# THE ANALYSIS OF DAIRY FARMING EFFICIENCY IN EAST JAVA: EVIDENCE POST THE FOOT AND MOUTH DISEASE OUTBREAK

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**Abstract**

**Background:** Foot and Mouth Disease is a highly contagious disease in livestock that can cause great economic losses when there is an outbreak of the disease.
**Purpose:** This study examines the characteristics and dynamics of milk production on smallholder farms in East Java after the outbreak of foot and mouth disease
**Design/methodology/approach:** The regencies of Malang and Pasuruan are the research locations because they are the centers of milk production in East Java. To obtain a representative sample, farmer households were disaggregated by farm location, with a total of 93 farmer households surveyed 45 from Malang Regency and 48 from Pasuruan Regency. East Java Province was recorded to have 282.364 dairy cows in 2022, accounting for 56% of the national dairy cattle population, making it the key region in dairy cattle production. Through a comparative analysis of key factors, such as feed management, labor efficiency, and animal composition, the study revealed significant differences in milk production between the two regions.
**Findings/Result:** The study found that the number of lactating cows positively impacted milk production, with farmers in both Malang and Pasuruan effectively optimizing concentrate feed. However, labor management challenges in Pasuruan hindered full resource utilization, highlighting the need for improved labor practices. To sustain dairy farming in East Java, tailored strategies that address regional differences, optimize resources, enhance labor quality, and invest in disease prevention and farmer education are essential for increasing productivity and resilience.
**Conclusion:** Policy implications highlight the need for targeted training programs, improved measures to prevent the spread of foot and mouth disease (FMD), and better access to veterinary services to support farmers in adapting to FMD. Ultimately, strengthening resilience in the dairy farming sector is critical to ensuring the sustainability and productivity of dairy farming in East Java.
**Originality/value (State of the art):** This study provides novel insights by not only analyzing the dynamics of milk production in these regions post-FMD but also by examining the specific factors affecting recovery, such as feed management, labor efficiency, and animal composition. This study offers a comparative analysis between the two major dairy-producing areas in East Java.

**Keywords:** dairy farming, foot and mouth disease, milk production, lactating cow, resource management

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## INTRODUCTION

Agriculture is one of the sectors that plays a major role in the total national Gross Domestic Product (Khairiyakh et al. 2015). The agricultural sector is supported by several other important subsectors, one of them is the livestock subsector. There is an increasing trend in the share of livestock subsector GDP in total GDP in the agricultural sector. The Gross Domestic Product of the livestock subsector increased in 2022 to 12.40% from the previous 11.94% in 2021 (Badan Pusat Statistik, 2022; Badan Pusat Statistik, 2023). One of the activities that support the increase in the livestock subsector is the dairy farming business. The development of dairy farming in Indonesia is supported by natural conditions that are quite suitable for business development so it has the potential to continue to be developed. Currently, the dairy farming business is expanding, especially in East Java Province.

Figure 1 shows the dairy cattle population by province in 2022, illustrating the distribution and concentration of dairy cattle across different regions. East Java Province was recorded to have 282,364 dairy cows in 2022. It can be seen that East Java dominates the dairy cattle population, accounting for 56% of the total, followed by West Java with 22%. Central Java comes in third with 20%, while North Sumatra, Yogyakarta, and other provinces each contribute a smaller share of 1% respectively. This distribution highlights East Java as the key region in dairy cattle production, with West Java and Central Java also playing significant roles in the industry. The high population of dairy cattle in the East Java region not only creates benefits but can also lead to challenges for farmers when an outbreak occurs in an area, one of which is Foot and Mouth Disease (FMD). FMD is a deadly disease of livestock that is the most important animal health problem worldwide because of its economic impact (Govindaraj et al. 2021). The disease is caused by the Foot and Mouth Disease Virus (FMDV) of the Picornaviridae family, genus Aphthovirus which is highly contagious. This is because FMDV can be transmitted through all secretions and excretions from acutely infected animals, including exhaled air, nasal secretions, saliva, urine, and feces (Colenutt et al. 2020; 2018). The virus affects a wide range of wild and domestic mammals, including livestock (Wong et al. 2020).

Foot-and-mouth disease spreads throughout the world, with Asia, and the Middle East as the most affected regions. The disease can cause reduced productivity, as well as increased mortality rates among infected animals (Rahman et al. 2025). The impact of Foot-and-mouth disease on the dairy sector is profound, as the disease has the dual effect of reducing milk production and increasing care and treatment costs for infected animals. As stated by Jackson et al. (2021), Foot and Mouth Disease is the most contagious and destructive disease affecting livestock operations, especially those involving cattle, sheep, goats, and pigs. This disease has a morbidity rate of up to 100%, resulting in significant damage to draft power, meat, and milk production. Consequently, foot-and-mouth disease exerts a significant economic influence due to its role in reducing productivity and restricting trade, both domestically and internationally (Azeem et al. 2020). In addition, farmers bear a considerable burden due to the combined impact of reduced production, trade restrictions, and costs associated with disease prevention and control (Jemberu et al. 2020).

Figure 2 shows the concerning situation of Foot and Mouth Disease (FMD) in East Java. The number of affected cattle up to August 2024 reached 201,669 animals in 38 affected regencies and cities. From this number, only 0.34% were sick, but 2.23% had severe symptoms, and 1.35% had to be slaughtered to prevent further spread. Although 96.06% of the infected animals recovered, these recovered cows tended to produce less milk than before the Foot and Mouth Disease (FMD) outbreak. The FMD outbreak was reported to have reappeared in Indonesia in 2022, with the initial case identified in the Gresik Regency of East Java (Rohma et al. 2022). This is due to a variety of factors, including the impact of stress experienced during the sickness, a decline in overall physical condition, potential damage to the mammary tissue, weakened immune function, and possible disruptions in feeding and care during the illness. As a result, although the cows have recovered, their milk productivity has not fully recovered.

Research on the impact of Foot and Mouth Disease (FMD) on dairy farming has been conducted in various regions. Al-Salihi (2019) provides an overview of the epidemiology of FMD outbreaks in Iraq, while Ashfaq et al. (2015) analyze the economic implications of dairy animal diseases, including FMD, in Punjab, Pakistan. Ismail et al. (2023) focus on the clinical examination

of FMD in dairy cows in West Java, Indonesia, which provides valuable insights into the disease's effects on dairy cattle health. Vyas et al. (2019) discuss innovative approaches to detecting FMD and mastitis using the Internet of Things, contributing to the technological understanding of disease management in dairy farms. However, few studies have focused specifically on the post-outbreak recovery of smallholder dairy farms in East Java, particularly in the regencies of Malang and Pasuruan.

Foot and Mouth Disease outbreaks negatively impact farmers because this disease can lead to the death of livestock. The losses experienced by farmers are also due to the forced slaughter of livestock to prevent the further spread of FMD (Permatasari et al. 2024). In addition, the milk production that dairy cows can produce decreases even though they have recovered from FMD. Therefore, in this context, it is important to assess how Foot and Mouth Disease outbreaks affect the efficiency of dairy farms in East Java. The efficiency of dairy farm operations is a key factor in determining the sustainability and competitiveness of the dairy farming sector.

Based on some of these previous studies, it can be concluded that the hypothesis of this study: 1) FMD has a negative impact in the form of economic losses experienced by farmers; 2) Recovery from the impact of the 2022 FMD outbreak on milk productivity will tend to be varied between regions.

Based on the existing conditions and problems, this study's purposes are to analyze: (1) the progression of dairy cattle ownership and milk productivity post-FMD; (2) the impact of economic losses due to FMD; (3) the technical efficiency of dairy farming by considering input factors, distribution of technical efficiency values, and sources of inefficiency. The results of this study are intended to provide a comprehensive understanding of the economic impact of Foot and Mouth Disease and formulate policy recommendations to improve the resilience of the dairy farming sector in East Java against the threat of livestock diseases. This study provides novel insights by not only analyzing the dynamics of milk production in these regions post-FMD but also by examining the specific factors affecting recovery, such as feed management, labor efficiency, and animal composition. While previous research has identified general economic losses and productivity declines due to FMD, this study offers a comparative analysis between the two major dairy-producing areas in East Java. Furthermore, it highlights the role of localized challenges in recovery, such as labor-management issues, and proposes targeted policy recommendations for improving resilience in the sector.

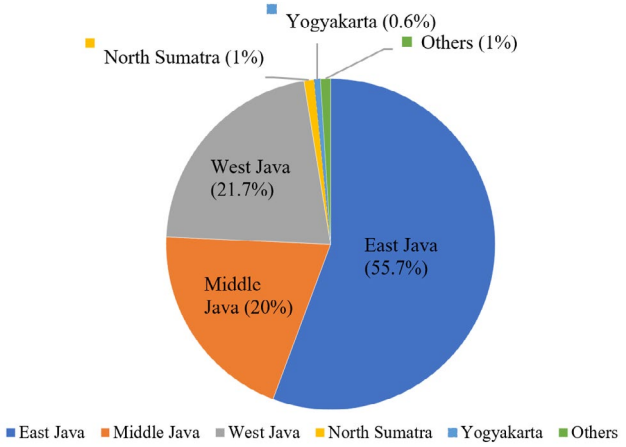



Figure 1. Dairy Cattle Population by Province in 2022 (Badan Pusat Statistik, 2024a)

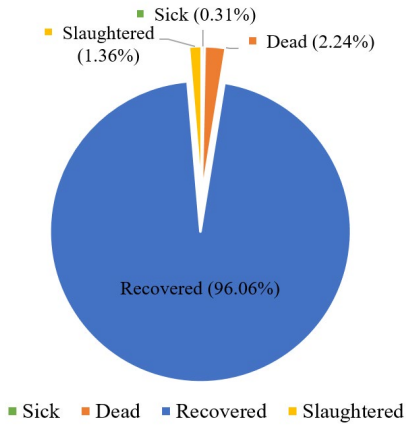



Figure 2. Foot-And-Mouth Affected Livestock in East Java in 2024 (Dinas Peternakan Provinsi Jawa Timur, 2024)

## METHODS

The East Java region was selected as the primary subject of this research study due to its distinction as the region within Indonesia with the largest proportion of lactating cows, accounting for approximately 56% of the national total. It was determined that Pasuruan Regency and Malang Regency, situated within the province of East Java, would be the optimal locales for conducting this study. This is because both regions are major centers of dairy farm production in East Java. In 2022, Pasuruan Regency had 90,304 dairy cows and Malang Regency had 83,595 dairy cows (Badan Pusat Statistik, 2024b). Therefore, these two regions were taken to represent the condition of dairy farms in East Java. The main data used in this study is primary data, which is obtained through in-depth interviews taken at sample farmer households. The respondents in this study are dairy farmers who manage smallholder dairy farms in both Pasuruan and Malang regencies. Primary data collection using the in-depth interview method is intended to obtain accurate data on the performance of dairy farming businesses. Data were collected using a questionnaire instrument in July-August 2024.

To obtain a representative sample, farmer households were disaggregated by farm location. The total sample surveyed was 93 farmer households consisting of 45 farmer households in Malang Regency and 48 farmer households in Pasuruan Regency. Subsequently, the 93 farming households were divided into two groups: those who owned 1-5 lactating cows and those who owned more than 5 lactating cows. The distribution of farmers in Pasuruan and Malang according to the number of cattle owned is as follows: 62.50% of farmers in Pasuruan and 68.89% of farmers in Malang were categorized as farmers with 1-5 lactating cows, while 37.50% of farmers in Pasuruan and 31.11% of farmers in Malang were categorized as farmers with more than 5 lactating cows.

This study employs a research framework to examine the impact of Foot and Mouth Disease (FMD) on dairy farms (Figure 3). In the event of an outbreak, it is anticipated that there will be a reduction in the number of cows kept by farmers, a corresponding decline in milk production, and an increase in production costs. These losses represent economic losses resulting from FMD outbreaks. Additionally, this research examined the impact of foot-and-mouth disease (FMD) on the characteristics of dairy farms and the technical efficiency of these enterprises. The two indicators of animal husbandry characteristics that are the subject of analysis are the development of dairy cow ownership and milk production. The technical efficiency analysis comprises determinants of production, the distribution of technical efficiency values, and sources of technical inefficiencies. These findings will inform the study's conclusion and recommendations, which aim to address the adverse effects of FMD on dairy farm productivity and suggest measures to improve efficiency.

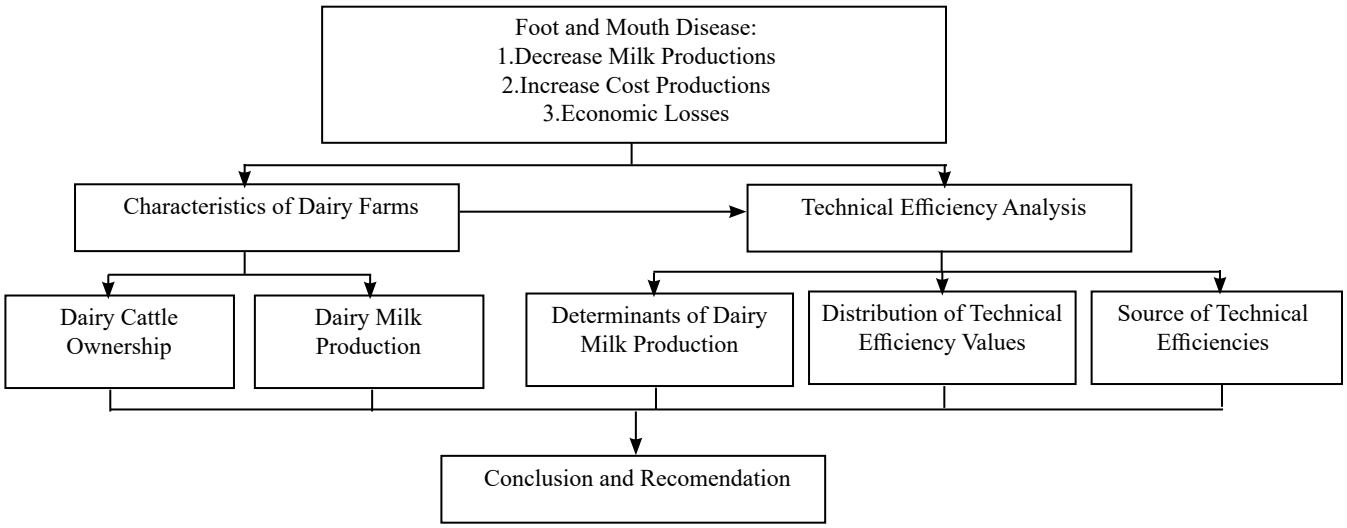



Figure 3. Research Framework

The efficiency analysis of farm businesses using the stochastic frontier approach has been conducted by the authors in previous studies (Asmara et al. 2016; Sudrajat et al. 2019). The stochastic frontier production function describes the maximum level of production that can be obtained with the use of a certain number of inputs. The function was developed by Liu et al. (2020) and Başeğmez (2021). In this study, the form of production function used is the Cobb-Douglas production function. This production function delineates the technology employed in this instance, pertaining specifically to the utilization of concentrate feed as the primary production input. The form of the Cobb Douglass function for dairy farms is determined as follows:

$$\ln Y_i=\beta_0+\beta_1 \ln X_{1i}+\beta_2 \ln X_{2i}+\beta_3 \ln X_{3i}+\beta_4 \ln X_{4i}+V_i+U_i$$

Description:Yi (Milk Production (liter/day)); X1 (Green Fodder (Cattle Food Forage) (kg/day)); X2 (Concentrate and Supplementary Feed (kg/day)); X3 (Labor (HOK/day)); X4 (Number of Lactating Cows (head)); Vi (Random error of the model); Ui (random variable that represents the technical inefficiency of the i-th farmer).

The technical efficiency of a dairy farm is defined as the ratio between actual output and frontier output, using available technology, formulated as follows:

$$TE = Yi/Yi^* = [E (Yi \mid Ui , Xi)/ E (Yi \mid Ui = 0 Xi) ]$$
$$= E [ \exp (-Ui)/\varepsilon i ]$$

Meanwhile, the identification of the sources that cause technical inefficiency is analyzed with the following model:

$$U_i = \beta_0 + \beta_1 Z_{1i} + \beta_2 Z_{2i} + \beta_3 Z_{3i} + \beta_4 Z_{4i}$$

Description: Ui (Technical Efficiency Value); Z1(Age (year)); Z2 (Length of Farming (years)); Z3 (Education (years)); Z4 (Dummy Grassland Ownership).

## RESULTS

### The Characteristics of Dairy Farms in East Java

The characteristics of dairy farms can be measured based on several criteria, including the number of cows, milk production, the type of cows reared, and the availability and source of breeding stock. Of these, the number of cows, especially lactating cows, is a particularly important benchmark because it determines the productivity and income of farmers. Table 1 illustrates the characteristics of dairy farms based on the number of cows owned post-FMD 2022.

Table 1 shows the difference in dairy cattle ownership in Malang Regency and Pasuruan Regency. The table shows that total cattle ownership on farms in Malang and Pasuruan decreased. In Malang, the average total cattle ownership decreased from 8.58 heads to 7.76 heads. Meanwhile, in Pasuruan, the average total cattle ownership decreased from 9 heads to 8.02 heads. Therefore, these figures show that the total cow ownership in Pasuruan is higher than the total cow ownership in Malang. Furthermore, in terms of the number of dairy cows owned, there are differences between Malang and Pasuruan farms. There was an increasing number of dairy cows owned by farms in Malang from 3.49 heads to 4.00 heads, while the number of dairy cows owned by farms in Pasuruan experienced a slight decrease from 4.96 heads to 4.33 heads. This increase in Malang can be attributed to a variety of factors, including more effective recovery practices post-FMD, such as better management of feed, improved veterinary care, and targeted government support or assistance programs aimed at boosting dairy cattle populations. Based on these results, it can be indicated that Malang farms have a more rapid recovery ability compared to Pasuruan farms. The more rapid recovery ability of Malang farms can be attributed to factors such as more effective management of resources, better access to veterinary services, targeted government support, and a higher level of resilience in farm management practices. The number of ownerships of dairy cows will have an impact on the amount of milk production which then affects the income earned from the dairy milk production. This is in line with research by Nurdiyansah et al. (2020) who stated that the level of income and fulfillment of farmers' needs is influenced by the large or small number of livestock ownership.

Table 1. Dairy Cow Ownership

| Dairy Cow Ownership | Malang | | Pasuruan | |
|---|---|---|---|---|
| | 1 | 2 | 1 | 2 |
| Male Calf | 0.84 | 1.53 | 0.67 | 1.06 |
| Female Calf | 1.47 | 1.36 | 1.10 | 0.88 |
| Heifers | 1.07 | 1.33 | 1.10 | 0.90 |
| Mature Males | 0.09 | 0.18 | 0.17 | 0.25 |
| Young Males | 0.07 | 0.00 | 0.19 | 0.08 |
| Lactating Female | 4.00 | 3.49 | 4.33 | 4.96 |
| Dry-cage Female | 0.31 | 0.78 | 0.48 | 1.08 |
| Total Average | 7.76 | 8.58 | 8.02 | 9.00 |

Description: 1) Dairy cow ownership in 2024; 2) Dairy cow ownership in 2023

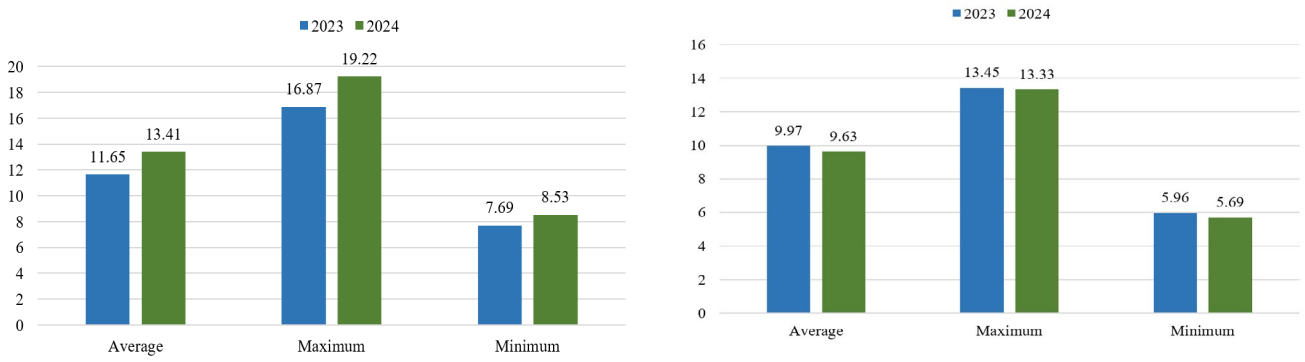
Figure 4 presents a comparative analysis of dairy milk production in Malang Regency and Pasuruan Regency. The average daily milk production of dairy cows per head in Malang farms increased from 11.65 liters to 13.41 liters. Similarly, the maximum daily milk production increased from the previous year of 16.87 to 19.22 liters and the minimum milk production increased from 7.69 liters to 8.53 liters. This corresponds with the number of dairy cows in Malang farms which increased from the previous year with an average of 3.49 heads to 4 heads in the current year.

In contrast, farms in Pasuruan experienced a slight decrease in the average number of dairy cows from 4.96 heads to 4.33 heads. This decline can be attributed to factors such as higher mortality rates, forced culling due to the effects of Foot and Mouth Disease (FMD), and possible economic constraints faced by farmers in Pasuruan that limited their ability to replenish their herds. This affected the milk productivity of Pasuruan farms. The average daily milk production per cow decreased from 9.97 liters to 9.63 liters with the maximum production decreasing from 13.45 liters to 13.33 liters and the minimum daily production being 5.69 liters from the previous year's 5.96 liters. Based on these results, it was found that despite the slight decrease, farms in Pasuruan had more dairy cows than farms in Malang. However, Malang farms are able to produce more milk than Pasuruan farms. This shows that regions with more dairy cows are not certainly able to produce more milk. This finding contradicts the research by Suroto et al. (2023) which states that if the number of dairy cattle ownership increases, then productivity in the form of cow's milk production also increases which further increases the income level of farmers.

**Dairy Farmers Losses Due to FMD in East Java**

The data regarding farmers affected by Foot and Mouth Disease (FMD) highlights significant differences in impact based on the region. Losses include the value of dead cattle, the value of forced slaughtered cattle, the economic value of cattle sold at lower prices, and additional costs incurred, such as for treatment.

Figure 5 shows that among 45 dairy farmers in Malang Regency, 48.89% reported losses due to cow mortality, and 4.44% were forced to cull their cows. In addition, 55.56% sold their cows at low prices, while 2.22% experienced other losses related to medical expenses. In comparison, among 48 dairy farmers in Pasuruan Regency, 68.75% experienced cattle deaths, and 2.08% were forced to cull their cattle, but most 58.33% chose to sell their cattle at low prices and no farmers reported other losses related to treatment. This indicates that FMD had a significant impact on farmers in both regions, although the types of losses were different. In order to prevent Foot and Mouth Disease (FMD), improved diagnostic capabilities along with vaccines are indispensable (Yirdaw & Abera, 2023). Vaccination has been identified as one of the most important steps in controlling FMD (Mari et al. 2024). Nevertheless, according to Chanchaidechachai et al. (2022), the effectiveness of a vaccine can be different due to several factors, such as the duration of the outbreak and the size of the farm, which lead to variations in the effectiveness of a vaccine, subsequently affecting the total economic loss significantly.




a) Malang b) Pasuruan

Figure 4. Dairy Milk Production (liters/cow/day)

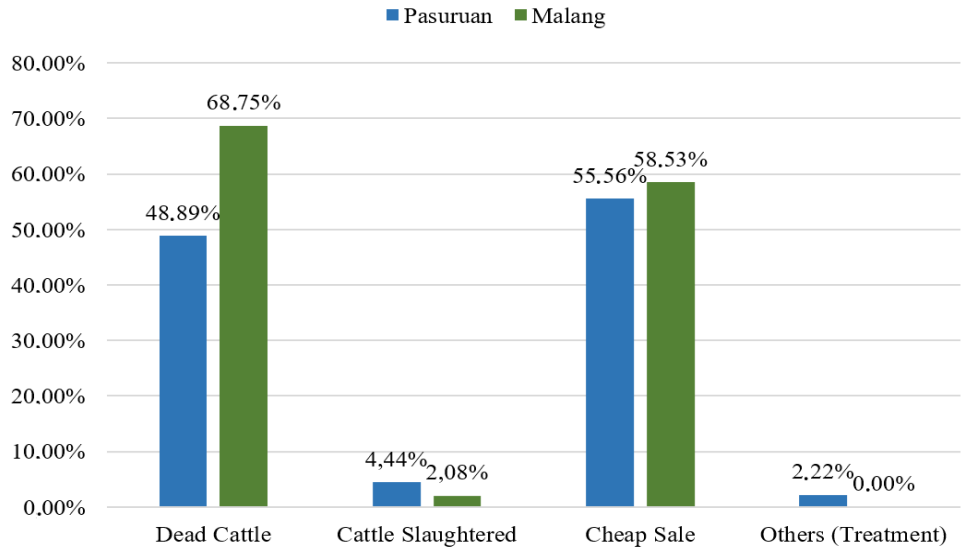
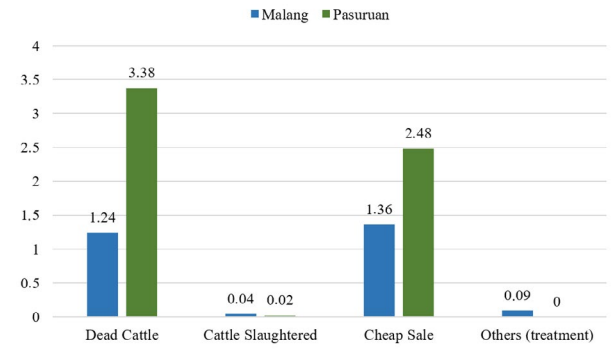


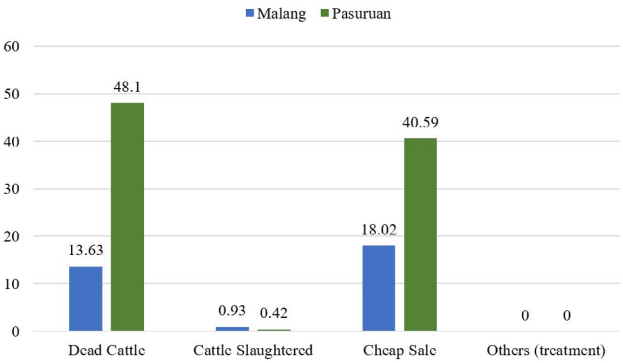

Figure 5. The percentage of total farmers samples affected by foot-and-mouth disease based on types of losses

Figure 6 shows a comparison of losses experienced by Malang and Pasuruan farms to evaluate the impact of Foot and Mouth Disease (FMD) in causing economic losses to cattle farmers. This table also shows the variation in the number of livestock affected and displays the financial losses experienced by farms in Malang Regency and Pasuruan Regency.

Economic losses of farmers during FMD outbreaks are caused by several major factors, one of them being the mortality of livestock. Farmers in Malang lost an average of 1.24 animals and farmers in Pasuruan lost an average of 3.38 animals due to mortality. In addition, livestock sold at low prices is also a big factor in economic losses for farmers. Farmers in Malang experienced losses due to the forced slaughter of an average of 0.04 animals and cheap sales of 1.36. Farmers in Pasuruan also experienced losses due to cheap sales with an average of 2.48 animals and 0.02 due to forced slaughter. The losses suffered by Pasuruan Regency farmers tended to be greater than those of Malang Regency farmers. According to Chanchaidechachai et al. (2022), the economic effects of FMD extend beyond decreases in milk yield to include higher mortality rates. These findings align with the research by Rohma et al. (2022) which states that FMD outbreaks lead to significant economic losses and highlight the pressing need for effective mitigation strategies. This shows that FMD negatively impacts farmers' profits.




a) Based on Number (Head)




b) Based on Value (Million IDR)

Figure 6. Average Economic Losses of Dairy Farmers Due to FMD

Many kinds of literature have documented the economic impact of the Foot and Mouth Disease (FMD) outbreak. FMS is an outbreak caused by a highly contagious virus for livestock, leading to significant economic losses for farmers (Yirdaw & Abera, 2023). Recent outbreaks in Indonesia and Thailand have underscored its negative impact on cattle, buffalo, and pig farms (Chanchaidechachai et al. 2022; Firman et al. 2022). Considering the large number of FMD cases that cause losses to farmers, it is necessary to provide appropriate interventions through financial support, improved access to livestock treatment, vaccination, and FMD risk prevention training considering the significant financial pressures and losses faced by farmers. Dede et al. (2024) emphasize the importance of implementing comprehensive policies for the eradication of FMD, including coordinated vaccination programs, better surveillance systems, and targeted interventions based on spatial distribution and environmental factors. These strategies are essential to reducing the spread of FMD and supporting farmers in managing the disease effectively.

## The Analysis of Factors Affecting Milk Production in East Java

The determinants of dairy milk production after the FMD outbreak are shown in Table 2. We are using four inputs to determine the dairy milk production, which are green fodder, concentrate, labor, and the number of lactating cows. In general, we can identify that there are some differences in terms of input significance.

A comparative analysis of the factors affecting milk production from dairy cows in Malang and Pasuruan regencies is presented in Table 2. This study identifies and examines the factors influencing milk production in the two regions, considering four key inputs: green fodder, concentrate, labor, and the number of lactating cows owned by farmers. The estimation results indicate the presence of disparities in the factors influencing milk production in the two study areas. These disparities are presumably associated with the prevailing conditions in each region. Specifically, the variables affecting milk production in the region of Malang include concentrate and lactating cows. Meanwhile, in Pasuruan, the variables affecting milk production consist of green fodder, concentrate, labor, and lactating cows. Following the outbreak of foot and mouth disease, it became evident that green fodder did not exert a significant influence on dairy milk production in Malang. In contrast, green fodder was found to have a markedly positive impact on dairy milk production in Pasuruan.

Table 2. Determinants of Dairy Milk Production

| Variable | Malang | Pasuruan |
|---|---|---|
| C | 1.87** | 0.23** |
| Green Fodder | 0.07 | 0.39** |
| Concentrate | 0.20* | 0.32** |
| Labor | 0.09 | -0.05** |
| Lactate Cow | 0.80** | 0.33** |
| Log-likelihood (MLE) | 15.91 | 3.09 |
| Log-likelihood (OLS) | 4.76 | 0.92 |

Note: *) Significant at α = 10%; **) Significant at α = 5%

The comparison between the dairy production systems in Malang and Pasuruan indicates the existence of distinct patterns in the influence of various inputs on milk yield. The analysis indicates that the inclusion of concentrate feed and the presence of lactating cows significantly enhances milk production in Malang. However, the inputs of green fodder and labor do not appear to exert a notable influence on output levels.

This implies that farmers in Malang are likely to be employing an optimized strategy of concentrate feed utilization and lactating cow management with a view to enhancing production, which could be indicative of a targeted resource allocation approach. This finding is consistent with the conclusions of Asmara et al. (2016), who asserted that the variables of the number of cows and concentrate feed have a positive effect on milk production.

Pasuruan, on the other hand, presents a more complex scenario. Here, a more balanced reliance on different nutritional resources is evident, with both forage and concentrate feed and lactating cows positively correlating with increased milk yield. However, labor input reveals a different story. It is significantly negatively correlated with milk production. This could indicate challenges related to labor efficiency. The labor inefficiency comes from foot and mouth disease. The loss of income due to reduced milk productivity directly affects the financial stability of farmers during FMD outbreaks. This is also supported by some literature. Farmers in Sidoarjo are affected by several types of losses due to FMD, including reduced milk production, loss of labor, and other types of losses, according to Sumartono et al. (2023).

In a national context, Sutawi et al. (2023) indicated that economic losses are a consequence of reduced milk yield, reduced beef cattle production, reduced labor availability, reduced cow fertility, reduced pregnancy rates, increased calf mortality, and selective culling of infected animals. Farmers often face significant economic pressures as a result of reduced milk production due to disease and culling of infected animals. This constraint forces them to implement cost-cutting measures, such as laying off workers or reducing hours, which can cause a workforce that is either insufficient in numbers or lacks the necessary skills and experience. Kargbo and Bangura (2024) highlight that these labor shortages, combined with financial losses, can further disrupt farm productivity and contribute to long-term socio-economic challenges for farmers. The economic challenges faced during an outbreak can be exacerbated by the combination of reduced income and these drastic labor adjustments, which can lead to inefficiencies in farm operations.

The different approaches adopted by farmers in response to local conditions are highlighted by these contrasting dynamics between the two regions. In Malang, the dependence on concentrates and dairy cows may reflect a strategic decision to focus on specific inputs that yield higher returns in milk production. In contrast, the situation in Pasuruan illustrates a broader strategy that integrates multiple feeding resources but also highlights vulnerabilities related to labor management. The ongoing challenges posed by Foot and Mouth Disease (FMD) outbreaks have further complicated these strategies, with farmers in both regions having to adapt to changing disease patterns. In Pasuruan, the persistence of FMD-related disruptions has increased reliance on alternative feeding methods and labor adjustments to manage the reduced productivity, while Malang's more focused approach has allowed for relatively better control over the disease's impact.

Figure 7 presents the distribution of technical efficiency in the Malang and Pasuruan Regencies. On average, the technical efficiency of farmers in Malang is higher than the technical efficiency of farmers in Pasuruan. The distribution of technical efficiency is classified into three categories: low efficiency (0.00-0.49), medium efficiency (0.59-0.79), and high efficiency (0.80-1.00). The majority of farmers in Malang are categorized in the high-efficiency group, at a rate of 65.90. The number of farmers is higher than the number of farmers in Pasuruan who are in the high-efficiency group, which is only 23.08. Farmers in Pasuruan were mostly in the medium efficiency group, at a level of 65.38. In the low-efficiency group, there were no farmers from Malang, while there were 11.54 Pasuruan farmers in the same category.

After the FMD outbreak, Pasuruan and Malang farmers had the opportunity to achieve the maximum production results as achieved by farmers with the highest level of technical efficiency. If the average farmer is able to achieve the highest efficiency value like its competitors, then Malang farmers have the potential to increase production by 11.11% (1-[0.80/0.90] x 100) and for Pasuruan farmers by 33.67% (1-[0.65/0.98] x 100). The percentages for Malang and Pasuruan show that Pasuruan farmers have greater potential to increase production. However, several inhibiting factors need to be overcome to achieve optimal technical efficiency. These factors include the limited availability of green fodder and the high cost of concentrates, which constrain farmers' ability to manage their livestock efficiently. Putra et al. (2024) also emphasize that such constraints, alongside the economic losses caused by

FMD, exacerbate the challenges in improving technical efficiency. Improved technical efficiency not only results in increased production, but also brings significant economic and social benefits. From an economic perspective, improved efficiency can increase farmers' incomes, strengthen the livestock sector's contribution to local food security, and stimulate economic growth in Malang and Pasuruan. This finding is in line with research by Asmara et al. (2016) which revealed that increasing the efficiency of dairy farming is still very much needed, valid for both Malang and Pasuruan farmers.

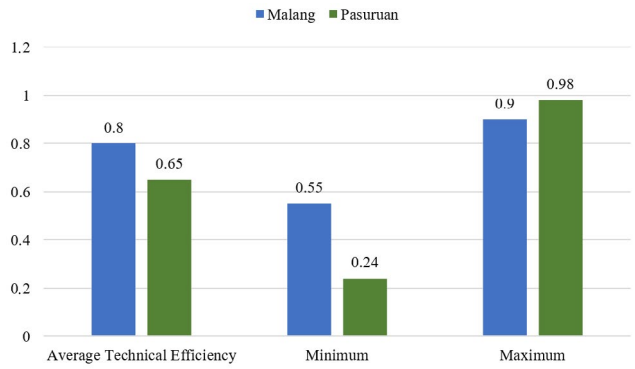
Table 3 shows the source of technical inefficiencies. These findings reveal that several factors determine technical inefficiency in cow's milk production. The significance of these factors may change over time. There are four key variables in analyzing the factors affecting technical inefficiency, including farmer age, farming experience, education level, and land ownership. For farmers in Malang, farmers' age has a significant effect on increasing milk production inefficiency, while farming experience has a significant influence on reducing inefficiency. This finding aligns with Mardhatilla (2018), who suggests that older farmers may face challenges in adopting new technologies or practices, which can contribute to inefficiency. On the other hand, farming experience has been found to be a key factor in enhancing farm management and milk production efficiency. As highlighted by Anindyasari et al. (2015), experienced farmers are better able to maintain livestock and produce quality fresh milk, which directly impacts technical efficiency. Meanwhile, the factors of education level and land ownership have no effect on cow's milk production for farms in Malang Regency.

Table 3. Source of Inefficiencies

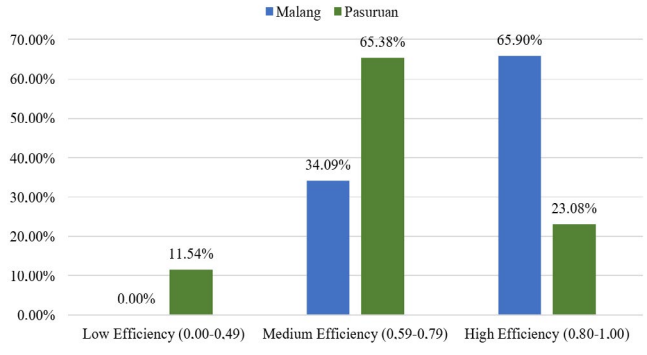
| Variable | Malang | Pasuruan |
|---|---|---|
| Age | 0.08* | -0.37* |
| Farming Experience | -0.04* | -0.29* |
| Degree of Education | -0.01 | 1.09* |
| Lawn Ownership | 0.02 | 0.06* |

Note: *) Significant at α = 10%; **) Significant at α = 5%

On farms in Pasuruan Regency, age and farming experience significant influence in reducing inefficiency in cow's milk production. Meanwhile, the factors of education level and land ownership have a significant effect on increasing milk production inefficiency. These results are different from those presented by Anindyasari et al. (2019) who stated that the level of education affects the attitude of farmers in running a livestock business, farmers with higher education will continue to increase efforts in developing their business. Overall, these results show that the factors have different influences based on location and time. Therefore, it is important to understand the changes in these factors in order to stimulate sustainable growth in the dairy farm industry.




a) Technical Efficiency Values




b) Distribution of Technical Efficiency

Figure 7. Distribution of technical efficiency values

### Managerial Implication

Based on the results of this research, there are several managerial implications, including: (1) The application of four input factors can affect milk production which then contributes to the efficiency level of dairy farms. These input factors can have different effects at different locations and times. Therefore, farmers need to enhance input management to be more efficient and have a positive impact on milk production. Better management of green fodder and concentrate-feeding will improve business efficiency. This is also applicable to the use of other inputs; (2) Farmers should improve the efficiency of dairy farming by reducing inefficiency factors on dairy farm productivity. Several factors can reduce inefficiency in dairy farming, including farming experience and degree of education. Therefore, to improve farming knowledge and skills, training and technical guidance can be conducted systematically and programmatically; (3) Foot and mouth disease outbreaks cause losses to farmers. To overcome and prevent greater losses, it is recommended to implement training programs for farmers to prevent the spread of foot-and-mouth disease. Such programs could include workshops on biosecurity measures, disease detection, and vaccination protocols. For instance, in Kenya, the government has implemented The Foot and Mouth Disease Control Program, which trains farmers on vaccination schedules, proper livestock handling, and maintaining hygiene on farms to prevent outbreaks**.** Compston et al. (2021) discuss how historical disease control strategies in Kenya have evolved and emphasize the importance of farmer education in implementing effective disease management practices. Improved access to livestock veterinary services is also needed to strengthen resilience and sustainability in the livestock sector. In addition, a successful example can be seen in India, where the National Animal Disease Control Program (NADCP) focuses on improving vaccination coverage and providing mobile veterinary units for remote areas, significantly reducing the incidence of FMD. Mohapatra and Sharma (2021) highlight the challenges faced during the execution of NADCP at the field level and provide solutions for enhancing its effectiveness in controlling FMD outbreaks. These programs help ensure timely interventions and better preparedness for outbreaks.

## CONCLUSIONS AND RECOMMENDATIONS

### Conclusions

Considering the findings on the characteristics and dynamics of dairy farm production in East Java, it is clear that addressing the challenges posed by foot and mouth disease (FMD) and optimizing resource management are critical for the sustainability of dairy farming. The need for customized strategies taking into account regional differences is underscored by differences in milk production and the different impacts of various inputs. To increase productivity, farmers in Malang and Pasuruan should adopt innovative practices that prioritize efficient use of resources, such as lactating cows, concentrate feed optimization, and improved livestock management. The results of this study align with several previous studies, particularly regarding the losses experienced by farmers due to FMD, as well as the analysis of variables affecting milk production and sources of inefficiency.

Moreover, investments in vaccination programs and preventive measures to control FMD must be prioritized to mitigate its economic impact and support the long-term viability of dairy farming in the region. Improved education and training of farmers is essential to enhance technical efficiency and overall farm management. To maintain consistent levels of milk production, helping farmers to develop better farm practices, specifically in improving labor quality, will be crucial. In addition to highlighting the potential for long-term improvements in dairy farm productivity through targeted interventions, this study also underscores the urgent need for effective disease management strategies. Through the promotion of resilience and adaptability among farmers, stakeholders can better manage the complexities of the dairy farm and secure its future in East Java.

### Recommendations

In order to support productivity and resilience, farmers can be helped to optimize their dairy cows and ensure that they receive the necessary nutrients to maintain high production levels through training programs that focus on efficient feed management. For Malang farmers, it is recommended to maximize the benefits of concentrate feed as the positive impact of concentrate feed on milk production has been observed. As for Pasuruan farmers, the negative impact of labor

highlights the need for improved labor management practices. The implementation of strategies such as training related to resource management and better feed management can help improve labor quality and productivity. In addition, stakeholders should cooperate with local governments and agricultural organizations to provide access to veterinary services and educational resources to empower farmers. The government should play a central role in addressing Foot and Mouth Disease (FMD) by strengthening surveillance systems, increasing vaccination coverage, and ensuring rapid response to outbreaks. Policy initiatives, such as subsidies for vaccination programs and incentives for farmers to adopt disease control practices, can enhance the effectiveness of these measures. Moreover, the government should collaborate with research institutions to develop strategies tailored to the local context of dairy farming, ensuring sustainable practices that protect both livestock and farm productivity. Investing in vaccination programs is also crucial as a measure to prevent the spread of Foot and Mouth Disease (FMD). Lastly, fostering communities of practice among dairy farmers can facilitate knowledge exchange.

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