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Demonstration Plots, New Technology Adoption, and Production Performance in Indonesia's Largest Evaporation Salt Farming

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ABSTRACT

The introduction of new production technologies, called geomembrane, is one of the Indonesian government's national policies aimed at improving the quality and quantity of domestic salt production while supporting the national self-sufficiency program. Madura Island, the largest producer of evaporated salt in Indonesia, was the first location targeted for this policy implementation. Using cross-sectional data from the 2023–2024 salt production season, this study randomly collected information from 215 small- to medium-scale salt farmers on Madura Island. The research highlighted the importance of ensuring salt farmers' access to demplots to encourage wider adoption of geomembrane technology and its impact on salt production performance. Production performance was measured using technical efficiency and land productivity indicators. The findings reveal that salt farmers' access to geomembrane demonstration plots remains limited, with only 29% of farmers reporting such access. Interestingly, access to demonstration plots exhibited an anomalous relationship with production performance: while technical

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efficiency showed a positive correlation, land productivity demonstrated a negative association. This research concluded that the demonstration plots provide significant differences in technical efficiency and productivity. The study recommends that the Indonesian government, through the Marine Affairs and Fisheries Agency, should continue providing training, outreach, and technological introductions to salt farmers to expand demonstration plot access to increase the adoption rate of geomembrane technology. Demonstration plots should be situated near impoverished communities that rely on traditional salt production methods or in locations traditionally designated for pilot programs to ensure productivity gains for marginalized and low-income households.

Keywords: Demonstration Plots; New Technology Adoption; Production Performance; Technical Efficiency; Productivity

1. Introduction

Indonesia's geographic location grants it one of the longest coastlines in the world, ranking second globally. This should, in theory, provide the country with an absolute advantage in salt production^[1]. Yet, Indonesia remains a net importer of salt. **Figure 1** illustrates the total national salt demand from 2019–2023, showing that demand is met through two channels: domestic production and imports to cover deficits. National salt demand has fluctuated significantly, reaching 5.02 million metric tons in 2023, of which domestic production supplied only 2.21 million metric tons. This necessitated imports of 2.81 million metric tons, which represents a substan-

tial volume.

Notably, while imports rose between 2022 and 2023, domestic salt production surged sharply from 2020 to 2023^[2,3]. This suggests concerted efforts by the ministry to optimize salt farms in key production hubs, including Madura Island. The decline in domestic production from 2020 to 2022 was primarily driven by La Niña, a climate phenomenon characterized by wind patterns that carry moisture toward Indonesia, triggering heavy rainfall even during the dry season^[4]. Salt production requires low precipitation and arid conditions, making it vulnerable to “wet droughts.” Consequently, output dropped in 2020 and plummeted further in 2022 due to these unusually rainy dry seasons.

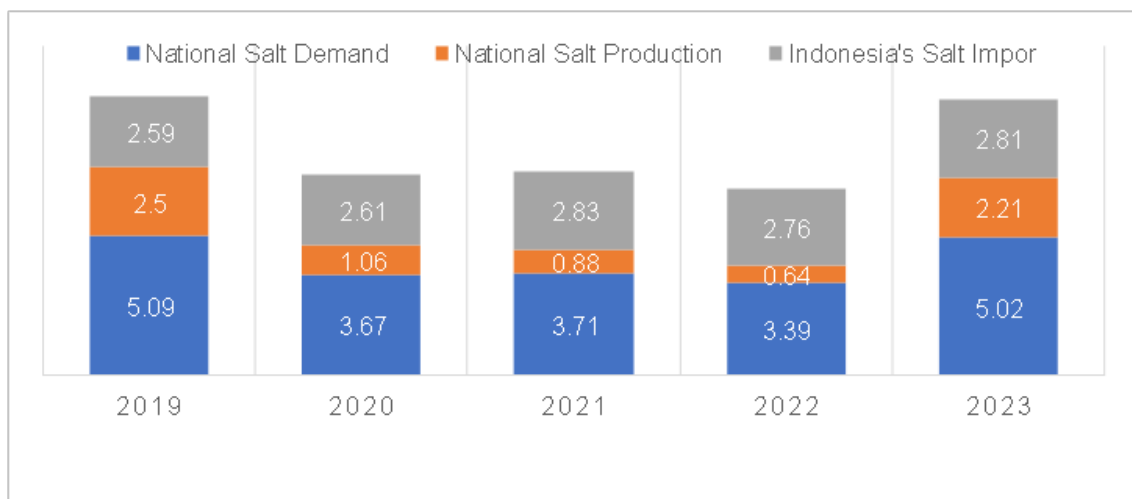


Figure 1. National Salt Demand, Domestic Salt Production, and Salt Imports 2019–2023 (in Million Metric Tons).

Source: Ministry of Maritime Affairs and Fisheries (KKP) and Statistics Indonesia (BPS), 2024 (processed).

National salt self-sufficiency remains a flagship government program. Although Indonesia achieved self-sufficiency in consumption-grade salt in 2012, it has since struggled to replicate this success for total national

salt demand^[5]. However, in 2024, the government as spearheaded by KKP, expressed renewed optimism, citing the marked increase in domestic production evident in **Figure 1**.

To achieve self-sufficiency, Indonesia has prioritized intensification policies comprising boosting production through technological innovation, such as adopting practices from foreign countries or through workshops between salt farmers and related stakeholders^[1,4,6,7]. One such advancement is HDPE (high-density polyethylene) plastic liners, now formalized as geomembrane production technology (**Figure 2**). This method

significantly improves output. The salt is whiter in color from avoiding soil contact and has higher NaCl levels with lower sand content, translating to higher market prices for farmers. Consequently, it enhances overall farm performance, including technical efficiency^[1], land productivity^[5], and farmer income^[6,8]. Previous studies have suggested that this production technology be disseminated by the government to improve the performance of national salt production^[5,6,8]. However, field data reveal that geomembrane adoption remains suboptimal among salt farmers^[1].



Figure 2. Comparison of Geomembrane-Based (left) and Traditional (right) Salt Production Methods.

Several factors explain why the adoption of production technologies among smallholder farmers in developing countries remains incomplete^[9–12]. Research indicates unequal access to agricultural resources and technological inputs as a primary barrier^[13–15]. Other studies highlight liquidity constraints, where farmers lack the cash reserves needed to finance technology adoption^[16–18]. Household characteristics also play a role, Kurniawan et al.^[12] found that larger households face fewer labor constraints during the initial implementation of modern technologies. However, the relationship between farm size and technology adoption shows mixed results: while Montojo et al.^[13] and Fisher et al.^[14] reported a positive correlation between landhold-

ing size and new technology adoption, Obiero et al.^[17] found either insignificant or neutral relationships. Notably, Ariyani et al.^[1], and Prihantini et al.^[7], demonstrated that salt farmers with access to demonstration plots show significantly higher probabilities of adopting innovative salt production technologies.

The introduction of geomembrane production technology aims to enhance Indonesia's salt production performance, with Madura Island being one of the primary implementation sites. As presented in **Figure 3**, East Java Province, as the nation's top salt producer, relies heavily on Madura Island as its main supplier. In 2023, four regencies on the island contributed 28.68% of national salt production, previously peaking at 31.5% in

2021. Within East Java, Madura Island supplied 78.76% of provincial salt production in 2023, following its highest contribution of 91.14% in 2022^[2].

This study focuses on the three largest producing regencies, using productivity as a key performance indicator. **Figure 4** displays 2023 land productivity across Madura's four regencies. Pamekasan Regency achieved the highest productivity (137.57 t/ha/season), followed by Sumenep (124.75 t/ha/season) and Sampang (87.04 t/ha/season). Bangkalan Regency ranked

last (62.81 t/ha/season). Only Pamekasan and Sumenep exceeded the national productivity benchmark of 96.37 t/ha/season. Overall, we examine (1) the relationship between demonstration plot access and willingness to adopt geomembrane technology, and (2) how this adoption affects production performance measured through technical efficiency and land productivity at the farm level. These empirical findings could inform Indonesian government policies to achieve optimal geomembrane technology adoption.

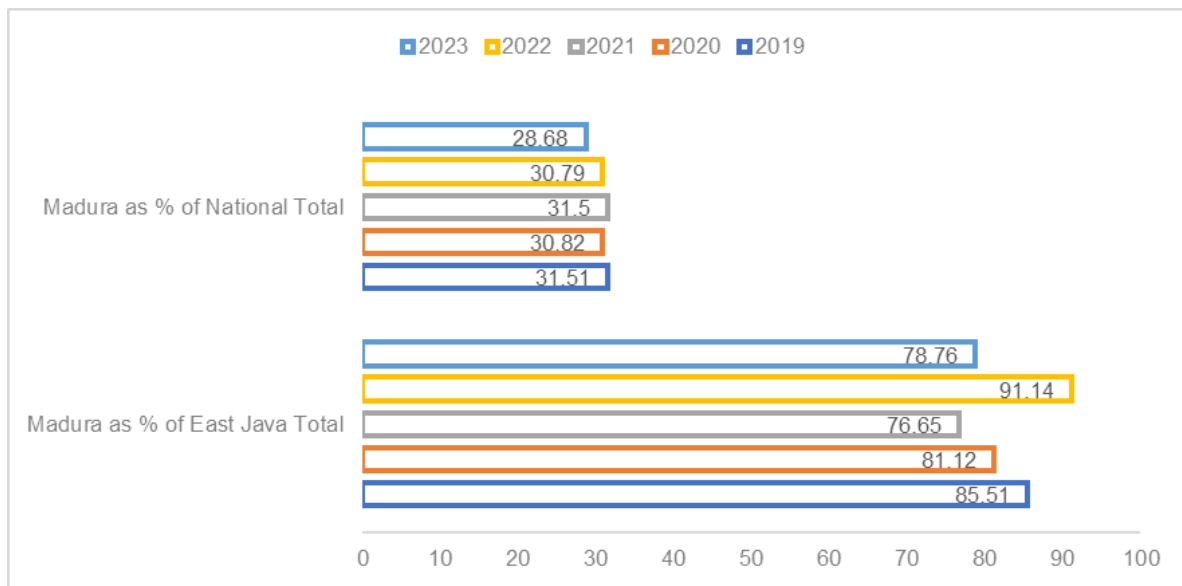


Figure 3. Percentage of Madura Island Salt Production within East Java and National Production (2019–2023).

Source: Ministry of Maritime Affairs and Fisheries, 2024 (processed).

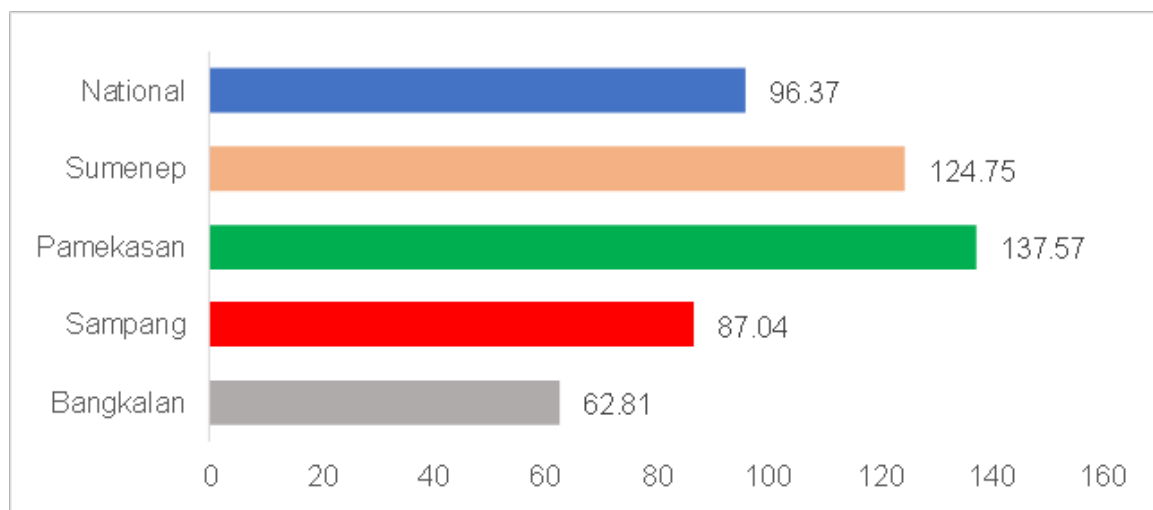


Figure 4. Salt Productivity in Madura Island in 2023 (t/ha/season).

Source: Ministry of Maritime Affairs and Fisheries, 2024 (processed).

2. Materials and Methods

2.1. Study Site, Sample Selection, and Data Collection

The salt farmers in this study were selected through multistage random sampling. First, Madura Island was purposively chosen as the study site due to its status as Indonesia's largest salt-producing region (**Figure 5**). Subsequent sampling of subdistricts and villages was based on three criteria: (a) the concentration of salt farmer enterprise groups (*Kelompok Usaha Garam Rakyat*, KUGAR) that reflected farmer engagement levels; (b) highest harvested area and/or salt productivity metrics; and (c) recommendations from key informants (local field extension officers of the Fisheries and Ma-

rine Affairs Office). The final farmer selection employed true randomization where researchers either alphabetized KUGAR member lists or assigned coded identifiers, then conducted lottery-style draws to ensure an unbiased selection. Sample sizes per regency were calculated using Slovin's formula^[7], with respondent counts (n) determined via Equation (1). This approach guarantees equal selection probability for all farmers, enhancing population representativeness.

$$n = \frac{N}{1 + (N \cdot e^2)} \quad (1)$$

Where:

N = total population,

n = sample size,

e = error margin.



Figure 5. Map of Madura Island, East Java, Indonesia Showing the Study Area.

Based on the equation, the study utilized a total sample of 215 respondents, distributed across three regencies: 60 from Sampang, 75 from Pamekasan, and 80 from Sumenep. Of their geomembrane technology adoption status, the total sample comprised 178 adopters and 37 non-adopters. Primary data were collected through structured open-ended questionnaires administered by the research team. The survey cap-

tured production input data, socioeconomic and cultural factors influencing geomembrane technology adoption decisions, and operational information from recent production years (2023/2024). The research team interviewed salt farmers to collect primary data related to the demonstration plots, new technology adoption, and the production performance for further analysis. The research permit for research work was given by the

Dean of Faculty of Agriculture, Fisheries, and Animal Husbandry, Universitas Sembilanbelas November Kolaka Number 189/UN.56D.01/PN.03.00/2024 on 27th December 2024. Informed consent was obtained from all subjects involved in the interview.

2.2. Data Analysis

This study employed two primary indicators to assess salt production performance: the technical efficiency of salt farms and the land productivity of individual salt farming operations.

2.2.1. Technical Efficiency Analysis of Salt Farms

The research utilized Data Envelopment Analysis (DEA) to evaluate the relative efficiency of salt farming operations. The DEA model offers several advantages compared to other analytical approaches: (a) it can simultaneously measure multiple input and output variables; (b) it does not require assumptions about functional relationships between measured variables (inputs and outputs); (c) it enables direct comparison among decision-making units (DMUs); and (d) it accommodates variables measured in different units^[19]. The efficiency scores range from 0 to 1, where a value of 1 indicates that the salt farm is relatively efficient, while scores below 1 suggest relative inefficiency. The technical efficiency calculations using DEA are presented in Equations (2)–(4).

$$\text{Aggregated input} = \sum_{i=1}^I u_i x_i \quad (2)$$

$$\text{Aggregated output} = \sum_{j=1}^J v_j y_j \quad (3)$$

$$\text{Efficiency} = \frac{\sum_{i=1}^I u_i x_i}{\sum_{j=1}^J v_j y_j} \quad (4)$$

The model was estimated using the Data Envelopment Analysis Program (DEAP) version 2.1. The meta-frontier function obtained from the DEA approach was calculated using Equation (5).

$$\begin{aligned} & \text{Max}_{\phi_{it}, \lambda_{it}} \quad \phi_{it} \\ & -\phi_{it} b_{it} + B_{it} \lambda_{it} \geq 0 \\ & a_{it} - A_{it} \lambda_{it} \geq 0 \\ & \lambda_{it} \geq 0 \end{aligned} \quad (5)$$

where b_{it} represents an $M \times 1$ vector of outputs for the i -th decision-making unit (DMU) in period t , while a_{it} denotes an $N \times 1$ vector of inputs for the i -th DMU in the same period. The term B_{it} constitutes an $M \times L$ matrix of outputs for all DMUs (where L = total number of DMUs), and A_{it} represents an $N \times L$ matrix of inputs across all DMUs. The weighting vector is given by λ_{it} , and ϕ_{it} represents a scalar value.

2.2.2. Salt Farm Productivity Analysis

Productivity can be defined as a measure of skill, expertise, discipline, and the appropriate use of production methods and inputs^[20]. Productivity serves as a key indicator of work effectiveness and efficiency, where higher productivity corresponds to greater production efficiency^[21–24]. Improving farm productivity requires farmers to possess skills in land preparation (planting, fertilizing, weeding, irrigation, and crop protection), harvesting, storage, and marketing to secure optimal prices^[23,25,26]. Consequently, farm productivity can serve as a performance indicator for agricultural operations. In this study, productivity is measured as the ratio of salt production output to land area (salt farm size), as expressed in Equation (6).

$$\text{Productivity} = \frac{\text{Total Seasonal Salt Production Output}}{\text{Salt Farm Area}} \quad (6)$$

Here, salt production is measured in metric tons per season, while salt farm area is measured in hectares (Ha), yielding productivity values in tons per hectare (t/Ha).

2.2.3. Mann-Whitney U Test

This study employs the Mann-Whitney U test to determine whether significant differences exist in salt production performance between two treatment groups. The Mann-Whitney test is used when the data fail to meet the classical assumptions required for an Independent Samples t -test. The Mann-Whitney test is a non-parametric analytical procedure for testing hypotheses about the medians of two independent populations^[27]. Developed by Mann and Whitney in 1947, this test does not require normally distributed or homogenous data, nor does it mandate equal sample sizes across compared populations. The hypotheses are formulated as follows:

H0. The median of Y is equal between the two populations.

H1. *The median of Y in Population 1 is greater than in Population 2.*

Decision rules:

If the probability (Asymp. Sig.) < 0.05, reject H0 and retain H1.

If the probability (Asymp. Sig.) > 0.05, retain H0 and reject H1.

3. Results and Discussion

3.1. Descriptive Statistics

Farmer age serves as a critical factor in understanding household dynamics and influences the adoption of new production technologies^[20]. While the World Health Organization (WHO) defines the productive age range as 15–64 years, cognitive and physical capacities vary significantly across this spectrum. Older age often correlates with reduced physical stamina and cognitive flexibility in agricultural operations^[28,29], which may diminish openness to novel farming technologies. Senior

farmers typically exhibit lower responsiveness to group-based training initiatives and greater risk aversion regarding production innovations^[30]. As shown in **Table 1**, 73% of sampled salt farmers fall within the productive age range.

Approximately 55% of respondents possess moderate farming experience (10–30 years). Prihantini et al.^[7] demonstrate that such experience cultivates empirical knowledge about optimal production methods. Beyond educational attainment, farming experience significantly influences decisions to adopt new technologies, ultimately determining the profitability and success of agricultural operations. However, prolonged experience may also foster conservatism, with some farmers preferring traditional techniques over modern alternatives^[31–33]. Farmers often maintain traditional methods passed down through generations. This persistence underscores how technology adoption decisions require both individual receptiveness to change and effective knowledge transfer by authorized entities, particularly agricultural extension workers.

Table 1. Demographic and Socioeconomic Features of Representative Salt Farmers.

	Category	Count	Percentage
Sampled Demographic Characteristics			
Age (years)	Young (<30)	3	1.40
	Mature (30–59)	157	73.02
	Senior (>59)	55	25.58
Farmer's Experience (years)	Low (<10)	57	26.52
	Moderate (10–30)	119	55.35
	High (>30)	39	18.13
Family Size (numbers)	Low (>2)	146	67.90
	High (<2)	69	32.10
Farmer's Education Level	No formal education	16	7.44
	Elementary School	112	52.09
	Middle School	37	17.21
	High School	47	21.86
	College	3	1.39
Marital Status	Married	27	12.56
	Single	188	87.44
Gender	Male	187	86.98
	Female	28	13.02
Social, Economic, and Cultural Characteristics			
Area (Ha)	Small (<0.5)	8	3.72
	Medium (0.5–1.0)	157	73.02
	Large (>1.0)	50	23.26

Table 1. Cont.

	Category	Count	Percentage
Social, Economic, and Cultural Characteristics			
Ownership Dummy	Self-owned	42	19.53
	Non-owner	173	80.47
Agricultural Extension Dummy	Available	134	62.33
	Not available	81	37.67
Gadget (Mobile Device) Dummy	Owns gadget	152	70.70
	Does not own gadget	63	29.30
Internet Access Dummy	Has access	91	42.33
	No access	124	57.67
Farmer's Organization Dummy	Member of KUGAR	134	62.33
	Not a member	81	37.67
Government Aid Dummy	Received	148	68.84
	Has not received	67	31.16
Demplot Access Dummy	Has access	64	29.77
	No access	151	70.23
Geomembrane Dummy	Adopted	178	82.79
	Non-adopted	37	17.21
Financing Dummy	Self-funded	70	32.56
	Borrowed	145	67.44

Table 1 reveals that 67% of sampled salt farmers have high household dependency, supporting more than two family members. Larger family size typically increases available household labor for salt production. Over 87% sampled farmers are married, and 86% are male, indicating that salt farming remains a male-dominated profession. This aligns with Sseguya et al.^[34] findings that women predominantly engage in domestic responsibilities rather than agricultural production.

Educational level significantly enhances farmers' capacity to acquire, process, and utilize technical information. The study by Prihantini et al.^[20] shows that farmers require sufficient information regarding technology to make the right decisions regarding their agricultural businesses. Wu^[35] and Sibhatu and Qaim^[29] demonstrate that education facilitates technological transformation, innovation, and market access by developing more adaptive cognitive frameworks. However, **Table 1** shows that 52% of respondents only completed elementary education.

Regarding operational scale, 73% manage salt ponds between 0.5–1.0 Ha, with over 80% working under sharecropping or leased arrangements, which are consistent with findings from Ariyani et al.^[1] and Pri-

hantini et al.^[7,8] that demonstrate how most salt farms in Madura Island operate under sharecropping systems. Land ownership significantly influences salt production technology adoption decisions, as landowners typically hold decision-making authority regarding technological implementation.

Over 62% of sampled salt farmers have participated in extension programs, corroborating research of Ariyani et al.^[6]. These programs cover various aspects of salt farming, including: modern production techniques, profitability analysis, harvest management solutions, and land preparation methods to address weed infestation in salt ponds, and other aspects to optimize production outcomes.

Approximately 69% of respondents belong to the salt farmer enterprise group KUGAR, which functions similarly to agricultural cooperatives but specializes in salt production—a medium for information and sharing experiences and obstacles for salt farmers. Research demonstrates that farmer group participation facilitates technology adoption by serving as platforms for information exchange^[28,36]. Wossen et al.^[37] emphasize these groups' importance as channels for disseminating technological innovations. However, ineffective communica-

tion within these groups may hinder technology adoption^[38], particularly when involving local language barriers^[28,35].

Mobile devices and gadgets have become essential communication tools with diverse applications in modern agriculture. For salt farmers, such technologies could potentially facilitate access to critical information about production innovations and market conditions. However, as shown in **Table 1**, while over 70% of sampled salt farmers own mobile devices, more than 57% lack internet access, significantly limiting their digital capabilities. Research demonstrates that effective utilization of mobile technology and internet connectivity can enhance agricultural marketing outcomes. Syafrial et al.^[28] found that digital tools help farmers improve product valuation and income through better market access. Furthermore, mobile internet connectivity enables global market participation, allowing producers to make informed marketing decisions, obtain favorable pricing information, and strengthen their competitive position^[39–41].

Table 1 indicates that over 68% of sampled salt farmers have received government assistance. Such support programs represent a strategic policy implementation tool to encourage community participation in new technological initiatives. During the initial rollout of geomembrane technology, provincial Trade Agencies and Fisheries and Marine Affairs Agencies distributed plastic liners to facilitate the adoption of this production method. While intended as both an introduction and enabler of the new technology, the program yielded mixed results^[1,8]. Some farmers effectively utilized the provided materials, while others engaged in secondary markets, reselling the allocated plastic liners to fellow producers.

Demonstration plots, colloquially known as '*demonstration plot*', serve as a strategic medium for introducing new production technologies and methods to salt farmers. These plots are designed to inspire and motivate farmers to adopt innovative practices^[1,8]. PT Garam, Indonesia's largest salt producer, has established geomembrane demonstration plots to encourage neighboring small-scale salt farmers to adopt this technology, particularly given the initial reluctance toward using geomembrane liners. As shown in **Table 1**, fewer than 30% of sampled salt farmers had accessed these demonstration

plots. Interestingly, the adoption rate of geomembrane technology remains remarkably high at over 82%, suggesting that adoption decisions are influenced by factors beyond direct exposure to demonstration plots. This finding indicates that while demonstration plots play an important role in technology transfer, they are not the sole determinant of technology adoption among salt farmers^[42–45].

Business capital serves as a fundamental component in salt production enterprises. Fauziyah et al.^[46] identify six key production factors for salt farming: (1) seawater, (2) land/terrain, (3) climate/weather conditions, (4) capital, (5) technology, and (6) labor. Capital sources can be categorized into two primary types: self-funded capital and borrowed capital. Prihantini et al.^[8] highlight that the principal challenges in agricultural sectors, including small-scale salt farming, predominantly concern marketing and financing issues. Notably, over 67% of sampled salt farmers rely on borrowed capital to finance their salt pond operations.

3.2. Relationship between Demonstration Plot Access and Technical Efficiency of Salt Farms

In this analysis, salt farmers were categorized into four distinct efficiency groups based on their Technical Efficiency (TE) scores. DMUs achieving a perfect TE score of 1.00 were classified as fully efficient. The second category, high efficiency, included DMUs with TE scores ranging from 0.81 to 0.99 ($0.81 < TE < 0.99$). Moderately efficient DMUs demonstrated TE values between 0.51 and 0.80 ($0.51 \leq TE \leq 0.80$), while those scoring ≤ 0.50 were classified as low efficiency ($TE \leq 0.50$).

Table 2 reveals significant findings regarding demonstration plot access: among farmers with geomembrane demonstration plot exposure, 62.5% achieved full efficiency status. Notably, no sampled farmers in this group fell into the low efficiency category. These results suggest that access to demonstration plots enhances farmers' capacity to optimize production inputs, leading to greater operational efficiency. These findings align with Shah and Wu^[47], who similarly demonstrated that demonstration plots significantly improve farmers' production input management practices^[34].

Table 2. Technical Efficiency Categories Among Salt Farmer Groups in Madura Island.

	TE Categories	Count	Percentage (%)
Access to Geomembrane Demonstration Plot	Full TE (TE = 1.00)	40	62.500
	High TE (0.81 < TE < 0.99)	10	15.625
	Moderate TE (0.51 < TE < 0.80)	14	21.875
	Low TE (≤ 0.50)	0	0.00
	Total	64	100
No Access to Geomembrane Demonstration Plot	Full TE (TE = 1.00)	75	49.67
	High TE (0.81 < TE < 0.99)	25	16.56
	Moderate TE (0.51 < TE < 0.80)	42	27.81
	Low TE (≤ 0.50)	9	5.96
	Total	151	100
Production Performance Indicator			
Technical Efficiency	Min	Max	Average
	0.22	1.00	0.8740

Table 2 also reveals that among salt farmers lacking access to geomembrane demonstration plots, 49% nevertheless achieved full technical efficiency. The remaining sample distribution showed 16% in the high efficiency category, 27% demonstrating moderate efficiency, and 5% classified as low efficiency. While these results suggest a positive correlation between demonstration plot access and production performance, the research team conducted further verification through Mann-Whitney U tests to determine the statistical significance of TE score differences between groups (see **Table 3**).

Table 3. Technical Efficiency Comparison Based on SPSS Output.

Group Statistics					
	Dummy Demplot	N	Mean	Std. Deviation	Std. Error Mean
TE	Demplot	64	0.9070	0.14623	0.01828
	Non-Demplot	151	0.8599	0.17961	0.01462
	Total	215			
Mann-Whitney Test					
Test Statistics					
TE					
Mann-Whitney U				4147.500	
Wilcoxon W				15,623.500	
Z				-1.783	
Asymp. Sig. (2-tailed)				0.075*	

Note: Statistical significance (Robust): ** $p < 0.05$, * $p < 0.1$.

The analysis reveals distinct efficiency outcomes between the two farmer cohorts. Farmers with demonstration plot access achieved a mean technical efficiency (TE) score of 0.907, compared to 0.8599 for those without access, representing a 4.71% (0.0471) efficiency differential. SPSS output showed an Asymp. Sig. (2-tailed) value of 0.075 for production performance differences based on TE scores in Madura Island. As this exceeds the standard 0.05 probability threshold, we conclude there

is no statistically significant difference in technical efficiency between farmers with and without geomembrane demonstration plot access.

3.3. Relationship between Demonstration Plot Access and Salt Farm Productivity

The second key performance indicator for salt production is land productivity. Numerous studies have em-

ployed productivity measurements as a metric for agricultural enterprise performance, including research of Shah and Wu^[47], Kone and Uzmay^[48], Ngoma et al.^[49], Tahir et al.^[50], and Maflahah et al.^[51]. Productivity in this context refers to a farmer's capacity to generate agricultural output effectively and efficiently, thereby opti-

mizing yield within a given land area^[5,52-54]. For salt farming operations specifically, productivity measures the quantity of salt produced per unit area of cultivated salt ponds. As shown in **Table 4**, salt pond productivity levels among the studied populations ranged from 12.22 to 360 t/Ha, with a mean productivity of 98.13 t/Ha.

Table 4. Land Productivity Levels among Salt Farmer Groups in Madura Island.

Productivity (t/Ha)	Production Performance Indicator		
	Min	Max	Average
	12.22	360.00	98.13

Table 5 presents the comparative analysis of salt pond productivity between the two farmer cohorts. The data reveal that farmers with geomembrane demonstration plot access achieved an average productivity of 94 t/Ha, which is 5 t/Ha lower than farmers without such access. This finding contrasts with previous research^[49,50,54].

The SPSS output presented in **Table 5** yields an Asymp. Sig. (2-tailed) value of 0.854 for salt production performance differences in Madura Island based on land productivity metrics. Since this value substantially exceeds the standard 0.05 probability threshold, we conclude there is no statistically significant

difference in salt pond productivity between farmers with and without geomembrane demonstration plot access. This finding suggests that demonstration plot access does not necessarily translate to superior production performance, as numerous other factors likely influence outcomes. This result contrasts with several established studies demonstrating the positive impacts of demonstration plots on various agricultural indicators, including production input optimization^[55-57], technical efficiency improvement^[8,37,39,40,58], land productivity enhancement^[50,59,60], farmer income and welfare^[32,35,61,62], and new technology adoption rates^[6,9,36].

Table 5. Productivity Value Comparison Based on SPSS Output.

Group Statistics					
	Dummy Demplot	N	Mean	Std. Deviation	Std. Error Mean
Productivity	Demplot	64	94	32.2	4.0
	Non-Demplot	151	99	41.9	3.4
	Total	215			
Mann-Whitney Test					
Test Statistics					
				Productivity	
Mann-Whitney U				4755.500	
Wilcoxon W				6835.500	
Z				-0.184	
Asymp. Sig. (2-tailed)				0.854	

Note: Statistical significance (Robust): ** $p < 0.05$, * $p < 0.1$.

4. Conclusions and Policy Implications

The study conducted across three locations in Madura Island reveals that only 29% of sampled salt

farmers had access to demonstration plots, indicating that 70% lacked such exposure. Field observations demonstrate that most Madurese salt farmers continue to rely on traditional knowledge and peer-to-peer information sharing when making production decisions. This

finding highlights that access to demonstration plots constitutes a critical factor in farmers' decision-making processes regarding geomembrane adoption and salt production techniques.

The analysis of salt production performance revealed contrasting outcomes across the two measured indicators. Regarding technical efficiency, salt farmers with access to demonstration plots exhibited higher efficiency values compared to those without access, though this difference was not statistically significant. A different pattern emerged for the second performance indicator, land productivity. Farmers with demonstration plot access demonstrated slightly lower productivity values than their counterparts without access, but this difference similarly lacked statistical significance.

The limited access to geomembrane demonstration plots has resulted in non-significant impacts on salt production performance in Madura Island. This finding suggests important policy implications for relevant stakeholders, indicating that strategic expansion of demonstration activities could partially address this issue. Effective policy implementation should prioritize the establishment of demonstration activities in strategic locations with wide household participation. For the Marine Affairs and Fisheries Agency, particularly extension personnel, the dissemination of geomembrane technology through demonstration plots should actively engage a large number of salt farmers to facilitate the adoption of innovative production practices. These initiatives should place special emphasis on reaching poor and marginalized farmers in order to enhance technical efficiency and overall productivity. Accordingly, it is recommended that the government institutionalize large-scale demonstration programs as a core element of agricultural extension services. Through continuous outreach, explanations, and counseling at the village level, marine affairs and fisheries extension workers can foster farmers' receptiveness to new technologies and support sustainable improvements in salt production systems.

5. Study Limitations

The primary data collected from salt farmers in Madura Island were obtained through self-reported sur-

veys assessing various variables, including education, salt pond size, income, training received, and social participation. Although enumerators have clarified questions, self-reporting introduces potential biases such as overestimation or underestimation of knowledge and skills due to modesty or social desirability factors. Some farmers even consulted peers before providing identical questionnaire responses. A key methodological limitation involves the study's exclusive focus on variability in geomembrane demonstration plot access as the sole exemplar for introducing this production technology. While adoption rates were relatively high, demonstration plot access appeared to yield no statistically significant effect on adoption decisions, which is an anomalous finding that contradicts established theories and prior research in agribusiness, agricultural economics, and potentially extension communication. This discrepancy warrants particular scholarly attention, as it may indicate unmeasured external barriers (such as limited household financial support, infrastructure challenges, or market access constraints) or internal constraints (such as knowledge gaps or competency limitations) that may affect farmers' ability to benefit from demonstration plots.

Author Contributions

Conceptualization, C.I.P.; methodology, C.I.P. and M.B.; software, F.A.; validation, C.I.P. and F.A.; formal analysis, F.A. and D.A.D.; investigation, C.I.P.; resources, C.I.P. and Y.P.; funding acquisition, M.B.; data curation, M.B.; visualization, D.A.D. and M.; writing—original draft preparation, C.I.P., Y.P., F.A., M.B., D.A.D. and M.; writing—review and editing, C.I.P.; supervision, C.I.P.; project administration, Y.P. and M. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement

Ethical review and approval were waived for this study because this research involves humans in a min-

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Informed Consent Statement

Informed consent was obtained from all participants. Consent was implied through the voluntary completion of the questionnaire after being informed about the study's objectives and procedures.

Data Availability Statement

The data presented in this study are available on request from the corresponding author.

Conflicts of Interest

The authors declare that there is no conflict of interest. All content decisions, interpretations, and conclusions were made by the authors. The authors used Grammarly Premium to assist with grammar, spelling, and readability checks during manuscript preparation. The authors reviewed and edited all content and take full responsibility for the final version.

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