59 traditional farmers. The value of propensity for geoisolator farmers ranges from 0.1961 to 0.9894 with an average of 0.7534, while for traditional farmers the value of propensity ranges from 0.1715 to 0.9543 with an average of 0.5474. The distribution of propensity values for geoisolator and traditional farmers is shown in Figure 1. This is to test the quality of the matching process after the prediction of the propensity values for both groups is carried out. Figure 1 shows that the upper half of the graph is the propensity value for geoisolator farmers, while the lower half is the propensity value for traditional farmers.

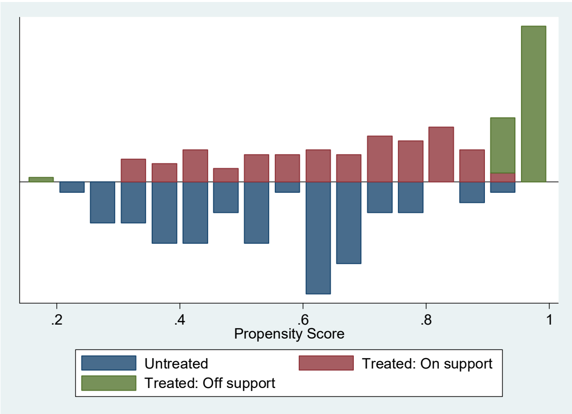

Figure 2. Distribution of Geoisolator and Traditional Farmers Propensity Scores

After matching the propensity value then comparing the balance is done with covariate imbalance testing. This was done to test the hypothesis that the covariates in both groups had the same distribution after matching. The test results show that there are significant differences before matching the variables between treated and untreated farmers but after matching there are no more significantly different variables. The matching process is carried out by issuing covariates that have a high percentage of bias, namely the size of the facility pond. The results of covariate imbalance testing before and after matching are presented in Table 3.

Based on the results of covariate imbalance testing (Table 3), it can be concluded that the covariates used in matching have the same distribution between geoisolator and traditional farmers, so the calculation of the impact of geoisolator application is not constrained by selection bias so it continues with calculating the impact of geoisolator application on saltworks business.

Table 3. Covariate Imbalance Testing Before and After Matching Geoisolator and Traditional Farmers

Variable	Sample	Mean		% bias	% bias reduction	t-test	
		G	T			t	p-value
Farmers' Age	Unmatched	47.66	50.31	-23.6	36.6	-1.52	0.129
	Matched	48.03	49.70	-15		-1.2	0.232
Farmers' Education	Unmatched	6.45	6.88	-13.8	64.3	-0.84	0.400
	Matched	6.81	6.96	-4.9		-0.4	0.693
Farmers' Experience	Unmatched	17.38	19.00	-15.8	47.1	-0.97	0.331
	Matched	18.18	19.04	-8.3		-0.62	0.539
The number of family members	Unmatched	2.73	3.10	-30.2	68.7	-1.95	0.053
	Matched	2.67	2.56	9.4		0.72	0.470
The Crystallization pond size	Unmatched	0.17	0.16	26.2	92.3	1.51	0.133
	Matched	0.16	0.16	2		0.15	0.878
Group Membership (dummy)	Unmatched	0.80	0.47	71.9	94.1	4.8	0.000
	Matched	0.75	0.73	4.2		0.31	0.753
	Unmatched	0.31	0.03	78.9	79.3	4.45	0.000

Extension Access (dummy)	Matched	0.13	0.19	-16.3	-1.12	0.263

G: Geoisolator; T: Traditional

Analysis of the common support to eliminate the distribution of overlapping propensity values. Based on the analysis of the common support there are 28 samples in the geoisolator (treatment) farmer group that have a propensity score out of range so they need to be excluded or removed from the analysis. Of the 190 samples used, only 162 samples were subsequently used to analyze the impact of the application of the geoisolator on saltworks.

Based on the estimation of the impact of the application of geoisolator on saltworks, it was found that the application of geoisolator had a significant effect on productivity, selling prices, income, fixed costs, and variable costs of saltworks. The results of the estimated impact of applying a geoisolator are presented in Table 4.

Productivity has a positive sign and significance at $p < 0.01$, meaning that the application of geoisolator has an impact on increasing the productivity of saltworks business. The magnitude of the impact of increasing the productivity of saltworks is estimated to be 26.81 tons/ha or an increase of 37.41% from the average productivity of saltworks in the study area. Productivity can be improved by improving farmers' skills in the production process. The purpose of applying geoisolator is to increase salt productivity and quality. The results of this study are in line with research by Ali et al. (2018), in Pakistan and (Manda et al. 2020) in Nigeria that technology adoption has an impact on increasing farm productivity.

The selling price of salt is positive and significant at $p < 0.01$, meaning that the application of geoisolator has an impact on increasing the price of crude salt produced. The magnitude of the impact of the increase in salt prices is estimated at Rp 190 thousand or an increase of 17.87% from the average price of salt in the study area. Based on observations in the field, salt is sold in the form of crude salt, the determination of quality and price is carried out by middlemen. Quality I salt is whiter and larger grains. The price of salt at the farm level tends to fluctuate despite the regulations. Fluctuations in salt prices make some farmers keep their salt in warehouses or at collecting points and some others continue to sell to middlemen because of limited capital they have. The salt processing industry must absorb 50% of the local salt from its import quota. However, farmers cannot sell directly to the salt processing industry. So it needs a partnership between farmers and the processing industry so that the price of salt received by farmers is more stable. The increase in the salt price as a result of the application of geoisolator is related to the quality of the salt produced. This result confirms the finding by Gitonga et al. (2013), among corn farmers, that technology adoption increases selling prices.

Saltworks income is positive and significant at $p < 0.01$, it means that the application of geoisolator has an impact on increasing income from saltworks. The magnitude of the impact of increased income from saltworks business is estimated to be around Rp. 37.10 million / ha or an increase of 77.74% of the average saltworks income. This result confirms the finding by Challa & Tilahun (2014), Ali et al. (2018), and Manda et al. (2020), who state that adoption of technology increases farmers' incomes so that welfare increases.

The fixed cost of a saltworks business is positive and significant at $p < 0.01$, meaning that the application of a geoisolator has an impact on increasing the fixed cost of a saltworks business. The magnitude of the impact of an increase in the fixed costs of the saltworks business is estimated to be around Rp. 3.99 million / ha or an increase of 25.91% of the average fixed cost of the saltworks business. This increase was due to the purchase of geoisolator for the crystallization pond base. The results of this study contradict Obayelu & Ojayi (2018), in Nigeria who state that adoption of technology results in lower fixed costs per hectare.

The variable cost of saltworks business is negative and significant at $p < 0.10$, it means that the application of geoisolator has an impact on the reduction in variable costs of salt farmers. The magnitude of the impact of the reduction in the variable costs of farmers from the saltworks business is estimated to be around Rp. 9.67 million / ha or reduced by 32.19% of the average variable cost of the pond business. These results are in line with the studies of Obayelu & Ojayi (2018) in Nigeria, but contrary to the Singha (2019) in India and Manda et al. (2020) in Nigeria which states that variable costs per hectare are higher with technology adoption.

Table 4. Impact of Geoisolator's Application on Saltworks Business

Variable	Sample	G	T	Diff.	%	S.E.	t-stat	Sig
Productivity (ton/ ha)	Unmatched	98.47	58.34	40.13		5.07	7.92	
	ATT	98.47	71.66	26.81	37.41	7.40	3.62	***
Selling price (Million Rp/ton)	Unmatched	1.26	1.05	0.21		0.02	13.77	
	ATT	1.26	1.07	0.19	17.87	0.02	8.96	***
Income (Million Rp/ ha)	Unmatched	84.83	36.89	47.94		5.01	9.57	
	ATT	84.83	47.73	37.10	77.74	6.10	6.08	***
Fixed cost (Million Rp/ ha)	Unmatched	19.40	15.62	3.78		0.57	6.62	
	ATT	19.40	15.40	3.99	25.91	0.56	7.16	***
Variable cost (Million Rp/ ha)	Unmatched	20.36	23.34	- 2.97		3.24	- 0.92	
	ATT	20.36	30.03	- 9.67	- 32.19	5.88	- 1.64	*
Total manpower (person-days/ha)	Unmatched	286.95	247.17	39.79		12.81	3.10	
	ATT	286.95	282.01	4.94	1.75	23.96	0.21	

*G: Geoisolator, T: Traditional

*Significant at p < 0.10, ** Significant at p < 0.05, *** Significant at p < 0.01

Source: Estimated from survey data

IV. CONCLUSION

Based on the results of the study, it can be concluded that the application of geoisolator is influenced by the number of family members, the size of facilities pond, group membership, and extension access. The application of geoisolator has an impact on increasing productivity, selling prices, income, and fixed costs, but reducing the variable costs of saltworks business.

The government needs to provide investment credit for the purchase of geoisolator so that the goal to increase production, competitiveness, and welfare of salt farmers can be achieved.

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