Examining the key factors influencing the sustainability of domestic wastewater reuse in Jakarta using AHP method

Eliza Sinta Theresia[1], Rachmadhi Purwana[2], Iftita Rahmatika[3]

[1] Magister Program of Environmental Science, School of Environmental Science Universitas Indonesia, Central of Jakarta, Jakarta, Indonesia

[2] School of Environmental Science, Universitas Indonesia, Jakarta Pusat, Jakarta, Indonesia

[3] Environmental Engineering, Universitas Indonesia, Depok, Jawa Barat, Indonesia

* Corresponding author: eliza.sinta21@ui.ac.id

ARTICLE INFO

Article history
Submission: 21th Jan 2025
Revised: 16th Feb 2025
Accepted: 17th Feb 2025

AHP
Domestic Wastewater Reuse
Water Crisis
Sustainability
AHP

https://doi.org/10.22219/oe.2025.v17.i1.133

ABSTRACT

Population expansion, urbanization, economic development, pollution, and climate change are all contributing factors to the growing global problem of water shortage. The Sustainable Development Goals (SDGs) are in danger of being achieved because of this dilemma, particularly SDGs 6 and 11 on clean water and sanitation and sustainable cities, respectively. Only 65.9% of Jakarta's population has access to potable water, and water stress levels range from 40 to 80%. The government is planning a wastewater treatment system (SPALD-T) to recycle household wastewater and produce clean water in order to address this issue. TB. Simatupang's Water Treatment Plant (WWTP) still faces obstacles in adopting wastewater reuse, nonetheless. In Indonesia, wastewater recycling has received little attention, with the majority of studies concentrating on technical concerns rather than sustainability considerations. In contrast, technologies such as desalination and rainfall harvesting are being investigated worldwide. The objective of this research is to examine the technical and non-technical elements that affect wastewater recycling's effectiveness for the generation of sustainable clean water. The results will offer crucial information to help Perumda Paljaya create policies that will effectively utilize wastewater, which will help Jakarta accomplish its sustainable development goals more broadly.

1. Introduction

Water is a fundamental element for life (Bilal dkk., 2023). The availability of water resources is significantly influenced by factors such as population growth, urbanization, and economic development, which are often accompanied by overconsumption, pollution, and the effects of climate change (Bilal *et al*., 2023; Thomaz *et al*., 2023; United Nations Environment Programme, 2023; Tortajada, 2020). Water scarcity poses a serious threat to the achievement of the Sustainable Development Goals, particularly SDG 11 on sustainable cities and communities, and SDG 6 on clean water and sanitation (He dkk., 2021). According to UNESCO (2023) and He *et al*. (2021), it is predicted that by 2050, global water scarcity will increase by 80% compared to the water crisis of 2016. Jakarta is also facing a clean water crisis, evidenced by water stress levels ranging from 40-80%, and a clean water service coverage of only 65.9%. This coverage falls short of the target to provide 100% clean water services by 2030 (Perumda PAM Jaya, 2021).

Please cite this article as: Theresia, E.S., Purwana, R. & Iftita Rahmatika, I. (2025). Examining the key factors influencing the sustainability of domestic wastewater reuse in Jakarta using AHP method. *Operations Excellence: Journal of Applied Industrial Engineering*, 17(1), 79-89. doi:5http://dx.doi.org/10.22441/oe.2025.v17.i1.133

Potential solutions to water scarcity include desalination, rainwater harvesting, and wastewater reuse (Gleick & Cooley, 2021). Among these, the reuse (recycling) of wastewater as a source of clean water is still not widely implemented (Tortajada, 2020).To address the clean water crisis in Jakarta, the government, through Perumda Paljaya, plans to construct a centralized domestic wastewater management system (SPALD-T) in TB. Simatupang, with a treatment capacity of 6,000 m³/day for the Water Treatment Plant (WWTP), and equipped with an ultrafiltration system to produce raw water that meets drinking water quality standards (Perumda Paljaya, 2023). However, efforts to implement domestic wastewater reuse at SPALD-T TB. Simatupang face various challenges, which is why it is necessary to analyze the factors affecting the success of domestic wastewater reuse at TB. Simatupang Wastewater Treatment Plant (WWTP) as a raw water source for Cilandak Water Treatment Plant (WTP).

Understanding the factors that influence domestic waste recycling efforts is critical, as they significantly impact the sustainability of these initiatives. Analyzing these factors serves as a guide for Perumda Paljaya in developing an appropriate implementation strategy. Therefore, gaining insight into the factors that contribute to the successful implementation of domestic wastewater reuse for raw water production at water treatment plants is essential in designing a sustainable solution. By understanding these factors, Perumda Paljaya can ensure that this technology not only effectively provides clean water but is also widely accepted and adopted by the community, thus contributing to the achievement of broader sustainable development goals.

Studies conducted between 2004 and 2024 (Adewumi et al., 2010; C.Visvanathan & Asano, 2004; Eid-Sabbagh et al., 2022; Sgroi et al., 2018; Stathatou et al., 2014) show that the majority of research on water recycling is dominated by developed countries such as the United States, Australia, the United Kingdom, Iran, and Spain. In contrast, the potential of domestic waste recycling as a solution to the water crisis has been rarely explored in Indonesia. Most domestic wastewater recycling research in Indonesia focuses on the technical aspects of meeting quality criteria, leaving the non-technical factors related to the sustainability of wastewater recycling underexplored. Thus, this study aims to analyze both the technical and non-technical factors influencing the sustainability of domestic waste recycling efforts.

2. Methods

Research Methods

The research methods in this article include literature study, preparation of research instruments, data collection and data processing using Analytic Hierarchy Process (AHP) .

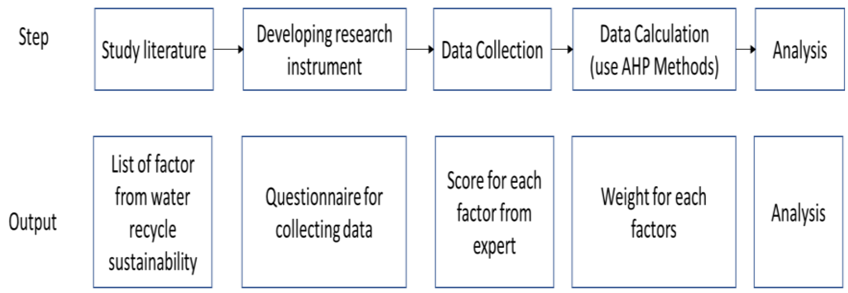

Fig 1. Research methods.

Case Illustration

Jakarta faces increasing demand for clean water, exacerbated by urbanization, population growth and periodic droughts. Jakarta relies heavily on limited freshwater sources, raising concerns over water availability and sustainability. Therefore, the case study in this research will take Jakarta as the object of research, especially in the case of domestic effluent recycle trials at the Buaran IPA, Cilandak IPA, Taman Kota IPA, Mookervaart IPA, and Penjaringan IPA by Perumda PAM Jaya.

Study Literature

Variable from this research found after conducting systematic literature review. Detail step on the literature review show on Fig.2.

Please cite this article as: Theresia, E.S., Purwana, R. & Iftita Rahmatika, I. (2025). Examining the key factors influencing the sustainability of domestic wastewater reuse in Jakarta using AHP method. *Operations Excellence: Journal of Applied Industrial Engineering*, 17(1), 79-89. doi:5http://dx.doi.org/10.22441/oe.2025.v17.i1.133

ISSN-p: 2085-1431
ISSN-e: 2654-5799

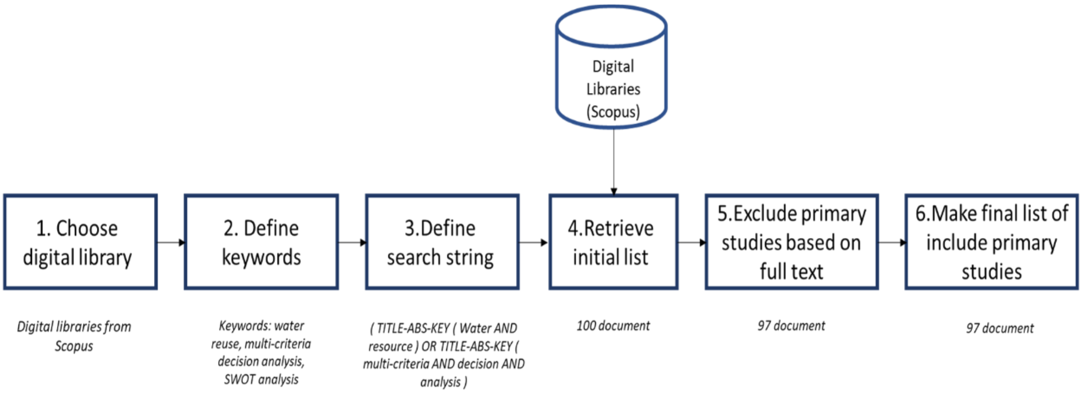

Fig. 2 Systematic literature review.

Based on the results of the literature review the factors influencing the sustainability of utilizing recycled domestic wastewater are seen in Table 1.

Table 1 Research variables

Factor	Sub-factor	Description	Source
Technical	Wastewater quantity	The amount of domestic wastewater generated from the community's domestic activities and then treated into a recycled water source.	Sgroi *et al*., 2018
	Wastewater quality	Recycled water must meet the standards set by relevant authorities, such as local health or environmental regulatory bodies, as well as established international standards.	Sgroi *et al*., 2018 Maryati *et al*., 2022
Economy	Investment cost	The costs incurred for the construction of recycling facilities include all expenses related to the planning and implementation of the project, including land acquisition, equipment procurement, construction costs, and administration of permits and approvals.	Chhipi-Shrestha *et al*., 2019, Ahmadi *et al*., 2020
	Operational and maintenance cost	The costs incurred for the operational and maintenance activities of recycled water facilities include all expenses related to daily operations, such as raw materials, energy, labor wages, routine maintenance, repairs, replacement of spare parts, and facility management administration.	Sgroi *et al*., 2018
	Wastewater reuse tariff	The costs charged by service providers to end users or beneficiaries of recycled domestic wastewater.	Cossio *et al*., 2020 Lee & Jepson, 2020
Social	Public acceptance	Public acceptance of the use of recycled domestic wastewater includes individuals' perceptions, beliefs, and attitudes toward its safety, quality, and benefits.	Chhipi-Shrestha *et al*., 2019
	Health risk	The potential hazards or threats to human health that may arise from the use of recycled domestic wastewater, particularly those related to pathogenic microorganisms, are a major concern.	Chhipi-Shrestha *et al*., 2019
	Government regulation	Policies and regulations established by the government to regulate and oversee the reuse of domestic wastewater.	Chhipi-Shrestha *et al*., 2019
	Field of word	Job opportunities arising from the activities of utilizing recycled domestic wastewater.	Akhoundi & Nazif, 2018

Please cite this article as: Theresia, E.S., Purwana, R. & Iftita Rahmatika, I. (2025). Examining the key factors influencing the sustainability of domestic wastewater reuse in Jakarta using AHP method. *Operations Excellence: Journal of Applied Industrial Engineering*, 17(1), 79-89. doi:5http://dx.doi.org/10.22441/oe.2025.v17.i1.133

Operations Excellence: Journal of Applied Industrial Engineering, 2025, 17(1): 79-89

Factor	Sub-factor	Description	Source
Environment	Clean water saving	The practice of using recycled domestic wastewater to reduce dependence on clean water from natural sources, such as rivers, lakes, and underground aquifers, is an effective way to save water.	Chhipi-Shrestha *et al*., 2019
	Energy usage	• The amount of energy required to operate the entire processing and recycling of domestic wastewater. • The amount of energy saved due to the use of recycled domestic wastewater.	Chhipi-Shrestha *et al*., 2019
	Carbon emission	• The amount of greenhouse gases released to the atmosphere as a result of the treatment and distribution process of domestic wastewater reuse. • The amount of carbon emissions not released to the atmosphere due to domestic wastewater reuse.	Chhipi-Shrestha *et al*., 2019
Institution	Establishment of rules and decision-making	The presence of regulations governing the treatment and use of recycled domestic wastewater ensures compliance with established safety and environmental standards. These regulations include technical requirements for treatment, water quality standards, and regulations related to the use and distribution of recycled water, all aimed at protecting public health and the environment, as well as maintaining the operational effectiveness of wastewater treatment facilities. These regulations form the foundation for decision-making.	Maryati *et al*., 2022
	Integrated corporate cooperation	Integrated company collaboration involves cooperation between wastewater companies, clean water providers, the government, and other private entities.	Maryati *et al*., 2022

The reason for selecting technical, economic, social, environmental and institutional factors is that these factors are considered to practically affect the sustainability of the domestic waste recycling process. Technical factors ensure the system is reliable, efficient and scalable; without effective technology, recycling is not feasible. “Economic” factors determine whether the system, which includes installation and maintenance costs, makes sense for the household. Environmental factors emphasize the importance of the system for water conservation and long-term sustainability, and social factors influence community acceptance and willingness to adopt the system, which is critical for widespread use. Finally, the “institutional” element ensures that policies, regulations, and incentives are in place to encourage and guide adoption.

Research Instrument

Analysis of the Sustainability Factors in Utilizing Recycled Domestic Wastewater Using Multi-Criteria Analysis (MCA). According to Silva *et al*. (2020), the steps involved in using the MCA analysis are as follows:

a. Determining factors and sub-factors: Identifying relevant factors for evaluating the alternatives.
b. Assigning weights to criteria: Building a hierarchy by assigning weights to each factor using the Analytical Hierarchy Process (AHP).
c. Evaluating alternatives: Assessing each alternative based on constructing a comparison matrix. Each element at the upper level is used to compare the elements at the lower level (alternatives).
d. Calculating final scores: Computing the final scores for each alternative based on the weight of each factor. These scores allow for comparison and selection of the most suitable alternative.
e. Selecting an alternative: The highest total score is the best solution.

ISSN-p: 2085-1431
ISSN-e: 2654-5799

In this study, the MCA analysis involves determining sustainability factors, identifying sub-factors, and assigning weights to each factor using the Analytical Hierarchy Process (AHP).

Analytical Hierarchy Process (AHP)

Saaty & Vargas (2012) states that AHP is an approach in decision-making that involves breaking down a problem into a hierarchy, illustrated by mapping the problem and making complex information more focused and detailed) (Saaty & Vargas, 2012). The main principle of AHP is to decompose a problem into systematic hierarchies and determine priorities using pairwise comparisons (Fukasawa & Mierzwa, 2020; Saaty, 1990, 2008). Step by step for AHP Calculation will be illustrated on Fig 3.

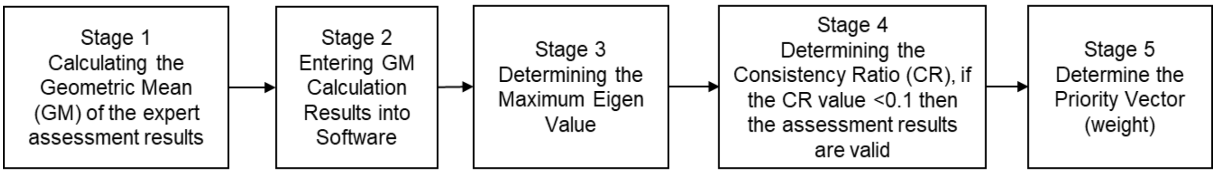

Fig 3. Step by Step AHP (Saaty & Vargas, 2012)

According to Saaty & Vargas (2012), there are 4 principles in the Analytical Hierarchy Process (AHP), namely (Mulyono, 2004):

1. Decomposition: is the process of solving a problem by breaking down the main complex issue into smaller and more detailed components using a hierarchical structure (Saaty, 1990). In this study, the model is constructed by considering three different levels: level 1 (research objective), level 2 (criteria), and level 3 (sub-criteria), as illustrated in Fig. 3.
2. Comparative judgement: is the process of giving a relative evaluation between two elements at a certain level. This evaluation is represented in a pairwise comparison matrix, which shows the preference levels between alternatives for each criterion. The weight of the evaluation is given on a scale from 1 to 9 for each criterion, indicator, and alternative in relation to the objective.
3. Synthesis of priority: is the presentation of the pairwise comparison matrix, which is then analyzed to determine the relative priority weights of each element in the matrix, including factors and sub-factors, to generate eigenvectors for determining local priorities. Since the pairwise comparison matrix appears at each level, synthesis of local priorities is done to obtain global priority.
4. Logical consistency: is the process of combining all eigenvectors generated from different hierarchical levels based on uniformity, relevance, and relationships between objects, resulting in a weighted composite vector to determine the decision-making sequence.

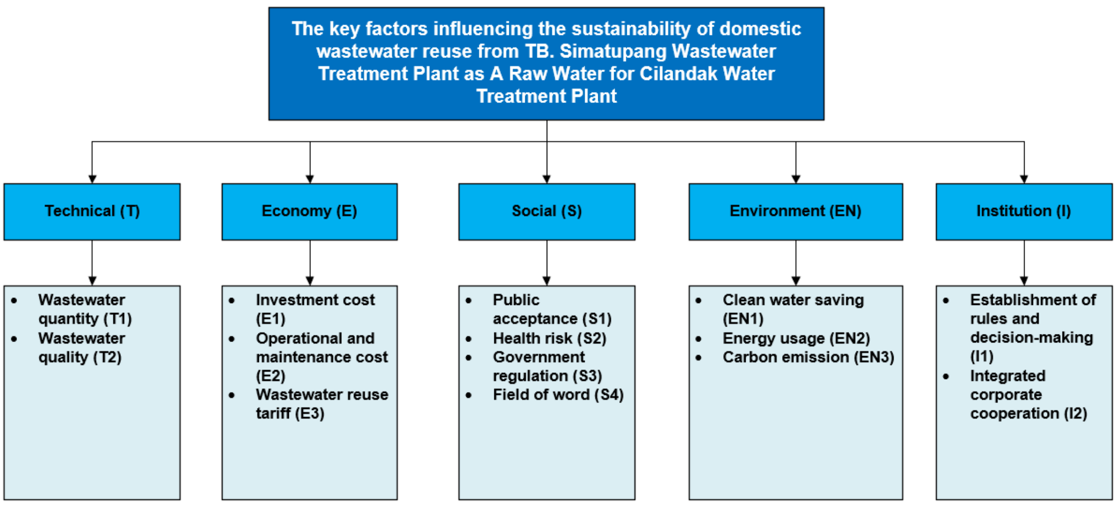

Fig. 3 Structure of AHP model.
Source: Author compilation, 2024

Please cite this article as: Theresia, E.S., Purwana, R. & Iftita Rahmatika, I. (2025). Examining the key factors influencing the sustainability of domestic wastewater reuse in Jakarta using AHP method. *Operations Excellence: Journal of Applied Industrial Engineering*, 17(1), 79-89. doi:5http://dx.doi.org/10.22441/oe.2025.v17.i1.133

AHP-OS

The Analytic Hierarchy Process Online System, abbreviated as AHP-OS, is a web-based software that adapts the multi-criteria decision-making method developed by Thomas L. Saaty. The main issue in traditional AHP is the inconsistency of respondents' answers, which is reflected in the Consistency Ratio (CR) value. Typically, the solution applied is to re-collect data until consistency is achieved, but this process is prone to repeated errors. With AHP-OS, the CR of respondents' answers can be calculated directly as they fill out the questionnaire, allowing them to assess and adjust the consistency of their answers in real-time (Goepel, 2018; Hutagalung & Hasibuan, 2019).

AHP-OS offers advantages in terms of easy modification of hierarchy definitions, convenient text file archiving, multi-language support with Unicode, and the ability to determine local weights, which are useful in evaluating alternatives (Goepel, 2018).In calculating the CR, AHP-OS uses the linear equation proposed by Alonso & Lamata (2006) , based on the average random consistency index, as a replacement for Saaty (2008) original consistency ratio calculation, as shown in the following equation:

OHP-OS Consistency ratio

$$CR = \frac{(\lambda_{max} - n)}{(2{,}7699n - 4{,}3513 - n)} \qquad (1)$$

Where:

λ_{max} = *Eigen value* maximum of matrix

n = Matrix of orde

If the consistency ratio exceeds 10%, AHP-OS will identify 3 inconsistent judgments. This equation can be applied to matrices larger than 10 x 10. In a decision hierarchy with more than one node, the consistency ratio of each hierarchical node is calculated, and for the global weights, the program will display the maximum value of all the consistency ratios (Goepel, 2018). Saaty & Vargas (2012), have shown that a CR value of <0.10 is acceptable or valid, whereas if the CR value is ≥0.10, the judgments provided by expert respondents are considered invalid and require re-examination.

Data Collection

The factor weight evaluation in this study was conducted by 12 respondents, including 10 practitioners and 2 academics. This approach was intended to ensure a comprehensive assessment. Table 2 presents the respondents who participated in the weight evaluation.

Table 2 List of respondents

No.	Party	Agency	Section	Category
1.	Central Government	Ministry of Public Works and Public Housing (PUPR)	Directorate General of Water Resources	Practitioner
2.	Regional Government	Regional Development Planning Agency (Bappeda) of DKI Jakarta Province	Urban Infrastructure and Environmental Management	Practitioner
3.	Regional Government	Environmental Agency (DLH) of DKI Jakarta Province	Environmental Planning Subgroup	Practitioner
4.	Regional Government	Water Resources Agency of DKI Jakarta Province	• Head of Geological, Raw Water Conservation, and Clean Water Supply Division • Head of Wastewater Management Division	Practitioner
5.	Regional Government	One-Stop Integrated Investment and Service Agency (DPM PTSP) of DKI Jakarta Province	-	Practitioner

Please cite this article as: Theresia, E.S., Purwana, R. & Iftita Rahmatika, I. (2025). Examining the key factors influencing the sustainability of domestic wastewater reuse in Jakarta using AHP method. *Operations Excellence: Journal of Applied Industrial Engineering*, 17(1), 79-89. doi:5http://dx.doi.org/10.22441/oe.2025.v17.i1.133

ISSN-p: 2085-1431
ISSN-e: 2654-5799

No.	Party	Agency	Section	Category
6.	Regional Government	Bureau of Development and Environmental Life, Regional Secretariat of DKI Jakarta Province	-	Practitioner
7.	Regional Government	Regional-Owned Enterprises (BP BUMD)	Business, Food, Utilities, Markets, and Industry Sector	Practitioner
8.	Regional-Owned Enterprise	Perumda Paljaya	President Director	Practitioner
9.	Regional-Owned Enterprise	Perumda PAM Jaya	President Director	Practitioner
10.	Non Governmental Organization	IUSWASH Tangguh	-	Practitioner
11.	University Lecturer	School of Environmental Science Universitas Indonesia	Lecturer	Academia
12.	University Lecturer	Environmental Engineering Universitas Indonesia	Lecturer	Academia

3. Results and Discussion

Calculation Results

One of the novelties in the analysis of factors affecting water recycling is the provision of a comprehensive framework that combines technical, economic, social and environmental elements. This framework shows how variables such as water quality, public acceptance, technological advances, and regulatory policies interact with each other, providing a broader understanding of water recycling issues. This method offers insights into creating customized, scalable, and sustainable recycling systems, especially in water-scarce regions, and helps inform policy and technology development.

The synthesis of the weighting results is a summary of the weighting results of the factors and subfactors determining the sustainability of the utilization of recycled water from TB. Simatupang Wastewater Treatment Plant (WWTP) as a raw water source for Cilandak Water Treatment Plant (WTP) which passed the consistency test. Table 3 is an overview of factor and subfactor weights. The weight value in column b of table 3 is the result of the calculation of the weight obtained from the results of the expert assessment at the variable level, while the assessment results in column d are the results of the assessment of each sub-factor. Factor and sub-factors assessments are obtained from the results of pairwise comparison questionnaire assessments at the factors and sub-factors levels conducted by experts.

Table 3 Calculation results of factor and sub factor weights using AHP

Factors	Weight	Sub factors	Weight Sub factors	Global weight	%	Rank
Technical (T)	0.20	Wastewater quantity (T1)	0.28	0.06	6%	10
		Wastewater quality (T2)	0.72	0.14	14%	1
Economy (E)	0.22	Investment cost (E1)	0.36	0.08	8%	4
		Maintenance and operational cost (E2)	0.31	0.07	7%	7
		Wastewater reuse tariff (E3)	0.33	0.07	6%	6

Please cite this article as: Theresia, E.S., Purwana, R. & Iftita Rahmatika, I. (2025). Examining the key factors influencing the sustainability of domestic wastewater reuse in Jakarta using AHP method. *Operations Excellence: Journal of Applied Industrial Engineering*, 17(1), 79-89. doi:5http://dx.doi.org/10.22441/oe.2025.v17.i1.133

Factors	Weight	Sub factors	Weight Sub factors	Global weight	%	Rank
Social (S)	0.25	Public acceptance (S1)	0.32	0.08	8%	5
		Human health risk (S2)	0.35	0.09	9%	3
		Government policy (S3)	0.24	0.06	6%	9
		Field of work (S4)	0.09	0.02	2%	14
Environment (L)	0.24	Clean water saving (EN1)	0.54	0.13	13%	2
		Energy usage (EN2)	0.28	0.07	7%	8
		Carbon emission (EN3)	0.18	0.04	4%	12
Institution (I)	0.09	Establishment of rules and decision-making (I1)	0.56	0.05	5%	11
		Integrated corporate cooperation (I2)	0.44	0.04	4%	13

Source: Author compilation, 2024

Based on the results of the weight calculation, it is known that according to the point of view of non-user stakeholder respondents, the Social factor has the highest weight of 0.25 (25%). The second highest weight is the Environmental factor with a weight of 0.24 (24%). Then the third highest weight is the Economic factor with a weight of 0.22 (22%). Then followed by Technical factors with a weight of 0.20 (20%). The lowest weight is on the Institutional factor with a weight of 0.09 (9%).

Globally, the level of importance of each sub factor to the research objectives shows that the sub factor Wastewater quality (T2) has the highest priority with a global weight of 0.14 (14%). The next most important sub factor is Clean water saving (EN1) with a global weight of 0.13 (13%), followed by the sub factor Human health risks (S2) which has a global weight of 0.09 (9%).

The justification for each research sub factor will be grouped into two classifications, namely high and low importance to the research objectives. This classification is determined based on the global weight through the scoring method, which is adjusted to the median global weight of each sub factor. The classification range is if the global weight of the sub factor is ≥ 0.07, then it falls into the high importance category, while if the global weight of the sub factor is < 0.07, it falls into the low importance category. Based on the classification results, eight sub-factors have a dominant influence on the sustainability of waste recycled water utilization, these eight factors include.

Wastewater quality (T2), Clean water savings (EN1), Human health risk (S2), Investment cost (E1), Public acceptance (S1), Wastewater reuse tariff (E3), Maintenance and operational cost (E2), and Energy usege (EN2) shown in the green graph. As for the subfactors that have a low effect on the sustainability of the utilization of recycled water TB. Simatupang Wastewater Treatment Plant (WWTP) as a raw water source for Cilandak Water Treatment Plant (WTP) is shown in a blue graph on Fig.4.

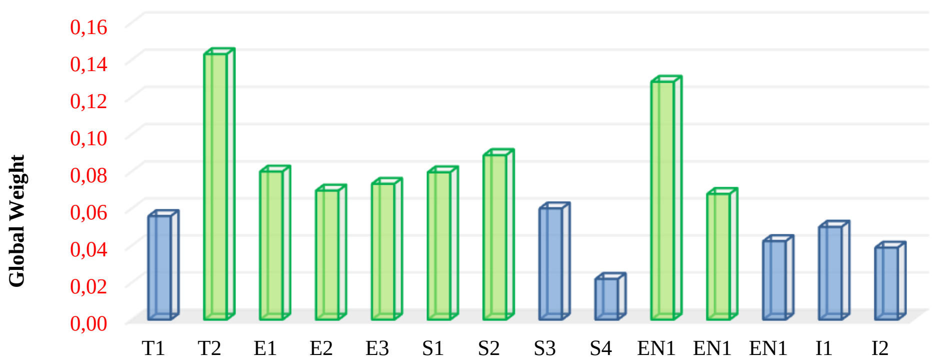

Fig 4. Sub-factor weight.

Analysis of Calculation Results

The weight in this study represents the contribution of factors to the utilization of recycled wastewater to meet clean water needs. A high weight value indicates that the factor has a large contribution. In this study, there are five factors that influence the utilization of recycled wastewater as a raw water source, namely economic, social, technical environment, and institutional factors (Tortajada, 2020). The role of the five factors in the utilization of recycled wastewater is in line with the pillars of sustainable development, this is in line with Tortajada's research, (2020) which reveals that economic, social and environmental factors in efforts to recycle wastewater are one of the efforts to achieve sustainable development goal number 6 (water and sanitation). The provision of clean water itself is also Indonesia's target in fulfilling access to clean water and sanitation, so knowing the factors that contribute to the successful utilization of recycled wastewater is in line with efforts to achieve sustainable development goals in Indonesia in general and Jakarta province in particular.

The results of the weight calculation using the AHP method show that the social factor with a weight of 0.251, is the most dominant factor. The second and third ranked influential factors are Environment (0.238) and Economy (0.228). This shows that the social aspect has the greatest contribution in decision-making, followed by environmental and economic factors. Social factors reflect the acceptance and benefits of water recycling for the community so that this factor will encourage other factors in an effort to support the implementation of domestic waste recycling to meet clean water needs. The Institutional factor has the lowest weight (0.089), indicating that the institutional aspect is the factor that has the lowest contribution.

Based on the results of the calculation of sub factor weights, from the Technical side, the quality of treated water (T2) has the highest global weight of 0.14. This achievement shows that the quality aspect is a priority in domestic wastewater utilization. The sub factor with the second priority is Clean water savings (L1) with a global weight of 0.13, indicating the importance of environmental impacts related to water savings. The sub-factor with the lowest weight is Sub factor Field of work (E4) with a global weight of 0.02. This shows that the aspect of job creation is a sub factor that has not seen its contribution in the community. The lack of new jobs from the new WWTP is an opportunity to develop a business (Priadi, C.R., Suleeman, E., Darmajanti, L., Novriaty, S., Suwartha, N., Resnawati, R., Handayani, R., Putri, G.L., Felaza, E., Tjahjono, 2017). This is in line with the research of Priadi et al., (2017) which shows that there is an additional new workforce in the company due to the additional WWTP facilities owned by the company, this case example shows that the utilization of domestic waste re-potential will absorb new workers.

In terms of ranking, the highest sub-factor is T2 (Wastewater quality), followed by EN1 (Clean water saving). This shows a strong focus on quality processed products and environmental sustainability. The lowest ranked is S4 (Field of work), followed by I2 (Integrated company cooperation). This aspect is less prioritized, perhaps because its impact is not as great as technical, economic or environmental aspects. Furthermore, sub-factors I2 (Integrated corporate cooperation) and I1 (Establishment of rules and decision-making) have low global weights. These values indicate that there is potential to improve institutional functioning and integration in project implementation. In addition, Field of work (S4) also has a very low global weight, indicating the need for additional strategies to increase social impact through job creation.

Research Contribution

The contribution of the results of this study on factors influencing the sustainability of water recycling lies in identifying and understanding the key elements that influence the successful implementation and long-term viability of household water recycling systems. The results of the influential factor analysis can be used in appropriate policy development efforts (providing governments and organizations with information on the regulations, incentives and support needed to promote the use of water recycling), knowing the appropriate technology design in water recycling sustainability and providing appropriate strategies to increase the public's desire to use recycled water.

Further Research

Further research could focus on technologies that facilitate the channelling of domestic sewage to centralized collection sites, and further research could also focus on cost-benefit models and financial incentives that can make water recycling more affordable and accessible. Further research could also focus on analyzing how domestic water recycling can be integrated with urban infrastructure to improve overall water management. These future research developments will not only advance water recycling systems but also create opportunities to patent technologies, making solutions more effective, scalable and feasible for global water conservation efforts.

4. Conclusion

The results of the AHP analysis show that social, environmental, and economic factors have the greatest contribution to the sustainability of the utilization of recycled water from TB. Simatupang Wastewater Treatment Plant (WWTP) as a raw water source for Cilandak Water Treatment Plant (WTP). Social factors gaining the highest weight (0.25), followed by environmental (0.24) and economic (0.22) factors. The most important sub factor is the quality of wastewater quality (T2) with a global weight of 0.14, followed by clean water saving (EN1) with a weight of 0.13. The institutional factor has the lowest weight, indicating that institutional aspects are less influential in wastewater utilization decisions. This analysis is in line with the principles of sustainable development and supports the achievement of the Sustainable Development Goals (SDGs), particularly in relation to water supply and sanitation in Indonesia.

References

Adewumi, J. R., Ilemobade, A. A., & Van Zyl, J. E. (2010). Treated Wastewater Reuse in South Africa: Overview, Potential and Challenges. *Resources, Conservation and Recycling*, *55*(2), 221–231. https://doi.org/10.1016/j.resconrec.2010.09.012

Ahmadi, E., McLellan, B., Mohammadi-Ivatloo, B., & Tezuka, T. (2020). The Role of Renewable Energy Resources in Sustainability of Water Desalination as a Potential Fresh-water Source: An Updated Review. *Sustainability (Switzerland)*, *12*(13). https://doi.org/10.3390/su12135233

Akhoundi, A., & Nazif, S. (2018). Sustainability Assessment of Wastewater Reuse Alternatives Using The Evidential Reasoning Approach. *Journal of Cleaner Production*, *195*, 1350–1376. https://doi.org/10.1016/j.jclepro.2018.05.220

Alonso, J. A., & Lamata, T. (2006). Consistency in The Analytic Hierarchy Process: A New Approach. *International Journal of Uncertainty, Fuzziness and Knowledge-Based Systems*, *14*(4), 445–459.

Bilal, M., Usman, M., Nadeem, M., & Shah, S. A. R. (2023). *Water Security and Environmental Impact Assessment: A Study for Developing Economies*. 90. https://doi.org/10.3390/ecws-7-14325

C.Visvanathan, & Asano, T. (2004). *The Potential for Industrial Wastewater Reuse: Vol. I*.

Chhipi-Shrestha, G., Rodriguez, M., & Sadiq, R. (2019). Selection of sustainable municipal water reuse applications by multi-stakeholders using game theory. *Science of the Total Environment*, *650*, 2512–2526. https://doi.org/10.1016/j.scitotenv.2018.09.359

Cossio, C., Norrman, J., McConville, J., Mercado, A., & Rauch, S. (2020). Indicators for Sustainability Assessment of Small-scale Wastewater Treatment Plants in Low and Lower-middle Income Countries. *Environmental and Sustainability Indicators*, *6*(March 2020), 100028. https://doi.org/10.1016/j.indic.2020.100028

Eid-Sabbagh, K., Roukoz, S., Nassif, M.-H., Velpuri, N., & Mateo-Sagasta, J. (2022). *Analysis of Water Reuse Potential for Irrigation in Lebanon*. IWMI Research Report 181.

Fukasawa, B. N., & Mierzwa, J. C. (2020). Identification of Water Reuse Potential in Metropolitan Regions using the Analytic Hierarchy Process. *Environmental and Sustainability Indicators*, *8*(July), 1–14. https://doi.org/10.1016/j.indic.2020.100064

Gleick, P. H., & Cooley, H. (2021). Freshwater Scarcity. *Annual Review of Environment and Resources*, *46*, 319–348. https://doi.org/10.1146/annurev-environ-012220-101319

Goepel, K. (2018). Implementation of an Online software tool for the Analytic Hierarchy Process (AHP-OS). *International Journal of the Analytic Hierarchy Process*, *10*(3), 469–487. https://doi.org/10.13033/ijahp.v10i3.590

He, C., Liu, Z., Wu, J., Pan, X., Fang, Z., Li, J., & Bryan, B. A. (2021). Future Global Urban Water Scarcity and Potential Solutions. *Nature Communications*, *12*(1), 1–11.

https://doi.org/10.1038/s41467-021-25026-3

Hutagalung, A. O., & Hasibuan, S. (2019). Determining the Priority of Medical Equipment Maintenance with Analytical Hierarchy Process. *International Journal of Online & Biomedical Engineering*, *15*(10).

Lee, K., & Jepson, W. (2020). Drivers and Barriers to Urban Water Reuse: A systematic Review. *Water Security*, *11*(February), 100073. https://doi.org/10.1016/j.wasec.2020.100073

Maryati, S., Firman, T., & Humaira, A. N. S. (2022). A Sustainability Assessment of Decentralized Water Supply Systems in Bandung City, Indonesia. *Utilities Policy*, *76*(March), 101373. https://doi.org/10.1016/j.jup.2022.101373

Mulyono, S. (2004). *Riset Operasi*. LP-Fakultas Ekonomi Universitas Indonesia.

Perumda Paljaya. (2023). *Pembangunan IPALD dan Pemasangan Pipa Air Limbah*.

Perumda PAM Jaya. (2021). *Annual Report PAM Jaya 2021*.

Priadi, C.R., Suleeman, E., Darmajanti, L., Novriaty, S., Suwartha, N., Resnawati, R., Handayani, R., Putri, G.L., Felaza, E., Tjahjono, T. (2017). Water Recycling Opportunity in the Business Sectors of Greater Jakarta Indonesia. *Indonesia. International Journal of Technology*, *8*(6), pp.1031-1039.

Saaty, T. L. (1990). *How to Make a Decision The Analytic Hierarchy Process* (Vol. 48, Nomor 1, hal. 9–26). European Journal of Operational Research.

Saaty, T. L. (2008). Decision Making With the Analytic Hierarchy Process. *Int. J. Services Sciences*, *1*(1).

Saaty, T. L., & Vargas, L. G. (2012). *Models , Methods , Concepts & Applications of the Analytic Hierarchy Process*. Springer New York Heidelberg Dordrecht London. https://doi.org/10.1007/978-1-4614-3597-6

Sgroi, M., Vagliasindi, F. G. A., & Roccaro, P. (2018). Feasibility, Sustainability and Circular Economy Concepts in Water Reuse. *Current Opinion in Environmental Science and Health*, *2*, 20–25. https://doi.org/10.1016/j.coesh.2018.01.004

Silva, H., Blengini, A., Mota, L., Pezzuto, C., Lavorato, M., & Carvalho, M. (2020). Multi-criteria Analysis of Brazilian Wind Farms. *International Journal of Renewable Energy Research*, *10*(2), 1042–1053. https://doi.org/10.20508/ijrer.v10i2.10914.g7976

Stathatou, P., Gad, F. K., Kampragou, E., & Grigoropoulou, H. P. (2014). *Treated Wastewater Reuse Potential: Mitigating Water Scarcity Problems in The Aegean Islands*. *July*. https://doi.org/10.1080/19443994.2014.934108

Thomaz, F. R., Miguez, M. G., de Souza Ribeiro de Sá, J. G., de Moura Alberto, G. W., & Fontes, J. P. M. (2023). Water Scarcity Risk Index: A Tool for Strategic Drought Risk Management. *Water (Switzerland)*, *15*(2). https://doi.org/10.3390/w15020255

Tortajada, C. (2020). Contributions of recycled wastewater to clean water and sanitation Sustainable Development Goals. *npj Clean Water*, *3*(1). https://doi.org/10.1038/s41545-020-0069-3

UNEP. (2023). *Wastewater – Turning Problem to Solution. A UNEP Rapid Response Assessment*. United Nations Environment Programme.

UNESCO. (2023). *The United Nations World Water Development Report 2023 - Partnerships and Cooperation for Water*. United Nations Educational, Scientific and Cultural Organization. https://doi.org/10.1016/B978-0-12-821057-4.00003-3

Please cite this article as: Theresia, E.S., Purwana, R. & Iftita Rahmatika, I. (2025). Examining the key factors influencing the sustainability of domestic wastewater reuse in Jakarta using AHP method. *Operations Excellence: Journal of Applied Industrial Engineering*, 17(1), 79-89. doi:5http://dx.doi.org/10.22441/oe.2025.v17.i1.133