Envirotek : Jurnal Ilmiah Teknik Lingkungan
Vol. 18, No. 2, Oktober, 2026, pp. 80-87
Journal Home Page: http://envirotek.upnjatim.ac.id/
e-ISSN 26231336 p-ISSN 2085501X

Socioeconomic Analysis and System Dynamics Modelling to Support Domestic Wastewater Management: A Case Study of Baruga Sub-district, Kendari City, Southeast Sulawesi

Dwiprayogo Wibowo*, Febry Samsudin, Moch. Assiddieq

Department of Environmental Engineering, Faculty of Engineering, Universitas Muhammadiyah Kendari, Jl. K.H. Ahmad Dahlan No. 10 Kendari 93115 – Sulawesi Tenggara, Indonesia

Corresponding Email (Authors): dwiprayogo@umkendari.ac.id

Received: 23-07-2026
Accepted: 12-09-2026
Published: 31-10-2026

Keywords:
Water, Waste, Domestic, Community, Modelling

ABSTRACT
The alarming condition of domestic wastewater pollution in an area has caused adverse effects on sanitation and threatened human health. This study examines the relationship between socioeconomic conditions and domestic wastewater management. The research approach used a mixed methods to assess the environmental conditions in the Baruga sub-district, Kendari City, Southeast Sulawesi Province, in relation to the hazards of domestic waste. A modeling approach was used to review ways to reduce domestic wastewater based on the social conditions of the community using a systems thinking and system-dynamics modelling applied in the Powersim Studio application. The results of the study indicate that the domestic wastewater samples collected in the Baruga Village area quantitatively exceeded the quality standards, such as the total suspended solid (TSS), pH, and oils and fatscontent parameters. The quantitative identification of social factors, such as community awareness, infrastructure availability, and community participation levels, significantly influenced perceptions and government responsibility in wastewater management. The findings also indicate that public understanding of waste management remains low, despite high expectations for improvements in sanitation systems. This study recommends enhancing education, strengthening domestic wastewater management system (DWMS) infrastructure, and fostering active collaboration between the government and the community to create an effective and sustainable wastewater management system.

1. INTRODUCTION

Rapid urbanization in Indonesia has led to a significant increase in the volume of domestic waste, both solid and liquid, posing considerable risks of environmental pollution and public health threats if not managed sustainably (Jurumai et al., 2023; Wibowo et al., 2026). Domestic wastewater represents one of the largest contributors to total waste generated by human activities, with approximately 90% of clean water consumption eventually discharged as wastewater (Agung et al., 2024). Wastewater management systems generally involve the collection of effluents into centralized treatment facilities designed to remove pollutants. However, in many developing countries, the majority of domestic wastewater remains untreated (Akpan et al., 2020).

In Indonesia, Rusdi et al. (2025) reported that 57.42% of households discharge wastewater from daily activities, such as bathing and washing, directly into drains, ditches, or rivers. Meanwhile, 18.71% dispose of wastewater into ground pits, 10.26% use septic tanks, and only 1.67% channel wastewater through centralized Wastewater Treatment Plants (WWTPs) or Sewerage Systems (Sherra et al., 2024). Household behavior in major Indonesian cities further indicates a significant influence of psychosocial factors on waste management practices, where perceived behavioral control exerts the strongest effect on 3R-based solid waste management behaviors ($\beta = 0.367$; $p \leq 0.001$) (Amir et al., 2025).

Previous studies have examined various determinants of successful domestic wastewater management. For example, Prasetyawati et al. (2018) highlighted the success of the Community-Based Sanitation Program (SANIMAS) in Yogyakarta, which was strongly influenced by community participation, particularly awareness levels and willingness to pay, both of which were critical for the sustainability of decentralized sanitation systems. Rahmasary et al. (2021) found that poor greywater management in densely populated areas of East Java was primarily attributable to limited public understanding of pollution impacts and inadequate communal treatment infrastructure. In terms of environmental quality,

Nurhasannah et al., (2024) and Wati et al., (2024) reported high levels of Total Suspended Solids (TSS) and fats/oils in household greywater, largely due to food waste effluents, which directly degrade surface water quality and heighten public health risks. Setiawati & Cadith, (2024), using a system dynamics approach, projected scenarios for improving decentralized sanitation quality through education and infrastructure interventions in urban areas, demonstrating a measurable reduction in pollution loads. Similarly, Narayan et al. (2021) emphasized the importance of adopting a holistic approach that integrates technical, social, and economic dimensions in sanitation planning, with program success largely determined by stakeholder synergy from the planning to implementation stages.

This study employs a mixed-methods approach, combining quantitative wastewater assessments with qualitative surveys capturing community awareness, infrastructure availability, and participation in Baruga subdistrict. The high density of residential housing in Baruga has been identified as a key driver of increased domestic wastewater pollution, underscoring a pressing sanitation crisis and the urgent need for intervention. Importantly, the interplay between wastewater management and socio-economic conditions in this local context has received limited scholarly attention (Dompasa et al., 2026). To address this gap, the study applies system thinking and dynamic modelling using Powersim Studio to project scenarios of socio-economic change such as educational interventions and infrastructure improvements and their impact on the quality of domestic wastewater management. This innovative methodological integration, rarely adopted in local studies, provides novel insights. The findings recommend intensive community education, strengthened decentralized sanitation infrastructure, and strategic multi-stakeholder collaboration from planning through implementation to establish an effective and sustainable domestic wastewater management system.

2. METHOD

2.1 Research Location

This research was conducted in Baruga Sub-district, Baruga District, Kendari City, Southeast Sulawesi Province.

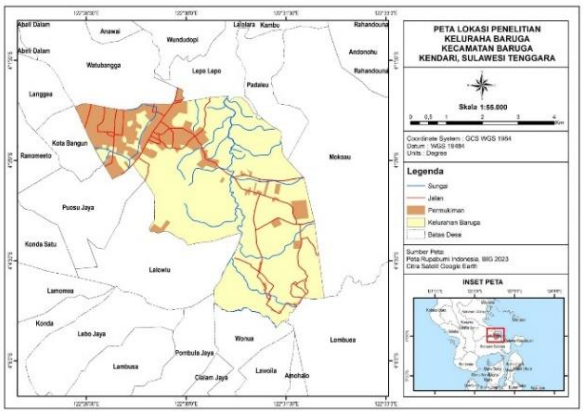


Figure 1. Study Location in Baruga Sub-district, Kendari City, Southeast Sulawesi Province

The site was selected as the study location because it represents a densely populated residential area characterized by socio-economically diverse households and insufficiently developed sanitation and domestic wastewater management systems. Geographically, the study area comprises 32 neighborhood units (RT) within 12 community units (RW), encompassing a total of 4,233 households. The area reflects typical characteristics of peri-urban and urban settlements in Indonesia, where rapid population growth is not always matched by adequate sanitation infrastructure.

2.2 Research Methodology

A mixed-methods approach was employed, integrating both quantitative and qualitative data collection. Quantitative data were obtained through household questionnaires and laboratory analyses of wastewater samples collected using grab sampling techniques. Qualitative data were derived from semi-structured interviews with community members. Wastewater parameters analyzed included pH, Total Suspended Solids (TSS), and oils and fats, with reference to quality standards specified in the Indonesian Ministry of Environment and Forestry Regulation No. 68/2016. Fieldwork was conducted in Baruga Sub-district between February and April 2025. Wastewater samples were collected from representative households. Statistical analyses were performed using SPSS, including descriptive statistics and multiple regression tests, while system dynamics modelling was carried out using PowerSim Studio to simulate wastewater management scenarios under varying socio-economic and infrastructural conditions.

2.3 Data Collection and Analysis

The integration of quantitative and qualitative approaches provided a broader understanding of the relationship between domestic wastewater characteristics, socio-economic conditions, and environmental factors within the study area. Descriptive statistical analysis was employed to examine the baseline conditions of wastewater, including system dynamics modelling socio-economic aspects were also assessed, such as household income, education, employment type, environmental awareness, and sanitation practices in Baruga subdistrict.

Correlation analysis was applied to identify relationships among variables, such as the link between household income levels and wastewater quality, as well as between community environmental awareness and domestic wastewater management practices. Factor analysis was further utilized to determine the primary drivers of wastewater quality, including environmental service availability, sanitation infrastructure, and socio-economic dimensions (income, education, employment). In addition, system-dynamics modelling was applied to assess the extent to which social interventions such as environmental education or infrastructure improvement could influence the sustainability of domestic wastewater management, thereby contributing to reduced environmental impacts.

3. RESULTS AND DISCUSSION

3.1 Characteristics of Domestic Wastewater

Laboratory analysis of domestic wastewater samples revealed that two out of three tested parameters (TSS and pH) did not comply with the quality standards set by the Indonesian

Ministry of Environment and Forestry Regulation No. 68/2016, while oils and fats concentrations remained within permissible limits. The TSS value was recorded at 510 mg/L, far exceeding the maximum allowable limit of 30 mg/L. This condition indicates extremely high turbidity levels, which may reduce light penetration in receiving waters and subsequently limit photosynthetic activity in aquatic organisms (Gayathri et al., 2026). These findings are consistent with Nguyen & Giao (2025), who demonstrated that elevated TSS levels in domestic wastewater contribute to increased turbidity, reduced dissolved oxygen, and adverse impacts on aquatic biota.

The pH value of the wastewater was 5.17, indicating acidic conditions below the acceptable range of 6–9 (Table 1). Such conditions may disturb aquatic ecosystem balance, as organic-decomposing microorganisms generally perform optimally under neutral to slightly alkaline pH conditions. This observation aligns with the study of Faradila et al., (2023), who reported wastewater pH levels of 5.64, attributed primarily to household activities such as washing and bathing, which tend to introduce acidic pollutants into water systems. The concentration of oils and fats were measured at 1.85 mg/L, below the standard threshold of 5 mg/L (Table 1). This results exhibit that most oils and fats fractions were already separated through natural hydrolysis processes occurring in the environment (Samarajeewa, 2024).

3.2 Correlation Between Domestic Wastewater Management and Social Conditions

Community characteristics were identified as a key factor in understanding the relationship between social conditions and domestic wastewater management. Survey results revealed respondents represented diverse age groups, gender, educational backgrounds, occupations, household sizes, and income levels. A total of 30 respondents from Baruga Sub-district were included, encompassing a broad spectrum of socio-economic backgrounds. Survey questions were categorized into seven independent variables: Community Awareness (X1), DWMS Management Quality (X2), Access to and Infrastructure of DWMS (X3), Health and Environmental Impacts (X4), Community Participation (X5), Knowledge Assets (X6), and Future Expectations (X7). These were analyzed against the dependent variable, Government Responsibility (Y). This framework highlights the multidimensional interaction between community socio-economic conditions and domestic wastewater management practices, suggesting that effective wastewater governance requires not only technical infrastructure but also active social engagement and institutional accountability.

The questionnaire data were analyzed descriptively using percentage distribution of responses, revealing that most community members perceived the current situation as inadequate. A majority of respondents (55.5%) assessed the quality of DWMS management (X1) as poor, while similarly negative perceptions were found regarding access and infrastructure (X3), with 60% of respondents rating the availability of facilities and infrastructure as very low or low. In addition, government responsibility (Y) was considered suboptimal, as reflected by 60% of respondents who disagreed or strongly disagreed with the adequacy of governmental roles in DWMS management.

On the other hand, awareness of health and environmental impacts (X4) was relatively high; more than 61.1% of respondents agreed that domestic wastewater management is essential for public health and environmental protection. Community participation (X5) showed mixed results. Certain aspects, such as willingness to contribute financially or in-kind, were moderately positive (46.7% agreement), whereas active engagement in DWMS-related activities remained low, with 22.2% of respondents disagreeing with direct involvement. Similarly, knowledge regarding DWMS (X6) was unevenly distributed, although a slight majority (55.6%) demonstrated an understanding of the importance of proper wastewater management.

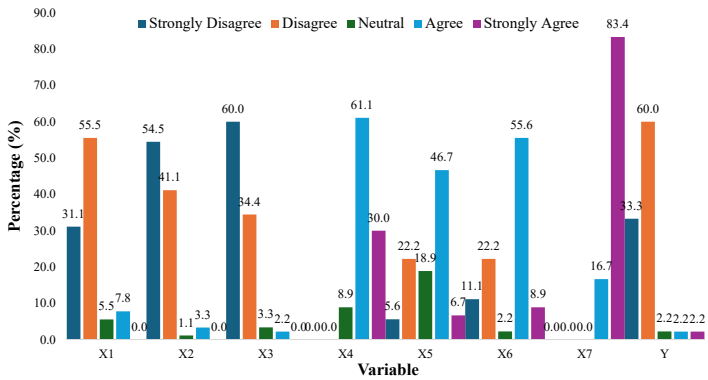


Figure 2. Descriptive Data of Community Responses for Each Variable

Future expectations (X7) were notably high, with more than 83.4% of respondents strongly agreeing on the necessity of improving and expanding DWMS systems. These findings suggest that, despite the inadequacies of current practices, there exists a substantial level of community optimism and demand for more effective and sustainable wastewater management systems. The results emphasize the importance of enhancing access to information, improving infrastructure and facilities, and ensuring stronger government involvement to achieve effective wastewater governance with broad community support.

Table 1. Results of Domestic Wastewater Characteristics Analysis

Parameter	Unit	Test Result	Quality Standard*	Remarks
Total suspended solid (TSS)	mg/L	510	30	Exceeds
pH (Acidity level)	-	5.17	6-9	Below the maximum limit
Oils and fats	mg/L	1.85	5	Below the maximum limit

* Quality standard based on Minister of Environment and Forestry Regulation No. 68/2016.

Table 2. Normality Test

One-Sample Kolmogorov-Smirnov Test	
N	30
Sig	.200[d]

Results of the normality test conducted using the One-Sample Kolmogorov–Smirnov test on the residual data, yielded an Asymp. Sig. (2-tailed) value of 0.200 > 0.05 (Table 2), indicating that the residuals were normally distributed. Multicollinearity tests (Table 3) further confirmed the robustness of the model, as all Variance Inflation Factor (VIF) values were less than 10 and tolerance values exceeded 0.1, suggesting the absence of multicollinearity.

Table 3. Multicollinearity

Model	Tolerance	VIF
X1	0.427	2.342
X2	0.467	2.142
X3	0.396	2.522
X4	0.773	1.293
X5	0.452	2.193
X6	0.505	1.981
X7	0.602	1.661

Heteroscedasticity testing (Table 4) was performed to assess whether the residual variance was constant. Heteroscedasticity may compromise regression accuracy by biasing standard errors, thus leading to misleading statistical inferences (Bucevska, 2025). In this study, all significance values exceeded 0.05, indicating no evidence of heteroscedasticity in the model.

Table 4. Heteroscedasticity Test

Model	Sig.	Model	Sig,
X1.1	.590	**X4.2**	.167
X1.2	.345	**X4.3**	.110
X1.3	.923	**X5.1**	.119
X2.1	.234	**X5.2**	.381
X2.2	.081	**X5.3**	.442
X2.3	.353	**X6.1**	.014
X3.1	.421	**X6.2**	.175
X3.2	.894	**X6.3**	.025
X3.3	.678	**X7.1**	.535
X4.1	.281	**X7.2**	.469

ANOVA results (Table 5) showed an F-value of 7.808 with a significance level of < 0.001, demonstrating that the regression model was statistically significant. This implies that the independent variables (X1–X7) jointly exert a significant effect on the dependent variable (Y) (Nugrahani, 2017).

Table 5. Correlation Test

ANOVA	
Model	F
Regression	7.808

The correlation coefficient (R = 0.844) indicates a very strong relationship among the variables in the regression model, approaching the maximum value of 1 (Table 6).

Table 6. Determination Test

Model Summary[b]	
Model	R
1	.844[a]

The purpose of multiple regression analysis is to determine the magnitude and significance of the influence of each independent variable on the dependent variable, thereby identifying which variables contribute most to the model's outcome (Keith et al., 2025). The resulting regression equation can be expressed as:

$$Y = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 + b_6x_6 + b_7x_7 \quad (1)$$

$$= 1.522 + 0.185x_1 + 0.030x_2 + 0.527x_3 + 0.133x_4 + (-0.272)x_5 + 0.257x_6 + (-0.124)x_7 \quad (2)$$

This model demonstrates how the dependent variable (Y: Government Responsibility) is influenced by seven independent variables (X1–X7). Each regression coefficient (B) reflects the expected change in Y for a one-unit increase in the respective independent variable, holding others constant:

- b_1 : Holding the other variables constant, a one-unit increase in X1 is associated with an estimated increase of 0.185 units in Y.).
- b_2 : Holding the other variables constant, a one-unit increase in X2 is associated with an estimated increase of 0.030 units in Y.
- b_3 : Holding the other variables constant, a one-unit increase in X3 is associated with an estimated increase of 0.527 units in Y.
- b_4 : Holding the other variables constant, a one-unit increase in X4 is associated with an estimated increase of 0.133 units in Y.
- b_5 : Holding the other variables constant, a one-unit increase in X5 is associated with an estimated decrease of 0.272 units in Y.
- b_6 : Holding the other variables constant, a one-unit increase in X6 is associated with an estimated decrease of 0.257 units in Y.
- b_7 : Holding the other variables constant, a one-unit increase in X7 is associated with an estimated decrease of 0.124 units in Y.

All seven independent variables (X1–X7) were found to significantly influence the dependent variable (Y), confirming the hypothesis (Ha) that community awareness, management quality, infrastructure, health-environmental perceptions, participation, knowledge, and expectations collectively shape perceptions of government responsibility. This highlights the critical role of government in domestic wastewater management, as these socio-environmental factors directly and indirectly influence public perceptions and expectations regarding the provision of adequate sanitation services and the sustainability of DWMS systems.

3.3 Determination of Domestic Wastewater Volume

Referring to the Indonesian National Standard (SNI 19-6728.1-2002), the average domestic water consumption is approximately 120 liters per person per day, with an estimated 80 liters per person per day discharged as wastewater. Of this volume, around 70% is classified as greywater (from bathing,

washing, and kitchen activities), while 30% is blackwater (from toilets). The average household water use habits in Baruga Sub-district, based on survey data, are presented in Table 7. The calculation of domestic wastewater generation was based on the following formula:

$$Q_{wastewater} = N \times C \times F \quad (3)$$
$$Q_{wastewater} = 14.203\ inhabitants \times 120\ L/person/day \times 0{,}8 \quad (4)$$
$$Q_{wastewater} = 1.324.128\ L/day \quad (5)$$

Q : Total domestic wastewater volume (L/day or m³/day)
N : Total population = 14,203 (as of 2023)
C : Per capita water consumption = 120 L/person/day
F : Conversion factor = 0.8 (proportion of consumed water discharged as wastewater)

Table 7. Daily Household Water Use Patterns in Baruga Sub-district

Time	Activity	Percentage of use
00:00 - 01:00	No activity	0%
01:00 - 02:00	No activity	0%
02:00 - 03:00	No activity	0%
03:00 - 04:00	No activity	0%
04:00 - 05:00	Prayer preparation	50%
05:00 - 06:00	Cooking + Washing + Bathing	
07:00 - 08:00	Cooking + Washing + Bathing	
08:00 - 09:00	Cooking + Washing + Bathing	
09:00 - 10:00	No activity	
10:00 - 11:00	No activity	
11:00 - 12:00	Prayer + Meals	10%
12:00 - 13:00	Prayer + Meals	
13:00 - 14:00	No activity	0%
14:00 - 15:00	No activity	0%
15:00 - 16:00	No activity	0%
16:00 - 17:00	Bathing + Prayer preparation	40%
17:00 - 18:00	Bathing + Prayer preparation	
18:00 - 19:00	Cooking + Washing	
19:00 - 20:00	Cooking + Washing	
20:00 - 21:00	No activity	0%
21:00 - 22:00	No activity	0%
22:00 - 23:00	No activity	0%
23:00 - 24:00	No activity	0%

Survey results further indicated that the average household of 3–4 members consumes approximately 300 liters per household per day, equivalent to 75 liters per person per day. Peak domestic water use was observed between 05:00 and 09:00, with 50% of total daily consumption occurring during this period. The peak demand period lasted for four hours, particularly between 06:00 and 10:00. Accordingly, the wastewater discharge during peak hours can be estimated as follows:

Peak Wastewater Volume = 75 L/person/day
= Peak Consumption Percentage × Total Wastewater Volume
= 50% x 1.363.488 L/day
= 662.064 L/4 hours ≈ 16,551L/hour

3.4 Intervention Strategies for Domestic Wastewater Management

Secondary data analysis indicates that each resident in Baruga Sub-district generates approximately 75–80 liters of domestic wastewater per day, equivalent to 27,000 liters per year per person. With a total population of 14,203 inhabitants in 2023, coupled with an annual population growth rate of 2.75% and a mortality rate of 0.5%, the total wastewater volume is estimated to exceed 1,000,000 liters per day. Based on dynamic system modeling, this volume could reach up to 4,000,000 liters per day by 2034 (Figure 3).

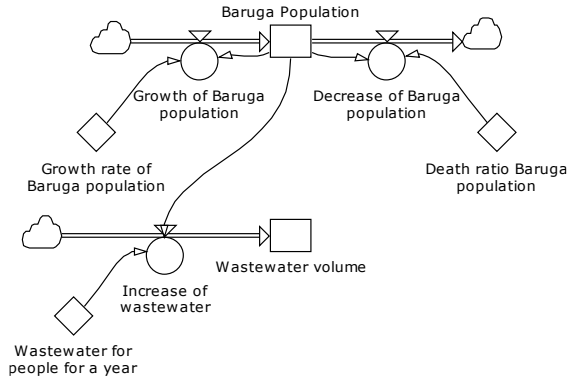


Figure 3. Simulation of the relationship between population growth and domestic wastewater generation

The simulation under the Business as Usual (BAU) scenario demonstrates a direct proportionality between population growth and the increase in domestic wastewater generation. This relationship is further visualized using PowerSim modeling (Figure 4). The absence of an effective wastewater management system in the area poses significant risks to both environmental and public health (Wirdatul et al., 2025).

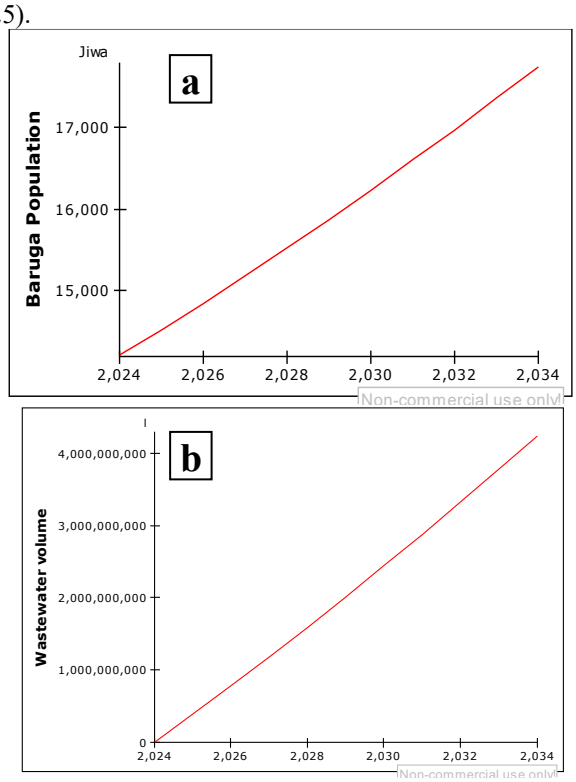


Figure 4. Dynamic system simulation: (a) annual population growth, (b) annual wastewater generation volume

The most evident impacts include water pollution in residential areas, which not only degrades environmental quality but also increases the risk of waterborne diseases such as diarrhea and skin infections. Moreover, unmanaged wastewater contributes to declining quality of life in terms of health, hygiene, and comfort, while also reducing productivity,

destabilizing local economic conditions, and hindering sustainable well-being.

To address these challenges, three levels of intervention scenarios were developed: simple, moderate, and intensive, using system dynamics modelling. These scenarios incorporate (1) community awareness initiatives, (2) community participation (neighborhood-level programs such as RT/RW-based interventions), and (3) improved access to DWMS infrastructure.

1) **Scenario 1:** Community Awareness

Scenario 1 assumes that community awareness regarding wastewater management is positively correlated with education levels, estimated at 23.7% of the population. Thus, approximately 3,366 residents are considered aware of proper wastewater management practices, while the remaining 10,837 residents (76.3%) are presumed to have limited awareness. Simulation results using PowerSim (Figure 5) show that increasing awareness alone yields modest reductions in wastewater generation compared to the BAU trajectory.

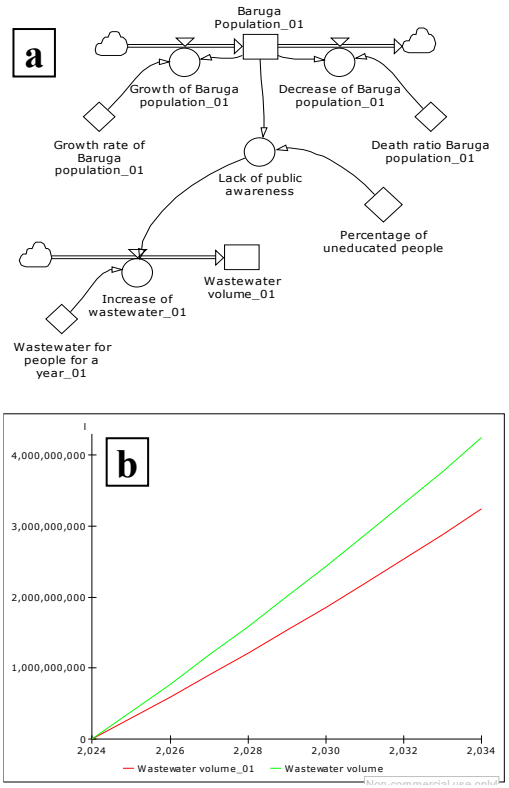


Figure 5. Simulation of community awareness impacts on wastewater reduction: (a) dynamic system modeling, (b) comparison between Scenario 1 (red line) and BAU (green line)

2) **Scenario 2:** Community Participation

In Scenario 2, the effect of community participation is examined. This scenarioassumes the introduction of government-supported programs such as SANIMAS (Community-Based Sanitation) with active involvement of approximately 40% of the population (5,681 residents), while the remaining 60% (8,522 residents) remain passive. Given the per capita wastewater generation of 75 liters/day, low participation levels significantly reduce the effectiveness of wastewater reduction efforts (Figure 6). Simulation results suggest that while participation enhances outcomes compared to Scenario 1, the intervention remains insufficient without broader coverage and sustained infrastructure support.

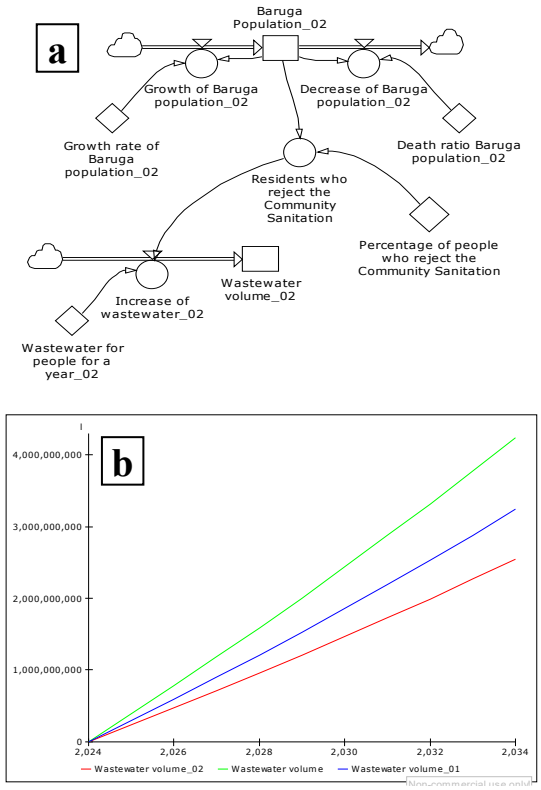


Figure 6. Simulation of intervention impacts on wastewater reduction: (a) dynamic system modeling, (b) comparison of Scenario 1 (blue line), Scenario 2 (red line), and BAU (green line)

3) **Scenario 3:** Access to DWMS, Government Programs, and Wastewater Reduction

This scenario evaluates the extent to which access to DWMS influences the volume of wastewater effectively treated within the community. Access to DWMS is considered one of the most critical determinants of how much domestic wastewater can be adequately managed. The estimation was based on the total population, the percentage of households with access to the DWMS, an assumed household size of four individuals, and the treatment efficiency of the system. The pollutant load reduction was estimated assuming that the DWMS removes 60% of the total domestic wastewater volume (Figure 7).

Simulation results indicate that the projected wastewater volume in 2034, which would otherwise continue to rise under the BAU trajectory, could be reduced to approximately 2,500,000 liters per day if DWMS facilities are made available in each household. This scenario highlights the substantial role of DWMS access in decreasing unmanaged wastewater volumes, making it a key factor in advancing more effective and sustainable wastewater management strategies. The findings underscore that a synergistic approach combining enhanced community awareness, active participation, and expanded access to DWMS can significantly mitigate domestic wastewater burdens. Therefore, domestic wastewater management must be addressed as a shared

responsibility between government and communities, involving infrastructure provision, public education, and empowerment programs, as well as the promotion of collective awareness as an integral component of sustainable sanitation systems.

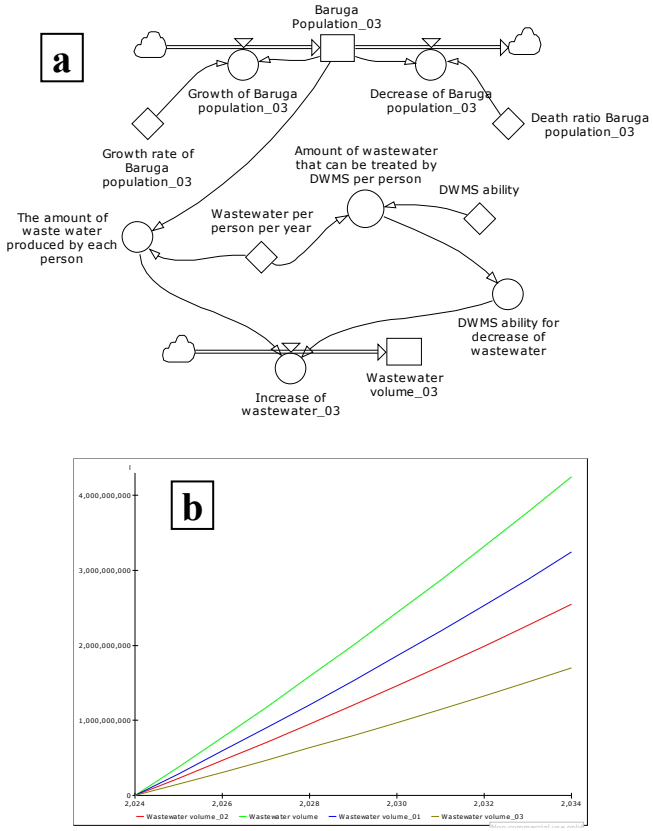


Figure 7. Dynamic system simulation of wastewater reduction: (a) dynamic system model, (b) comparison of Scenario 1 (blue line), Scenario 2 (red line), Scenario 3 (dark green line), and BAU (green line)

4. CONCLUSION

The analysis of wastewater parameters revealed that TSS and pH levels exceeded the permissible standards set by the Ministry of Environment and Forestry Regulation No. 68 of 2016, indicating that pre-treatment processes are required before wastewater can be discharged into the environment. Public perceptions of government responsibility in wastewater management remain low, with most respondents reporting insufficient education, inadequate DWMS infrastructure, and limited government support. Regression analysis confirmed that access, infrastructure, and educational factors significantly influence community perceptions of governmental responsibility. Furthermore, the dynamic system analysis demonstrated that population growth directly correlates with an increase in domestic wastewater generation, which, if left unmanaged, would exacerbate water and soil pollution, thereby posing severe risks to public health. Simulation of intervention scenarios highlighted that improved DWMS systems, coupled with greater community participation and supportive government programs, may reduce wastewater volumes and mitigate pollution impacts under the simulated conditions. Collectively, these findings emphasize the urgent need for integrated and participatory approaches to establish sustainable domestic wastewater management systems that align environmental, social, and health objectives.

ACKNOWLEDGMENT

The authors gratefully acknowledge the residents of Baruga Sub-district, Kendari City, for their cooperation during the data collection process. Appreciation is also extended to Universitas Muhammadiyah Kendari for providing institutional support and facilitating the implementation of this research.

REFERENCES

Agung, A. L. P., Ciptaningtyas, D., Pratopo, L. H., & Thoriq, A. (2024). Restoration of treated domestic wastewater quality at a bottled water factory in North Sumatra, Indonesia using DMAIC framework. *Environmental Nanotechnology, Monitoring & Management*, *22*, 100959. https://doi.org/10.1016/J.ENMM.2024.100959

Akpan, V. E., Omole, D. O., & Bassey, D. E. (2020). Assessing the public perceptions of treated wastewater reuse: opportunities and implications for urban communities in developing countries. *Heliyon*, *6*(10), e05246. https://doi.org/10.1016/j.heliyon.2020.e05246

Amir, F., Miru, A. S., & Sabara, E. (2025). Urban Household Behavior in Indonesia: Drivers of Zero Waste Participation. *ArXiv Preprint ArXiv:2505.17864*, *17*, 1–23. https://doi.org/10.48550/arXiv.2505.17864

Bucevska, V. (2025). Heteroscedasticity. In *International Encyclopedia of Statistical Science* (pp. 1110–1113). Springer.

Dompasa, S. N., Wibowo, D., & Sumarlin, S. (2026). Identifying Public Awareness and Implementation Challenges in 3R-Based Household Waste Management : A Case Study of Kendari City , Southeast Sulawesi Pendahuluan. *Wicaksana: Jurnal Lingkungan Dan Pembangunan*, *10*(1), 29–41. https://doi.org/0.22225/wicaksana.10.1.2026.29-41

Faradila, R., Huboyo, H. S., & Syakur, A. (2023). Rekayasa pengolahan air limbah domestik dengan metode kombinasi filtrasi untuk menurunkan tingkat polutan air. *Jurnal Kesehatan Lingkungan Indonesia*, *22*(3), 342–350. https://doi.org/10.14710/jkli.22.3.342-350

Gayathri, K., Saranraj, P., Nayak, A. K., Kesavardhini, K., Lokeshwari, B., & Cardoso, A. M. (2026). Microbial Innovations for Sustainable Wastewater Management: A Comprehensive Review of Azo Dye Bioremediation. *Sustainability*, *18*(6), 3041. https://doi.org/10.3390/su18063041

Jurumai, L. P., Abidin, A. A., Soetrisno, E. T., & Wibowo, D. (2023). Impact of population growth and housing development on the riverine environment: Identifying environmental threat and solution in the Wanggu River, Indonesia. *Ecological Modelling*, *486*, 110540. https://doi.org/10.1016/j.ecolmodel.2023.110540

Keith, T. Z., Reynolds, M., & Caemmerer, J. (2025). *Multiple regression and beyond: An introduction to multiple regression and structural equation modeling*. Routledge.

Narayan, A. S., Marks, S. J., Meierhofer, R., Strande, L., Tilley, E., Zurbrügg, C., & Lüthi, C. (2021). Advancements in and integration of water, sanitation, and solid waste for low-and middle-income countries. *Annual Review of Environment and Resources*, *46*(1), 193–219. https://doi.org/10.1146/annurev-environ-030620-042304

Nguyen, G., & Giao, N. T. (2025). A Review of Potential Impact of Total Suspended Solids on Surface Water Quality and Water Uses in the Vietnamese Mekong Delta. *Vietnam Journal of Agriculture and Environment*, *2025*(2), 83–90. https://doi.org/10.71254/t0fdde93

Nugrahani, T. S. (2017). Pengaruh dewan komisaris dan komite audit pada kualitas laporan keuangan. *Akmenika: Jurnal Akuntansi Dan Manajemen*, *14*(1), 838–849. https://doi.org/10.31316/akmenika.v14i1.1011

Nurhasannah, S., Rosdiana, R., & Wibowo, D. (2024). Pemanfaatan Adsorben Karbon Cangkang Kemiri untuk Pemisah Lemak dan Minyak pada Air Limbah Rumah Makan. *Jurnal TELUK: Teknik Lingkungan UM Kendari*, *4*(1), 31–35. https://doi.org/10.51454/teluk.v4i1.561

Prasetyawati, N. D., Gravitiani, E., & Sunarto, S. (2018). Willingnes to Pay dan Ability to Pay Pelayanan Sanitasi di Kota Yogyakarta. *Jurnal Teknologi Kesehatan (Journal of Health Technology)*, *14*(2), 71–81. https://doi.org/10.29238/jtk.v14i2.371

Rahmasary, A. N., Koop, S. H. A., & van Leeuwen, C. J. (2021). Assessing Bandung's governance challenges of water, waste, and climate change: lessons from urban Indonesia. *Integrated Environmental Assessment and Management*, *17*(2), 434–444. https://doi.org/10.1002/ieam.4334

Rusdi, R., Oktaviani, L., & Renata, R. (2025). Technological Innovation in Domestic Wastewater Treatment at FT. UNTIRTA Using a Combination of Ozonation, UV Light, and Aeration Processes. *World Chemical Engineering Journal*, *9*(2), 49–54. https://doi.org/10.62870/wcej.v9i2.37045

Samarajeewa, U. (2024). Safety, processing, and utilization of fishery products. *Fishes*, *9*(4), 146. https://doi.org/10.3390/fishes9040146

Setiawati, R., & Cadith, J. (2024). Institutions in System Implementation Waste Water Management Domestic Centralized (SPALD-T) in Pekayon Village Subdistrict Sukadiri Tangerang Regency. *Jurnal Multidisiplin Indonesia*, *3*(4), 3963–3967. https://doi.org/10.58344/jmi.v3i4.1148

Sherra, B. El, Dewata, I., & Anisa, L. (2024). Supporting capacity of water resources in fulfilling the target of sustainable development goals in Payakumbuh city. *AIP Conference Proceedings*, *3001*(1), 80025. https://doi.org/10.1063/5.0184176

Wati, F., Wibowo, D., Rosdiana, R., & Ilham, I. (2024). Analisis Potensi Kulit Jagung sebagai Media Adsorben terhadap Limbah Minyak dan Lemak. *Jurnal TELUK: Teknik Lingkungan UM Kendari*, *4*(1), 25–30. https://doi.org/10.51454/teluk.v4i1.566

Wibowo, D., Utomo, S. W., Nurdin, M., & Laksmono, B. S. (2026). Environmental Factors for Social Acceptance and Implementation Challenges of Desalination Technology: Insights from the Bajau Tribe in Southeast Sulawesi, Indonesia. *Sustainable Water Resources Management*, *12*(3). https://doi.org/10.1007/s40899-026-01330-y

Wirdatul, C., Hardianti, S., Sumianto, S., Asnimawati, A., & Gustriana, E. (2025). Peran Edukasi Masyarakat dan Dampak Banjir terhadap Kesehatan Lingkungan serta Proses Belajar Anak SD di Desa Batu Belah, Kabupaten Kampar. *ANTHOR: Education and Learning Journal*, *4*(2), 19–28. https://doi.org/10.31004/anthor.v4i2.373