ANALYSIS OF THE EXTERNAL VALUE OF LIQUID ORGANIC FERTILIZER (POC) PRODUCED BY PT MAZARAAT LOKANATURA INDONESIA FROM ENVIRONMENTAL, ECONOMIC, AND SOCIAL ASPECTS

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ABSTRACT

The cheese processing industry produces whey waste that has the potential to pollute the environment if not utilized optimally. One effort to manage this waste is by processing whey into Liquid Organic Fertilizer (POC), which is expected to provide environmental, economic, and social benefits. This study aims to analyze the positive externalities of using POC made from whey waste on the environmental, economic, and social aspects based on the perceptions of user farmers. This study was conducted at PT Mazaraat Lokanatura Indonesia using a quantitative approach with a saturated sampling technique on all 15 POC user farmers. Data were collected through questionnaires, observation, and documentation, then analyzed using descriptive analysis and Structural Equation Modeling–Partial Least Squares (SEM-PLS). The results show that the utilization of whey waste into POC provides positive externalities on the environmental aspect by reducing the use of chemical fertilizers and improving the quality of agricultural land. From an economic aspect, POC can increase fertilizer cost efficiency and provide added value to whey waste. From a social aspect, the use of POC increases farmers' knowledge about environmentally friendly agriculture and strengthens the relationship between the company and farmers. Utilizing whey waste as POC has the potential to support more sustainable waste management while providing benefits to various parties.

KEYWORDS whey waste, liquid organic fertilizer, positive externalities, sustainable agribusiness.

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INTRODUCTION

The increase in food industry production has contributed to an increase in organic waste that has the potential to pollute the environment if not managed optimally. One of the waste products produced by the dairy processing industry is whey, a liquid left over from the cheese-making process that still contains lactose, protein, minerals, and other organic compounds. Despite its nutritional value, whey also has high Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) values, potentially degrading water quality if discharged directly into the environment. This situation demonstrates that whey waste management is not only the responsibility of companies but also a crucial part of realizing a sustainable industry (Buchanan, *et al*., 2023).

PT Mazaraat Lokanatura Indonesia is an artisan cheese processing company that produces whey waste daily as a byproduct of its production process. The company has utilized some of the whey waste into Liquid Organic Fertilizer (POC) as a means of implementing the circular economy concept. However, this waste utilization has not been optimal. During the period from December 2025 to May 2026, the company produced 46,893 liters of whey waste, but only 5,200 liters, or approximately 11.09% of the total waste produced, were successfully processed into POC (Polyester Fertilizer). The POC production process, which occurs once a week, requires the whey waste to be stored in a storage tank. Under certain conditions, the tank capacity is unable to accommodate all the waste produced, resulting in waste accumulation. When the storage capacity is full, some of the waste has the potential to overflow and pollute the surrounding environment. This situation indicates that whey waste management still requires optimization efforts to reduce the risk of pollution while increasing the utilization of waste into value-added products.

Table 1. Production and Management of Whey Waste at PT Mazaraat Lokanatura Indonesia

No	Month	Waste Generated (L)	Waste Managed (L)	Percentage of Waste Managed (%)
1	December 2025	10.245	1.000	9,76%
2	January	5.400	800	14,81%
3	February	7.888	800	10,14%
4	March	5.384	600	11,14%
5	April	7.776	800	10,29%
6	May	10.200	1.200	11,09%
	Total	**46.893**	**5.200**	**11,09%**

Utilizing whey waste as fertilizer (POC) not only has the potential to reduce environmental pollution but also creates positive externalities for various parties. For farmers, the use of POC can reduce dependence on chemical fertilizers and support more environmentally friendly cultivation. For companies, previously worthless waste can be processed into products with economic value. Furthermore, utilizing waste as fertilizer also has the potential to increase public knowledge and awareness about the importance of waste management in supporting sustainable agriculture.

Various studies have reported that liquid organic fertilizer made from organic waste can enhance plant growth, improve soil fertility, and support the implementation of a circular economy. However, these studies generally focus on fertilizer quality or its effectiveness on plants. Studies examining the positive externalities of using whey waste-based liquid organic fertilizer (POC) from an environmental, economic, and social perspective, based on farmer perceptions, are still limited. This information is crucial for understanding the perceived benefits of users and providing a basis for developing more sustainable waste management (Obayomi, *et al*., 2026).

Based on these conditions, this study aims to analyze the positive externalities of utilizing liquid organic fertilizer (POC) made from whey waste from an environmental, economic, and social perspective, based on the perceptions of POC-using farmers at PT Mazaraat Lokanatura Indonesia. This analysis was conducted to determine the extent to which POC utilization can provide benefits in reducing environmental impacts, increasing economic value, and providing social contributions to both the company and the farmer users. The results of this study are expected to form the basis for developing sustainable whey waste management strategies through the application of the circular agribusiness concept.

RESEARCH METHOD

The research was conducted at PT Mazaraat Lokanatura Indonesia, Sleman Regency, Yogyakarta Special Region, from February to May 2026. The study employed a quantitative approach with a survey method. The population consisted of 15 farmers using Liquid Organic Fertilizer (POC), all of whom were selected as respondents using a saturated sampling technique. Data were collected through a five-point Likert-scale questionnaire, observation, documentation, and company data.

Data analysis used descriptive analysis and Structural Equation Modeling–Partial Least Squares (SEM-PLS) with SmartPLS 4. Model evaluation included validity and reliability tests for the outer model, while the inner model was analyzed using the coefficient of determination (R^2) and hypothesis testing through bootstrapping procedures based on t statistics and p values. SEM-PLS analysis was applied to test the relationship between the positive externality value of whey waste-based POC and its impact on environmental, economic, and social aspects based on farmers' perceptions.

RESULT AND DISCUSSION

Respondent Characteristics

The characteristics of respondents are presented to provide a general overview of farmers using Liquid Organic Fertilizer (POC) from PT Mazaraat Lokanatura Indonesia. The study included 15 farmers selected using a saturated sampling technique, as all POC users were included. The respondent characteristics were analyzed based on age, gender, and farming experience to describe the background and level of understanding of farmers in assessing the benefits of whey waste-based POC implementation

Table 2. Characteristics of Research Respondents

Characteristics	Category	Number	Percentage (%)
Age	20-30 years	2	13,33
	31-40 years	6	40,00
	41-50 years	5	33,33
	>50 years	2	13,33
Gender	Male	14	93,33
	Female	1	6,67
Years of Farming	1-10 years	13	86,67
	11-21 years	2	13,33

Source: Processed primary data, 2025

Based on Table 2, the majority of respondents were aged 31–40 years (40.00%), male (93.33%), and had 1–10 years of farming experience (86.67%). This composition indicates that most respondents were of productive age and had considerable experience in farming activities. This situation supports the implementation of whey waste-based

fertilizer (POC), as productive-age farmers are generally more open to the use of new technologies and products that can increase farm productivity. This is in line with research by Nurmaida, *et al*., (2023), which states that the higher a farmer's ability to accept innovation, the greater the chance of successful implementation of technologies that support sustainable agriculture. This situation supports the respondents' ability to assess the use of whey waste-based POC because they have directly applied it on their farms.

Analysis Of The External Value Of Liquid Organic Fertilizer (POC) Produced By Pt Mazaraat Lokanatura Indonesia From Environmental, Economic, And Social Aspects

The research data analysis was conducted using the Structural Equation Modeling–Partial Least Squares (SEM-PLS) method with the assistance of SmartPLS 4 software. Model evaluation was conducted in two stages: an outer model evaluation to test the validity and reliability of the constructs, and an inner model evaluation to determine the relationships between the latent variables in the study. According to Ringle & Sarstedt, (2025) SEM-PLS is suitable for use in research with relatively small sample sizes because this method does not require normal data distribution and is capable of analyzing relationships between constructs simultaneously. Data analysis was conducted using Structural Equation Modeling–Partial Least Squares (SEM-PLS) with SmartPLS 4. Model evaluation included testing the outer and inner models to ensure validity, reliability, and relationships between variables.

1. Outer Loading Test (Measurement Model)

There are criteria for using SEM-PLS data analysis techniques to assess the outer model, namely Convergent Validity, Discriminant Validity, and Reliability.

a. Convergent Validity Results

The convergent validity test was conducted to determine the ability of each indicator to measure the construct under study. This test uses the outer loading value, where an indicator is declared valid if it has an outer loading value > 0.70. The following are the results of the data analysis based on the respondent questionnaire data, presented in Table 4.9.

Table 3. Outer Loading Results

Variabel	Indicator	*Outer Loading*	Description
Positive Externality Value of POC (X)	X1.1	0.895	Valid
	X1.2	0.824	Valid
	X1.3	0.855	Valid
	X1.4	0.896	Valid
	X1.5	0.902	Valid
Enviromental Aspect (Y1)	Y1.1	0.905	Valid
	Y1.2	0.738	Valid
	Y1.3	0.855	Valid
	Y1.4	0.895	Valid
	Y1.5	0.736	Valid
Economic Aspect (Y2)	Y2.1	0.894	Valid
	Y2.2	0.880	Valid
	Y2.3	0.831	Valid
	Y2.4	0.893	Valid
	Y2.5	0.930	Valid
Social Aspect (Y3)	Y3.1	0.870	Valid
	Y3.2	0.717	Valid
	Y3.3	0.872	Valid
	Y3.4	0.777	Valid
	Y3.5	0.828	Valid

Data Source: SmartPLS Secondary Data, 2026

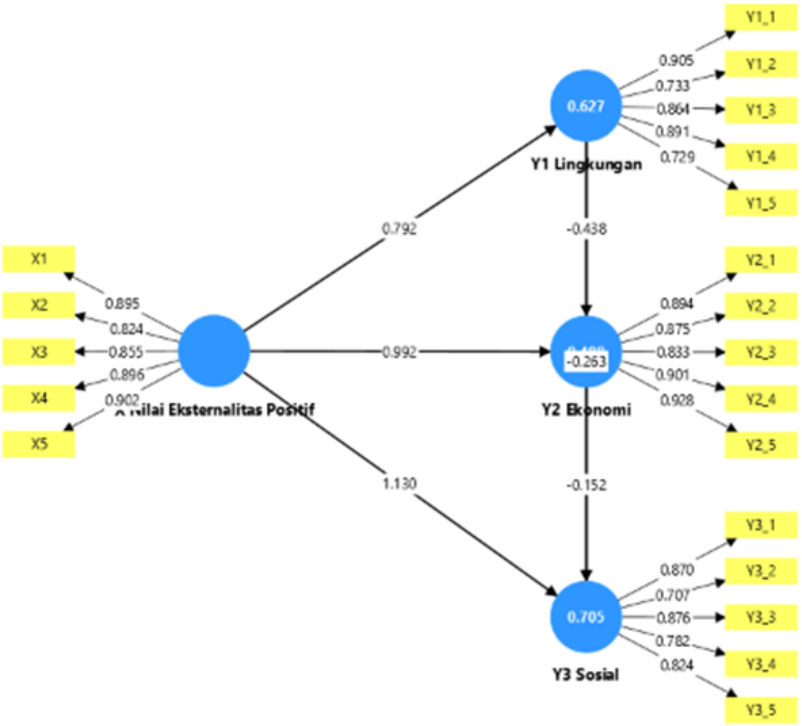


Figure 1. Outer Model Variables X, Y1, Y2, and Y3 (SmartPLS Primary Data, 2026)

Based on the analysis results in Table 3 and Figure 1, all indicators in the positive externality value variable POC (X), environmental aspects (Y1), economic aspects (Y2), and social aspects (Y3) have outer loading values ranging from 0.717 to 0.930. All outer loading values are > 0.7, indicating that they meet the validity requirements based on the outer loading value. This value indicates that all indicators have met the convergent validity criteria and are therefore valid and capable of representing the construct being measured.

b. Discriminant Validity Results

Discriminant validity was conducted to ensure that the concept of each latent variable is distinct from the other variables. Discriminant validity testing was conducted using the Heterotrait-Monotrait Ratio (HTMT). Discriminant validity was declared to be met if the HTMT value was < 0.90. The results of the discriminant validity test in this study are as follows:

Table 4. Discriminant Validity Results

Variabel	X	Y1	Y2	Y3
Positive Externality Value of POC (X)	-	-	-	-
Enviromental Aspect (Y1)	0.805	-	-	-
Economic Aspect (Y2)	0.657	0.396	-	-
Social Aspect (Y3)	0.847	0.595	0.511	-

Data Source: SmartPLS Secondary Data, 2026

Based on the analysis results in Table 4, all HTMT values between variables range from 0.396 to 0.847, thus all are below the maximum limit of 0.90. The HTMT value between the positive externality value of POC (X) and the environmental aspect (Y1) is 0.805, with the economic aspect (Y2) is 0.657, and with the social aspect (Y3) is 0.847. In addition, the HTMT value between the environmental aspect (Y1) and the economic aspect (Y2) is 0.396, the environmental aspect (Y1) and the social aspect (Y3) is 0.595, and the

economic aspect (Y2) and the social aspect (Y3) is 0.511. Based on these results, it can be concluded that all constructs in this study have met discriminant validity.

c. Composite Reliability Results

Composite reliability is used to measure the true value of a construct's reliability and is better at estimating internal consistency. Construct reliability is tested by measuring composite reliability and Cronbach's alpha. If the composite reliability value for a variable is >0.7, it is deemed to meet the criteria. If the Cronbach's alpha is >0.6, the variable is reliable. The results of the composite reliability test in this study are as follows:

Table 5. Composite Reliability Results

	Cronbach's alpha	*Composite reliability (rho_a)*	*Composite reliability (rho_c)*	*Average variance extracted (AVE)*
Positive Externality Value of POC (X)	0.923	0.928	0.942	0.766
Enviromental Aspect (Y1)	0.891	0.940	0.916	0.688
Economic Aspect (Y2)	0.932	0.952	0.948	0.785
Social Aspect (Y3)	0.878	0.909	0.908	0.664

Data Source: SmartPLS Secondary Data, 2026

Based on the data analysis results in Table 5, the positive externality value variable POC (X) has a composite reliability (rho_c) value of 0.942, the environmental aspect (Y1) of 0.916, the economic aspect (Y2) of 0.948, and the social aspect (Y3) of 0.908. All of these values are above the minimum threshold of 0.70, indicating that each variable has a very good level of internal consistency. The data analysis concludes that all constructs in this study meet the composite reliability criteria, thus declaring the research instrument reliable and capable of consistently measuring the positive externality value variable POC, environmental aspect, economic aspect, and social aspect.

2. Structural Model Testing (Inner Model)

The structural model evaluation of the inner model was conducted to determine the relationships between latent variables in the research model. This test aimed to determine the model's ability to explain endogenous variables through the R-square value and to test the significance of the influence between variables using bootstrapping results indicated by the path coefficient, t-statistic, and p-value.

a. R-Square Test

The coefficient of determination (R-Square) is used to measure the ability of exogenous variables to explain endogenous variables in a study. R^2 values are generally categorized as: 0.75 = strong, 0.50 = moderate, 0.25 = weak. The results of the R-Square test in this study are as follows:

Table 6. R-Square Results

	R-square	*R-square adjusted*
Y1 Enviromental	0.627	0.598
Y2 Economic	0.488	0.403
Y3 Social	0.705	0.625

Data Source: SmartPLS Secondary Data, 2026

The test results showed an R^2 value of 0.627 for the environmental aspect, 0.488 for the economic aspect, and 0.705 for the social aspect. These values indicate that the positive POC externality value variable is able to explain variations in environmental and

social aspects in the moderate category, while the economic aspect is in the weak to moderate category. Hypothesis testing was conducted to determine the effect of the POC externality value (X) on environmental aspects (Y1), economic aspects (Y2), and social aspects (Y3). Testing was conducted using the bootstrapping method in SmartPLS by examining the path coefficient, t-statistic, and p-value. The results of the hypothesis test are presented in Table 7.

Table 7. Bootstrapping Hypothesis Test Results

	Original Sample (O)	**Sample mean (M)**	**Standard deviation (STDEV)**	**T statistics (|O/STDEV|)**	**P values**
X Nilai Eksternalitas Positif -> Y1 Lingkungan	0.792	0.795	0.147	5.398	0.000
X Nilai Eksternalitas Positif -> Y2 Ekonomi	0.992	0.967	0.347	2.856	0.004
X Nilai Eksternalitas Positif -> Y3 Sosial	1.130	1.058	0.530	2.132	0.003
Y1 Lingkungan -> Y2 Ekonomi	-0.438	-0.415	0.408	1.073	0.283
Y1 Lingkungan -> Y3 Sosial	-0.263	0.232	0.414	0.635	0.525
Y2 Ekonomi -> Y3 Sosial	-0.152	-0.114	0.311	0.487	0.626

Data Source: SmartPLS Secondary Data, 2026

Hypothesis testing using bootstrapping showed that all relationships between variables were significant ($p<0.05$). The path coefficients were 0.792 for the environmental aspect, 0.992for the economic aspect, and 1.130 for the social aspect. These results indicate that the positive externality value of organic fertilizer (POC) positively influences all three aspects of the study. Based on the data analysis, the following is an explanation of the hypotheses for each variable in this study:

The Effect of Positive Externality Value of POC on Environmental Aspects

Positive externality value of POC significantly influences environmental aspects ($\beta = 0.792$; $t = 5.398$; $p < 0.001$). Farmers believe that the use of POC helps reduce dependence on chemical fertilizers, maintains soil fertility, and supports a more environmentally friendly agricultural system. Utilizing whey waste into POC also reduces the potential for pollution, thus providing environmental benefits. These results align with research by Nafiati, *et al.*, (2025), which states that POC made from organic waste can support sustainable agriculture without causing negative impacts on the environment. The results of this study align with those of Drewniok, *et al*., (2023), who stated that utilizing food industry waste as organic fertilizer is an effective strategy for reducing environmental pollution while supporting sustainable production systems.

The Effect of Positive Externality Value of Organic Fertilizer on Economic Aspects

The positive externality value of organic fertilizer significantly impacts economic aspects ($\beta = 0.992$; $t = 2.856$; $p = 0.004$). The use of organic fertilizer is considered capable of improving plant growth, thus potentially increasing crop yields. In addition to providing benefits to farmers, utilizing whey waste also increases the added value of waste into products with economic value. This finding supports the research of Nurhadi, *et al*., (2023), which stated that organic fertilizer has economic prospects and is feasible to be developed as a product that benefits both businesses and farmers. The processing of whey waste into

liquid fertilizer (POC) demonstrates the application of the circular economy concept, transforming previously uneconomical waste into products that benefit the agricultural sector. The results of this study indicate that utilizing waste as fertilizer not only reduces environmental burden but also produces an alternative product that can be reused in agricultural production systems. Research on the production of liquid fertilizer from organic waste indicates that the waste valorization process can produce value-added products and has economic potential for broader development (Fernández-delgado *et al*., 2022).

The Effect of Positive Externality Value of Organic Fertilizer on Social Aspects

The positive externality value of organic fertilizer significantly impacts social aspects (β = 1. 130 ; t = 2.132 ; p = 0.003). The use of organic fertilizer increases farmers' knowledge of environmentally friendly agriculture, encourages information exchange between farmers, and raises awareness of utilizing waste into valuable products. These findings indicate that organic fertilizer innovation not only provides technical benefits but also encourages behavioral changes towards sustainable agriculture. These results are in line with research by Putri, *et al*., (2025) which states that the use of POC can increase farmers' knowledge, attitudes, and participation in implementing more environmentally friendly agricultural technology. According to Suparti *et al*.,(2022), utilizing organic waste to produce liquid fertilizer can increase public awareness and encourage participation in sustainable environmental management. This demonstrates that waste management innovation not only produces new products but also creates behavioral changes toward more environmentally friendly production patterns.

CONCLUSION

Utilizing whey waste as a fertilizer (POC) offers positive externalities for the environment, economy, and social aspects. Waste processing can reduce the potential for environmental pollution, increase economic value by converting waste into marketable products, and benefit farmers and raise awareness of the importance of sustainable waste management. Based on the conclusions obtained from this study, several recommendations can be proposed to optimize the utilization of whey waste-based liquid organic fertilizer (POC) and maximize its positive externalities for environmental, economic, and social aspects. PT Mazaraat Lokanatura Indonesia is recommended to expand the utilization and distribution of POC to more farmers and conduct socialization activities regarding the benefits of POC so that the positive externalities generated can be experienced by the wider community on a broader scale.

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