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Evaluating Water Governance Sustainability Through an Environmental, Social, and Governance (ESG) Lens: A Case Study of Kudus Regency, Central Java, Indonesia

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ABSTRACT

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Industrial agglomeration and the progressive degradation of the Mount Muria catchment area have placed Kudus Regency, Central Java, at serious risk of a structural hydrological deficit. This study analyzes the sustainability of water resource management in Kudus Regency through the Environmental, Social, and Governance (ESG) framework, addressing a literature gap between studies treating regional water security as either a purely hydro-physical or a purely utility-management problem, rarely as an integrated policy system. Using a descriptive qualitative case study design based on systematic desk review, the study triangulates 2021-2025 secondary data, including Regional Environmental Performance Reports (DIKPLH), river-basin water balance records, national statistics, and regulatory documents, guided by a parameter matrix adapted from the GRI 303 water-and-effluents standard. The analysis shows that the overall water sustainability status of Kudus Regency is Vulnerable and trending toward Critical. Under the Environmental pillar, dependable streamflow declined by 4.2% annually amid upstream deforestation and selective corporate disclosure of groundwater extraction. Under the Social pillar, a pronounced spatial asymmetry was found: 84.2% piped-water coverage in the urban sub-district versus 31.5% in agrarian sub-districts, compounded by a hidden double financial burden from bottled-water substitution. Under the Governance pillar, the recentralization of groundwater permit issuance has paralyzed local enforcement capacity, while conservation spending remains below 0.85% of the regional budget. The study concludes that strong performance in one ESG pillar cannot offset failure in another, and proposes a Mandatory Water Offsetting scheme and an Integrated Groundwater Supervisory Desk as policy instruments to avert a Tragedy of the Commons.

Keywords: Environmental, Social, and Governance (ESG) Framework; Kudus Regency; Mandatory Water Offsetting; Public Sector Water Management; Tragedy of the Commons; Water Governance.

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INTRODUCTION

The global freshwater crisis has shifted from a narrowly ecological concern into a systemic threat to social resilience and economic stability (World Economic Forum, 2024). Recent global monitoring data underscore the scale of the problem: as of 2022, some 2.2 billion people still lacked safely managed drinking water and 3.5 billion lacked safely managed sanitation, figures that have improved only marginally against the pace required to meet the 2030 deadline (World Health Organization & United Nations Children's Fund [WHO & UNICEF], 2023). Within the architecture of the Sustainable

Development Goals, Target 6 explicitly demands more than incremental infrastructure expansion; it calls for a governance transformation that stops treating water purely as a commercial commodity to be supplied on demand. Against this backdrop, the Environmental, Social, and Governance (ESG) framework has emerged as a holistic instrument for measuring the sustainability of water systems. Where water management was historically evaluated through a narrow supply-side lens, coverage ratios, treatment capacity, tariff recovery, the ESG paradigm compels stakeholders, whether public utilities or private industry, to simultaneously account for their hydrological extraction footprint, the distributive fairness of access, and the transparency of the regulatory architecture that governs them (Ceres, 2022). Emerging scholarship on ESG in the water sector further argues that governance quality, rather than environmental compliance alone, is what ultimately determines whether water institutions can innovate and adapt under scarcity pressure (Minea et al., 2025).

In Indonesia, the tension between industrial agglomeration and groundwater availability has become a critical issue across densely populated regions (Kementerian PPN/Bappenas, 2023). As a common-pool resource, water is structurally vulnerable to the classic collective-action dilemma: unrestrained extraction by one actor directly erodes the usufructuary rights of others (Ostrom, 2015). Compounding this vulnerability, Indonesia's groundwater governance architecture has been described as fragmented and internally inconsistent, with overlapping regulatory instruments, multiple licensing authorities, and weak enforcement mechanisms that collectively undermine the country's capacity to meet its Sustainable Development Goal 6 commitments (Zaidi & Handayani, 2025). Urban water governance research similarly finds that Indonesia's water policy domain is characterized by a dense, poorly coordinated network of actors operating under separate legal mandates, a structural condition that predates and helps explain many localized water crises (Mulyana & Prasoj, 2020). Applying ESG principles to regional water management therefore cannot be separated from cross-sectoral accountability: local government must act simultaneously as the custodian of conservation mandates and the guarantor of basic rights, while industrial actors must operate as users bound by the ecological limits of hydrological recovery (Saraswati & Suhariyanto, 2023).

Kudus Regency exemplifies this dynamic in an acute form. Geographically, the regency depends on the slopes of Mount Muria as its principal water catchment area (Nugroho et al., 2021). At the same time, Kudus is one of Central Java's largest centers of processing industry and economic turnover. The dominance of capital-intensive manufacturing has driven high rates of deep-groundwater abstraction, generating a latent competition between the domestic raw-water needs coordinated by the regional water utility, Perumda Tirta Muria, and the escalating water demand of the industrial sector (Wibowo & Hidayat, 2022). Land-use conversion in the upper Muria catchment, combined with early signs of groundwater-table decline in downstream areas, signals that the regency's hydrological system is already under considerable strain. Kudus is nationally recognized as the historic center of Indonesia's *kretek* (clove cigarette) manufacturing industry and has since diversified into paper, food, and other processing sub-sectors, all of which are water-intensive at the production stage. This industrial identity is precisely what makes the regency an instructive case: unlike metropolitan water crises driven mainly by population density, Kudus's hydrological stress is driven by a concentrated, capital-intensive production base operating within a comparatively small and hydrogeologically sensitive catchment, a combination that is increasingly common across Java's secondary industrial cities but remains underexamined in the water governance literature.

Evaluating Kudus's water governance through an ESG lens provides a more measurable diagnostic framework than single-dimension assessments. Under the Environmental pillar, the relevant tests concern the regional water balance, the effectiveness of upstream conservation in the Muria catchment, and the control of industrial effluent pollution. Under the Social pillar, the priority lies in equitable access for vulnerable groups, the mitigation of use conflicts between agriculture and industry, and tariff affordability. Under the Governance pillar, the key parameters are the rigor of law enforcement over Groundwater Utilization Permits (Surat Izin Pemanfaatan Air Tanah, SIPA), the transparency of water-balance data, and the institutional synergy among the Kudus Regency Government, the Pemali Juana River Basin Authority (Balai Besar Wilayah Sungai, BBWS), and private industry (Pratama, 2024).

Prior research on Kudus's water resources, however, remains divided into two disconnected strands. One strand is grounded almost exclusively in hydro-physical modeling of groundwater vulnerability and catchment conservation (Nugroho et al., 2021); the other is confined to the financial efficiency and service-coverage performance of the regional water utility (Wibowo & Hidayat, 2022). Neither strand treats environmental sustainability, social equity, and institutional accountability as interlocking variables within a single policy diagnostic, a limitation that mirrors a broader pattern in the international literature, where ESG-water scholarship has been developed largely around regulated utilities in high-income, centralized regulatory settings rather than the decentralized, multi-actor governance context typical of a mid-sized Indonesian industrial regency (Minea et al., 2025). This study addresses that gap directly: no existing analysis positions Kudus's water resilience within an integrated ESG matrix that treats environmental, social, and governance performance as mutually conditioning rather than independently assessed. Accordingly, this research aims to analyze the sustainability of water resource management in Kudus Regency using the ESG approach, in order to formulate a more resilient regional water policy architecture and to demonstrate how fragmented single-pillar performance can mask compounding systemic risk.

METHODS

This study employs a descriptive qualitative design using a case study approach, executed through secondary data tracing, or desk review (Creswell & Poth, 2018). This approach was selected because testing the Environmental, Social, and Governance (ESG) framework against public infrastructure governance is not a matter of eliciting individual subjective perception; rather, it requires a critical reading of legal instruments, official institutional reporting, and the audit trail of the regional water balance (Yin, 2018). The research locus is the administrative territory of Kudus Regency, and the analysis incorporates three stakeholder representations: the Kudus Regency Government as regulator, Perumda Tirta Muria as the public operator, and the processing-industry sector as the commercial extractor.

Following the principle of secondary-source data triangulation (Denzin, 2017), the data collected for this study span the 2021-2025 period and are classified into three groups aligned with the three ESG pillars. Environmental pillar data were obtained from the Regional Environmental Performance Information Document (Dokumen Informasi Kinerja Pengelolaan Lingkungan Hidup Daerah, DIKPLH) of Kudus Regency, the Water Resources Balance Sheet of the Pemali Juana River Basin Authority (BBWS Pemali Juana), and Water Quality Index (Indeks Kualitas Air, IKA) data published by the Central Statistics Agency (Badan Pusat Statistik, BPS) of Kudus Regency. Social pillar data were obtained from the annual report of Perumda Tirta Muria (with emphasis on domestic service coverage and tariff structure), the Kudus Regency People's Welfare Statistics, and archives of credible mass-media reporting on public complaints regarding clean-water availability in drought-prone areas such as Undaan Sub-district. Governance pillar data were obtained from the Kudus Regency bylaw on the Regional Spatial Plan (Rencana Tata Ruang Wilayah, RTRW), the Regional Government Work Plan (Rencana Kerja Pemerintah Daerah, RKPD) concerning water-resource conservation budget allocations, and the recapitulation of Groundwater Utilization Permit (SIPA) ownership published by the Kendeng Muria Regional Branch of the Energy and Mineral Resources Office (ESDM).

To minimize assessment bias, the secondary-data extraction process was guided by a modified instrument combining the global Global Reporting Initiative standard GRI 303: Water and Effluents (GRI, 2018) with the public-sector water risk assessment framework developed by Ceres (2022). The resulting parameter matrix was operationalized as follows.

- Environmental (E) parameters were measured through (a) the efficiency of groundwater extraction relative to the natural recharge rate at the foot of Mount Muria, and (b) the compliance rate of major Kudus industries in operating Wastewater Treatment Installations (Instalasi Pengolahan Air Limbah, IPAL) prior to discharge into river bodies.
- Social (S) parameters were measured through (a) the equity ratio of water-supply distribution between the urban sub-district (Kecamatan Kota) and peripheral sub-districts, and (b) the

affordability ratio of domestic drinking-water tariffs relative to the Kudus Regency Minimum Wage (Upah Minimum Kabupaten, UMK).

- Governance (G) parameters were measured through (a) the availability and transparency of public information portals concerning the groundwater balance; (b) the rigor of law enforcement against industries operating without a SIPA permit; and (c) the share of Direct Expenditure in the Kudus Regional Budget (APBD) dedicated to raw-water source protection.

Because this study relies entirely on documentary secondary data rather than field observation or interviews, methodological rigor was safeguarded through source triangulation across institutional origins, ensuring that no single finding rests on one document alone (Denzin, 2017). Credibility was reinforced by prioritizing primary institutional sources, government regulations, official statistical releases, and audited utility reports, over secondary journalistic accounts, which were used only to corroborate or contextualize patterns already visible in the formal record. Dependability was supported by the reference-management audit trail described above, which allows every extracted data point in the ESG matrix to be traced back to its original document and publication date. This procedure does not substitute for primary fieldwork, a limitation addressed explicitly in Section 5, but it provides a defensible basis for the descriptive and diagnostic claims advanced in the Results and Discussion sections.

RESULTS

The review of water balance documents and environmental performance reports indicates that Kudus Regency is experiencing an ecological deficit that has been obscured by strong regional economic growth. According to the Regional Environmental Performance Information Document (DIKPLH), dependable surface-water discharge within the Kudus Groundwater Basin (Cekungan Air Tanah) declined by 4.2% annually over the 2021-2025 period (Pemerintah Kabupaten Kudus, 2025). Read through an ESG lens, this hydrological deficit is not a pure climatic anomaly but a constructed vulnerability, arising from the widening gap between the extraction rate required to meet domestic needs managed by Perumda Tirta Muria and the escalating groundwater consumption of downstream capital-intensive industry.

Environmental Pillar

The first anomaly under the Environmental pillar appears in the water-recharge zone on the slopes of Mount Muria, particularly in Dawe and Gebog Sub-districts. Land-cover data indicate that secondary forest has been converted into seasonal agricultural land and commercial tourism destinations at a rate of 11.4% over the past decade (Pemerintah Kabupaten Kudus, 2025). The resulting decline in vegetation density in the upstream zone directly reduces the natural groundwater recharge rate. This finding is consistent with Nugroho et al. (2021), who show that the loss of infiltration function at the foot of Mount Muria causes rainfall to be diverted increasingly into surface runoff, fueling flooding in southern Kudus, rather than replenishing the shallow aquifer. Still within the Environmental pillar, an assessment of compliance among major industries, particularly the tobacco and paper processing sectors concentrated in Jati and Kaliwungu Sub-districts, reveals a bias in sustainability reporting. Administratively, most Kudus corporations hold Green PROPER certification from the Ministry of Environment and Forestry and operate Wastewater Treatment Installations (IPAL) that meet effluent quality standards (Saraswati & Suhariyanto, 2023). Yet, under the GRI 303 standard, sustainability cannot be measured solely by the clarity of effluent returned to the river; it must also account for the total volume of freshwater permanently withdrawn from the hydrological cycle, or water consumption. The formation of a cone of depression around industrial zones demonstrates that corporations tend to practice selective environmental accounting, highlighting compliance in wastewater treatment while obscuring the scale of their deep-groundwater extraction (Ceres, 2022).

Social Pillar

Turning to the Social pillar, water management in Kudus Regency reveals a stark spatial inequity. Central Statistics Agency data show that piped water-service coverage from Perumda Tirta Muria

reached 84.2% in the urban Kecamatan Kota, yet plummeted to 31.5% in agrarian sub-districts such as Undaan and Jekulo (BPS Kabupaten Kudus, 2025). During prolonged dry seasons associated with El Nino, residents of Undaan have been forced to rely on emergency water-tanker deliveries. This produces a social irony: the farming communities in southern Kudus, who hold the mandate for regional food security, experience acute water scarcity, while industrial zones in the north continue uninterrupted deep-groundwater extraction. This pattern breaches the principle of distributive justice within the Social pillar of the ESG framework (World Health Organization, 2023).

On the question of affordability, the tariff structure of Perumda Tirta Muria is, on paper, still relatively populist. With a base household tariff of approximately IDR 4,500 per cubic meter, average domestic water spending in Kudus consumes only 2.6% of the Kudus Regency Minimum Wage (UMK), below the WHO's commonly cited safe threshold of 3% of household income (Wibowo & Hidayat, 2022). However, social vulnerability is concealed in substitution costs. Because piped water quality is frequently reported as turbid during peak-demand hours, most lower- and middle-income households are compelled to allocate an additional 4-5% of income toward bottled or refill drinking water for oral consumption. As a result, a utility tariff that "looks cheap on paper" fails to protect households from a compounded financial burden in securing safe water.

Governance Pillar

Under the Governance pillar, the erosion of Kudus's water resilience is most visible in the fragility of permit enforcement. Since the enactment of the Job Creation Law (UU Cipta Kerja) and its implementing regulations, the authority to issue Groundwater Utilization Permits (SIPA) was withdrawn to the central government and is now coordinated through the Pemali Juana River Basin Authority (BBWS Pemali Juana) and the Central Java Provincial ESDM Office (Pratama, 2024). Consequently, the Kudus Regency Government now occupies the position of a "regulator without teeth." When the Kudus Environmental Agency (DLH) identified thousands of commercial boreholes operated by medium-scale industries and boarding houses without SIPA permits or water meters, the regency government lacked any executory instrument to seal the wells, and could only issue a recommendation memo to the provincial authority.

This governance weakness is further compounded by the political posture of regional budgeting. In the Kudus Regency Budget (APBD) for fiscal years 2024 and 2025, Direct Expenditure specifically allocated to the "Conservation and Preservation of Water Resources" program was recorded at less than 0.85% of total regional expenditure (Pemerintah Kabupaten Kudus, 2025). This empirical fact almost perfectly demonstrates Elinor Ostrom's (2015) postulate on the Tragedy of the Commons. Because groundwater in Kudus is treated as an underpriced common asset, its extraction cost not reflecting its real scarcity value, every industrial actor is incentivized to maximize withdrawal to minimize production cost, while the long-term costs, including land subsidence, are socialized across the wider population.

Synthesis: ESG Parameter Matrix

Applying the three-point classification scheme described in Section 2.4, a pillar is scored toward the Resilient end of the spectrum when documented practice meets or exceeds the relevant regulatory or international benchmark (for instance, GRI 303 compliance reporting or the WHO affordability threshold), toward Vulnerable when formal benchmarks are nominally met but underlying structural indicators (recharge rate, distributional equity, enforcement capacity) show clear deterioration, and toward Critical when both formal and structural indicators fail concurrently. Measured against this scheme, none of the three Kudus pillars qualifies as Resilient, and the Governance pillar in particular sits closest to the Critical boundary. Table 1 synthesizes the three pillars by juxtaposing the ideal condition implied by ESG standards against the empirical regulatory and factual condition documented in Kudus Regency, following the Data Display stage of the analytical procedure described in Section 2.4.

Table 1. ESG Parameter Matrix: Ideal Conditions and Empirical Findings in Kudus Regency (2021-2025)

Pillar	Parameter	Ideal Condition (ESG Standard)	Empirical Condition in Kudus Regency
Environmental	Groundwater extraction vs. natural recharge rate (Mount Muria foothills)	Extraction remains within sustainable recharge capacity; stable or expanding catchment forest cover	Dependable water discharge declining 4.2% per year (2021-2025); 11.4% of secondary forest converted to farmland/tourism land use over the past decade
Environmental	Industrial IPAL compliance and groundwater consumption disclosure	Full wastewater-treatment compliance and transparent disclosure of total groundwater consumption (GRI 303)	Widespread Green PROPER certification and IPAL compliance, but no disclosure of groundwater extraction volume; a cone of depression detected around industrial zones
Social	Equity of piped-water distribution: urban vs. peripheral sub-districts	Comparable coverage across sub-districts; minimal urban-rural gap	84.2% coverage in Kecamatan Kota vs. 31.5% in Undaan/Jekulo; emergency tanker-water dependency during El Nino droughts
Social	Tariff affordability relative to the Regency Minimum Wage (UMK)	Domestic water expenditure at or below 3% of household income (WHO threshold)	Base tariff equals 2.6% of UMK (nominally compliant), but an additional 4-5% of income is spent on bottled/refill water due to turbidity complaints
Governance	Transparency of groundwater balance data / public information portal	Publicly accessible, regularly updated water-balance and SIPA permit registry	No accessible public data portal identified; figures compiled only through institutional DIKPLH/BBWS reporting
Governance	Enforcement against unlicensed (non-SIPA) groundwater use	Local government holds executory authority to seal or sanction illegal wells	SIPA authority centralized post-Job Creation Law; Kudus DLH limited to recommendation memos to the province; thousands of unlicensed boreholes identified
Governance	Regional budget (APBD) allocation for water-resource conservation	Budget allocation proportionate to conservation risk and priority	Less than 0.85% of Direct Expenditure (FY2024-2025) allocated to "Conservation and Preservation of Water Resources"
Overall ESG Status	Composite sustainability classification	Resilient	Vulnerable, trending toward Critical

Note. UMK = Upah Minimum Kabupaten (Regency Minimum Wage); IPAL = Instalasi Pengolahan Air Limbah (Wastewater Treatment Installation); SIPA = Surat Izin Pemanfaatan Air Tanah (Groundwater Utilization Permit); DLH = Dinas Lingkungan Hidup (Regional Environmental Agency); DIKPLH = Dokumen Informasi Kinerja Pengelolaan Lingkungan Hidup Daerah (Regional Environmental Performance Information Document); BBWS = Balai Besar Wilayah Sungai (River Basin Authority); APBD = Anggaran Pendapatan dan Belanja Daerah (Regional Budget).

Synthesizing the three pillars, the sustainability of water management in Kudus Regency sits within the Vulnerable spectrum and is moving in a near-linear trajectory toward the Critical phase. A fatal policy disconnection is evident: the Environmental pillar continues to degrade upstream, the Social pillar exhibits pronounced distributive inequity downstream, and the Governance pillar remains trapped in a central-regional authority disorientation. Consequently, the ESG framework in the Kudus context can no longer be reduced to a corporate-style annual compliance checklist. To rescue the regional water balance, the Kudus Regency Government, together with the Regional House of Representatives (DPRD), must press for a Mandatory Water Offsetting scheme within the revision of the RTRW bylaw, a substantive clause requiring that every industrial actor extracting one liter of deep groundwater downstream in Kudus be legally obligated to finance the injection of 1.2 liters of harvested rainwater into recharge wells within the Mount Muria catchment area.

DISCUSSION

The findings above resist a single-pillar reading and instead demand an integrated interpretation, precisely because the pillars in Kudus interact rather than operate independently. Emerging ESG-water scholarship argues that governance quality functions as the binding constraint on sustainability outcomes: environmental and social performance can only be as reliable as the institutional architecture that verifies, discloses, and enforces them (Minea et al., 2025). The Kudus case illustrates this proposition with unusual clarity. Industrial compliance with effluent standards under the Environmental pillar, evidenced by widespread Green PROPER certification, creates an appearance of sustainability that is not corroborated by upstream hydrological indicators, because compliance reporting under Indonesia's current disclosure regime captures discharge quality but not extraction volume. This is not a data gap so much as a governance design flaw: without a disclosure requirement tied to GRI 303's water-consumption metric, corporate ESG performance can be favorably reported even as the resource base it depends upon is being depleted (Ceres, 2022; Saraswati & Suhariyanto, 2023). The cone of depression identified around Kudus's industrial zones is, in this sense, a governance artifact as much as a hydrological one.

The Social pillar findings reinforce this diagnosis from a distributive angle. The 52.7-percentage-point gap between urban and agrarian piped-water coverage is not simply an infrastructure financing shortfall; it reflects the same upstream-downstream extraction imbalance documented under the Environmental pillar, now expressed as unequal access rather than unequal extraction. Structurally, this recalls the fragmented, multi-actor character of Indonesian urban water governance identified by Mulyana and Prasajo (2020), in which overlapping institutional mandates make coordinated, equity-oriented water allocation difficult to achieve even where aggregate supply appears adequate. The apparent affordability of Perumda Tirta Muria's base tariff, below the WHO's 3%-of-income threshold, further illustrates how a single favorable metric can mask a compounded burden once substitution costs for bottled water are included, a pattern consistent with the WHO and UNICEF's (2023) broader finding that safely managed access, not nominal coverage or price, is the metric that determines real household welfare.

The Governance pillar findings are arguably the most consequential, because they explain why the Environmental and Social deficits persist despite the existence of formal regulatory instruments. The recentralization of SIPA permit authority under the Job Creation Law and its derivative regulations has produced a jurisdictional mismatch: the tier of government with the closest operational knowledge of local extraction points, the regency, has been stripped of executory power, while the tier with formal authority, the province and the river basin authority, lacks the on-the-ground capacity for continuous monitoring. This dynamic parallels the broader diagnosis of Indonesian groundwater regulation as unclear and internally fragmented, where overlapping mandates across ministries and levels of government dilute accountability for any single outcome (Zaidi & Handayani, 2025). Regionally, the near-absence of conservation budgeting, under 0.85% of Direct Expenditure, confirms that this is not merely an implementation gap but a revealed budgetary priority. Read together with Ostrom's (2015) theory of collective-action failure in common-pool resource systems, the Kudus case exhibits nearly all of the classic preconditions for a Tragedy of the Commons: a resource without well-defined

extraction boundaries, extraction costs decoupled from ecological replacement costs, and monitoring authority separated from enforcement authority.

What the Kudus case adds to this theoretical picture is a demonstration that ESG cannot be practiced as a cherry-picking exercise in public infrastructure governance, a caution already implicit in ESG-utility scholarship developed in higher-income regulatory contexts (Minea et al., 2025) but rarely tested empirically in a decentralized developing-economy setting. A locally strong Environmental score (effluent compliance) and a locally strong Social score (nominal tariff affordability) do not aggregate into sustainability if the Governance pillar cannot enforce extraction limits; instead, they function as a reputational shield that allows extractive practices to continue unchecked. This has a direct implication for how ESG assessments of public water utilities and regional governments should be constructed: aggregate or averaged ESG scores risk concealing exactly the kind of pillar-level compensation that this case shows to be analytically and practically dangerous. A more defensible approach, consistent with the "weakest link" logic implicit in common-pool resource theory (Ostrom, 2015), is to treat the lowest-performing pillar, rather than the composite score, as the binding indicator of systemic water security.

The policy instrument proposed in the results, Mandatory Water Offsetting at a 1:1.2 recharge ratio, should accordingly be understood not as a stand-alone environmental fix but as a governance correction: it re-attaches an extraction cost to the resource that current regulation has left effectively unpriced, directly addressing the underpricing mechanism that Ostrom (2015) identifies as central to commons failure. Embedding the offsetting obligation in the RTRW bylaw, rather than in a sectoral environmental regulation, is deliberate: spatial planning instruments in Indonesia carry stronger legal durability and cross-sectoral binding force than annual budgetary programs, and are less exposed to the kind of central-regional authority disputes that have already neutralized SIPA enforcement. Complementing this with an Integrated Groundwater Supervisory Desk addresses the jurisdictional mismatch identified above by creating a standing coordination mechanism among the Kudus Regency Government, BBWS Pemali Juana, and the Central Java Provincial Government, precisely the multi-actor coordination gap that both Mulyana and Prasajo (2020) and Zaidi and Handayani (2025) identify as a structural weakness of Indonesian water governance more broadly.

A further point of theoretical interest concerns the instruments used to conduct this diagnosis in the first place. Both GRI 303 and the Ceres water-risk framework were designed primarily for corporate disclosure, not for evaluating regional government performance. Their successful application to Kudus in this study suggests that public-sector water governance can be productively audited using corporate-style sustainability instruments, provided the unit of analysis is expanded from a single firm to the full set of actors sharing a catchment, government, utility, and industry alike. This adaptation matters conceptually because it relocates the accountability question: under a firm-level ESG audit, the Kudus tobacco and paper industries would likely score well, given their PROPER certification and IPAL compliance; under the catchment-level audit conducted here, the same industries appear as contributors to a shared resource deficit that no single actor's disclosure captures. This suggests that future ESG instruments for public infrastructure should be explicitly designed at the scale of the resource system rather than the scale of the reporting entity.

The Kudus findings also speak to Indonesia's broader decentralization debate. The 2020 Job Creation Law recentralized several natural-resource permitting functions on the premise that national coordination would improve regulatory consistency and investment certainty. The Kudus case suggests an unintended consequence: where central agencies retain formal authority but lack the local presence to monitor thousands of dispersed extraction points, recentralization can produce an enforcement vacuum rather than improved oversight. This is not necessarily an argument for reversing recentralization outright, but it does indicate that permitting authority and monitoring capacity need not be recentralized in tandem; a hybrid model, in which permitting remains centralized while routine monitoring and first-line enforcement are delegated back to regency-level agencies operating under provincial supervision, would be more consistent with the operational realities documented here. The proposed Integrated Groundwater Supervisory Desk is, in effect, an institutional proxy for exactly this kind of hybrid arrangement.

RESEARCH LIMITATIONS

The main limitation of this study is its reliance solely on secondary data. Consequently, the research has not been able to quantitatively examine and calculate the actual water footprint of each industrial cluster in Kudus Regency. Therefore, this limitation simultaneously opens up avenues for future research to address this gap.

CONCLUSION

Based on the analysis of the three ESG pillars, the sustainability of water resource management in Kudus Regency can be classified as Vulnerable, with a degradation trajectory pointing toward a Critical phase. The regency's hydrological resilience is trapped in a policy paradox: strong formal corporate compliance with wastewater treatment standards (Environmental) and a nominally populist piped-water tariff (Social) together conceal a substantial groundwater balance deficit and a fragile local oversight apparatus (Governance). A sharp spatial and sectoral asymmetry runs through the findings: the upstream Muria catchment is losing infiltration capacity, the central industrial belt monopolizes deep-groundwater extraction, and the downstream agrarian periphery absorbs both water scarcity and a compounded financial burden.

Theoretically, this study demonstrates that the ESG framework cannot be meaningfully applied to public infrastructure through fragmented, pillar-by-pillar assessment. Positive performance on one pillar cannot compensate for failure on another. The clarity of industrial effluent returned to the river (E) loses its sustainability meaning when upstream raw-water extraction produces a water crisis for farming communities in southern Kudus (S), and when the Kudus Regency Government loses jurisdictional authority to act against illegal commercial boreholes due to regulatory recentralization (G). The market failure culminating in a Tragedy of the Commons in Kudus Regency is shown to be driven by the absence of an economic valuation of groundwater that reflects its true ecosystem-restoration cost, a dynamic consistent with, and empirically illustrative of, Ostrom's (2015) foundational theory of common-pool resource governance.

As a strategic mitigation step, the Kudus Regency Government is called upon to reconstruct its regional water policy architecture through two key interventions. First, it should adopt a Mandatory Water Offsetting scheme, a reciprocal recharge obligation at a 1:1.2 ratio, within the revision of the Regional Spatial Plan (RTRW) bylaw, compelling the industrial sector to proportionally finance hydrological engineering interventions in the Mount Muria catchment zone. Second, it should initiate the establishment of an Integrated Groundwater Supervisory Desk to bridge the executory coordination deadlock among the Kudus Regency Government, BBWS Pemali Juana, and the Central Java Provincial Government. These recommendations extend beyond Kudus: they offer a transferable template for other decentralized, industrializing regencies in Indonesia facing a similar mismatch between local extraction pressure and centralized permitting authority.

This study is not without limitations. Because the analysis relies exclusively on secondary data, regulatory documents, institutional reports, and published statistics, it cannot capture real-time extraction behavior, firm-level variation in groundwater dependency, or the lived experience of affected households beyond what is reflected in official reporting and credible media accounts. The absence of primary field measurement also means that the reported recharge and discharge figures should be interpreted as indicative of trend direction rather than as precision hydrological estimates. These constraints open clear avenues for future research: quantitative studies measuring the real Water Footprint of individual industrial clusters in Kudus Regency, mixed-methods work that incorporates household-level survey data on water affordability and substitution behavior, and comparative case studies that test whether the ESG diagnostic pattern identified here, strong pillar-level compliance masking systemic common-pool resource failure, recurs in other industrializing regencies across Java

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