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ESTIMATION OF ECONOMIC LOSSES TO THE COMMUNITY AS A RESULT OF BATIK WASTE POLLUTION

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Abstract

This study aims to estimate total economic losses from batik waste pollution and identify the factors influencing them. This study employs a quantitative approach using the cost of illness (COI) and replacement cost (RC) to estimate the value of economic losses, and multiple linear regression analysis is used to identify the factors influencing economic losses. Primary data was obtained through interviews with 35 respondents living within a 100-meter radius of the polluted river who had previously used river water. The results indicate that the average economic loss amounts to IDR 1,539,255 per month, with an average economic loss of IDR 114,807 per household per month. Factors with a significant positive influence on economic losses are length of residence and income. The longer the duration of residence, the greater the economic loss; similarly, as income increases, economic loss also increases. Meanwhile, the variables of number of dependents and distance from home have a significant negative effect: the more dependents, the greater the economic loss; the farther from home, the lower the economic loss. This study underscores the importance of integrated batik waste management as the foundation for formulating sustainable environmental policies.

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INTRODUCTION

Environmental pollution from industrial activities is a global issue that is becoming increasingly crucial for sustainable development. One of the largest sources of pollution comes from the textile industry and its derivatives, including the batik industry, which produces coloured liquid waste containing hazardous chemicals such as heavy metals, synthetic dyes, and organic compounds that are difficult to break down (Periyasamy, 2024). Globally, around 80 percent of industrial liquid waste in developing countries is discharged directly into the environment without adequate treatment, causing the degradation of terrestrial and aquatic ecosystems and reducing the economic productivity of surrounding communities (Suárez et al., 2023). This phenomenon is not only an ecological threat but also has an economic impact, especially for communities that depend on water resources.

In Indonesia, the batik industry is a cultural heritage and a source of economic livelihood for the community, but it also contributes to water pollution, especially in traditional batik production centres (Kusumawati et al., 2020). Several studies show that batik wastewater has chemical oxygen demand (COD) and biochemical oxygen demand (BOD) levels that far exceed environmental quality standards and contains azo dyes (chemical dyes) that are harmful to aquatic organisms (Diyah et al., 2023; Indah & Utami, 2024). The impact of batik wastewater not only degrades the environment but also causes economic losses due to reduced productivity in sectors that utilise water resources (Periyasamy, 2024). Therefore, poor batik wastewater management not only harms the environment but also undermines local economic stability, necessitating the adoption of sustainable production practices to mitigate economic losses.

Batik production in Pamekasan is one of the pillars of the community's economy, but it also poses a significant risk of polluting rivers due to liquid dye waste. Batik is a source of income that can improve the welfare of the people of Pamekasan Regency (Hoirina et al., 2025). This pollution not only poses health risks to the community but also degrades water quality and increases the cost burden households must bear for medical treatment and a clean water supply. There are 349 batik industries spread across Pamekasan Regency (Table 1).

Table 1.
Distribution of the Batik Industry Sector in Pamekasan District in 2025

District	Number of Batik Industries
Galis	10
Kadur	17
Larangan	16
Pademawu	11
Palenggaan	68
Pamekasan	54
Pegantenan	16
Proppo	153
Tlanakan	4
Total	**349**

Source: Pamekasan Regency Industry and Trade Office, 2025

Pamekasan Regency, one of the main batik centres on Madura Island, faces pollution problems from batik industry waste. Wastewater treatment plants (IPALs) in the batik industry in Pamekasan Regency show a low level of implementation that is still inadequate (Vibriyanto et al., 2025). The small number of IPALs causes economic losses due to batik production activities in Pamekasan that discharge untreated liquid waste, resulting in economic losses for the community (Setiawati & Hamzah, 2024; Anna et al., 2025). Batik production, which is mostly carried out by small industries and households, has not yet fully implemented an environmentally friendly waste treatment system. This condition creates potential economic losses for the community that are not borne by batik producers, either directly or indirectly. This condition results in economic losses for the community, including increased health, water, and electricity costs. If this condition is not properly addressed, it will undermine community welfare and financial stability. Studies Zhou et al. (2022) emphasize that estimating the value of economic losses is an important basis for formulating compensation and mitigation policies.

The unsustainable management of the batik industry has resulted in environmental pollution that directly impacts the community's economic losses and has the potential to hamper regional development (Pebrina & Dewi, 2025; Puspita, 2025). Despite numerous studies on the characteristics of batik waste and its environmental impact, information on the magnitude of economic losses directly felt by affected communities remains limited, especially at the household level and with respect to the socioeconomic factors that Influence these losses. In this context, this study aims to estimate the total economic losses caused by batik waste pollution and identify the factors that Influence them, so that it can serve as a basis for formulating sustainable batik waste management policies that take into account the economic welfare of affected communities.

The economic losses households incur from environmental pollution are not uniform; they depend on each household's economic characteristics. Differences in the number of family dependents, length of residence in the affected area, distance from the source of pollution, and income level can affect exposure, vulnerability, and households' ability to cope with pollution. Households with greater vulnerability tend to bear a greater economic burden, both through increased expenditure and reduced welfare. Therefore, it is important to identify the factors that Influence the amount of economic losses experienced by communities affected by batik waste pollution. Based on theoretical foundations and previous empirical Research results, the following Research hypothesis was formulated:

H_1: Family dependents have a positive effect on economic losses

Household economics theory explains that households have limited resources and more complex needs due to larger family sizes, and that the number of dependents usually leads to higher expenses. If expenses exceed income, the risk of economic loss or problems increases (Bitana et al., 2024). Various empirical studies show that the size of the dependent family significantly affects the economic vulnerability of families when facing environmental shocks, such as environmental disturbances caused by batik waste. Lee et al. (2024) found that an increase in the number of family members is associated with higher consumption expenditure and lower saving capacity, making families more vulnerable to external economic difficulties. Similar results were reported by (Bitana et al., 2024), who showed that an increase in dependents reduces families' ability to adapt to income declines caused by environmental degradation. Furthermore, (Campos et al., 2024) highlight that households with a large number of dependents and fixed incomes have weak economic elasticity in responding to environmental shocks (Kim & Lee, 2025) highlight the social and psychological impacts that widen the gap between family welfare and economic hardship. Therefore, an increase in the number of dependents within families is associated with greater economic damage to residents from environmental hazards caused by batik production waste in Pamekasan Regency.

H_2: Length of stay has a positive effect on economic losses

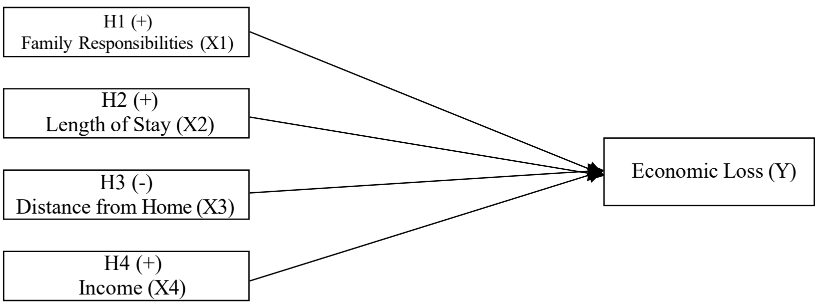
Place attachment theory explains the emotional, social, and economic relationships between individuals or groups and the environments in which they live (Wahyudie et al., 2021). Recent studies show that the length of time spent in a region significantly affects the economic losses communities experience from environmental pollution. D. Liu et al. (2025) found that long-term exposure to pollution in residential environments leads to declines in economic well-being and public health, especially among long-term residents. Similar results were reported by (Xu et al., 2024), who explained that environmental degradation directly reduces household income and work productivity, with a greater impact on groups that have lived in the area for a longer period. Ma et al. (2023) also emphasized that long-term environmental exposure increases the cumulative burden of health costs and economic losses. In line with this, (Li et al., 2023) highlight that communities with strong place attachment tend to remain in polluted areas and ultimately suffer greater economic losses due to their limited ability to adapt to environmental changes.

H_3: Distance from home hurts economic losses

Distance-decay theory states that how close or exposed a home is to danger is an important variable (Elhorst et al., 2024). Various studies show that the distance of a home from the source of a disaster significantly affects the level of economic loss to households. Abrar et al. (2025) found that homes located near pollution sources experienced the highest losses. De Silva & Kawasaki (2022) show that homes in polluted areas can cause economic losses. Johar et al (2022) show that the distance of homes from pollution sources significantly affects the magnitude of economic losses borne by the community. Homes located closer tend to cost more, though this does not always imply lower income. Meanwhile (Dartanto, 2022) prove that households in areas closer to disaster centres in Indonesia are at greater risk of experiencing a decline in welfare. Additionally, Rodríguez et al. (2024) show that increased disaster intensity magnifies economic losses. Secara empiris. Empirically, these findings confirm that the closer a home is to the disaster centre, the greater the economic losses households incur.

H_4: Income has a positive effect on economic losses

The absolute income theory, developed by Keynes, holds that household consumption is influenced by current income, while interest rates are considered insignificant. The consumption function formula based on this theory shows a direct relationship between consumption and absolute household income (Saraswati et al., 2022). Thus, income is the main indicator for assessing the magnitude of household economic losses. Empirical studies show that income is significantly associated with the level of economic loss individuals and households experience. Research by Tasri et al. (2022) shows that the higher a region's income level or economic activity, the greater the potential for economic losses. A. Li et al. (2023); Zhu et al. (2021) found that high-income groups tend to experience larger economic losses in nominal terms. In addition, Lyu et al. (2023) demonstrate that environmental disturbances not only affect directly affected sectors but also influence broader community economic activities. This concept is relevant for explaining household economic losses resulting from batik waste pollution, which not only incur health costs and mitigation expenses but can also reduce community economic productivity.

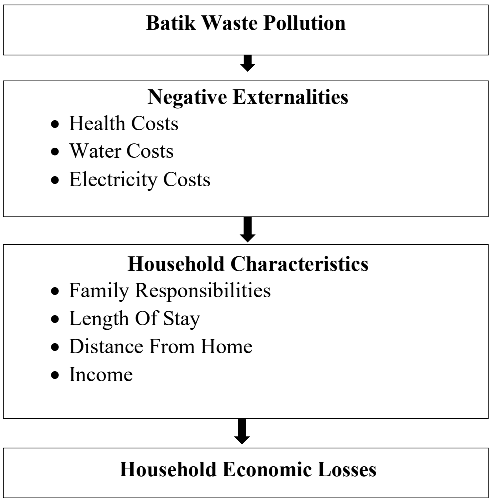


Source: Researcher, 2025

Figure 1. Research Hypothesis Chart

Batik waste pollution is a form of environmental pressure that affects household economic welfare through several main exposure pathways. The decline in water quality caused by batik wastewater limits households' access to clean water, thereby driving up spending on alternative sources. In addition, exposure to waste increases the risk of health problems, leading to additional medical expenses, and increases energy needs, particularly electricity, to support the use of water pumps, filtration systems, and alternative water sources. Thus, batik waste pollution affects household economic conditions by increasing defensive spending needed to maintain existing welfare levels.

The magnitude of these economic losses is not uniform, but is influenced by household characteristics. Household economics theory explains that the number of dependents determines consumption pressure and the economic capacity of households in facing environmental shocks. Place attachment theory shows that length of stay is related to cumulative exposure duration and mobility limitations, which can increase the accumulation of economic losses. Distance-decay theory holds that spatial proximity to pollution sources determines the intensity of the impact on households. Meanwhile, the absolute income hypothesis explains that income levels affect households' ability to make avoidance and mitigation expenditures. Therefore, the conceptual framework of this study places batik waste pollution as the main determinant of household economic losses through environmental exposure, with household characteristics as factors that Influence the magnitude of these impacts, which are reflected in increased spending on clean water, health, and energy, as well as their implications for the economic welfare of the affected communities (figure 2).



Source: Researcher, 2025

Figure 2. Conceptual Framework Chart

RESEARCH METHOD

This Research was conducted in Pamekasan Regency. Data collection was carried out in September–October 2025 through structured interviews with residents who use river water and live within a maximum radius of 100 meters of the river polluted by batik industry waste. The Research sample included heads of households living near the polluted river, totalling 35 respondents. Data analysis used a quantitative approach to estimate the economic loss to the community through the cost of illness (COI) approach, based on total expenditures for the treatment of diseases arising from pollution. The cost of illness (COI) formula in this study is presented below.

$$RBB = \frac{\sum_{i=1}^{n} BBi}{n} \quad \ldots\ldots(1)$$

Explanation:

RBB = average medical expenses (IDR/household/month)

BBi = medical expenses of respondent i (IDR)

n = number of respondents (households)

i = respondent i (1,2,3,. ,n)

In addition to using the cost of illness (COI) approach, this study also applied the replacement cost (RC) approach to estimate the economic loss. Replacement cost (RC) is the cost incurred by the community to replace water sources polluted by the batik industry's waste, and to provide alternative water sources suitable for daily use. In this study, the replacement cost includes the cost of purchasing clean water and the electricity used to operate water pumps that distribute water from alternative sources to household reservoirs. The replacement cost (RC) components in this study are limited to actual direct household expenditures, excluding potential indirect economic losses, such as opportunity costs in the form of time spent obtaining clean water, loss of productivity, and other non-monetary losses. In addition, each cost component is calculated based on different expenditure types to minimise the risk of double-counting. Thus, the replacement cost value produced represents direct economic losses that can be observed and measured monetarily at the household level. The replacement cost (RC) formula in this study is presented below.

$$RBP = \frac{\sum_{i=1}^{n} BPi}{n} \quad \text{.....................(2)}$$

Explanation:

RBP = average replacement cost of water (IDR/household/month)
BPi = replacement cost for respondent i (IDR)
n = number of respondents (households)
i = respondent i (1,2,3,. ,n)

$$RBP = \frac{\sum_{i=1}^{n} BPi}{n} \quad \text{.....................(3)}$$

Explanation:

RBP = average electricity replacement cost (IDR/household/month)
BPi = replacement cost for respondent i (IDR)
n = number of respondents (households)
i = respondent i (1,2,3,. ,n)

Factors affecting the WTA value are analysed using multiple linear regression with the equation:

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon \quad \text{.....................(4)}$$

Explanation:

Y = Total Economic Loss (IDR/household/month)
α = Constant
β = Regression Coefficient
X1 = Family Dependents (Persons)
X2 = Length of Stay (Years)
X3 = Distance from Home (Meters)
X4 = Income (IDR/household/month)
ε = Error

The independent variables in this study include several socioeconomic factors related to households. Family dependents are defined as the number of family members who are financially dependent on the respondent, measured in persons. Length of residence indicates the duration of the respondent's residence in the study location, measured in years. Distance from home is the distance between the respondent's residence and the river near the batik craft centre, measured in meters using Google Maps.

Income includes the total monthly income of the respondent or household, measured in Rupiah, using both the income and monthly expenditure approaches. This study uses a survey-based economic valuation approach to estimate the financial losses suffered by the community due to batik waste pollution in Pamekasan Regency. Estimates were calculated by averaging the loss per business unit or household and extrapolating to the entire affected population. The analysis began with testing classical assumptions, followed by applying a multiple linear regression model at the 5 percent significance level to assess the effect of each independent variable on economic losses.

RESULTS AND DISCUSSION

Batik waste pollution in Pamekasan Regency has affected the community's economic conditions, particularly those living around the river used as a waste-disposal site. Continuous batik production without adequate waste treatment has led to declines in water quality and environmental degradation, resulting in economic losses for the surrounding community. Before the pollution occurred, the rivers in the batik industry area of Pamekasan Regency played an important role for the community. River water was the main source for various daily needs, such as washing clothes, bathing, and watering plants. For children, the river also served as a place to play and interact socially. However, with the development of the batik industry and the increase in the volume of untreated liquid waste discharged, the quality of river water has declined. Currently, the river's role as the main water source is slowly being replaced by well water and tap water, prompting households to switch and incur additional costs to dig wells or install tap water, thereby creating a new economic burden.

This study estimates the financial losses from batik waste pollution in Pamekasan Regency using the cost of illness (COI) and replacement cost (RC) approaches. The cost of illness (COI) approach refers to the expenses incurred for treating diseases caused by exposure to batik waste. Batik waste pollution, containing chemicals from the production process, poses health risks, forcing the community to incur costs for treatment and disease prevention. Based on the study results, one disease was reported: itching. A total of 14.29 percent of respondents experienced economic losses in the form of increased health costs, 22.86 percent in water costs, and 62.86 percent in electricity costs.

Table 1.
Health Costs (Medical Treatment)

No	Description	Value	
1	Total Health Care Costs (Medical Treatment) (IDR/Month)	IDR	180,000 (a)
2	Respondents (households)	IDR	5 (b)
3	Average Replacement Cost (IDR/household/month)	IDR	36,000 (c=a/b)

Source: Processed Data, 2025

These figures reflect the healthcare costs incurred by the community due to industrial batik pollution (Table 1). The impact of this pollution not only reduces the quality of life but also increases the frequency of visits to healthcare facilities and household medical expenses. These findings are in line with Research by De Silva & Kawasaki (2022), which shows that residents who use polluted water sources incur higher health expenditures than those in unpolluted areas.

Then there is the replacement cost (RC) approach, which is the cost of replacing river water previously used to meet daily household needs but now underutilised due to batik waste pollution. This condition reflects a substantial shift in household water consumption patterns. Communities that previously used river water for daily needs have now switched to well, reservoir, and PDAM water. This behaviour change has increased the cost of obtaining clean water, thereby raising household expenditures (Choueiri et al*.,* 2022). Nevertheless, these costs still reflect the indirect economic burden resulting from increased dependence on paid clean water providers. Respondents experienced financial losses in the water cost component, totalling IDR 214,000/household/month and averaging IDR 26,750/household/month (Table 2).

Table 2.
Water Replacement Costs

No	Description	Value	
1	Total Water Replacement Cost for Respondents (IDR/Month)	IDR	214,000 (a)
2	Respondents (households)	IDR	8 (b)
3	Average Replacement Cost (IDR/household/month)	IDR	26,750 (c=a/b)

Source: Processed Data, 2025

The economic loss in electricity costs is IDR 1,145,255/month, with an average of IDR 52,057/household/month (Table 3). This shows that river pollution that disrupts household water sources forces people to increase the use of electric pumps to obtain clean water, thereby increasing energy consumption. This finding aligns with Research (Q. Liu & Zhao, 2023), which states that a decline in water quality increases household energy use due to independent water treatment and filtration efforts.

Table 3.
Electricity Replacement Costs

No	Description	Value	
1	Total Electricity Replacement Cost for Respondents (IDR/Month)	IDR	1,145,255 (a)
2	Respondents (households)	IDR	22 (b)
3	Average Replacement Cost (IDR/household/month)	IDR	52,057 (c=a/b)

Source: Processed Data, 2025

Overall, the analysis shows economic losses from batik waste pollution. The value of financial losses is calculated based on the components of health, water replacement, and electricity costs that the community must incur (Table 4). This analysis provides an overview of the economic losses that households in affected areas must bear due to batik waste pollution.

Table 4.
Total Economic Losses

No	Economic Loss	Average loss (IDR/household/month)		Total cost of loss (IDR/month)	
1	Healthcare Costs (Medical Treatment) (IDR/month)	IDR	36,000	IDR	180,000 (a)
2	Water Replacement Costs (IDR/month)	IDR	26,750	IDR	214,000 (b)
3	Electricity Replacement Cost (IDR/month)	IDR	52,057	IDR	1,145,255 (c)
	Total economic loss (IDR/month)	IDR	114,807	IDR	1,539,255 (d=a+b+c)

Source: Processed Data, 2025

The total economic loss suffered by the community due to batik waste pollution in Pamekasan Regency reached IDR 1,539,255/month, with an average loss of IDR 114,807/household/month (Table 4). The magnitude of these losses indicates that batik waste pollution, which contaminates household water sources, forces the community to switch to alternative water sources that require additional costs to obtain clean water other than from rivers. Overall, these total economic losses indicate that batik waste pollution imposes real financial pressure on the community, especially through increased spending on health, electricity, and water. These findings confirm that environmental damage not only has ecological impacts but also has significant economic implications for household welfare in affected areas.

Multiple linear regression was conducted to test the direct effect of financial losses on family dependents, length of stay, distance from home, and income. The results of the multiple linear regression analysis are presented in (Table 5).

Table 5.
Multiple Linear Regression Analysis Test Results

Variable	Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
(Constant)	6.665	3.210		2.077	0.046
Family responsibilities	-0.602	0.070	-0.982	-8.594	0.000
Length of Stay	0.801	0.050	1.595	16.164	0.000
Distance from Home	-0.217	0.046	-0.443	-4.725	0.000
Income	0.005	0.002	0.177	3.054	0.005

Source: Processed Data, 2025

The results of multiple linear regression tests show that the variables of family dependents and distance from home hurt economic losses, while the variables of length of stay and income have a positive effect (Table 5). The number of family dependents has a negative and significant effect on economic losses. The number of dependents has a negative and significant effect on household economic losses. These results indicate that households with more dependents tend to experience lower monetary economic losses. These results do not indicate that households with more dependents experience lower pollution impacts; rather, they reflect limited economic capacity to undertake mitigation expenditures. Id et al. (2021) and Wang & Zhao (2023) show that households with limited resources tend to reduce defensive expenditure as part of their economic adaptation strategy, resulting in lower measurable economic losses even though the level of environmental exposure remains high. This condition leads households with more dependents to limit spending on health, clean water, and other mitigation needs, resulting in lower measurable economic losses. This is in line with the findings (Anuz et al*.,* 2023) in the household economics literature that emphasise the role of family structure in empirically moderating the impact of economic shocks.

The distance of the house negatively affects economic losses. Houses located closer to batik waste pollution experience greater economic losses due to more intense exposure to contaminated water and soil, thereby increasing the risk of health problems and economic costs. Conversely, the further away the house is, the lower the economic losses tend to be. These findings are consistent with the distance-decay theory, which states that the impact of a hazard decreases with distance (Elhorst et al*.,* 2024). Households located closer to the source of batik waste pollution experience more intense exposure to contaminated water and soil, thus incurring greater health costs and economic losses. Conversely, the farther the house is from the source of pollution, the lower the exposure intensity and the smaller the economic losses experienced by households.

Length of residence has a positive and significant effect on economic losses. The longer households reside in polluted areas, the greater the financial losses they incur from cumulative exposure to pollution. These findings align with place attachment theory, which emphasizes the emotional, social, and economic attachment between individuals and their living environment (Wahyudie et al*.,* 2021). This attachment makes communities that have lived in an area for a long time more likely to remain in the polluted area, even as environmental quality declines, resulting in repeated, prolonged exposure to pollution. This condition makes exposure to pollution continuous and cumulative, ultimately increasing economic losses.

Income has a positive effect on economic losses. The higher the household income, the greater the economic losses. This means that the higher a person's income, the higher their consumption level. This aligns with Keynes' theory, which holds that current income is the primary determinant of household consumption (Saraswati et al*.,* 2022). According to household economic theory (Id et al*.,* 2021), an increase in income will raise households' minimum acceptable standards for water quality, health, and housing, leading households to respond to environmental disturbances by increasing mitigation spending. Conversely, low-income households often have limited economic capacity to make such avoidance expenditures, so they tend to tolerate poorer environmental quality and reduce mitigation expenditures even though they face the same risks. Therefore, higher economic losses among high-income households reflect their greater ability to take protective measures, rather than indicating that they experience more severe welfare impacts from pollution. Thus, income increases households' economic capacity to adapt to environmental pressures by boosting mitigation spending.

Overall, these findings indicate that economic losses from batik waste pollution are influenced by household characteristics (number of dependents, length of residence, income) and by spatial factors (distance from the pollution source). Households with many dependents, who have lived in the polluted area for a long time, have higher incomes, and are located closer to the pollution source, tend to face the greatest economic losses.

CONCLUSION AND SUGGESTION

This study successfully estimated the economic losses incurred by the community due to batik waste pollution at IDR 1,539,255.00/month, with an average loss of IDR 114,807.00/household/month. Factors that Influence the amount of economic loss, including the number of dependents and the distance from home, which has a negative effect, while the length of stay and Income has a positive effect on the value of economic loss. However, this study is still limited to measuring direct economic losses and uses snapshot data, so it does not fully describe the long-term impact and the dynamics of changes in economic losses over time.

This study is still limited to 35 households and a relatively short observation period, so the results are more representative of local conditions in Pamekasan Regency and cannot be generalised to all batik industry centres in Indonesia. Therefore, these findings should be understood as local and indicative empirical evidence. Further Research is recommended to expand the sample size. extend the observation period, and include indirect economic losses and environmental quality parameters so that the analysis of the impact of pollution on community welfare becomes more comprehensive and has stronger generalizability.

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