

EVALUATING ENVIRONMENTAL GOVERNANCE OF HAZARDOUS WASTE MANAGEMENT: EVIDENCE FROM THE CIKARANG INDUSTRIAL ZONE, BEKASI REGENCY

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ABSTRACT. Bekasi Regency is one of the biggest industrial areas in Indonesia. There are 12 industrial zones, one of which is the Cikarang Industrial Zone. The rapid growth in manufacturing activities has led to a rapid increase in the Hazardous Toxic Waste (B3) volume from 285,791 tonnes in 2022 to 626,813 tonnes in 2024. Although there is a comprehensive regulatory framework, i.e. Law No. 32 of 2009, Government Regulation No. 22 of 2021 and Minister of Environment and Forestry Regulation No. 6 of 2021, the implementation in the field still faces serious and persistent challenges. This study aims to evaluate the B3 waste management policy in Bekasi Regency and to identify the inhibiting factors of its effective implementation. This study used a descriptive qualitative method with seven informants (five selected through purposive sampling and two through snowball sampling), in-depth interviews, field observation, and document analysis as the data collection techniques. The analytical framework is based on William N. Dunn's (2003) six-dimensional model of policy evaluation: effectiveness, efficiency, adequacy, appropriateness, responsiveness, and equity. The results of the study show that responsiveness is the only dimension that is relatively doing well. The other five dimensions are still sub-optimal. Three main inhibiting factors are budgetary and human resource constraints, persistently low industry compliance and weak coordination across levels of government in oversight activities. Based on these findings, the study recommends proportional increases in DLH budget allocations and inspection personnel, introduction of graduated and consistently enforced sanctions to strengthen deterrence, development of an integrated cross-jurisdictional digital oversight platform, and revision of Bekasi Regent's Regulation No. 8 of 2012 to align with current national regulatory standards. Beyond its practical recommendations, the study contributes theoretically by illustrating how community co-production can partially substitute for formal state monitoring capacity in resource-constrained environmental governance settings.

Keywords: policy evaluation, Hazardous Waste (B3), Cikarang Industrial Zone, Bekasi Regency, environmental management

INTRODUCTION

One of the primary pillars of the Indonesia's national economy is industrial sector. This sector has experienced steady growth over the years (Prabowo, 2025). The manufacturing industry's contribution to Gross Domestic Product (GDP) rose from 18.34 percent in 2022 to 18.67 percent in 2023. It is projected to rise to 18.98 percent by 2024. Although these economic achievements are impressive, the increase in industrial activity has led to a corresponding increase in the generation of Hazardous and Toxic Waste (B3). There is a threat to the quality of soil, water and air in production units and surrounding communities resulted from the increase of industrial output (Zakianis et al., 2023). Indonesia is not the only country experiencing this issue. At the global level, industrialization is still one of the main drivers of hazardous waste accumulation, particularly in countries with rapid economic transition (Ferronato & Torretta, 2019).

Bekasi Regency plays a strategic role in the industrial map of Indonesia, acting as a national industrial hub with 12 industrial zones operational, the most prominent of which is the Cikarang Industrial Zone (Sitogasa & Alim, 2023). The data from Bekasi Regency Environmental Agency (Dinas Lingkungan Hidup, DLH) shows the amount of B3 waste stored in temporary storage facilities (TPS) increased from 285,791 tonnes in 2022 to 626,813 tonnes in 2024. This pattern indicates that the amount of waste generated by industrial operations is outstripping the existing capacity for waste management. Nursabrina et al. (2021) has proved that

the production of industrial B3 waste in Indonesia exceeds the capacity of regulatory enforcement in the local context which is quite comparable to the conditions in Bekasi Regency.

The legal framework for B3 waste governance in Indonesia is quite comprehensive on paper. It contains technical procedures and requirements for B3 waste management as outlined in Law No. 32 of 2009 concerning Environmental Protection and Management, Government Regulation No. 22 of 2021, and Minister of Environment and Forestry Regulation No. 6 of 2021. However, the evidence from the field tells a different story. The Ministry of Environment and Forestry has sealed numerous companies, but serious violations continue to emerge. Illegal waste dumping and manipulation of environmental documents continue to be a problem. The difference between the regulatory intention and the reality on the ground indicates a structural problem in the implementation of policy at the local level. Dompok and Riyanda (2018) identified a similar gap in Batam, where the programs of the environmental management agency were not able to reach their targets. Despite the availability of sufficient regulatory instruments, this was mainly due to the capacity of institutions.

Previous studies on B3 waste management in Indonesia have mostly focused on the technical and operational aspects at the organizational level (Dinayah & Novembrianto, 2023; Hardiyanto et al., 2022; Dirgawati & Amitasyah, 2024). There is a limited amount of normative assessment about the implementation of public policy. This gap becomes the basis of the present study that explores the B3 waste management policy implementation in the Cikarang industrial area of Bekasi Regency using a comprehensive policy evaluation framework. Existing policy evaluation studies of Indonesian environmental governance have also tended to examine single dimensions in isolation rather than applying a complete multi-dimensional framework capable of showing how these dimensions interact. Cikarang is a theoretically useful case for closing this gap because it combines an unusually dense concentration of industrial B3 waste generators with a governance structure fragmented across central, provincial, and regency jurisdictions, conditions under which the interaction between policy dimensions, rather than any single dimension in isolation, is most likely to explain implementation outcomes. Ridwan and Delima (2021) highlighted the deficiency in environmental supervision by local government agencies in industrial zones and underscored the need for studies that evaluate, rather than only focus on technical aspects.

This research has two objectives, namely: (1) to evaluate the B3 industrial waste management policy in the Cikarang Industrial Zone, Bekasi Regency; and (2) to identify factors that cause the policy to be implemented ineffectively. The analytical framework of the policy evaluation theory by William N. Dunn (2003) was chosen because it combines the evaluation of policy performance with equity, efficiency, and appropriateness, which is suitable for the complexities of environmental governance.

Public Policy and Policy Evaluation

Public policy can be defined as a set of actions or deliberate inactions undertaken by government in response to particular issues (Knill & Tosun, 2020). This is summed up in Thomas R. Dye's (2002) much-cited formulation: public policy is whatever governments choose to do or not to do. According to this definition, decisions loaded with political, economic, and social consequences are reflected in policy. Anderson (2014) elaborates the deliberate nature of governmental actions by elaborating that public policy is a purposeful course of action taken by an actor or group of actors in addressing an issue.

In Dunn's (2003) perspective, public policy is an analytical process intended to generate valid information regarding the effectiveness of a policy, in order to inform decisions regarding its continuation, revision, or termination. Dunn proposes six dimensions of evaluation. Effectiveness is determined by the extent to which a policy yields outcomes that are in accordance with its stated objectives. Efficiency means the correlation between resources deployed and results obtained. Adequacy evaluates whether the policy effectively address the problem it was intended to solve. The equitable distribution of the benefits and burdens of the policy is the focus of equity. Responsiveness measures the degree to which policy responds to the needs and values of affected communities. Finally, there is the issue of appropriateness: whether the goals the policy

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is trying to achieve are appropriate and well-founded. Dunn's framework is particularly beneficial for assessing redistributive and regulatory policies for which both outcomes and processes must be simultaneously evaluated (Wibawa et al., 1994). These criteria have been widely used in environmental governance studies.

Environmental Policy and Industrial Governance in Indonesia

Indonesia's environmental policy landscape has changed considerably over the last three decades. The transition from Law No. 23 of 1997 to the more comprehensive Law No.32 of 2009 was a significant turning point. The latter law introduced a more detailed system of permits and environmental impact assessments, made environmental rights a constitutional matter and imposed more stringent duties on polluting industries. Then, Government Regulation No. 22 of 2021 elaborated this by establishing technical standards for B3 waste in each phase of the waste management chain. The Ministry Regulation No. 6 of 2021 converted these standards into detailed procedural requirements that companies and local governments are meant to follow in a daily basis.

This legislative framework indicates Indonesia's commitment to establishing a legal structure for environmental preservation. According to Ardiansyah et al. (2015), the problem lies in the disparity between the legal provisions and their actual implementation. This disparity arises partly from Indonesia's decentralization reforms in the early 2000s, which transferred significant environment monitoring obligations to regional governments but did not provide the necessary resources, staff, or technical capacity for them to successfully discharge such tasks. Consequently, environmental management at regency level often experiences a structural constraint: the national framework demands a great deal, but local authorities have insufficient resources to meet these demands.

Industrial B3 Waste Management

Industrial waste B3 is a residual substance coming from the manufacturing process. It contains harmful and poisonous materials which can contaminate the environment and endanger human health and other living organisms (Salsabilla et al., 2023). The management of such waste requires a series of controlled activities, including source reduction, temporary storage, collection, transportation, utilization, treatment, and final disposal (Sipahutar & Sukmawati, 2021). The Indonesian law states that the main responsibility for the waste generated by the legislation is the duty of each waste producing business (Sutanto & Karianga, 2023). However, Fajriyah and Wardhani (2020) noted that many companies registered under Indonesian B3 waste regulations often failed to comply with storage and labelling standards, which shows the difference between actual compliance and formal compliance.

According to Kumar et al. (2023), comprehensive preventive and recovery techniques integrated within a circular economy framework are just as important for sustainable hazardous waste governance as end-of-pipe solutions. Similarly, Khoshsepehr et al. (2023) emphasize that the most significant challenges in industrial waste management arise not only from technical limitations but also from deficiencies in cross-sectoral management systems and oversight mechanisms. In their investigation of hazardous waste management in developing country, Mmereki et al. (2016) concluded that the main obstacles to efficient governance are dispersed institutional duties and insufficient enforcement. This finding closely aligns with the Indonesian context.

METHOD

This research employs a descriptive qualitative approach grounded in a post positivist paradigm. Creswell and Creswell (2023) assert that post positivism begins with the premise that an objective social reality exists, although our ability to completely comprehend it is always limited by the tools and perspectives we use. This paradigm is appropriate here since the research aims to evaluate policy not only based on factual

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outcomes but also concerning the social and institutional contexts influencing the implementation process. Moreover, Sugiyono (2021) emphasizes that qualitative approaches are particularly appropriate for policy evaluation due to their capacity to capture the complexity, context, and lived experiences that quantitative data may occasionally fail to capture.

Data collection was conducted out at the Environmental Agency (DLH) of Bekasi Regency and the Cikarang Industrial Zone in January 2026. Informants were selected through combination of purposive and snowball by targeting individuals who are directly involved in B3 waste monitoring. There were seven informants in total: five core informants selected through purposive sampling (the Head of the Environmental Agency, the Head of Pollution and Environmental Damage Control Division, the Head of the Environmental Law Enforcement Team, the Head of the Environmental Monitoring Team, a field inspection officer) and two residents living along Cilemahabang river. The two residents were recruited through snowball sampling to obtain a community-level perspective unavailable from official sources alone. No representatives from industry were interviewed directly; this omission is acknowledged as a limitation in the Conclusion.

Data collection was conducted through in-depth interviews, direct field observation, and official documents review. The in-depth interviews were intended to capture informants' experience of B3 waste management from their perspective. The direct field observation enabled the researchers to observe the real condition of storage, signage, and operational practices instead of entirely relying on what informants described. The official documents review was carried out to verify and contextualize interview accounts by inspecting records, penalty notifications, and waste volume reports. The triangulation of sources was used to ensure the reliability of the analysis.

Data analysis was carried out using the interactive model developed by Miles et al. (2014) consisting of three interconnected stages: data condensation, data display, and conclusion drawing. Data condensation was the process of choosing, simplifying, and rearranging the raw data from interviews and observations around the six Dunn's dimensions. Data display involved creating structured summaries which made patterns across dimensions visible. Conclusion drawing was considered to be an ongoing process, evaluating early interpretations as further data were received and assessing whether the patterns identified at each stage were consistent with the whole evidence base.

Several procedural details are reported here to strengthen the trustworthiness of the analysis. Interviews were conducted face-to-face, audio-recorded with informants' consent, and transcribed verbatim; each interview lasted approximately 45–90 minutes. Transcripts were coded manually using an a priori coding scheme derived from Dunn's six evaluation dimensions, supplemented by emergent codes for themes that did not fit the initial scheme. Data collection continued until no substantially new codes emerged from successive interviews, indicating that thematic saturation had been reached within the scope of the seven informants interviewed. Preliminary interpretations were shared with two informants (the Head of the Environmental Agency and one community informant) for member checking, and an audit trail of coding decisions was maintained throughout the analysis. Because the first author is professionally affiliated with the Bekasi Regency government, the second and third authors — who have no institutional affiliation with Bekasi Regency — independently reviewed the interview protocol, coding scheme, and draft interpretations to reduce the risk of interviewer or confirmation bias; this reflexive arrangement is reported here in the interest of transparency. Two limitations in the sampling strategy should also be noted at the outset: no representatives of regulated industries were interviewed, so the study captures regulator and community perspectives on compliance rather than firms' own account of their compliance decisions; and, as detailed in the Effectiveness sub-section below, the roughly fifty companies inspected annually by DLH are not selected through random sampling, which limits how far inspection findings can be generalized to the wider population of uninspected firms.

RESULTS AND DISCUSSION

Policy Evaluation Using Dunn's Framework

Applying the six dimensions of Dunn's framework to B3 waste management in the Cikarang Industrial Zone reveals a policy that falls short in many critical aspects. Responsiveness is the one area in which DLH made improvement. The other five dimensions (effectiveness, efficiency, adequacy, appropriateness, and equity) show significant gaps suggesting more than simply operational failure; they suggest fundamental faults in the policy's structure and resource distribution. Riyadi et al. (2024) identified a similar pattern in Boyolali, suggesting that the combination of partial success and widespread underperformance may be fairly common in how environmental control works within Indonesian industrial areas. The scale of industrial activity in the Cikarang case, and the limited supervision capacity, further accentuates differences.

1. Effectiveness

Effectiveness concerns the degree to which a policy accomplishes its objectives. Although the regulatory instruments for B3 waste management are formally complete, effectiveness in practice remains limited. The DLH's field inspection team consists of twelve officers who are capable of conducting inspections of approximately fifty companies annually. These fifty companies are not selected through random sampling; DLH inspectors typically prioritize the most accessible and visible facilities, together with those already flagged by prior complaints or violation history. This coverage is quite weak against the background of thousands of industrial units across the Cikarang zone and its surroundings. The situation is further complicated by the fact that the fifty inspections discovered violations in nearly every company visited. Because this sample is not randomly drawn, the finding of near-universal non-compliance among inspected firms cannot be generalized with statistical confidence to the uninspected population; it remains a troubling signal, however, since even the companies DLH considers most visible and most likely to comply are, in practice, almost invariably found in violation.

This interpretation is supported by the waste accumulation statistics. The amount of B3 waste sitting in temporary storage facilities increased from 285,791 tons in 2022 to 305,607 tons in 2023, then climbed dramatically to 626,813 tons in 2024. This trajectory is simply not consistent with a policy working as intended; it shows that waste is accumulating faster than the system can process and dispose of it. As Riyadi et al. (2024) found in a comparable setting, high density industrial zones require supervision capacity that grows proportionally with industrial activity, and there is now a significant gap between inspection capacity and the scope of the task. Nursabrina et al. (2021) similarly found that effective policy implementation is fundamentally challenging since the vast amount of B3 waste produced by Indonesian industry often surpasses the monitoring and enforcement capabilities of regional environmental authorities.

The 2022–2024 waste-accumulation trend cited above should be read with a methodological caveat in mind. The year-on-year increase between 2023 and 2024 (from 305,607 to 626,813 tons, more than 100 percent) is far larger than the increase between 2022 and 2023 (about 6.9 percent), and the data available to this study do not rule out non-substantive explanations for that jump, such as a change in DLH's recording methodology, an increase in the number of industries submitting reports, or a redefinition of waste categories during this period. Absent further verification against DLH's internal records, the trend is treated here as a suggestive rather than a conclusive indicator of declining effectiveness.

Field observation added another layer to this imagery. Several companies visited during the study had waste sitting in temporary storage well beyond the time limits set by Regulation No. 6 of 2021, which caps storage duration by waste category. In some cases, the DLH was already aware of this but had not been able to follow up with the enforcement action needed to bring the company into compliance. This points to an effectiveness problem that goes beyond simply having too few inspectors: the agency occasionally lacks the

follow-through capability to compel remediation in a consistent and expeditious manner, even when violations are identified.

Read together, these patterns point to an institutional mechanism rather than a simple resource shortfall. Because DLH's twelve field officers cannot cover the full population of industrial units, inspection targeting necessarily relies on proxies for risk — visibility, accessibility, and prior complaint history — rather than on systematic risk-based sampling. This targeting logic has two compounding effects: it concentrates enforcement attention on a small, non-random subset of firms, which is the sampling limitation noted above; and it creates limited incentive for firms outside that subset to comply, since their probability of being inspected in any given year is low. The near-total non-compliance found among inspected firms is therefore better read as a signal about the targeting mechanism's blind spots than as a representative estimate of the wider population's behavior.

A related effectiveness problem, beyond the raw inspection numbers discussed above, is what might be called paper compliance: companies that are formally registered, hold valid permits, and appear in the SIMPLE SPEED reporting system, but whose actual practices fall well short of what those documents are supposed to certify. Physical inspection consistently revealed conditions that did not match what the official record showed.

The root of this pattern is economic. Doing B3 waste management properly is expensive. Constructing compliant storage facilities, obtaining the necessary technical permits (Rintek), contracting certified waste transporters, and arranging treatment through licensed facilities all add up to real operating costs. In competitive industries with tight margins, the temptation to cut these costs is strong—especially when the probability of inspection is so low. Fajriyah and Wardhani (2020) documented a similar pattern in another setting: companies maintaining formal registration while failing to meet substantive requirements, with cost avoidance as the primary driver. Liu et al. (2021) further found that the level of environmental compliance in manufacturing firms tends to track closely with how credible and consistent regulatory pressure actually is.

The SIMPLE SPEED application is worth discussing specifically in this context. It was introduced as a digital tool to give regulators more timely visibility into waste storage volumes and movements. But because the data in the system comes primarily from company self-reporting, and because the system's accuracy is rarely verified against field conditions, it has become an instrument that facilitates rather than exposes the paper-compliance problem. Inspectors in this study described visiting facilities where storage volumes reported in SIMPLE SPEED were a fraction of what was physically on site. The technology is not the problem here; the problem is using self-reported data as a primary verification mechanism in an environment where the economic incentive to misreport is strong.

2. Efficiency

Efficiency addresses the relationship between resources invested and outcomes produced. In Bekasi's case, this question is complicated by the fact that the resources available are so limited that even well-managed operations struggle to achieve much. Environmental management is classified as a non-basic service under Indonesia's regional budgeting framework, which means it consistently loses out when budgets are allocated and education, health, and infrastructure take priority. In recent years, broader fiscal tightening has made this competition for funds even harder.

The DLH divisions responsible for B3 oversight typically have five to ten staff members each. This is far too few for the scale of oversight work needed in an area like Cikarang. As Nur and Nur (2025) demonstrate, the effectiveness of any B3 waste governance regime ultimately depends on the availability of adequate resources and efficient bureaucratic support. Dompok and Riyanda (2018) confirmed that institutional resource constraints, particularly inadequate staffing and operational budgets, are the primary limiting factors in the effectiveness of regional environmental management programs in Indonesia.

There is also a practical dimension to the efficiency problem that is easy to overlook, namely travel time. The Cikarang Industrial Zone is geographically spread out across a large area containing dozens of separate estates managed by different private operators. Inspectors travelling between sites can spend a substantial part of their working day simply getting from one place to another. Smarter scheduling and clustering of inspections by location could reduce some of this waste, but the underlying resource deficit is too large to be resolved through better logistics alone. The efficiency analysis ultimately shows that this policy is being asked to do far more than its resource base can reasonably support.

Two clarifications are in order regarding this Efficiency dimension. First, it substantially overlaps in content with the structural resource constraints discussed under Inhibiting Factors below; the distinction intended is that this sub-section evaluates the input–output ratio itself (how far a given level of staffing and budget goes), while the Inhibiting Factors section explains why that ratio is so poor as a matter of institutional and fiscal design. Second, this study did not collect the data needed to quantify that ratio precisely for example, cost per inspection or travel time as a share of total working hours and the discussion above should be read as a qualitative, proxy-level judgment rather than a measured efficiency ratio. Future research combining DLH's internal activity logs with budget data could make this dimension considerably more rigorous.

3. Adequacy

Adequacy examines whether the policy is capable of resolving the problem it addresses. Regulation No. 6 of 2021 is normatively adequate: it covers the full chain of B3 waste management, from waste classification through to final disposal. But there is a meaningful difference between a policy being normatively adequate and being practically adequate, meaning it can actually make a dent in the problem under real-world conditions. In Bekasi Regency, the two are quite far apart. Many industries depend heavily on third party waste service providers, yet oversight of these subcontracting arrangements remains thin.

Repeated incidents of company sealing, administrative sanctions, and illegal dumping demonstrate that the current regulatory architecture has not produced a strong deterrent effect. The disparity between demanding national technical standards and limited local enforcement capacity is the principal factor that prevents the policy from delivering adequate environmental risk control across the board. Mmereki et al. (2016) observed that in developing-country contexts, the gap between national regulatory standards and local enforcement capacity frequently renders even well designed policies inadequate in practice. Their findings point to the need for capacity building measures that accompany regulatory reform.

One specific gap in adequacy that deserves mention is the uneven treatment of small and medium enterprises (SMEs) within the industrial zone. The regulatory framework was built primarily with large manufacturing facilities in mind, and the permit, documentation, and reporting requirements it imposes reflect that assumption. Smaller firms (subcontractors, component suppliers, and support industries that operate within and around the Cikarang zone) often lack the administrative staff to manage these requirements properly. The result is a kind of compliance cliff: large firms can absorb the cost and effort of formal compliance even when they do not always achieve it substantively, while smaller operators face regulatory demands that simply do not fit their scale or capacity. The policy as written does not make much allowance for this difference.

4. Appropriateness

Appropriateness, in Dunn's framework, asks a different question from the five dimensions discussed above: not whether the policy is being implemented effectively, efficiently, adequately, responsively, or equitably, but whether the goals it pursues are themselves well-founded given the problem and the context in which it operates. Two aspects of the underlying goals of B3 waste management policy are examined here.

The first concerns the policy's implicit assumption that formal registration, documentary compliance, and self-reported data constitute an adequate proxy for actual environmental outcomes. As the discussion of

paper compliance under Effectiveness above shows, that assumption does not hold well in practice: firms can satisfy the policy's formal requirements while producing outcomes the policy is meant to prevent. This points to a goal-setting problem rather than only an implementation problem, a policy built around documentary compliance as its primary success indicator will struggle to detect, let alone deter, exactly the kind of gap between paper and practice this study observed.

The second concerns the appropriateness of a uniform, one-size-fits-all regulatory design for a highly heterogeneous industrial population. As noted under Adequacy above, the current framework was designed with large manufacturing facilities in mind and applies comparable documentation and reporting burdens regardless of firm size. Whether it is appropriate to hold small subcontractors and large multinational manufacturers to procedurally identical requirements is a question the policy's design does not appear to address explicitly. Ardiansyah et al.'s (2015) broader observation that Indonesia's decentralized environmental governance distributes regulatory authority without a matching distribution of resources or technical capacity applies with particular force here: the policy's goals were set at a level of generality that does not anticipate the resource and scale differences among the actors it regulates. On both counts, the goals underlying B3 waste management policy in Bekasi Regency appear only partially well-founded for the specific conditions of the Cikarang industrial zone.

5. Responsiveness

Responsiveness is the dimension where the DLH's performance is most encouraging. The agency has developed a community-based complaint system that operates through social media channels and a tiered coordination structure reaching down to the village level. When a complaint is received, it triggers a Field Verification Task Order, and when inspectors confirm a violation, administrative sanctions or temporary facility closures follow. Field observation and interviews with residents suggest that this mechanism actually functions in which responses are fairly timely and follow-through is reasonably consistent.

Residents along the Cilemahabang river have become active partners in this system, organizing informal monitoring groups to track suspicious waste truck movements and report them to the authorities. The collaboration between firm governmental responses, regular industry outreach and education, and community-based surveillance has produced a system that, within its resource constraints, is genuinely responsive to public concerns. Local residents acknowledge this positive shift, even as they note that pollution events still occur. Ridwan and Delima (2021) noted that community participation in monitoring industrial pollution is an effective compensatory mechanism when formal inspection capacity is insufficient, though it carries the limitation of being reactive rather than preventive. Xiao et al. (2017) similarly demonstrated that citizen knowledge and social motivation are more influential drivers of public participation in waste governance than institutional factors alone.

This is to say, responsiveness has real limits. The complaint-and-response mechanism works well for pollution events that people can see, smell, or otherwise directly perceive (discolored water, chemical odors, unusual night-time truck movements). It is much less useful for slower or more diffuse forms of contamination, for violations occurring in parts of the industrial zone far from residential areas, or for problems that do not produce obvious visible signals. The system is fundamentally reactive; it responds to what communities report rather than systematically scanning for problems. Turning it into something more preventive would require the kind of expanded inspection capacity that the DLH currently does not have.

The comparatively strong performance of responsiveness relative to the other five dimensions is theoretically informative. Collaborative-governance and co-production theory suggest that where state monitoring capacity is constrained, formal enforcement can be partially substituted by mechanisms that distribute monitoring labor to affected communities themselves — provided those communities have sufficient incentive, local knowledge, and a credible channel through which to act. All three conditions are present in Cikarang: residents along Cilemahabang river have direct, repeated exposure to pollution events, first-hand

knowledge of normal versus abnormal local conditions, and a functioning administrative pathway (the Field Verification Task Order) that converts a complaint into a documented, actionable response. Effectiveness, efficiency, adequacy, and appropriateness, by contrast, all depend primarily on DLH's own institutional capacity, which this study has shown to be severely constrained; equity depends on that same constrained capacity being distributed fairly. Responsiveness is the one dimension where an external actor — the community — can compensate, at least partially, for the state's capacity shortfall. This carries a broader implication for governance theory and policy design: where state enforcement capacity cannot realistically be expanded in the short term, formalizing and resourcing community co-monitoring channels may offer a more achievable route to improved outcomes than attempting to scale up formal inspection alone — though, as noted above, such channels remain inherently reactive and cannot substitute for the proactive, systematic oversight that only a properly resourced regulator can provide.

6. Equity

Equity examines how evenly the benefits and burdens of policy implementation are distributed. In Bekasi Regency, the distribution of regulatory attention is uneven in ways that matter for environmental justice. The oversight system is divided by jurisdiction: large national industrial estates such as JABK and Lippo Cikarang fall under central government authority, cross-boundary issues are the province's responsibility, and companies outside designated zones are managed at the regency level. This division makes administrative sense on paper, but in practice it produces patchy coverage with no single agency having a complete picture of what is happening across the zone.

With only around 50 companies inspected per year from a pool of thousands, a large share of firms goes without direct inspection in any given annual cycle. A rotation system is supposed to spread coverage more evenly over time, but it cannot compensate for the scale of the underlying deficit. Moreover, limited information sharing between central, provincial, and regency-level agencies means that the DLH often lacks visibility into whether companies under other jurisdictions are actually being supervised, even when those companies operate within Bekasi's administrative boundaries. As discussed under Effectiveness above, this rotation is also not random, which means the equity concern here is compounded: the firms most likely to be inspected repeatedly are not a representative cross-section of the regulated population. The equity dimension of environmental governance in multi-jurisdictional settings is particularly sensitive, as Khoshsepehr et al. (2023) highlight: the uneven distribution of regulatory oversight burdens communities in lightly supervised areas with disproportionate environmental risks.

There is also a fairness issue within the industry itself. Companies that happen to be inspected in a given year face scrutiny that companies not inspected that year do not face, even when those uninspected companies may be equally or more non-compliant. This creates an unlevel playing field. Firms that have genuinely invested in compliant infrastructure are in the position of bearing costs that their less scrupulous competitors avoid. Over time, this can erode the motivation to maintain compliance: if doing things properly confers no competitive advantage and may actually put a firm at a disadvantage relative to non-compliant competitors, the rational response is to invest less in compliance. The equity problem, in other words, risks gradually undermining whatever compliance culture currently exists.

Placed in comparative perspective, Cikarang's experience is broadly consistent with recent international literature on hazardous-waste governance in decentralized and developing-country settings, while also illustrating why such settings differ systematically from the more centralized, resource-rich contexts that dominate the OECD-oriented regulatory literature. Liu et al. (2021) found that credible and consistent regulatory pressure, not merely the existence of rules, is what drives manufacturing-sector compliance in China's more centrally coordinated system — a condition Bekasi's DLH is currently unable to sustain given its inspection coverage. Yudartha et al.'s (2026) systematic review of waste-management policy implementation across developing countries similarly identifies fragmented multi-level authority and resource-

mandate mismatches, rather than the absence of formal regulation, as the dominant barrier to effective implementation — a pattern this study's findings on Bekasi's jurisdictional fragmentation (see Equity above) directly reproduce. Compared with OECD jurisdictions, where responsive-regulation models typically assume a baseline inspection capacity sufficient to make graduated sanctioning credible, Cikarang's case suggests that in capacity-constrained decentralized systems, community co-production (see Responsiveness above) may need to substitute for, rather than merely supplement, formal inspection before graduated-sanctioning models of the kind common in OECD contexts can function as intended.

Factors Inhibiting Policy Implementation

Three interconnected factors underlie the performance gaps identified across the evaluation dimensions.

Whereas the Efficiency dimension above assessed the ratio between resources and results at a descriptive level, this first factor explains the underlying structural cause of that poor ratio: chronic under-resourcing relative to the scale of the oversight task. The first is the structural inadequacy of budgetary and human resources. With approximately 12 field inspectors in the law enforcement division and no more than 6 in the monitoring and guidance unit, the DLH is tasked with overseeing thousands of industrial sites ranging from multinational manufacturers to small domestic firms. When the resources available for a task are fundamentally out of proportion with the task itself, even the most comprehensive regulatory framework will struggle to deliver results. Ferronato and Torretta (2019) identified limited institutional capacity as the primary structural barrier to effective hazardous waste governance in developing nations, noting that technical regulations without proportionate enforcement infrastructure remain largely aspirational documents.

The second factor is persistently low industry compliance, which is driven less by ignorance of the rules than by deliberate economic calculation. The full cost of legally compliant B3 waste management, covering standardized storage infrastructure, technical permits, licensed transporters, and certified treatment facilities, represents a significant operational expense. For some companies, particularly those with tighter margins, circumventing these requirements is treated as a cost-saving measure. Gray and Shimshack (2011) argue persuasively that the deterrent effect of environmental law enforcement depends above all on businesses perceived probability of detection and the magnitude of the expected sanction. When only 50 out of thousands of companies face inspection each year, that perceived probability is very low, and the incentive structure tilts against full compliance. Tietenberg and Lewis (2018) note that the economic logic behind environmental noncompliance is straightforward: when the expected cost of a penalty is lower than the cost of compliance, rational firms will choose non-compliance regardless of the strength of the regulatory text.

The third factor is weakness in the inspection system itself. Both of the existing oversight mechanisms have notable limitations. Routine inspections are too narrow in scope because of budget and staffing constraints. Complaint driven inspections, by definition, depend entirely on reports being filed: violations in locations distant from residential areas, or those whose effects are not immediately visible, may go unreported and therefore undetected. The SIMPLE SPEED reporting application, which was intended to provide a monitoring backstop, has also proved unreliable; inspectors found, on multiple occasions, that reported storage volumes were substantially understated compared with what they observed on site. The absence of effective cross level information sharing further compounds these weaknesses, leaving the regency without reliable data on whether companies supervised by higher level authorities are actually complying. Kumar et al. (2023) argue that sustainable hazardous waste governance requires the integration of digital monitoring systems with field inspection protocols, and that reliance on self-reported data alone is insufficient to ensure regulatory compliance in high volume industrial settings.

CONCLUSION

EVALUATING ENVIRONMENTAL GOVERNANCE OF HAZARDOUS WASTE MANAGEMENT:
EVIDENCE FROM THE CIKARANG INDUSTRIAL ZONE, BEKASI REGENCY

(Fahmi Setiawan, Mutiar Fitri Dewi, Dadan Adam Ismail, Nina Karina)

Applying William N. Dunn's six-dimensional policy evaluation framework to B3 waste management in the Cikarang Industrial Zone yields a sobering assessment: with the exception of responsiveness, the policy performs poorly across the other five evaluative dimensions, on the evidence available from this study's seven informants and its non-random sample of the roughly fifty companies inspected annually—a scope that, as discussed above, warrants some caution in generalizing to the full population of regulated firms. Responsiveness is where the DLH has made genuine progress, through its complaint-response mechanisms and the active role communities have come to play in environmental surveillance. Effectiveness, efficiency, adequacy, appropriateness, and equity each face serious challenges that a well-designed regulatory framework alone cannot resolve.

The three principal inhibiting factors are structural in nature. The first is the chronic mismatch between the scale of the oversight task and the resources available to carry it out. The second is an industry compliance culture that remains shaped by economic shortcuts rather than internalized environmental responsibility. The third is an inspection system whose two mechanisms, routine and complaint driven, each have inherent limitations that leave large portions of the regulated population effectively unsupervised.

On the basis of these findings, the study offers four policy recommendations. First, the regency government should work toward a proportional increase in environmental oversight budgets and inspection personnel, commensurate with the density and complexity of industrial activity in the area. This should be phased over the next two budget cycles (FY2027–FY2028), funded jointly through the regency's own APBD allocation and, where eligible, national DAK (Dana Alokasi Khusus) environmental transfers, with a target of at least doubling annual inspection coverage from roughly fifty to at least one hundred companies by the end of the second cycle. Second, the enforcement regime should be strengthened through sanctions that are applied consistently and carry a credible deterrent effect. Implementation responsibility should sit with DLH's Environmental Law Enforcement Team, operating under a published, graduated sanctions schedule (written warning, then administrative fine, then temporary closure) so that penalties are predictable and consistently applied rather than discretionary. Third, cross level coordination and information sharing mechanisms between central, provincial, and regency governments need to be substantially improved, including through integrated digital oversight platforms. This would require a formal data-sharing agreement between the Ministry of Environment and Forestry, the West Java provincial environmental agency, and Bekasi's DLH, ideally anchored to the existing SIMPLE SPEED platform, with a target of full three-tier data integration within eighteen months. Fourth, the Bekasi Regent's Regulation No. 8 of 2012, which governs B3 waste management at the district level, should be revised promptly to align with the more recent national frameworks established by Government Regulation No. 22 of 2021 and Regulation No. 6 of 2021, ensuring that local legal instruments reflect current standards. This revision falls under the authority of the Bekasi Regional House of Representatives (DPRD) working with the regency legal bureau, and could realistically be completed within one legislative session, since it primarily involves harmonizing existing local provisions with already-enacted national standards rather than drafting new substantive policy.

The Cikarang case carries implications that go beyond Bekasi. Indonesia has built a reasonably detailed legal framework for B3 waste management, and that framework is not the problem. The problem is that the framework has been handed to regional agencies without the resources they need to implement it at a scale that matches the industrial activity they are supposed to govern. Closing that gap is the central challenge for B3 waste governance across Indonesia's industrial zones.

Beyond its practical recommendations, this study contributes to policy evaluation theory in two ways. First, it demonstrates empirically that Dunn's six dimensions are not independent of one another in resource-constrained settings: efficiency, effectiveness, and equity all trace back to the same underlying capacity constraint, while responsiveness is the one dimension capable of drawing on a resource external to the state—community monitoring capacity—to partially compensate for that constraint. Second, it suggests a boundary condition for collaborative-governance theory: community co-production functioned well here specifically

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because the pollution in question was locally visible and directly experienced; the theory's predictive power for diffuse, non-visible environmental harms — the majority of what this policy is meant to regulate — remains an open question that this single case cannot resolve.

This study has several limitations that should qualify how its findings are read. First, and most importantly, it draws on interviews with regulators and community members but not with representatives of regulated industry; firms' own account of their compliance decisions is therefore absent, and future research incorporating that perspective could substantially deepen the Effectiveness and Appropriateness analyses in particular. Second, the roughly fifty companies DLH inspects each year are not randomly selected, which—as discussed throughout the Results—limits how confidently this study's compliance findings generalize to the wider population of uninspected firms. Third, this is a single-site case study of one industrial zone in one regency; while Cikarang shares structural features (jurisdictional fragmentation, resource-constrained oversight) with many other Indonesian industrial areas, the specific findings reported here should not be assumed to generalize automatically to zones with different industry compositions or governance arrangements. Finally, the first author's professional affiliation with the Bekasi Regency government, while managed through the reflexivity measures described in the Method section, cannot be fully eliminated as a potential source of interpretive bias, and readers should weigh the findings with that context in mind.

Future research could usefully pursue three directions: a comparative multi-site study spanning several Indonesian industrial zones with differing governance structures, to test whether the mechanisms identified here (targeting-driven sampling bias, community co-production as a partial substitute for state capacity) hold more generally; a mixed-methods design that pairs the qualitative approach used here with a randomly sampled inspection audit, to produce a statistically generalizable effectiveness estimate; and research that directly incorporates the perspective of regulated firms, to better understand the compliance-cost calculations this study could only infer indirectly from regulator and community accounts.

REFERENCES

- Anderson, J. E. (2014). *Public Policymaking* (8th Edition). Cengage Learning.
- Ardiansyah, F., Marthen, A. A., & Amalia, N. (2015). *Forest and Land-Use Governance in a Decentralized Indonesia: A Legal and Policy Review*. Center for International Forestry Research (CIFOR). <https://doi.org/10.17528/cifor/005695>
- Creswell, J. W., & Creswell, J. D. (2023). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (6th Edition). SAGE Publications, Inc.
- Dinayah, I. P., & Novembrianto, R. (2023). Evaluasi Sistem Pengelolaan Limbah B3 PT Y. *INSOLOGI: Jurnal Sains dan Teknologi*, 2(3), 561–571. <https://doi.org/10.55123/insologi.v2i3.1984>
- Dirgawati, M., & Amitasyah, A. (2024). Evaluasi Pengelolaan Limbah Bahan Berbahaya dan Beracun di PT. X Industri Plastik. *Jurnal Serambi Engineering*, IX(2), 8481–8489.
- Dompak, T., & Riyanda, R. (2018). Analisis Efektivitas Kebijakan Dan Program Badan Pengendalian Dampak Lingkungan Daerah (BAPEDALDA) Kota Batam Terhadap Peningkatan Persentase Pelaksanaan Amdal. *Jurnal Niara*, 11(1), 62–70. <https://doi.org/10.31849/nia.v11i1.1571>
- Dunn, W. N. (2003). *Pengantar Analisis Kebijakan Publik* (M. Darwin, Ed.; S. Wibawa, D. Asitadani, A. H. Hadna, & E. A. Purwanto, Trans.; Edisi Kedua). Gadjah Mada University Press.
- Dye, T. R. (2002). *Understanding Public Policy*. Prentice Hall.
- Fajriyah, S. A., & Wardhani, E. (2020). Evaluasi Pengelolaan Limbah Bahan Berbahaya dan Beracun (B3) di PT. X. *Jurnal Serambi Engineering*, 5(1), 711–719. <https://doi.org/10.32672/jse.v5i1.1597>

- Ferronato, N., & Torretta, V. (2019). Waste Mismanagement in Developing Countries: A Review of Global Issues. *International Journal of Environmental Research and Public Health*, 16(6), 1060. <https://doi.org/10.3390/ijerph16061060>
- Gray, W. B., & Shimshack, J. P. (2011). The Effectiveness of Environmental Monitoring and Enforcement: A Review of the Empirical Evidence. *Review of Environmental Economics and Policy*, 5(1), 3–24. <https://doi.org/10.1093/reep/req017>
- Hardiyanto, B. D., Kartini, A. M., & Pramitasari, N. (2022). Evaluasi Pengelolaan Limbah B3 Pada Industri Air Minum Dalam Kemasan (amdk) Di Pt.x. *Jukung (Jurnal Teknik Lingkungan)*, 8(2), 81–94. <https://doi.org/10.20527/jukung.v8i2.14913>
- Khoshsepehr, Z., Alinejad, S., & Alimohammadlou, M. (2023). Exploring Industrial Waste Management Challenges and Smart Solutions: An Integrated Hesitant Fuzzy Multi-Criteria Decision-Making Approach. *Journal of Cleaner Production*, 420, 138327. <https://doi.org/10.1016/j.jclepro.2023.138327>
- Knill, C., & Tosun, J. (2020). *Public Policy: A New Introduction* (2nd Edition). Bloomsbury Academic.
- Kumar, A., Thakur, A. K., Gaurav, G. K., Klemesš, J. J., Sandhwar, V. K., Pant, K. K., & Kumar, R. (2023). A Critical Review on Sustainable Hazardous Waste Management Strategies: A Step Towards a Circular Economy. *Environmental Science and Pollution Research*, 30(48), 105030–105055. <https://doi.org/10.1007/s11356-023-29511-8>
- Liu, M., Liu, Y., & Zhao, Y. (2021). Environmental Compliance and Enterprise Innovation: Empirical Evidence from Chinese Manufacturing Enterprises. *International Journal of Environmental Research and Public Health*, 18(4), 1924. <https://doi.org/10.3390/ijerph18041924>
- Miles, M. B., Huberman, A. M., & Saldana, J. (2014). *Qualitative Data Analysis: A Methods Sourcebook* (3rd Edition). SAGE Publications.
- Mmereki, D., Baldwin, A., Hong, L., & Li, B. (2016). The Management of Hazardous Waste in Developing Countries. In *Management of Hazardous Wastes*. IntechOpen. <https://doi.org/10.5772/63055>
- Nur, A. C., & Nur, A. I. (2025). Enhancing Hazardous Waste Management Through the “SIPENGOLAH LIMBAH B3” Innovation: Implementation Analysis and Impact. *International Journal of Public Administration in the Digital Age*, 12(1), 1–19. <https://doi.org/10.4018/IJPADA.368716>
- Nursabrina, A., Joko, T., & Septiani, O. (2021). Kondisi Pengelolaan Limbah B3 Industri Di Indonesia Dan Potensi Dampaknya: Studi Literatur. *Jurnal Riset Kesehatan Poltekkes Depkes Bandung*, 13(1), 80–90. <https://doi.org/10.34011/juriskesbdg.v13i1.1841>
- Prabowo, R. (2025). Kontribusi Industri terhadap Pertumbuhan Ekonomi Nasional. *Factory Jurnal Industri, Manajemen dan Rekayasa Sistem Industri*, 3(2), 55–57. <https://doi.org/10.56211/factory.v3i2.731>
- Ridwan, R., & Delima, S. (2021). Implementasi Pengawasan Dinas Lingkungan Hidup Dalam Mengatasi Pencemaran Lingkungan Pada Kawasan Industri Di PT. Perkebunan Nusantara VI. *Jurnal Politik Dan Pemerintahan Daerah*, 3(2), 88–100. <https://doi.org/10.36355/jppd.v3i2.31>
- Riyadi, R., Waluyo, W., & Candrakirana, R. (2024). Efektivitas Pelaksanaan Pengawasan Oleh Dinas Lingkungan Hidup (DLH) Kabupaten Boyolali Terhadap Industri Berisiko Tinggi. *Hakim: Jurnal Ilmu Hukum dan Sosial*, 2(2), 233–242. <https://doi.org/https://journal.stekom.ac.id/index.php/Hakim/article/view/1768>
- Salsabilla, Y., Dewajani, H., & Chumaidi, A. (2023). Analisis Sistem Pengelolaan Limbah Bahan Berbahaya Dan Beracun (b3) Pada Perusahaan Pestisida. *DISTILAT: Jurnal Teknologi Separasi*, 9(4), 548–557. <https://doi.org/10.33795/distilat.v9i4.4177>
- Sipahutar, M., & Sukmawati, S. N. (2021). A Waste Management in the Service Company for Hazardous Waste Treatment in Balikpapan. *Jurnal Green Growth Dan Manajemen Lingkungan*, 10(2), 65–76.

- Sitogasa, P. S. A., & Alim, M. S. (2023). Kajian Pengelolaan Limbah Bahan Berbahaya dan Beracun (B3) Industri Rokok Kabupaten Pasuruan. *Student Scientific Creativity Journal*, 1(4), 245–260. <https://doi.org/10.55606/sscj-amik.v1i4.1623>
- Sugiyono. (2021). *Metode Penelitian Kuantitatif, Kualitatif, Dan R&D* (Edisi Ke-3). Alfabeta.
- Sutanto, Y. S., & Karianga, K. (2023). Hukum Terkait Pengelolaan Limbah Bahan Berbahaya Dan Beracun Medis Rumah Sakit. *Jurnal Hukum Kesehatan Indonesia*, 3(02), 103–115. <https://doi.org/10.53337/jhki.v3i02.101>
- Tietenberg, T., & Lewis, L. (2018). *Environmental and Natural Resource Economics* (11th Edition). Routledge. <https://doi.org/10.4324/9781315208343>
- Wibawa, S., Purbokusumo, Y., & Pramusinto, A. (1994). *Evaluasi Kebijakan Publik*. Raja Grafindo Persada.
- Xiao, L., Zhang, G., Zhu, Y., & Lin, T. (2017). Promoting Public Participation in Household Waste Management: A Survey Based Method and Case Study in Xiamen City, China. *Journal of Cleaner Production*, 144, 313–322. <https://doi.org/10.1016/j.jclepro.2017.01.022>
- Yudartha, I. P. D., Yuwono, T., & Suwitri, S. (2026). Waste Management in Developing Countries: A Systematic Literature Review of Policy Implementation. *Frontiers in Environmental Science*, 14, 1812062. <https://doi.org/10.3389/fenvs.2026.1812062>
- Zakianis, Lestari, F., Fauzia, S., Fitria, L., Zulys, A., Hartono, B., Muzanni, A., Satyawardhani, S. A., Shaw, R., & Prabowo, S. (2023). Identification of Hazardous Waste Risk Level in Central Java Province, Indonesia. *Sustainability*, 15(8), 6390. <https://doi.org/10.3390/su15086390>