Original Research Article

Effectiveness and Spatial Distribution of Wastewater Land Application Technical Approval in East Java

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Abstract

The management of industrial wastewater presents a considerable challenge to governments globally, mainly because of the difficulties faced in ensuring that regulatory frameworks are properly instituted. This study evaluated the success of the technical approval for using wastewater" regulatory framework and its geographic spread across East Java. This was evaluated using data from 35 business participants from 16 different districts/cities via a combination of quantitative (survey) and qualitative (spatial analysis) methods. The overall effectiveness of the regulatory framework was rated high (84.69%), with the dimension "Regulatory Appropriateness" rated the highest (85.57%), while the dimension "Environmental Appropriateness" ranked the lowest (84.14%). From the geographic analysis, it was evident that cities and industrial centers dominated the level of support, with many non-industrial areas displaying very little engagement. Collectively, these results demonstrate the need for policies to be designed with a geographic perspective and for sufficient institutional support to be targeted towards non-urban areas. This will allow stakeholders to provide the required technical support, increase the utilization of technology to enhance service delivery, and engage the local workforce to the greatest degree possible to enable sustainable and equitable environmental governance.

Keywords: East Java; Effectiveness; Irrigation; Spatial Analysis; Technical Approval; Wastewater

1.   Introduction

East Java Province represents the second largest share of Indonesia's Gross Regional Domestic Product (GRDP), as a result of a high degree of industrial activity within the province. In 2024, there were an estimated 858,000 industrial businesses operating within East Java Province (East Java Provincial Department of Industry and Trade, 2025). While industrial growth has provided considerable economic benefits, it has also led to an increased burden on environmental resources. Considerable scholarly efforts have illustrated that the increase in industrial activity and the related degradation of the natural environment associated with industrial activity have become a national and global concern (Fuller _et al._, 2022). This situation has led to the need for policies regarding wastewater management that not only encourage compliance but can also be successfully implemented.

To address these concerns, the Indonesian government has undertaken to transform its policies through the Job Creation Law and Minister of Environment Regulation Number 5 of 2021. This regulation changed the mechanism for obtaining a liquid waste discharge permit (IPLC) to obtaining technical approval to comply with wastewater quality standards. It also promotes the use of wastewater through land application as a new and more environmentally friendly approach for reusing wastewater. However, to date, there have been no adequate studies to investigate how this policy can be implemented and the degree of variability in implementation at the regional level owing to differing industrial characteristics within each region.

Most past research has relied on the results from individual companies or sectors that utilize land for their operations and has provided evidence of how Rahmatanti and Purnomo, 2024). Previous studies on land-based wastewater treatment have generally focused on individual companies or specific sectors, demonstrating successful implementation in certain cases (Safa et al., 2025; Rahmatanti & Purnomo, 2024). However, these studies lack a broader regional perspective to evaluate the overall effectiveness of the policy. Furthermore, there is limited literature addressing how the policy is applied across different regions and how geographical variations may influence its implementation. Existing research has also not adequately identified systemic barriers that hinder companies from adopting this approach. According to the East Java Provincial Environmental Agency, there is a significant gap between the level of industrial interest and the actual implementation of policies related to the use of agricultural land for wastewater treatment. Although many companies have obtained technical approval, only a small proportion have proceeded with implementation.
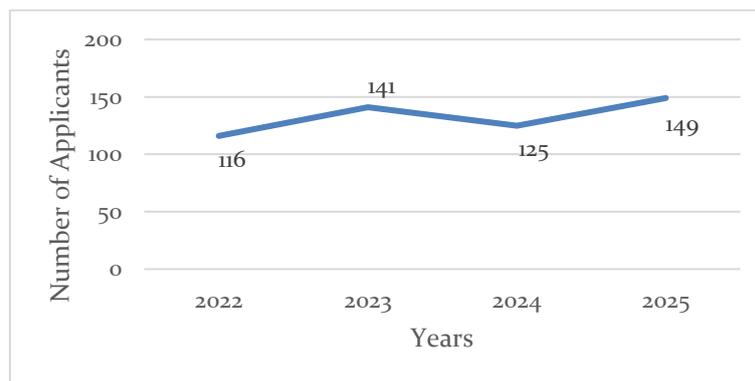

Figure 1 Graph of applicants for technical approval for wastewater utilization for land application, 2022 – 2025

Source : East Java provincial environmental services, March 2025

Considering this gap, this study intends to investigate the outcomes from applying technical approval for land-based wastewater utilization by using a multi-dimensional approach using spatial analysis. Although technical approval to use land for wastewater (WW) has been distributed across many locations, there is little information available regarding its current implementation across different locations or its effectiveness. The evaluation of the effectiveness of technical approval for land-based wastewater utilization in being implemented correctly, supporting active engagement, and ensuring that the policy is being targeted appropriately to achieve sustainable WW management will assist with the identification of how to better inform future policy changes. Unlike micro-level studies conducted previously, this study has developed a new methodology using the five-dimensional effectiveness framework and combining it with GIS analysis to identify WW usage hotspots, cold spots, and priority use areas. This research will provide scientifically based information about spatially based policies for environmental management and will enable the development of evidence-based recommendations.

In summary, prior studies have largely focused on success factors at the micro level, with limited attention paid to systemic and multidimensional barriers or comprehensive effectiveness measurements.

This study addresses that gap by applying Riant Nugroho's Five Dimensions of Policy Accuracy (5 Tepat) within an integrated effectiveness framework, combined with spatial analysis, to evaluate the implementation of Technical Approval for land-based wastewater utilization in East Java Province, thereby offering a novel, holistic, and evidence-based perspective for adaptive and targeted policy improvement

2. Methods

2.1 Research Design

This study employs a total population approach, as described by Ahmed and Khalid (2025), which involves including all members of the population to ensure data accuracy and representativeness. The study population consisted of all business actors holding a technical permit for wastewater utilization for land application that were active as of June 2024, with a minimum wastewater discharge of 10 m³/day, totaling 35 business actors. The 35 business actors represented the entire population that met these criteria. A minimum limit of 10 m³/day was chosen to ensure that the business units analyzed had a significant operational scale and environmental impact, thus making the evaluation of policy effectiveness more relevant at a macro-regional level. Because the population size is limited and cannot be fully accessed, this study used the total population as a sample, including every business actor with a wastewater discharge criterion of ≥10 m³/day. Therefore, probabilistic sampling calculations, such as the Slovin or Cochran formulas, were not used because the entire relevant population was analyzed to increase precision and reduce sampling bias.

2.2 Research Location and Time

From July to November 2025, data collection was conducted in East Java Province via the province 's 29 regencies and nine cities. East Java Province is one of the largest contributors to Indonesia's gross regional domestic product (GRDP); by 2024, it will house approximately 858,000 industrial locations (East Java Provincial Department of Industry and Trade, 2025). The concentration of industrial activities in East Java contributes to environmental pressures, including the generation of wastewater, thus providing an appropriate opportunity to assess the effectiveness of the Technical Approval of Wastewater Utilization (TAWUP) Policy. The geographic areas selected for this study reflect all administrative areas that have been approved for wastewater usage by business entities. Therefore, they serve as representative samples of the target population.

2.3 Population and Sample

This study employs a total population approach, as described by Ahmed (2024), which involves including all members of the population to ensure data accuracy and representativeness. The study population consisted of all business actors holding a technical permit for wastewater utilization for land application that were active as of June 2024, with a minimum wastewater discharge of 10 m³/day, totaling 35 business actors. The number of research samples was 35 business actors; therefore, the relevant population was limited to these 35 business actors spread across 38 regencies/cities in East Java Province. The minimum limit of 10 m3/day was chosen to ensure that the business units analyzed had a significant operational scale and real environmental impact, such that the evaluation of policy effectiveness was more relevant macro-regionally. Because the population is limited and can be accessed comprehensively, this study uses the total population as a sample; therefore, every business actor with a wastewater discharge criterion of ≥10 m³/day was included. Thus, no probabilistic sampling calculations, such as the Slovin or Cochran formulas, were performed, as the entire relevant population was analyzed to increase precision and reduce sampling bias.

The sampling process was conducted on business entities permitted by the East Java Provincial Environmental Service that discharge wastewater at a minimum rate of 10 m³/day and successfully obtained Technical Approval (Pertek) in 2024. This study's sampling included 35 businesses divided by

administrative areas throughout East Java to ensure a representative sample concerning where each business is located, including 29 districts and 9 municipalities. The following illustrates the number of businesses located within each of the aforementioned areas: Surabaya City (11), Mojokerto Regency (3), Sampang Regency (1), Pasuruan Regency (3), Sidoarjo Regency (4), Gresik Regency (2), Nganjuk Regency (1), Malang Regency (1), Malang City (2), Batu City (1), Tulungagung Regency (1), Situbondo Regency (1), Madiun City (1), Bangkalan Regency (1), Ponorogo Regency (1), and Jombang Regency (1). By using spatial analysis of these businesses to find clusters, hotspots, and cold spots where this policy is being implemented in East Java, it also provides a better understanding of where industrial density is located and its relationship to the level of success in implementing Technical Approvals.

2.4   Analysis of the Effectiveness of Wastewater Technical Approval Policy Implementation

To assess the effectiveness of executing Technical Approval for Wastewater Utilization, five of Tepat Nugroho's (2012) dimensions were compiled, and questionnaires from 35 business respondents were used. The five dimensions of Tepat Nugroho (2012) used to assess the implementation of waste management policy are assessed as follows. The analysis will evaluate the full scope of environmental policy implementation, from how environmentally friendly and sustainable waste management practices, as well as other types of waste management practices, such as industry requirements, environmental impacts, and effective project management practices, were incorporated into and developed through the research method used. This comprehensive methodology is an important consideration for future recommendations regarding sustainable, adaptive, and targeted wastewater management practices and will serve as a measure for assessing the overall success of the policies implemented. The specific key area indicators of each dimension are shown in Table 1 along with the closed-ended questionnaire, which utilized a Likert scale to measure responses.

$$Effectiveness = \frac{Achieved\ Score}{Expected\ Score}\ x\ 100\%$$

Table 1. Questionnaire dimensions and indicators

Dimensions	Indicators	Questions
Appropriate Policy	- Environmental effectiveness and water efficiency - Quality of studies and technical databases - Policy adaptability to regional variations and business types - Regulatory compliance	- Technical approval for wastewater utilization for land applications is appropriate and beneficial for addressing water pollution issues (e.g., businesses can conserve clean water for irrigation activities). - Technical approval for wastewater utilization for land application is based on adequate data and technical studies and is adapted to current conditions. - Technical approval for wastewater utilization for land application can be adapted to regional conditions and different business types (e.g., can be seen from the calculation of wastewater dosage based on rainfall in each region and soil conditions if wastewater is used for irrigation). - The technical approval policy for wastewater utilization for land application complies with the provisions of Minister of Environment Regulation Number 5 of 2021.
Appropriate Process	- Transparency and Clarity of Licensing Mechanisms	- The mechanism for issuing technical approvals for wastewater utilization for land application is clear, transparent, and easy for business actors to

Dimensions	Indicators	Questions
	- Compliance with Standard Operating Procedures (SOPs) - Quality of Communication and Coordination - Compliance with Wastewater Quality Standards	understand. - The process for submitting, reviewing, and discussing technical documents is conducted in accordance with standard operating procedures (SOPs). - Communication and cooperation between business actors and the East Java Provincial Environmental Agency in the technical approval process for wastewater utilization for land application is effective and responsive. - The application of wastewater quality standards is in accordance with the type of activity and applicable regulatory provisions (National Quality Standard References, such as the Ministry of Environment's Wastewater Quality Standard Directive for Watering Activities, Regulation of the Minister of Environment and Forestry Number 5 of 2014, and Regulation of the Minister of Environment and Forestry Number 68 of 2016)
Targeted	- Policy relevance to business producing liquid waste - Environmental and operational benefits compared to discharge into water bodies - Business commitment to waste management - Perception of policy fairness for all business scales	- Technical approval for wastewater utilization for land application targets businesses that have the potential to generate significant amounts of liquid waste (do companies agree to the technical limitations imposed by wastewater discharge)? - The policy on technical approval for wastewater utilization for land application is more beneficial than discharge into water bodies. - Technical approval for wastewater utilization for land application encourages businesses to be more committed to waste management. - The rules in the technical approval for wastewater utilization for land application are perceived as fair by small, medium, and large businesses.
Environmentally Appropriate	- Reducing the impact of water pollution - Improving wastewater quality - Adopting environmentally friendly technologies - Increasing environmental awareness and commitment	- Implementing technical approval for wastewater utilization for land application significantly contributes to reducing water pollution. - After implementing technical approval for wastewater utilization for land application, wastewater quality improves (meets quality standards; if not, state the parameters that do not meet them) - Technical approval for wastewater utilization for land application encourages the use of environmentally friendly technologies appropriate to business conditions. - Technical approval of wastewater utilization for land application encourages business actors to be more concerned with environmental management.

Dimensions	Indicators	Questions
Appropriate Implementation	- Quality of technical assistance provided by the Provincial Environmental Agency - Responsibility and resolution of obstacles - Consistency of supervision and evaluation - Participation of business actors and consultants in technical approvals for wastewater utilization	- The East Java Provincial Environmental Agency (DLH) provides adequate technical assistance regarding the implementation of technical approvals for wastewater utilization for land application. - The East Java Provincial Environmental Agency (DLH) is responsive and provides solutions to obstacles faced by business actors in implementing technical permits for wastewater utilization for land application. - Monitoring and evaluation of the implementation of technical permits for wastewater utilization for land application are conducted routinely and on a scheduled basis. - The preparation of technical approvals for wastewater utilization for land application involves business actors and consultants to ensure that the results are more in line with field conditions.

Based on the score measurement results, further analysis was conducted to compare the effectiveness measurements across the measurement scale and classification. The measurement scales and classifications are presented in Table 2.

Table 2 Measurement scales and classifications

Measurement	Criteria
≤20%	Very ineffective
21% – 40 %	Ineffective
41% – 60 %	Moderately effective
61% – 80 %	Effective
81% – 100 %	Very effective

Source : Prinardi, et al., 2023

2.5 Data Analysis Techniques

The questionnaire instrument used in this study underwent validity and reliability testing to ensure data quality. Validity testing was conducted by comparing the r values calculated with the table r values. If the calculated r value was higher than the table r value, the question was considered valid. In contrast, if the calculated r value was lower than the table r value, the question was considered invalid. Furthermore, reliability testing was conducted using Cronbach's alpha coefficient. The questionnaire was considered reliable if Cronbach's alpha was higher than 0.70; otherwise, it was considered unreliable. The validity and reliability tests of the questionnaire were done using the Statistical Package for the Social Sciences (SPSS) software.

The spatial analysis in this study integrated hotspot analysis (Getis-Ord Gi*), spatial autocorrelation (Moran's I), and overlay analysis to evaluate the implementation of the Technical Approval for Compliance with Wastewater Quality Standards (Persetujuan Teknis Pemenuhan Baku Mutu Air Limbah, hereafter referred to as Pertek BMAL) application on land. Hotspot analysis identified groups of areas with high or low implementation, Moran's I assessed spatial dependencies between locations, and overlay analysis evaluated the suitability of business locations with the regional spatial plans of districts or cities in East Java Province. This combination of methods maps spatial patterns of

implementation, determines priority groups for intervention, and supports adaptive and targeted wastewater management policy planning.

3. Result and Discussion

A descriptive quantitative approach describes phenomena through numerical data analysis (Nurhabibah et al., 2023). This quantitative approach was used to calculate the level of effectiveness based on business actor compliance indicators.

3.1 Instrument Reliability

To ensure that the distributed questionnaire accurately reflects the conditions in the field, validity and reliability testing were conducted prior to its widespread use. Validity testing is necessary to ensure that each question is genuinely relevant and represents the aspects intended to be measured. When the calculated r value is greater than the table r value, the questionnaire is considered valid (Kaligis et al., 2022).

Following the validity test, a reliability test was conducted. Reliability testing ensures that the questionnaire provides consistent results, ensuring that respondents' answers are reliable and do not vary simply due to differences in completion time. When the Cronbach's Alpha value is greater than 0.7, the statement is considered reliable (Izah et al., 2024). The test was conducted at a 95% confidence level, with the results shown in Table 3.

Table 3. Results of validity and reliability testing of research instruments

No	Dimension	R calculate	R table	Validity	Reliability
1.		0.821	0.334	Valid	
2.	Appropriate	0.894	0.334	Valid	0.856
3.	policy	0.927	0.334	Valid	
4.		0.701	0.334	Valid	
5.		0.840	0.334	Valid	
6.	Appropriate	0.925	0.334	Valid	0.867
7.	process	0.887	0.334	Valid	
8.		0.741	0.334	Valid	
9.		0.930	0.334	Valid	
10.	Targeted	0.748	0.334	Valid	0.842
11.		0.774	0.334	Valid	
12.		0.871	0.334	Valid	
13.		0.837	0.334	Valid	
14.	Environmentally	0.882	0.334	Valid	0.852
15.	appropriate	0.923	0.334	Valid	
16.		0.696	0.334	Valid	
17.		0.719	0.334	Valid	
18.	Appropriate	0.905	0.334	Valid	0.852
19.	implementation	0.799	0.334	Valid	
20.		0.925	0.334	Valid	

The analysis of validity value variations demonstrates the instrument's sensitivity to respondent perceptions. Item 3, in the "on target" dimension, has the highest validity (0.930), indicating that institutional coordination is highly relevant and easy to understand, and a crucial factor in successful policy implementation. Conversely, Item 9, in the "on environmental" dimension, has the lowest validity (0.696), still above the threshold, but more sensitive because of the complexity of assessing environmental conditions and the relationship between technical measures and ecological impacts.

These results emphasize the need to focus on indicators with lower validity to ensure accurate and consistent interpretation of the environmental dimensions.

Based on reliability testing, all dimensions of the study variables demonstrated Cronbach's Alpha values above 0.70, indicating excellent internal consistency (Saleh et al., 2022). This high value indicates that the items within each construct are consistently correlated, such that each question consistently contributes to the measurement of the same variable. In other words, the instrument accurately and uniformly captures the concepts being measured, making it reliable and suitable for further analysis.

This high reliability coefficient meets statistical requirements and has important substantive implications for research, namely, the coherence of the theoretical framework, which empirically proves that the five dimensions in the framework (Morris, 2021)–policy, process, target, environment, and implementer–are not separate constructs but form a solid and interrelated conceptual unit in measuring policy effectiveness.

3.2 Spatial Distribution Findings

Spatial analysis was carried out to identify the geographical distribution of patterns in the implementation of Technical Approval policies, which could not be deduced from descriptive statistics alone. Figure 2 depicts a striking spatial division in East Java Province. The greatest concentration of technical approval applicants using wastewater for soil irrigation is in urban and industrial areas, especially in Surabaya City and Sidoarjo Regency, resulting from high levels of business activity and compliance with waste management regulations. In total, applicants are spread out over 38 regencies/cities, with the highest figures in the industrial areas of Surabaya, Sidoarjo, Gresik, and Pasuruan. In contrast, the Jombang, Bojonegoro, and Banyuwangi areas are showing signs of an upturn in participation. This demonstrates the increasing awareness of business actors regarding sustainable waste management.
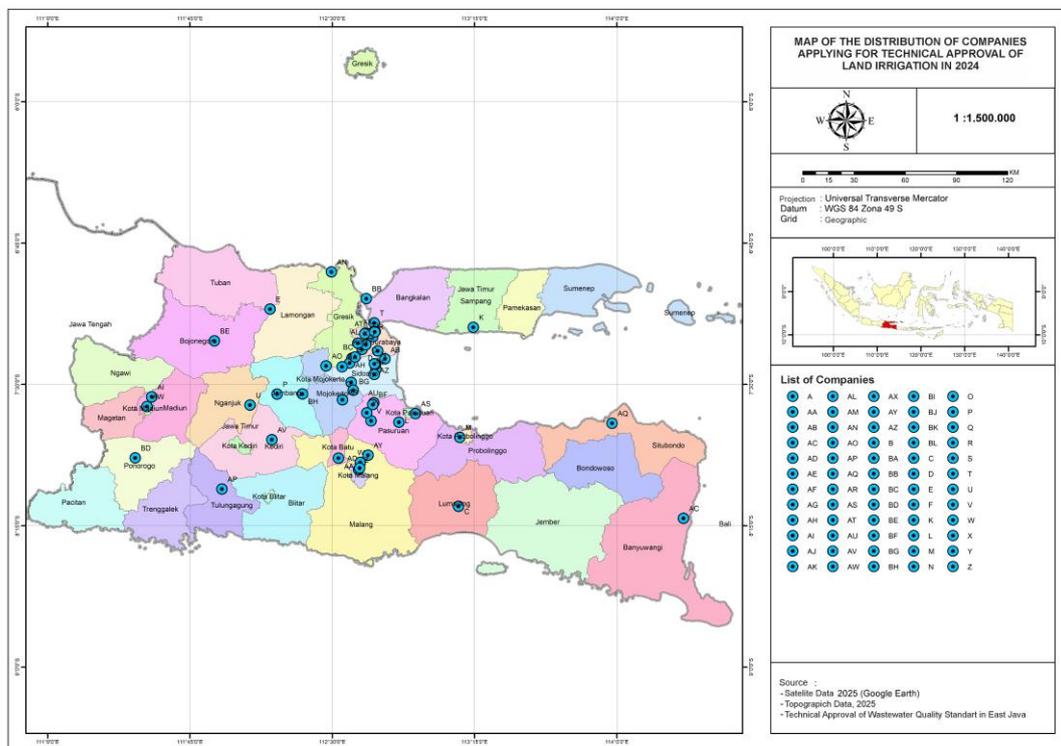

Figure 2. Map of distribution of technical approval applicants

Several regions, such as Trenggalek, Pacitan, Jember, Bondowoso, Ngawi, Magetan, Kediri, Tuban, Pamekasan, and Sumenep, have not submitted technical approvals for wastewater utilization for

soil irrigation. According to clarification from the East Java Provincial Environmental Agency (DLH), this situation is primarily due to the absence of changes in business activities that would require the submission of a new technical approval, as businesses in these areas generally continue to operate in accordance with the existing liquid waste discharge permit (IPLC) they already hold. In addition, the characteristics of the region, which is dominated by small- and medium-sized businesses, have resulted in limited waste management obligations, such that most businesses are not yet required to have a complete waste treatment system and thus are not regularly monitored. Another contributing factor is the limited dissemination of regulations and the level of business compliance with waste management, which is influenced by limited access to information, technical capacity, and assistance (Haidar et al., 2024; Annahar et al., 2023). This spatial imbalance indicates the need to strengthen guidance, technical assistance, and regulatory education in areas with relatively low business activity intensity. Conversely, areas with high industrial activity intensity, such as Surabaya and Sidoarjo, show a greater number of technical approval applications due to a higher frequency of business activity changes and relatively stronger compliance with regulations (Dias et al., 2023).

Application locations combined with information from the East Java Provincial Spatial Plan (RTRW) were used to perform an overlay analysis of the application of Technical Approval for wastewater utilization for soil irrigation. This study refers to the irrigation location's alignment with the spatial plan. As shown in Figure 3, most of the approved applicants' locations fall under the areas designated as industrial and cultivation in the 2023–2043 RTRW (Regional Spatial Plan), with the highest industrial-related locations in Surabaya, Sidoarjo, Gresik, Mojokerto, and Pasuruan. Places with only small wastewater discharges, such as Madiun, Kediri, Jember, and Banyuwangi, show a more random pattern; however, they are more manageable because of their land capacity and ecological potential. The study points out a steep spatial division in the uptake of the policy in the whole East Java Province.
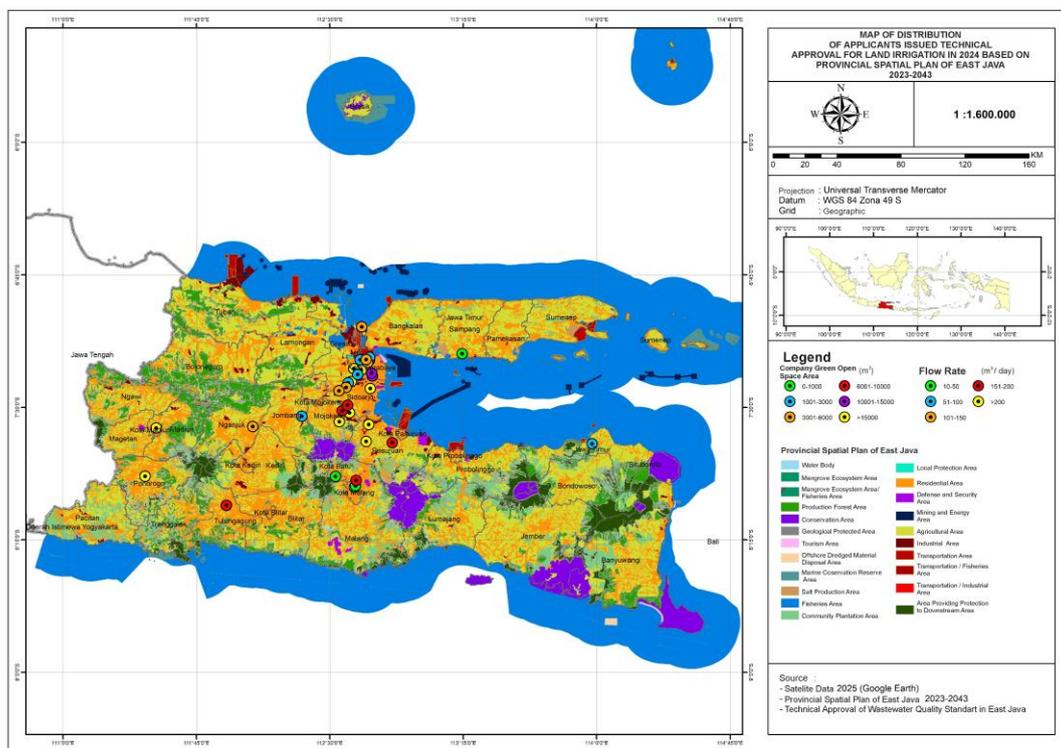

Figure 3. Location map of applicants for the 2024 land application technical approval based on the regional spatial planning plan

The spatial distribution of applicant correspondence and spatial allocation pointed towards a rate of effectiveness of 84.69%, hence the majority of wastewater applications to land are effectively targeted by spatial function with high technical compliance (Fidelis et al., 2025). However, approximately 15.31 % of

these activities are notidealal as they generally take place in areas with little green space, unstable waste quality, or varying technical capacities of the business actors,includinge problems of understanding procedures and minimal mentoring. This problem illustrates the necessity for continuous technical mentoring, capacity building of human resources, and cross-sector coordination. In summary, the overall distribution pattern is in accordance with the Spatial Plan (RTRW), and its high effectiveness implies that the Pertek policy for the use of wastewater for irrigation is executed in an adaptive, sustainable, and humane manner, thereby making wastewater a resource that is used responsibly and, at the same time, maintaining ecological balance (Lopez-Serrano et al., 2020).

3.3   Effectiveness Scores

Effectiveness is the ability to reach goals or objectives suitably by generating expected outputs. The method for determining effectiveness is the use of five aspects: the appropriateness of the policy, appropriateness of the implementation, appropriateness of the target, appropriateness of the environment, and appropriateness of the process (Mawuntu et al., 2024).

Effectiveness was quantified via predetermined indicators that allowed each aspect to be evaluated in a systematic and unbiased manner. Table 4 summarizes the effectiveness scores of the implementation of the technical approval policy for the use of wastewater for irrigation according to five assessment dimensions: appropriate policy, appropriate process, appropriate target, appropriate environment, and appropriate implementation. Each dimension was gauged through the scores of the instruments, which were then pooled to obtain the achievement score, which was subsequently compared with the maximum score to establish the effectiveness score. The following data were originated from the questionnaire related to the execution of technical approval for the use of wastewater for irrigation.

Table 4. Accumulated respondent scores

No	Dimension	Score instrument	Dimension effectiveness			Total effectiveness		
			Score achieved	Max score	Percentage	Score achieved	Max score	Percentage
1.	Appropriate	152	599	700	85.57%	2964	3500	84.69%
2.	policy	148						
3.		146						
4.		153						
5.	Appropriate	144	593	700	84.71%			
6.	process	149						
7.		152						
8.		148						
9.	Targeted	125	593	700	84.71%			
10.		139						
11.		150						
12.		134						
13.	Environmentally	1522	589	700	84.14%			
14.	appropriate	136						
15.		148						
16.		153						
17.	Appropriate	152	590	700	84.29%			
18.	implementation	149						
19.		143						
20.		146						

The effectiveness measurement outcome revealed that the execution of the Technical Approval policy for the use of wastewater for irrigation was highly effective, with an aggregate score of 2,794 out of 3,325 and an average effectiveness of 84.69%. This success signals that most policy elements have been actively carried out and are operational as envisaged. In the environmental policy implementation framework, an effectiveness level above 80% indicates that, in addition to compliance with the policy, real changes are also being initiated in wastewater management practices by business actors.

Specifically, "policy-appropriate" received the highest rating, 599 out of 700 (85.57%), which, in essence, means that there is very good coordination between the objectives of the policy, the mandates of the institution, and the requirements of appropriate water pollution management at the ground level. Such a score is evidence of a policy framework that is being viewed as the key to bringing about a paradigm shift from disposal to more sustainable wastewater usage (Kesari et al., 2021; Silva, 2023).

The process-appropriate and target-appropriate factors are each rated at 593 out of 700 (84.71%); thus, the various phases of implementation, that is, from policy acceptance via technical adoption to strategic readiness, have been quite optimal and have touched the right targets. Yet, the like nature of scores of these two aspects also suggests that the problem of low administrative efficiency and the business scale capacity gap among the tiny, small and medium enterprises (Morris, J., 2021; Sendawula, K., et al., 2024) keeps on existing.

The success of this aspect suggests that collaborative approaches and technical support have been two of the main factors in ensuring steady policy implementation (Moreira et al., 2024; Zhang et al., 2020).Moreover, the proper implementation aspect achieved a score of 590 out of 700 (84.29%), which reflected that the capacity and coordination of the policy implementers, especially of the Environmental Agency and the business actors, were at a good level. The success of this aspect suggests that collaborative approaches and technical support have been two of the main factors in ensuring a steady policy implementation (Moreira et al., 2024; Zhang et al., 2020).

This score indicates that the policy has played a significant role in protecting environmental quality; however, there is still a need to strengthen certain aspects, such as improving monitoring and reporting, and expanding the adoption of environmentally friendly processing technologies (Trotta et al., 2024).In contrast, the appropriate environmental aspect received the lowest score, which was 589 out of 700 (84.14%), although it remained at a highly effective level. The score shows that the role of the policy in protecting environmental quality has been significant but there is still a need for strengthening the aspects, such as better monitoring and reporting, and wider adoption of environmentally-friendly processing technologies (Trotta et al., 2024).

Therefore, the next effectiveness enhancement measures will focus more on capacity building of business actors, optimization of monitoring systems, and use of the region-based approach to convert these high levels of effectiveness into visible and sustainable progress in environmental quality. Basically, the near-equal spread of the scores across the dimensions reveals that the problems of policy implementation are more related to daily activities and technical matters than to the structure. That is why the next effectiveness enhancement measures will be more about the capacity building of the business actors, the optimization of monitoring systems, and the use of the region-based approach so that these very high levels of effectiveness can be more permanently converted into visible and sustainable progress in environmental quality.

3.4 Comparison with Literature

The high score for the policy appropriateness dimension (85.57%) in this study supports such an argument. The mean effectiveness level of technical approval for wastewater utilization policy at 84.69% in the highly effective category is consistent with previous studies, which stress that environmental-related policies are effective if their design, the capacity of the implementers, and local contexts are well aligned. Kesari et al. (2021) demonstrated that polices for water pollution control that have a clear objective framework in line with the institutional mandate are likely to reach effectiveness levels above

80%, especially when the policy is handled as a substantial instrument and not merely as an administrative obligation. The high score for the policy appropriateness dimension (85.57%) in this paper is an endorsement of such a kind of argument.

Here, the fact that the process dimension achieved a relatively high score indicates that most business actors have almost completely gone through acceptance and adoption; however, there are still administrative barriers and resource limitations, as also mentioned by Fidler et al. (2022).The literature reports that failure at any of these levels would significantly diminish policy effectiveness.Regarding the implementation process stage, the process appropriateness effectiveness of 84.71% is in line with the Morris (2021 framework,k which focuses on three major steps: policy acceptance, policy adoption, and strategic readiness. It has been reported through literature that failure at any of these levels would significantly diminish policy effectiveness. Here, the fact that the process dimension achieved a relatively high score indicates that most business actors have already gone through the acceptance and adoption almost completely, however, there are still administrative barriers and resource limitations, as also mentioned by Fidler et al. (2022). Mokhtar et al. (2025) are hindered in their work efficiency by these factors, especially when it comes to the small and medium enterprise scale.

Nevertheless, the body of knowledge also accepts and explains the existence of different degrees of capacity among businesses of different scales, as indicated by the results obtained in this work, namely, the variations in readiness between large and small- and medium-sized industries. The 84.71% on-target effectiveness is in line with Sendawala et al. (2024), who found that economic environmental policies are more effective when aimed at groups that have sufficient technical capacity to adopt sustainable practices. Nevertheless, the related body of knowledge also accepts and explains the existence of the different degrees of capacity among business scales which has been indicated in the obtained results of this work, namely the readiness variations between large and small- and medium-sized industries. Kusumawardani et al., (2024) also argued that the factors behind the success of the policy include not only the targeting accuracy but also the level up of the technical help and support intensities.

The study results contribute to this line of reasoning by revealing that a harmonious relationship between the environmental agency and business actors is a key factor for stability and effectiveness across dimensions.The findings of these studies suggest that a partnership among environmental agencies, business entities, and experts leads to improvements in compliance and the quality of implementation.With regard to the implementation dimension, the effectiveness of 84.29% corroborates Moreira et al. (2024) and Zhang et al. (2020) who pointed out that coordination among stakeholders plays a pivotal role in the implementation of environmental policies. Findings of these studies suggest that a partnership among environmental agencies, business entities, and experts leads to improvement in compliance and quality of implementation. The study results contribute to this line of reasoning by revealing that a harmonious relationship between the Environmental Agency and business actors is a key factor for stability and effectiveness across dimensions.

Therefore, while only administrative and institutional compliance has been achieved, environmental quality can be significantly improved through further interventions. In contrast, the slightly lower effectiveness of appropriate environmental policies (84.14%) compared to other dimensions reflects a pattern identified in the international literature. Trotta et al. (2024) argue that the environment is the most difficult aspect to address since it calls for the acquisition of technology, the establishment of continuous monitoring systems, and the very nature of the problem requires long-term changes in the operation practices and processes of organizations. Therefore, while only administrative and institutional compliance has been achieved, the environmental quality can be significantly improved only by means of further interventions.

Thus, this research not only confirms previous findings but also provides additional evidence that provincial-level technical approval policies have been highly effective in terms of implementation but still require some reinforcement in the environmental aspects to achieve more measurable and sustainable ecological impacts. Ultimately, the research piece under discussion reiterates what has been previously

suggested in the literature: high levels of effectiveness of environmental policies do not have to be associated with ecological impacts. According to Del Villar and Garcia – Lopez (2023) and Al Hadidi and Al Hadidi, (2021), the factors that determine the sustainability of wastewater utilization policies the most are regular monitoring, enhancement of the capacity of business actors, and the integration of the policy with local characteristics. Thus, this research piece not only bombards confirmation of the previous findings but also provides us with additional proof that provincial-level technical approval policies have been highly effective in terms of implementation but still require some reinforcement in the environmental aspects to bring about more measurable and sustainable ecological impacts.

3.5 Policy Implications

This indicates that the regulatory framework and deployment levers are aligned, albeit in need of strategic strengthening to generate more measurable and sustainable environmental impacts. The assessment of the Technical Approval policy for wastewater utilization for land application, which garnered a score of 84.69%, has substantial implications for the DLH, as the policy executor. This feat signals that the regulatory framework and deployment levers are basically lining up, albeit they still need to be strengthened strategically in order to generate more measurable and sustainable environmental impacts.

Consequently, future policy emphasis will no longer be about drafting new regulations but rather on making the best use of old ones, particularly by simplifying the technical procedures and clarifying the operational guidelines for business technical approvals.Consequently, future policy emphasis will no longer be on drafting new regulations but rather on making the best use of existing ones, particularly by simplifying technical procedures and clarifying operational guidelines for business technical approvals. Consequently, future policy emphasis will no longer be on drafting new regulations but rather on making the best use of existing ones, particularly by simplifying technical procedures and clarifying operational guidelines for business technical approvals. Consequently, future policy emphasis will no longer be on drafting new regulations but rather on making the best use of existing ones, particularly by simplifying technical procedures and clarifying operational guidelines for business technical approvals. First, the policy's appropriateness area is known to have strong efficiency (85.57%), indicating that the policy direction of the East Java Provincial DLH is in harmony with water pollution control and environmental protection mandates. As a result, future policy emphasis will no longer be about drafting new regulations but rather on making the best use of old ones, particularly by simplifying the technical procedures and clarifying the operational guidelines for business technical approvals.

This means in practice for DLH that they have to adopt a more nuanced manner, especially when it comes to small- and medium-sized industries, through technical assistance that caters to their needs, the creation of simple technical templates, and at the same time intensified policy dissemination in areas where readiness levels are low. Second, on-process and on-target compliances (84.71% each) evidence achieving implies that the policy acceptance and adoption mechanisms have been quite solid; however, capacity gaps still exist across business units. What this means in practice for DLH is that they have to adopt a more nuanced manner, especially when it comes to small- and medium-sized industries, through technical assistance that caters to their needs, the creation of simple technical templates, at the same time intensified policy dissemination in areas where readiness levels are low. This way it would be easy to ensure that policies are accessible and thus not only effective for large-scale businesses.

In addition to boosting administrative efficiency, this measure will enhance the accountability of policy implementation. The DLH in East Java needs to invest in human resource development, enhance cross-sectoral coordination, and apply digital technology to improve verification, monitoring, and reporting for technical approvals, if they are to confirm and strengthen this role.In addition to boosting administrative efficiency, this measure will enhance the accountability of policy implementation.The DLH in East Java needs to invest in human resource development, enhance cross-sectoral coordination, and apply digital technology to improve verification, monitoring, and reporting for technical approvals if

it is to confirm and strengthen this role.Third, the implementation effectiveness (84.29%) points out that the DLH is a policy broker by mediating regulatory demands with local practices. DLH in East Java needs to invest in human resource development, enhance cross-sectoral coordination, and apply digital technology to improve verification, monitoring, and reporting for technical approvals if they are to confirm and strengthen this role. Besides boosting administrative efficiency, this measure will also enhance the accountability of policy implementation.

Therefore, significant implications for the East Java Provincial DLH include the following: They should enhance environmental performance-based monitoring and evaluation systems and make periodic reporting mandatory; they should make use of spatially accurate water-quality data; and they should foster the use of environmentally friendly treatment technologies by providing incentives or through development schemes.Its lowest score suggests that mere administrative compliance has not been sufficient for environmental quality to show a commensurate improvement.Therefore, DLH should consider the following: enhancing environmental performance-based monitoring and evaluation systems, making periodic reporting mandatory, using spatially accurate water-quality data, and fostering the use of environmentally friendly treatment technologies by providing incentives or through development schemes. Its lowest score suggests that mere administrative compliance has not been sufficient to show commensurate improvement in environmental quality. Fourth, the environmental aspect (84.14%), which is still very effective, is the most critical policy indicator. Its lowest score suggests that mere administrative compliance has not been sufficient for the environmental quality to show a commensurate improvement. There are therefore significant implications for DLH to include the following: They should consider enhancing the environmental performance-based monitoring and evaluation systems whereby they also make periodic reporting mandatory; they should make use of spatially accurate water-quality data; and they should foster the use of environmentally friendly treatment technologies by providing incentives or through the scheme of development.

Technical approvals thus go beyond being regulatory tools, as they also facilitate policy learning and support sustainable environmental governance. In essence, the research outcome supports the fact that technical approval policies for wastewater utilization have successfully functioned as environmental governance instruments at the provincial level. Nevertheless, DLH will have to reorient the policy focus from merely procedural compliance to further strengthening environmental impacts in a more tangible way through the region-based approach, the adaptive technical assistance, and the more responsive monitoring system if they are to ensure sustainability in the long run. Technical approvals thus go beyond being regulatory tools as they also facilitate policy learning and are supportive of sustainable environmental governance.

4. Conclusions

Most of the implementation is still in urban and industrial areas; thus, policy effectiveness relies not only on regulatory design but also on geographical, infrastructural, and institutional factors. Based on the analysis, the implementation of technical approval for wastewater utilization for land application in East Java Province has been generally successful, with an overall effectiveness rating of very effective. The five-dimensional evaluation assesses the congruence of the policy with institutional mandates and local conditions, as well as the paradigm shift from disposal to sustainable waste utilization. Based on spatial analysis in combination with effectiveness, it can be inferred that policy performance varies spatially. A majority of the implementation is still in urban and industrial areas; thus, policy effectiveness relies not only on regulatory design but also on geographical, infrastructural, and institutional factors. While it is true that the environmental appropriate achievement has the lowest value, the technical approval nevertheless, still acts as a lever in making sure that wastewater is used safely and in a controlled way, hence, there is a need for optimization by the means of mentorings and socializations, digitizing monitoring systems, improving human resource capacity, cross-sector coordination, evidence-based policy evaluation, synchronizing with the RTRW through the regulation of green open space zoning, and

having an East Java Governor Regulation that explicitly deals with technical approval for the use of wastewater application to the ground.

5. Policy Recommendations

Based on the data analysis, several strategic recommendations can be formulated to optimize the implementation of the policy, including the following: strengthening continuous technical assistance and more inclusive outreach, particularly for small and medium-sized industries as well as areas with low adoption levels; integrating digital technologies into wastewater quality monitoring and reporting systems to enhance supervisory efficiency, data transparency, and assessment accuracy; improving human resource capacity through structured training programs and the development of technical competencies in waste management for business actors and government officials; optimizing cross-sectoral coordination between the Environmental Agency, business actors, industry associations, and environmental consultants to create synergistic actions that are adaptive to local characteristics, including hydrogeological conditions and the availability of green open spaces; implementing periodic evaluation and policy revision mechanisms based on evidence-based research to address dynamic field situations and advancements in the latest wastewater treatment plant technologies, thereby maintaining the effectiveness of implementation and environmental sustainability objectives; synchronizing the implementation of wastewater technical approval with the Regional Spatial Plan through adjustments to the substance of Zoning Directive Indication (IAZ) related to the allocation of green open spaces owned by business actors in the utilization of wastewater land application, serving as a clear and effective spatial planning regional; and developing a Governor Regulation of East Java Province specifically dedicated to technical approval for the utilization of wastewater land application.

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Ethics Statement

This study did not involve human participants, animals, or sensitive data; therefore no ethical approval was required.

Credit Author Statement

Erika Hakasmanti: Conceptualization, Research Design, Data Analysis, Spatial Distribution Assessment, Manuscript Preparation and Wrote Paper. **Bambang Semedi:** Review of Technical Approval and Policy Document, Support in Effectiveness Analysis. **Arief Tri Hardjoko:** Compilation and Processing of Secondary Data, Spatial Data Support, Asisstance in Data Interpretation. **Maharani Pertiwi:** Proofreading and Language Editing, Consistency Cecking of the Manuscript. **Supriyadi:** Methodological Supervision and Critical Review, Scientific Validation to Strengthen the Analytical Framework.

References

Ahmed, S.K. 2024. How to choose a sampling technique and determine sample size for research: a simplified guide fo researchers. Elsevier: Oral Oncolgy Reports 12(100662), 1–7.

Sustainability of reclaimed wastewater effluents from decentralized wastewater plants for irrigation.Sustainability of reclaimed wastewater effluents from decentralized wastewater plants for irrigation.Al Hadidi, N., and Al Hadidi, M. 2021. Sustainability to reclaimed wastewater effluent from decentralized wastewater plant for irrigation. Applied Water Science 11, 1–11

The road to inclusive decentralized village governance in Indonesia.Annahar, N., et al. 2023. The road to

inclusive decentralized village governance in indonesia. MDPI: Sustainability 15(8616), 1–23.

Dias, F. T., et al. 2023. Land use and global environmental change: an analytical proposal based on a systematic review. MDPI: Land 12(115), 1–14.

Fidelis, T., et al. 2025. Integrating spatial concerns into water reuse regulations: insiht from the european union and the iberian peninsula. MDPI: Water 17(1625), 1–17.

Fidler, R. Y., et al. 2022. Paticipation, not penalties: community involvement and equitable governance contribute to more effective multiuse protected areas. Science Advances: Ecology 8(eabl8929), 1–12.

Fuller, R. *et al.* 2022. Pollution and health: a progress update. The Lancet Planetary Health 1–37.

Haidar, M. R. A; Wasistha, A. N. P; dan Rajib, R.K.. (2024) "Implementasi Hukum Lingkungan terhadap Pengelolaan Limbah Industri di Indonesia," *Jurnal Ilmiah Penelitian Mahasiswa*, 2(3), pp. 60–64.

Izah, S. I., et al. 2024. Cronbach's alpha: a cornerstone in ensuring reliability and validty in environmental health assessment. ES Energy & Environment 23(1057), 1–14.

Kaligis, F., et al. 2022. Translation, validity, and reliability of mental health literacy and hel – seeking behavior questionnaires in indonesia. Frontiers in Psychiatry 12(764666), 1–11.

Kesari, K., et al. 2021. Wastewater treatment and reuse: a review of its application and health implications. Water, Air, and Soil Pollution (232), 1–28.

Kusumawardani, S. D. A., et al. 2024. Readiness in implementing green industry standard for smes: case of indonesia's batik industry. *Heliyon* 10, 1–13.

Lopez-Serrano, M. J., et al. 2020. Sustainable use of wastewater in agriculture: a bibliometric analysis of worldwide research. Sustainability 12(8948), 1–20.

Mawuntu, P., et al. 2024. The effectiveness of the micro-scale community activity restrictions (ppkm) policy on the spread of COVID-19 in warembangan village. Jurnal Administrasi Publik 8(113), 107–118.

Mokhtar, Z., et al. 2025. Challanges for compliance with industrial effluent regulations – an industry perspective. Challanges 16(1), 1–17.

Moreira, F. D., et al. 2024. Stakeholder engagement for inclusive water governance in a rural community in brazil. Frontiers in Water 1–10.

Morris, J., et al. 2021. Barriers in implementation of wastewater reuse: identifying the way forward in closing the loop. Circular Economy And Sustainability 1, 413–433.

Nugroho, R. 2012. Public policy: formulation, imlemention, and evaluation.

Nurhabibah, F. D., et al. 2023. Higher order thinking skill (HOST) ability in differentiated learning at SD 19 palembang. Jurnal Ilmiah PGSD FKIP Universitas Mandiri 9(3), 492–504.

Prinardi, G., et al. 2023. Effectiveness of plastic bag use reduction policy implementation in sukabumi city. Kebijakan: Jurnal Ilmu Administrasi 14(2), 152–166.

Rahmatanti, A., and Purnomo, Y. S. 2024. Utilization of domestic wastewater from pt. X, surabaya city, for irrigation of green open spaces. Jurnal Sains dan Teknologi 3(1), 1–9.

Safa, A. P., et al. 2025. Utilization of waste for irrigation of green open spaces in hospital development planning in east java. Jurnal Serambi Engineering 10(3), 13998–14005.

Saleh, Y., Ghazali, MKA., Mahat, H., Hashim, M., Nayan, N.S. 2022. Validasi instrumen indeks kota berkelanjutan dengan analisis faktor. Jurnal Wilayah Dan Lingkungan 10(03), pp. 246–266.

Sendawula, K., et al. 2024. Environmental knowledge, regulatory compliance mechanisms, and environmental sustainability practices of manufacturing small and medium enterprises (SMEs) in Uganda. Journal of Innovation and Entrepeneurship 13(75), 1–19.

Silva, J. A. 2023. Wastewater treatment and reuse for sustainable water resources management: a systematic literature review. Sustainability 15(14), 10940.

Trotta, V., et al. 2024. Risks associated with wastewater reuse in agriculture: investigating the effects of contaminants in soil, plants and insects. Frontiers in Environmental Science.

Del Villar, A., and Garcia – Lopez, M. 2023. The potential of wastewater reuse and the role of economic valuation in the pursuit of sustainability: the case of the Canal de Isabel II. MDPI: Sustainability 15(843), 1–21.

Zhang, W., et al. 2020. Enabling wastewater treatment process automation: leveraging innovations in real time sensing, data analysis, and online controls. Environmental Science: Water Research & Technology 6, 2973–2992.