

Local Government Capacity in Solid Waste Management Governance to Support Sustainable Community Health in Bone Bolango Regency

Ellys Rahman^{1*}, Tety Thalib², Siti Maryam Latifatul Zannah Ngabito³

^{1,2}Department of Administrative Science, Universitas Bina Taruna Gorontalo, Gorontalo, Indonesia

³Department of Health Promotion, Universitas Bina Taruna Gorontalo, Gorontalo, Indonesia

ORCIDs / Email:

First AUTHOR : <https://orcid.org/0000-0002-1113-6347> / ellysrachman12@gmail.com

Second AUTHOR : <https://orcid.org/0009-0005-4393-6559> / tetythalib72@gmail.com

Third AUTHOR : <https://orcid.org/0009-0003-0157-900X> / maryamngabito09@gmail.com

Corresponding author email: ellysrachman12@gmail.com

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Abstract

Solid waste management in Indonesia, including in Bone Bolango Regency, remains hindered by governance fragmentation among community-level actors, particularly primary schools and Family Welfare Empowerment (PKK) groups, making it difficult for the Environment, Land, and Transportation Agency (DLHPP) to monitor the real contribution of these two nodes to regional achievements. This study aims to explore and formulate an integrated solid waste management governance model based on a supply chain management digital platform that connects primary schools, PKK groups, and DLHPP to support sustainable improvements in community health. The study used a qualitative approach with a case study design across several sub-districts of Bone Bolango Regency. Data were collected through field observation, in-depth interviews, focus group discussions, and document review, then analyzed using the Miles and Huberman interactive model with the assistance of NVivo 12 software through open coding, axial coding, and selective coding, and validated through source and method triangulation. The findings reveal six main themes: governance fragmentation at the primary school and PKK nodes; the role of primary schools as ecological education nodes; the role of PKK groups as economic and operational nodes in the informal supply chain; the design of a digital platform based on reverse logistics and green logistics principles; the implementation process and cross-node technical assistance; and policy support through an Academic Manuscript and Appropriate Technology. The resulting model has the potential to strengthen cross-node coordination, data transparency, and the sustainability of environmental health in the Bone Bolango community

Keywords: solid waste governance; digital platform; supply chain management; community health; reverse logistics



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INTRODUCTION

The waste problem in Indonesia has evolved into a multidimensional issue that can no longer be regarded merely as a technical environmental matter, but is closely linked to governmental governance, community health, and sustainable regional development. The principles of good governance encompassing transparency, accountability, and public participation are considered key to the success of local waste management, although implementation in the field is often inconsistent with the regulatory frameworks established by the government (Mumpuni & Kusumawati, 2021). Household waste that is not properly managed has been shown to pollute air, soil, and water sources, which in turn degrades the health of surrounding communities (Hasibuan, 2016). A study of upstream-to-downstream waste management in Bandung City reinforces this picture, finding that source-level sorting is practiced by only a small proportion of households and that the collection process at temporary storage sites has not consistently separated organic from inorganic waste (Irmawartini et al., 2023).

The impact of this problem becomes more evident in areas adjacent to large-scale waste facilities, as demonstrated by a study on the presence of a final disposal site and the welfare of surrounding communities (“Dampak Keberadaan Tempat Pembuangan Akhir Sampah,” 2023). At a deeper level, poor environmental sanitation is associated with chronic nutritional disorders in children such as stunting (Khoirun Nisa & Sukesu, 2022), increases the risk index of environment-based diseases (Amirus et al., 2022), and contributes to a heightened risk of vector-borne diseases such as Dengue Hemorrhagic Fever (Hidayah et al., 2021). These findings confirm that weak waste governance is a critical determinant of community health that must be addressed systemically, starting from the sources of waste generation closest to everyday life households and educational institutions.

Primary schools represent a strategic point of intervention, not only as a daily source of waste generated from teaching-learning activities and student snack consumption, but also as a space for shaping the habits of future generations. Extracurricular-based waste-bank practices in schools show that solution-based education can go hand in hand with concrete benefits, such as contributing to the financing of school activities (Apriliani et al., 2018). At the community level, structured waste bank programs, supported by community education and inter-resident collaboration, have been shown to raise environmental awareness while also providing economic benefits (Prawisudawati et al., 2024). Nevertheless, these initiatives generally operate independently and have not yet been systematically connected to local government databases.

Bone Bolango Regency, as the recipient of the 2022 national Best Environmental Quality Index (IKLH) award, possesses relatively adequate institutional capacity in public service delivery (Rachman et al., 2023; Medaa et al., 2025). Nevertheless, school- and PKK-based waste management programs in the regency still operate partially without an integrated database, making it difficult for the Environment, Land, and Transportation Agency (DLHPP) to measure the real contribution of these two nodes to the regency's overall waste management achievements.

On the other hand, digital transformation has opened opportunities for innovations that can address these governance weaknesses. The smart waste management revitalization program in Bekasi City has successfully been combined with improved household waste sorting behavior (Saputra et al., 2021), while several Android-based applications have been developed to support waste bank operations, as in case studies in South Tangerang (Sansprayada & Mariskhana, 2020) and Pasuruan Regency (Cahyono et al., 2023), both of which reported improved transaction-recording efficiency and resident participation. However, these applications generally still function as one-way administrative tools for a single type of user.

Supply chain management principles offer a conceptual framework for overcoming these limitations. The reverse logistics approach governs the backward flow of used materials toward recycling or further processing (Dwicahyani & Rifa, 2021), while the green logistics principle emphasizes the importance of minimizing the environmental impact of collection and transportation processes (Sadam et al., 2023). Both principles form the conceptual basis for designing a single digital platform capable of connecting multiple nodes within the regional waste management chain. Strengthening the legal framework is also an important prerequisite for the sustainability of waste management policy, including plastic waste policy (Maskun et al., 2022).

The novelty of this study lies in its effort to integrate supply chain management principles to unite two main target nodes primary schools and PKK groups in Bone Bolango Regency into a single digital

platform directly connected to DLHPP as the monitoring center, complemented by a sustainability-oriented education component specifically designed for two different audiences. The urgency of this study for the DLHPP partner in Bone Bolango Regency is high, since the absence of a digital platform specifically reaching schools and PKK groups results in the loss of important data potential for evidence-based policy planning. Based on the foregoing, this study aims to explore and formulate an integrated solid waste management governance model based on a supply chain management digital platform to support sustainable improvements in community health in Bone Bolango Regency. This article proceeds by outlining the qualitative research method used, followed by results and discussion organized into six themes, and concludes with a conclusion and recommendations.

RESEARCH METHOD

Research Design

This study used a qualitative approach with a case study design, aimed at gaining an in-depth understanding of the phenomenon of cross-node solid waste management governance within its natural context. A qualitative case study is well suited to research problems concerning cross-institutional governance and collaborative practice that require direct engagement with participants embedded in the phenomenon under study.

Research Location and Time

The study was conducted at the Department of Environment, Land, and Transportation (DLHPP) of Bone Bolango Regency and in several selected sub-districts involving partner primary schools and PKK groups. Fieldwork, including preliminary observation, interviews, and documentation review, was carried out over a period of several months in 2026.

Informants

Research informants were purposively selected, consisting of school principals, teachers, and representative primary school students; PKK administrators and members; and DLHPP officials and staff responsible for the waste bank program and regional waste governance. Snowball sampling was used to reach additional relevant informants based on recommendations from key informants.

Data Collection

Data were collected through four main techniques: (1) field observation of waste management activities in school environments and PKK secretariats; (2) semi-structured in-depth interviews using two separate interview guides designed for school representatives and PKK administrators/members; (3) cross-node focus group discussions (FGDs) involving representatives from schools, PKK groups, and DLHPP; and (4) document review of regional policies, IKLH achievement reports, and waste generation data.

Data Analysis

Data were analyzed using the Miles and Huberman interactive model, comprising data reduction, data display, and conclusion drawing/verification, with the assistance of NVivo 12 software through three coding stages open coding, axial coding, and selective coding to identify the main themes (Hendrayadi et al., 2023). Data trustworthiness was established through source and method triangulation, comparing interview, observation, and document results from various informants and locations, as well as through member checking with several key informants. This qualitative case study design was selected on the consideration that the phenomenon of cross-node governance is contextual and requires in-depth exploration that cannot be reduced to quantitative measures alone, as emphasized in studies on various research designs and stages (Waruwu, 2024). Research ethics were maintained through informed consent from all informants and the protection of personal identity confidentiality in reporting.

RESULTS AND DISCUSSION

Thematic analysis of observation, in-depth interview, and focus group discussion data produced six main themes describing the existing conditions and the development direction of an integrated solid waste management governance model in Bone Bolango Regency, as outlined below.

Governance Fragmentation at the Primary School and PKK Nodes

Observation and interview results show that waste management at both target nodes remains partial and unintegrated. Most primary schools already have waste bins, but organic-inorganic waste sorting is not consistently practiced and lacks systematic record-keeping. PKK groups operating waste banks generally still rely on manual, passbook-based recording without synchronization with DLHPP's reporting system. DLHPP informants reported difficulty in monitoring the real contribution of both nodes to regional waste management achievements due to the absence of an integrated database.

This condition can be interpreted as a manifestation of incomplete institutionalization rather than an absence of local initiative. Both nodes have already internalized the basic behavior of waste separation and collection, yet these practices remain confined within each institution's own operational boundary and have not been elevated into a shared, verifiable governance instrument. In good-governance terms, what is missing is not participation since both schools and PKK groups are demonstrably active but the transparency and accountability dimension that would allow their contributions to be documented, aggregated, and reported upward (Mumpuni & Kusumawati, 2021). Without a common recording standard, the same volume of sorted or collected waste effectively becomes invisible to the regency's monitoring system, even though it represents genuine progress at the community level.

This gap also reflects a structural rather than a motivational constraint. The persistence of manual, passbook-based recording among PKK groups suggests that the barrier lies less in willingness and more in the absence of an accessible, low-cost digital tool that fits administrators' daily routines. Similarly, the inconsistency of sorting practices in schools points to a lack of embedded monitoring mechanisms such as periodic checklists or teacher-assigned verification rather than a lack of student awareness. These patterns imply that any intervention aimed at closing the gap must address the recording infrastructure itself, not merely reinforce socialization activities that have already reached both nodes to some extent.

The consequence of this fragmentation extends beyond administrative inconvenience. Because DLHPP cannot verify the actual scale of waste diverted from disposal sites through these two informal channels, the regency's official waste-reduction indicators likely understate real community performance, which in turn weakens the evidentiary basis for allocating further support to schools and PKK groups. This finding resonates with, and helps explain at the local level, the broader upstream-to-downstream pattern documented by Irmawartini et al. (2023), where losses of environmental and health value repeatedly occur at the sorting and collection stages rather than at final disposal. It further reinforces the argument that unmanaged or under-recorded waste streams carry tangible environmental and health consequences for surrounding communities, as shown in studies on final disposal sites ("Dampak Keberadaan Tempat Pembuangan Akhir Sampah," 2023) and on the association between sanitation risk and environment-based disease (Amirus et al., 2022). Taken together, these findings suggest that closing the fragmentation at the SD and PKK nodes is not merely a technical fix but a precondition for the credibility of Bone Bolango's broader waste governance claims.

Primary Schools as Ecological Education Nodes from an Early Age

Interviews with principals, teachers, and students revealed that waste management activities embedded in the curriculum and extracurricular programs effectively build sorting habits from an early age. Consistent with extracurricular waste-bank programs that demonstrate the potential link between student participation and concrete benefits such as support for school activity financing (Apriliani et al., 2018), teacher informants act as facilitators who reinforce environmental care values, while students act as agents of change with the potential to carry sorting habits into their respective households.

This finding suggests that the school's contribution to waste governance operates through two distinct but complementary pathways: a behavioral pathway, in which repeated, curriculum-embedded practice normalizes sorting as routine rather than optional conduct, and a diffusion pathway, in which children transmit newly acquired habits into household decision-making that would otherwise remain

unreached by regency-level programs. This second pathway is particularly significant given that households, rather than institutions, generate the largest and most dispersed share of daily waste, making children an efficient entry point for behavior change that adult-oriented campaigns often struggle to achieve.

Nevertheless, limited sorting facilities and minimal ongoing monitoring mean that these educational achievements have not yet been documented as data verifiable by DLHPP. This disconnect between behavioral impact and administrative visibility echoes the broader pattern identified at the PKK node, indicating that the constraint is systemic rather than confined to a single actor: solution-based education can shift attitudes and daily practice (Sriagustini & Nurazijah, 2022), but its outcomes remain unmeasured wherever supporting infrastructure and verification routines are absent. Consequently, the school node's genuine contribution to regional sorting targets is likely undercounted, weakening the case for sustained investment in facilities and teacher-supervised recording that would convert informal educational gains into evidence the regency can formally credit and build upon.

PKK Groups as Economic and Operational Nodes in the Informal Supply Chain

PKK groups serve as economic and operational nodes in the informal waste management chain, through activities of collecting, sorting, and processing household waste into economically valuable products such as compost and recycled handicrafts. This finding is consistent with the success of community-based waste bank management, which shows that structured management, community education, and inter-resident collaboration are key to program sustainability (Prawisudawati et al., 2024). However, the PKK structure, which reaches down to the neighborhood (RT/RW) level, has not been systematically connected to the official local government database, making its contribution to regional targets difficult to measure quantitatively a condition paralleling the challenges faced by the school node.

This pattern indicates that PKK groups already function as a de facto reverse-logistics network at the grassroots level, converting household waste streams into value-added outputs well before any digital platform is introduced. Their embeddedness at the RT/RW level is in many respects an organizational asset rather than a limitation: it provides the regency with a ready-made, trust-based distribution channel that reaches households far more intimately than any centrally administered program could achieve on its own. The interpretive challenge, therefore, is not whether PKK groups perform meaningful economic and environmental work, but why this work remains structurally invisible to the formal governance system that is meant to recognize and scale it.

Part of the answer lies in the transactional, cash-and-passbook nature of waste-bank operations, which was designed around member incentives rather than upward reporting, leaving no built-in mechanism for aggregating neighborhood-level results into regency-level indicators. This absence of vertical data flow means that DLHPP effectively governs the waste system from the demand side of policy while remaining blind to a substantial portion of the supply-side activity already occurring informally. The parallel between the PKK and school nodes further suggests that this is not an isolated administrative oversight but a shared structural gap across grassroots actors, reinforcing the argument that closing it requires a common integration mechanism rather than node-specific fixes capable of translating dispersed, informally verified community contributions into data that regional planning and resource allocation can legitimately draw upon.

Design of a Digital Supply Chain Management Platform Based on Reverse Logistics and Green Logistics

Based on needs identified through cross-node focus group discussions, the digital platform design was formulated by adopting the principle of reverse logistics so that the backward flow of waste from the source (schools and PKK groups) toward processing or recycling can be systematically tracked (Dwicahtyani & Rifa, 2021), complemented by the principle of green logistics to minimize the environmental impact of collection and transportation processes (Sadam et al., 2023). The system architecture was designed with three modules: an educational-interactive module for primary school students, a transaction-recording module for PKK administrators, and a centralized monitoring module

for DLHPP. This multi-module design differs from Android-based waste bank applications, which are generally one-way administrative tools for a single type of user (Sansprayada & Mariskhana, 2020; Cahyono et al., 2023), while also adapting good practices from the smart waste management revitalization experience that successfully changed household waste sorting behavior through technology support combined with outreach (Saputra et al., 2021).

Implementation Process, Technical Assistance, and Cross-Node Technology Adoption

The piloting and technical assistance stages were designed separately for each node, namely educational-interactive technical assistance for primary school students and transaction-recording technical assistance for PKK administrators, with DLHPP acting as the coordinator that assigns schools and facilitates field access to PKK groups. Informants stated that intensive mentoring and materials tailored to the user context were key factors in technology acceptance, consistent with the importance of solution-based education in improving community awareness and skills in managing household waste (Sriagustini & Nurazijah, 2022). Challenges that emerged from the interviews include limited digital literacy among some older PKK administrators and the need to adapt school technical assistance materials to the existing curriculum.

Policy Support and Program Sustainability through the Academic Manuscript and Appropriate Technology

An Academic Manuscript was formulated as the basis for drafting regional regulations that explicitly accommodate the roles of primary schools and PKK groups within the solid waste governance ecosystem, consistent with the importance of strengthening the legal framework as an umbrella for the sustainability of waste management policy (Maskun et al., 2022). Appropriate Technology (TTG) in the form of a digital-platform-based governance system was registered as an output ready for adoption by local government and the community. DLHPP informants affirmed their commitment to follow up on the research findings together with the network of primary schools and PKK groups within regional policy, as a guarantee of the model's sustainability beyond the research period.

CONCLUSION

This study shows that solid waste management in Bone Bolango Regency, particularly at the primary school and PKK nodes, still experiences governance fragmentation that makes it difficult for DLHPP to measure the real contribution of both nodes to regional achievements. Primary schools play a strategic role as ecological education nodes that build waste-sorting habits from an early age, while PKK groups serve as economic and operational nodes within the informal waste management chain at the community level. An integrated solid waste management governance model based on a supply chain management digital platform, which adopts the principles of reverse logistics and green logistics and connects three user modules (schools, PKK groups, and DLHPP), offers a solutive framework for addressing this fragmentation while supporting sustainable improvements in community health.

The success of this model's implementation depends on continuous technical assistance, strengthened digital literacy among specific user groups, and regional regulatory support through the Academic Manuscript and the registration of Appropriate Technology. This study is limited by its geographic scope, covering only several selected sub-districts, and by its exploratory-qualitative nature, so the findings require further strengthening through testing at a broader scale and quantitative impact evaluation following implementation. Future research is recommended to replicate this model in other sub-districts of Bone Bolango Regency or in regions with similar characteristics, to strengthen digital literacy programs for PKK administrators, and to integrate waste management material more formally into the primary school curriculum.

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AUTHOR CONTRIBUTIONS

Conceptualization, E.R., T.T., and S.N.L.Z.N.; Methodology, E.R. and T.T.; Validation, E.R.; Formal Analysis, T.T.; Data Curation, E.R.; Writing-Original Draft Preparation, E.R.; Writing-Review & Editing, E.R. and T.T.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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