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Evidence-Based Household Waste Management Policy in Bandar Lampung, Indonesia

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Abstract: This study aims to design an evidence-based policy (EBP) model for household waste management at the village level, emphasizing the importance of a contextual and collaborative approach. The central research question is: How can a household waste management policy model be developed to effectively respond to local dynamics, citizen preferences, and institutional capacity? This research combines quantitative and qualitative approaches through surveys, observations, in-depth interviews, and focus group discussions (FGDs) in eight sub-districts in Bandar Lampung City. The evaluation was conducted using the analytical hierarchy process (AHP) framework and actor mapping with an influence-interest grid to identify the relationship structure and stakeholder contributions.The findings of this study indicate that a policy scenario combining regulations, incentives, and education (scenario C) is the most effective and sustainable alternative in aggregate. However, citizen preferences and institutional capacity across urban villages continue to vary, necessitating adaptive and contextual policy design. The city government (Environmental Agency) remains a key actor, while waste banks, local communities, and neighborhood associations play strategic roles in strengthening institutional social capacity. The proposed policy model emphasizes the integration of micro (citizens and communities) and macro (regulations and institutions) dimensions, and encourages inclusive, adaptive and evidence-based local socio-ecological transformation. This study emphasizes the importance of waste management policies that are evidence-based, collaborative among actors, and flexible to the socio-ecological context. The EBP model developed is relevant for replication in medium-sized cities in the Global South with similar challenges. However, effective replication requires a bottom-up learning approach, namely learning from residents' narratives, micro-observations, and community-based experimentation, rather than simply copying policies.

Keywords: Evidence-based policy; Institutional collaboration; Waste management; Citizen participation; Analytical hierarchy process; Medium-sized cities

1 Introduction

Household waste management remains a crucial challenge in environmental governance in developing countries, especially in the global south, which faces the dual pressures of rapid urbanization and limited institutional capacity [1, 2]. Globally, municipal waste generation has reached 2.01 billion tons per year and is projected to increase to 3.4 billion tons by 2050 without significant policy intervention.

In Indonesia, Presidential Regulation No. 97 of 2017 targets a 30% reduction in waste and 70% waste management by 2025. However, implementation at the local level, especially in medium-sized cities such as Bandar Lampung, still faces serious challenges due to the weak institutionalization of evidence-based policy (EBP) approaches.

The literature shows that many local waste policies are normative and top-down without systematic integration of local microdata and citizen preferences [3, 4]. Strategies such as Reduce, Reuse, Recycle (3R), waste-to-energy (WTE),

and refuse-derived fuel (RDF) have been implemented, but their success is highly dependent on the effectiveness of implementation at the micro level, namely the sub-district [5, 6].

The sub-district acts as the foremost administrative unit and direct link between national policy and the community [7]. In the institutional structure, the sub-district should be a strategic node for implementing an EBP approach through the use of microdata, citizen narratives, and collaborative participation [4, 8–10].

However, to date, there has been little research that systematically examines why EBP has not been institutionalized in local environmental policies in Indonesia, particularly in household waste management. Previous studies have emphasized technical or macro-institutional aspects, without discussing the direct relationship between local evidence, micro-actors, and policy design [4, 11–13].

This study aims to fill this gap by designing an evidence-based household waste management policy model at the sub-district level in Bandar Lampung. This model integrates micro-local data, community participation, and institutional actor mapping to produce contextual and adaptive policies.

Using a mixed methods approach [14], this model was developed through three main stages: (1) spatial analysis of waste accumulation and management practices; (2) a survey of residents' preferences regarding policy instruments (regulatory, incentive, educational, voluntary); and (3) mapping the roles and interactions between institutional actors.

The novelty of this study lies in the integration of the EBP approach, collaborative governance, and the circular economy framework in the context of sub-district policy in medium-sized cities in Indonesia. This study contributes a measurable instrument for assessing the suitability of policies to complex local dynamics.

In response to the research question, namely how to develop an adaptive and contextual evidence-based household waste management policy model, this study is based on the assumption that policy effectiveness will increase if it is developed participatively based on micro-local evidence and managed through collaboration between formal and informal actors.

2 Methodology

This study uses a mixed methods approach with a sequential exploratory design to develop an evidence-based household waste management policy model at the sub-district level in Bandar Lampung City. This design integrates quantitative and qualitative data in gradual and mutually reinforcing stages, enabling a triangulation process to enhance the conceptual and contextual validity of the findings [14, 15].

A total of eight sub-districts were purposively selected based on four main criteria: (1) socio-ecological diversity, (2) relative distance to temporary and final disposal sites (temporary waste disposal sites and final waste disposal sites), (3) the existence of management communities such as waste banks, and (4) variation in regional functions (residential, educational, commercial). This selection considered the strategic position of sub-districts as nodes of implementation between macro policies and micro practices, in line with the institutional view of collaborative governance [3].

Data collection was conducted using five main techniques:

First, a survey was conducted on 400 households to assess residents' preferences for four household waste management policy instruments: regulatory, incentive, educational, and voluntary. The questionnaire used a five-point Likert scale and measured four evaluative dimensions, namely: (1) effectiveness (the impact of policies on waste reduction and environmental improvement); efficiency (cost, facilities, and access to services); (3) participation (level of community involvement); and (4) sustainability (long-term institutional support). Each dimension was operationalized through specific indicators ET1–ET5, ES1–ES3, PR1–PR5, and KB1–KB2. The sample distribution used stratified random sampling, with proportional allocation based on the number of households per urban village. This technique ensures the geographical and social representation of the eight predetermined sub-districts [16].

Second, in-depth interviews were conducted with key stakeholders, including the Environmental Agency, landfill managers, neighborhood association and sub-district association leaders, waste bank administrators, academics, and local non-governmental organizations (NGOs). The interviews explored perceptions, challenges, and potential synergies in the institutional system [17].

Third, visual documentation and field notes were used to assess the physical condition of waste management facilities (temporary and final disposal sites, recycling facilities) and the actual behavior of residents.

Fourth, the Delphi approach was used to filter input from experts and practitioners, followed by focus group discussions (FGDs) to assess the feasibility and relevance of policy scenarios in a participatory manner.

Fifth, document analysis was conducted on local regulations (e.g., Local Regulation No. 3 of 2023 on waste management), waste accumulation data, community reports, and local public policy records.

The quantitative data was analyzed descriptively, then modeled using the analytical hierarchy process (AHP) method to evaluate policy scenarios based on four main criteria: effectiveness, efficiency, participation, and sustainability [18–20].

The AHP stages include: (1) Preparation of a pairwise comparison matrix by a panel of experts based on the priority of each criterion, comparing each policy criterion in pairs based on its relative level of importance in the context of household waste management. The assessment is carried out using the Saaty scale 1–9; (2) Seven experts

were involved, consisting of representatives from the Environmental Agency (2 structural officials), 2 academics, 2 contracting the waste bank community (Kaliawi and Bakung Sub-districts), and 1 policy practitioners (Local NGO); (3) The weights of the criteria and sub-criteria were calculated using the geometric mean, then normalized; (4) Assessment consistency is tested by calculating the consistency ratio (CR), with a maximum threshold value of $\leq$0.1 to ensure validity [18]; (5) The final score for each scenario is used to determine the best policy preference based on public perception and expert consideration.

Qualitative data is analyzed thematically, with institutional actors mapped using an influence–interest grid model to identify key actors and relationships between actors. Validity is strengthened through triangulation of methods and sources [15]. All analyses aim to formulate evidence-based policies that are contextual, adaptive, and can be implemented participatively at the sub-district level.

3 Result and Discussion

3.1 Result

3.1.1 Spatial analysis of household waste generation and existing household waste management conditions in Bandar Lampung City

This research utilizes an EBP approach to design waste management policies based on micro-data and local context. As stated by Nutley et al. [21] and Araiza-Aguilar et al. [22], the systematic use of evidence is the primary foundation for accountable and adaptive public decision-making. At the micro-level, such as the sub-district level, data-driven policies can improve management effectiveness and adapt policies to diverse socio-ecological conditions [19].

Data collected from eight sub-districts provides a more detailed picture of the challenges and capacities of household waste management, particularly in terms of waste generation burden distribution and infrastructure disparities. This approach draws on the OECD's Policy Instruments for the Environment (PINE) framework [23], which emphasizes the importance of flexible environmental policies tailored to local characteristics, including demographic and geographic characteristics.

The spatial analysis results show significant disparities between urban villages, influenced by variables such as population density, daily waste volume, sorting rate, and collection frequency. Urban villages close to landfills (TPA) tend to have more regular waste collection patterns but lower sorting practices. Conversely, areas with high population density often face greater waste accumulation and limited space for community-based management initiatives.

Table 1 shows sharp disparities between sub-districts. Daily waste generation volumes range from 3.87 tons (Korpri Jaya) to 7.59 tons (Pasir Gintung), reflecting a direct relationship between population and waste production. The highest sorting rate was recorded in Sukarame Baru (72%), while Bakung only achieved 21%, indicating weak participation and institutional capacity. Collection frequency varies from 2 to 5 times per week, with Bakung and Kuripan having the lowest service levels.

Table 1. Spatial analysis of 8 sub-districts

Village/Sub-District	Population	Waste Volume (tons/day)	Sorting Percentage (%)	Transportation Frequency (times/week)
Kaliawi	9055	6.3385	62	4
Pasir Gintung	10837	7.5859	55	3
Rajabasa Raya	5823	4.0761	48	5
Rajabasa Nunyai	8153	5.7071	60	4
Korpri Jaya	5524	3.8668	51	5
Bakung	9304	6.5128	21	2
Kuripan	7291	5.1037	34	3
Sukarame Baru	10185	7.1295	72	5

These findings show that sub-districts like Bakung and Kuripan are most vulnerable, marked by low scores on three key indicators. Conversely, Sukarame Baru and Kaliawi sub-districts performed relatively better due to the support of local institutions such as waste banks and community involvement. Observations and documentation support these findings: inadequate temporary waste disposal sites (TPS) in Kuripan as seen in Figure 1, and illegal dumping in Pasir Gintung, as seen in Figure 2.

Overall, the study findings emphasize the importance of EPB to avoid a one-size-fits-all approach and instead encourage the design of contextual and region-specific interventions. Within the EBP framework, the integration of spatial data with local community participation opens up opportunities to develop policies that are not only reactive to technical issues but also responsive to local social and institutional needs [24, 25].

These findings are consistent with the findings of several previous studies showing that the effectiveness of waste management policies is highly dependent on understanding and adapting to the local context [11, 26]. Cairney and

Figure 1. Condition of the temporary waste disposal site in Kuripan (sub-district)

Figure 2. Condition of the temporary waste disposal site in Pasir Gintung (sub-district)

Oliver [3] also underscored the importance of micro-level management to strengthen the implementation of more effective and sustainable environmental policies.

Furthermore, the existing conditions present a quantitative and systematic comparison of policy implementation in the eight sub-districts that served as study locations. The analysis relies on field observations and refers to four key evaluative dimensions in public policy studies: effectiveness, efficiency, participation, and sustainability. The analysis yields an understanding of how contextual variations at the sub-district level influence policy implementation performance and serve as a basis for developing more adaptive and responsive intervention strategies. Table 2 presents the standardized values of each variable per sub-district.

Table 2. Comparison of household waste management implementation values based on four evaluation criteria in 8 sub-districts

Village/Sub-Districts	Effectiveness	Efficiency	Participation	Sustainability
Kaliawi	0.20	0.20	0.22	0.38
Korpri Jaya	0.26	0.22	0.22	0.30
Kuripan	0.25	0.24	0.21	0.30
Rajabasa Nunyai	0.25	0.23	0.19	0.33
Rajabasa Raya	0.24	0.17	0.22	0.37
Sukarame Baru	0.29	0.23	0.21	0.27
Pasir Gintung	0.25	0.16	0.19	0.40
Bakung	0.26	0.22	0.22	0.30

3.1.2 Evaluation of preferences and effectiveness of policy instruments

The assessment of the effectiveness of household waste management policies at the sub-district level was conducted through two main approaches: (1) analysis of residents' preferences for four types of policy instruments and (2) the development and evaluation of policy scenarios based on the AHP method. This approach was designed to capture not only community perceptions but also the most adaptive intervention strategies to micro-local conditions in Bandar Lampung.

(1) Citizens' preferences for policy instruments

The citizen perception survey was designed based on the OECD's PINE framework [23], which classifies environmental policies into four main types: norms (sanctions and binding regulations); incentives (economic incentives) (subsidies, rewards, and cost reductions); education (training, outreach, and public campaigns); and voluntary (participatory community action). A total of 400 households in eight urban villages were surveyed using a 1–5 Likert scale to assess the effectiveness, efficiency, participation, and sustainability of the four instrument types. The survey results showed that: 1) educational instruments scored the highest (average 4.3), followed by economic incentives (average 4.1); regulatory and voluntary instruments scored lower (average 3.2 and 3.0), primarily because residents perceived them as burdensome or institutionally inadequate. 2) Demographically, preference for educational instruments was higher among younger age groups and those with higher education, reflecting their greater openness to knowledge- and awareness-based approaches. 3) On the other hand, incentive instruments are preferred by lower-middle-income households, who are more interested in the direct financial benefits of the policy. This emphasizes the importance of tailoring policy strategies to local socioeconomic conditions to increase participation and policy success.

(2) Policy priority modeling with analytical hierarchy process

The next step was to develop four policy scenarios, which combined instruments from the PINE framework, and then evaluated them using AHP. The assessment was based on four main criteria: 1) effectiveness: the extent to which the policy reduces waste generation and improves environmental quality; 2) efficiency: resource optimization in policy implementation; 3) participation: citizen involvement in management practices; and 4) sustainability: the long-term sustainability of the policy.

In Table 3, the four policy scenarios were designed based on a combination of instruments within the OECD-PINE framework:

Table 3. Combination of scenarios and their goals

Scenario	Instrument Combination	Strategic Objectives
A	Regulation + Education	Increased public compliance and awareness
B	Regulation + Economic Incentives	Encouraging behavior through direct incentives
C	Regulation + Incentives + Education	Comprehensive and sustainable interventions
D	Regulation + Voluntary	Value-based participation without incentives

Complex scenarios that did not meet the principle of variable isolation (such as combinations of incentives and voluntary) were excluded to maintain the validity of the AHP logic. In Table 4, AHP evaluation of the scenarios was conducted by key informants (academics, policy practitioners, community leaders) through pairwise comparison.

Table 4. Analytical hierarchy process (AHP) evaluation results between scenarios

No.	Scenario	Effectiveness	Efficiency	Participation	Sustainability	Total AHP Score
1	A (Regulation)	0.27	0.26	0.22	0.25	0.25
2	B (Regulation + Economic Incentives)	0.25	0.28	0.23	0.24	0.25
3	C (Regulation + Incentives + Education)	0.31	0.29	0.32	0.33	0.31
4	D (Regulation + Voluntary)	0.17	0.17	0.23	0.18	0.19

The results of Table 5 illustrate that scenario C (regulation, incentives, education) achieved the highest aggregate score, reflecting that the combination of normative, motivational, and educational strategies is the most effective, efficient, and sustainable model. Scenario D (regulation, voluntary) only excelled in Bakung, indicating the importance of institutional support in contexts with high participation but limited incentives. Finally, scenarios A and B had limited advantages and were less optimal in terms of participation or sustainability.

Table 5. Average analytical hierarchy process (AHP) score based on village

Sub-district	Scenario A	Scenario B	Scenario C	Scenario D	Selected Model
Kaliawi	0.20	0.24	0.45	0.11	Scenario C
Korpri Jaya	0.28	0.26	0.37	0.09	Scenario C
Kuripan	0.29	0.15	0.35	0.21	Scenario C
Nunyai	0.28	0.26	0.37	0.09	Scenario C
Rajabasa Raya	0.22	0.25	0.42	0.11	Scenario C
Sukarame Baru	0.25	0.22	0.37	0.16	Scenario C
Pasir Gintung	0.22	0.25	0.42	0.11	Scenario C
Bakung	0.26	0.16	0.23	0.34	Scenario D
Average	0.25	0.23	0.37	0.15	Scenario C

The combined approach of preference surveys and AHP confirmed that the regulatory-incentive-educational strategy (scenario C) combination is the most optimal strategy in the local context of the Bandar Lampung sub-district. These results, visualized through the multi-level framework in Figure 3, not only demostrate residnets prefrences but also provide a policy basis that can be implemented realistocally and sustainably. This approach aligns with the principles of EPB and provides a strong basis for designing interventions based on local context and measurable social preferences.

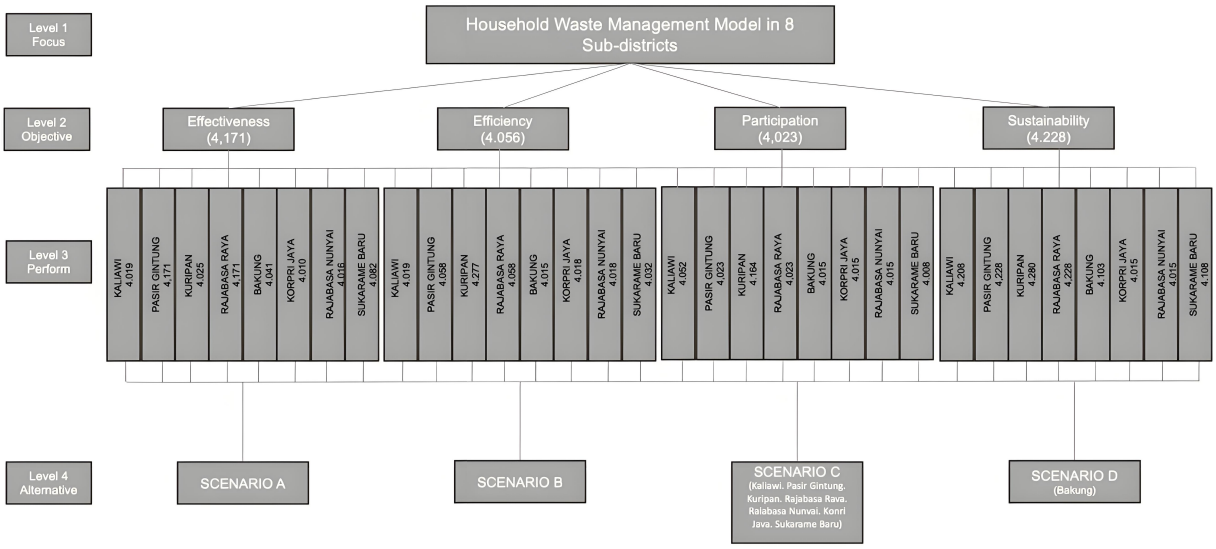

Figure 3. Analytical hierarchy process (AHP) household waste management and policy priorities

3.1.3 Stakeholder analysis and institutional dynamics

Stakeholder analysis was conducted as an integral part of answering research questions regarding key actors, institutional capacity, and the dynamics of collaboration in the implementation of household waste management policies. By combining in-depth interviews, FGDs, and field observations, this approach provides a comprehensive overview of the structure, relationships, and functions of actors in the waste management system in eight sub-districts in Bandar Lampung City.

This methodology adopts a two-dimensional grid-based stakeholder mapping: interests and influence. This classification aims to assess the extent to which an actor has a driving force for change (influence) and a stake in the success of the policy (interest). This approach supports participatory and adaptive intervention design, in accordance with EBP principles, and serves as a foundation for developing collaborative and contextual policy models.

(1) Key actor/stakeholder mapping

Based on the analysis, four main actor categories were consistently identified across all sub-districts: 1) key actors (A): the Environmental Agency has regulatory authority and control over resources, making it the primary decision-maker; 2) strategic actors (B): waste banks and local communities act as bridges between the formal system and residents. They have moderate influence but contribute significantly to program success; 3) contextual actors (C): neighborhood associations have high social interests but low policy influence. They are effective in reaching residents informally; 4) target group (D): residents and business actors have very high interests but are not involved in policy design.

The distribution of these actors is shown in Table 6 which maps stakeholder positions per sub-district based on dimensions of influence and interest. This mapping demonstrates the consistency of institutional patterns across the study locations.

Table 6. Matrix of interests and influence of waste management stakeholders per sub-district

Sub-District	Actor	Interest	Influence	Category
Kaliawi	Environmental Agency	high	high	A: Key
	Neighborhood Units	high	low	C: Contextual
	Waste Bank	medium	medium	B: Strategic
	Residents/Businesses	high	low	D: Target Group
Korpri Jaya	Environmental Agency	high	high	A: Key
	Neighborhood Units	high	low	C: Contextual
	Waste Bank	medium	medium	B: Strategic
	Residents/Businesses	high	low	D: Target Group
Kuripan	Environmental Agency	high	high	A: Key
	Neighborhood Units	high	low	C: Contextual
	Waste Bank	medium	medium	B: Strategic
	Residents/Businesses	high	low	D: Target Group
Rajabasa Nunyai	Environmental Agency	high	high	A: Key
	Neighborhood Units	high	low	C: Contextual
	Waste Bank	medium	medium	B: Strategic
	Residents/Businesses	high	low	D: Target Group
Rajabasa Raya	Environmental Agency	high	high	A: Key
	Neighborhood Units	high	low	C: Contextual
	Waste Bank	medium	medium	B: Strategic
	Residents/Businesses	high	low	D: Target Group
Sukarame Baru	Environmental Agency	high	high	A: Key
	Neighborhood Units	high	low	C: Contextual
	Waste Bank	medium	medium	B: Strategic
	Residents/Businesses	high	low	D: Target Group
Pasir Gintung	Environmental Agency	high	high	A: Key
	Neighborhood Units	high	low	C: Contextual
	Waste Bank	medium	medium	B: Strategic
	Residents/Businesses	high	low	D: Target Group
Bakung	Environmental Agency	high	high	A: Key
	Neighborhood Units	high	low	C: Contextual
	Waste Bank	medium	medium	B: Strategic
	Residents/Businesses	high	low	D: Target Group

(2) Analysis of institutional roles and dynamics

To complement the structural analysis, the study delved into operational functions and interactions between actors. Qualitative data revealed variations in role implementation, the quality of synergies, and inhibiting factors that emerged at the local level.

Table 7 summarizes the roles of data producers, agents of change, sources of obstacles, and the forms of synergy or conflict that occur. Key findings indicate: 1) The Bandar Lampung City Environmental Agency acts as a data and regulatory control center, but its effectiveness is highly dependent on coordinating capacity with local actors; Waste Banks and Communities emerge as forces of change in several sub-districts such as Bakung and Pasir Gintung, playing a role in educating and mobilizing residents; and Rukun Tangga/Rukun Warga, despite having limited formal positions, play an important role in bridging communication and policy socialization. 2) Key obstacles include a lack of facilities (TPS, fleet), low community awareness, and a weak human resource training system. 3) Actor interactions vary from strong synergy (e.g., the Environmental Agency-Waste Bank in Nunyai) to latent conflict due to unmet expectations (e.g., Sukarame Baru).

Thus, this analysis strengthens the argument that local relational structures and institutional capacity are key determinants of policy success. Within the EBP framework, understanding this institutional landscape should serve as the basis for developing interventions that are realistic, rooted in social conditions, and lead to long-term collaboration.

Table 7. Analysis of actor roles and dynamics

Sub-District	Data Producer	Driver of Change	Inhibitor	Synergy/Conflict
Kaliawi	Environmental Service, Waste Bank, community	Waste Bank, Neighborhood Units	Low public awareness, limited waste disposal sites	Synergy between the Environmental Service and Waste Bank; conflict due to low citizen participation
Korpri Jaya	Environmental Service, Waste Bank	Neighborhood Units, Bank Sampah	Lack of education, dependence on the Environmental Service	Waste Bank–Neighborhood Units synergy; formal–informal conflict
Sukarame Baru	Environmental Service, Waste Bank, citizen survey	Waste Bank, Neighborhood Units	Low participation, minimal incentives	Weak synergy between the Environmental Agency and the Waste Bank; conflict due to minimal policies
Kuripan	Neighborhood Association/Citizens Association, community, Environmental Service	Environmental cadres, community leaders, Waste Bank	Limited facilities, low awareness	Potential synergy between the Environmental Service and Waste Bank; hampered by awareness
Rajabasa Nunyai	Environmental Service, Waste Bank, FGD/survey data	Waste Bank, women's group	Limited reporting system, lack of education	Synergy between the Environmental Service and Waste Bank; conflict in actors' understanding
Rajabasa Raya	Environmental Service, Waste Bank, survey/observation	Waste Bank, Neighborhood Units	Limited waste disposal sites, low awareness	Limited synergy between actors; conflict over citizen participation
Pasir Gintung	Environmental Service, Waste Bank, community leaders	Waste Bank, Neighborhood Units	Low participation, minimal waste disposal sites, distance to waste disposal sites, low awareness	Synergy between the Environmental Agency and Waste Banks; friction between the roles (coordination not yet optimal)
Bakung	Environmental Service, community, Waste Bank	Community, Neighborhood Units	Lack of training, logistics, support from the Environmental Service	Potential RT–community synergy; coordination conflict with the Environmental Agency

3.2 Discussion

3.2.1 Towards an evidence-based and contextual household waste management policy model

This study aims to answer the main question: how to develop an evidence-based, contextual, and adaptive household waste management policy model at the sub-district level? To that end, the approach used is based on the EBP and collaborative governance frameworks, with the assumption that policy effectiveness is determined by the integration of micro-local evidence, public participation, and functional institutional coordination [3, 27].

Theoretically, the developed model is built on three main propositions:

1. Policies designed based on local data and evidence have higher intervention precision;
2. Policy effectiveness is influenced by the degree of alignment between policy instruments and citizen preferences;
3. Collaboration between formal actors (such as local government) and informal actors (communities, neighborhood associations) is a key requirement for adaptive governance [4, 28–30].

The findings of this study show strong support for all three propositions. Through triangulation of survey results, actor mapping, and AHP analysis, three central dimensions were obtained that reinforce the design of this policy model:

First, the importance of micro-local evidence. Eight sub-districts showed heterogeneous patterns of preference regarding policy instruments. For example, Bakung Sub-district preferred a community-based voluntary approach.

This contrasted with Kaliawi and Rajabasa Raya, which were more receptive to educational and regulatory instruments. This heterogeneity underscores the importance of utilizing local data as the basis for formulating policies that are responsive to spatial and social diversity, as recommended in the EBP approach [21].

Second, the relevance of instrument selection. The survey shows that educational and incentive instruments received the highest effectiveness scores (average > 4 on a 1–5 Likert scale), reflecting the high need for positive incentives and continuous education. This finding is consistent with the multi-instrument approach in the environmental policy literature [23], which underscores the importance of balancing control, motivation, and social learning.

Third, the importance of collaborative governance. Stakeholder mapping shows that the success of policies is not solely determined by the regulatory power of the Environmental Agency, but by the capacity of community actors such as waste banks, neighborhood associations, and environmental cadres. In the context of collaborative governance, they act as an interface between formal policies and the daily practices of the community.

Integrating these three dimensions, this study developed a conceptual model of EBP-based and collaborative policies, which not only addresses local needs but also opens up opportunities for replication in other medium-sized cities.

This model in Figure 4 consists of four systemic stages:

1. Identification and activation of local capacity: Neighborhood units, waste banks, and communities are activated as nodes for data production and participation facilitation;

2. Production and integration of microdata: Data on citizen behavior, waste accumulation, and facilitators;

3. Designing flexible sub-district-based policies: Residents' preferences for four types of instruments are analyzed through AHP to form adaptive policy scenarios;

4. Participatory evaluation and circular economy transformation: Feedback and innovation mechanisms based on the Reduce, Reuse, Recycle, Recovery, Redesign principle are implemented.

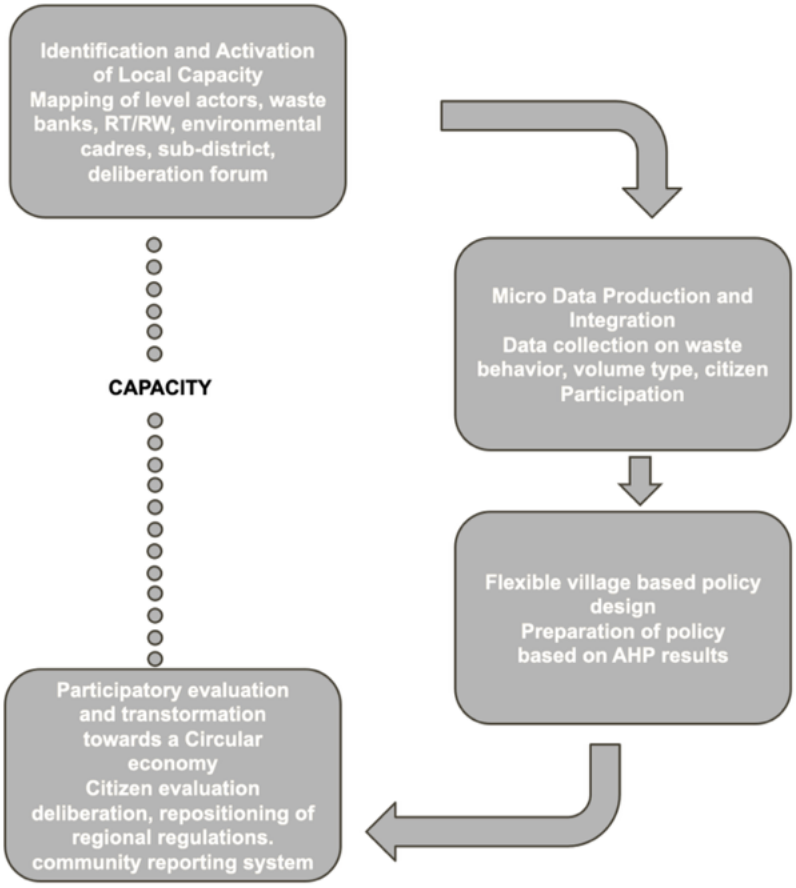

Figure 4. An integrative model of evidence-based waste management policy and community participation

3.2.2 Integration of field findings with literature

Field findings in eight subdistricts in Bandar Lampung City confirm that the effectiveness of household waste management policies is highly dependent on three main pillars: (1) citizen participation, (2) local institutional capacity, and (3) the suitability of policy instruments to socioeconomic conditions. These three pillars reinforce the urgency of an evidence-based and context-sensitive approach in local policy design [3, 31].

First, citizen engagement is at the heart of the EBP approach, which emphasizes that evidence should not only be technocratic in nature but should also reflect public values and local preferences [3]. Findings in the field show that sub-districts with high levels of community participation, such as Bakung Sub-district, tend to choose a voluntary approach. This seems to deviate from the general preference for educational-incentive instruments, but when analyzed through the lens of collaborative governance, this preference reflects the social power of the community as a source of legitimacy and capacity for informal policy implementation [32].

Second, in an institutional context, EBP requires institutional infrastructure capable of absorbing and integrating micro-local data into policy design. In sub-districts such as Kaliawi and Rajabasa Raya, the dominance of formal structures (the Environmental Agency) reinforces regulatory and educational roles. However, this model becomes less adaptive if it is not accompanied by bottom-up feedback from local communities, so it only functions effectively when supported by active stakeholder engagement [33].

Third, analysis using the OECD-PINE approach shows that scenario C (a combination of educational, incentive, and regulatory measures) is the most effective because it combines coercive instruments with motivational and cognitive approaches. This supports the policy mix model proposed by Wang et al. [19], where success lies in the synergy between restrictions, incentives, and social learning. However, deviations such as those in Bakung reflect that the effectiveness of instruments is not only determined by policy design, but also by the fit between the instruments and local social capital.

In addition, the EBP approach allows for the integration of microdata, citizen preferences, and institutional capacity within a single decision-making framework. This confirms the findings of Cairney and Oliver [3] that the successful implementation of EBP at the local level requires synergy between empirical evidence, social legitimacy, and political-bureaucratic capacity. These results are consistent with the meta-analysis by Wang et al. [19]. The policy model generated from this study shows that evidence-based interventions are not only more responsive to local needs but also have a greater chance of being replicated in medium-sized cities with similar characteristics in the Global South.

3.2.3 Local policy implications and replication

The findings of this study indicate that the formulation of household waste management policies at the sub-district level requires the application of the principle of decentralized responsiveness, namely policy design that is adaptive to the local socio-ecological context and based on collaboration between stakeholders [4]. This approach marks a shift from a top-down intervention model to policies based on microdata and cross-actor dialogue (stakeholder-inclusive deliberation).

First, uniform policies across regions (one-size-fits-all) have proven ineffective. This study shows thet al.though Scenario C (a combination of regulation, incentives, and education) was rated most effective in aggregate by residents and stakeholders, these findings do not indicate uniform effectiveness across all regions. For example, Bakung Sub-district showed a strong preference for a community-based voluntary approach. This deviation is not an anomaly, but rather reflects the strength of social capital and local community leadership in filling the void of formal institutions. This is in line with the collaborative governance framework that emphasizes the importance of policy co-production by state and non-state actors in diverse social contexts [34].

Second, strengthening the capacity of local institutional actors such as neighborhood associations, waste banks, and communities is a key component of the policy roadmap. This study reinforces the argument by Elsässer et al. [33] that policy effectiveness in the Global South is more influenced by the capacity of local social networks than by regulatory strength alone.

Third, an EBP approach developed through a combination of quantitative and qualitative analysis, including actor mapping, policy instrument surveys, and AHP, has been proven to produce measurable and contextual results. Wang et al. [19] demonstrated that this methodology is effective in generating adaptive policy designs amidst the complexity of waste governance in urban areas.

The policy implications of these findings underscore the importance of responsive decentralization [4], which is a bottom-up policy approach that takes spatial and social variations into account. This process requires local institutions to have the capacity to absorb evidence, open up space for public deliberation, and support contextual policy experiments. The principle of bottom-up learning is key to replication: not simply copying successful models, but adopting a spirit of local learning based on evidence, participation, and existing institutional ecosystems [3].

In the context of replication, this EBP model is relevant for application in other medium-sized cities in the Global South facing similar pressures: accelerated urbanization, institutional fragmentation, and limited fiscal capacity. The practical implications of this approach are also transformational, not only improving formal procedures but also restructuring the relationship between the state and citizens in environmental governance. The effectiveness of future policies will depend heavily on the capacity of institutions to: (1) facilitate inclusive public deliberation, (2) strengthen social-collective networks, and (3) integrate local data into fair and adaptive decision-making processes.

4 Conclusions

This study formulates a contextual and adaptive EBP model for household waste management at the sub-district level, with a case study in Bandar Lampung City, Indonesia. Using a mixed methods approach, the integration of quantitative and qualitative data shows that policy effectiveness is strongly influenced by residents' preferences, the structure of local actors, and the institutional capacity specific to each region.

The main findings show that Scenario C (a combination of regulation, incentives, and education) is the most effective policy configuration in aggregate. However, the results also show significant variations: in some sub-districts, such as Bakung, a community-based voluntary approach was chosen due to the strength of social capital and local capacity. This confirms that policy effectiveness is not universal but depends on the fit between instruments and social context, as emphasized in the EBP and collaborative governance frameworks.

Actor mapping also reveals that the success of implementation is greatly influenced by collaboration between key actors (Environmental Agency), strategic actors (waste banks, communities), and contextual actors (neighborhood associations). A collaborative structure and proportional distribution of roles form the foundation of sustainable governance at the micro level.

The practical implications of this study emphasize the need for an approach that prioritizes three main principles: (1) spatial contextuality, (2) social legitimacy through citizen preferences, and (3) cross-actor institutional collaboration. This approach enables the transformation of policy from an instructional model to a community-based adaptive learning system.

As a scientific study, this research expands the understanding of the application of EBP and collaborative governance in an urban context in the Global South. The model developed can be a reference for the formulation of evidence-based policies that are inclusive, adaptive, and rooted in local institutional realities.

Author Contributions

Conceptualization, H., N.T., and P.B.; methodology, N.T. and A.S.; software, N.T. and A.D.; validation, H., N.T., P.B., A.D., N.D., and A.S.; formal analysis, N.T., A.D., and N.D.; investigation, N.T., P.B., and A.S.; resources, H. and N.D.; data curation, N.T. and A.S.; writing—original draft preparation, N.T. and A.S.; writing—review and editing, H., N.T., P.B., A.D., N.D., and A.S.; visualization, N.T. and A.D.; supervision, H. and P.B.; project administration, N.T. and N.D. All authors have read and agreed to the published version of the manuscript.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

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Conflicts of Interest

The authors declare no conflict of interest.

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