AL-KAUNIYAH: Jurnal Biologi, 19(2), 2026, 416-426
Website: http://journal.uinjkt.ac.id/index.php/kauniyah
P-ISSN: 1978-3736, E-ISSN: 2502-6720

STAKEHOLDER INTERACTIONS IN PLASTIC WASTE MANAGEMENT ALONG THE CILIWUNG RIVERBANKS IN DKI JAKARTA

HUBUNGAN ANTAR AKTOR DALAM PENGELOLAAN SAMPAH PLASTIK DI BANTARAN SUNGAI CILIWUNG WILAYAH DKI JAKARTA

Ferry Fauzi[1,2], Widiatmaka[3]*, M. Ekayani[4], M. R. Cordova[5], I. Firmansyah[6]
[1]*Natural Resource and Environmental Management, Doctoral Program, IPB University, Bogor*
[2]*Universitas Indraprasta PGRI, Jakarta*
[3] *Department of Soil Science and Land Resources, IPB University, Meranti St, Kampus IPB Dramaga, Bogor*
[4]*Department of Resource and Environmental Economics, Faculty of Economics and Management, IPB University, Bogor*
[5]*Research Center for Oceanography, Badan Riset dan Inovasi Nasional (BRIN), Pasir Putih 1, Ancol, Jakarta*
[6]*System Dynamics Center, IPB University, Bogor*
**Coresponden author:* widiatmaka@apps.ipb.ac.id

Submitted: 4 March 2026; Revised: 27 April 2026; Accepted: 2 June 2026

Abstract

Plastic waste management represents a sustainable development challenge, particularly in urban riverbank areas such as the Ciliwung River in DKI Jakarta. Plastic waste management along riverbanks involves multiple actors with diverse roles, including government institutions, local communities, community organizations, universities, the private sector, and non-governmental organizations. This study aims to develop an actor-based model of plastic waste management along the Ciliwung riverbanks in DKI Jakarta using the MACTOR method. Actor identification was conducted through a literature review and interviews with key informants. The results indicate that the Balai Besar Wilayah Sungai Ciliwung Cisadane, universities, and the private sector function as dominant actors influencing policy directions in waste management. Local government agencies, technical implementation units, community organizations, and residents serve as key relay actors in policy implementation, while the informal sector represents dependent stakeholders with tangible contributions but limited involvement in decision-making processes. All actors support efforts to reduce the volume of plastic waste along the Ciliwung Riverbanks, accompanied by improvements in river water quality and reductions in public health risks.

Keywords: Actor-based model; Ciliwung riverbanks; DKI Jakarta; Plastic waste management

Abstrak

Pengelolaan sampah plastik merupakan tantangan pembangunan berkelanjutan, khususnya di kawasan bantaran sungai perkotaan seperti Sungai Ciliwung di DKI Jakarta. Pengelolaan sampah plastik di bantaran sungai melibatkan berbagai aktor dengan peran yang beragam, antara lain instansi pemerintah, masyarakat, komunitas, perguruan tinggi, sektor swasta, dan organisasi nonpemerintah. Penelitian ini bertujuan untuk mengembangkan model berbasis aktor dalam pengelolaan sampah plastik di bantaran Sungai Ciliwung wilayah DKI Jakarta menggunakan metode dan aplikasi MACTOR. Identifikasi aktor dilakukan melalui studi literatur dan wawancara dengan narasumber kunci. Hasil penelitian menunjukkan bahwa Balai Besar Wilayah Sungai Ciliwung Cisadane, perguruan tinggi, dan sektor swasta berperan sebagai aktor dominan yang memengaruhi arah kebijakan pengelolaan. Instansi pemerintah daerah, unit pelaksana teknis, komunitas, dan masyarakat berperan sebagai aktor penghubung dalam implementasi kebijakan, sementara sektor informal merupakan aktor dependen dengan kontribusi nyata, namun keterlibatan terbatas dalam pengambilan keputusan. Seluruh aktor mendukung upaya pengurangan volume sampah plastik di bantaran Sungai Ciliwung, disertai peningkatan kualitas air sungai dan penurunan risiko kesehatan masyarakat.

***Kata Kunci**: Bantaran sungai Ciliwung; DKI Jakarta; Model berbasis aktor; Pengelolaan sampah plastik*

Permalink/DOI: http://dx.doi.org/10.15408/kauniyah.v19i2.50332

INTRODUCTION

Plastic waste is a major environmental threat to riverine and coastal ecosystems worldwide. Improperly managed plastic waste can be transported by river flows to the ocean, positioning rivers as the primary pathways of land-based plastic pollution to marine environments. Empirical studies indicate that urban rivers are significant sources of macro- and microplastic transport due to high population density, urban development, and insufficient waste management infrastructure, particularly in developing regions such as Southeast Asia (Cleveland et al., 2025).

Several studies have demonstrated that plastic composition varies among rivers; however, single-use plastics and macroplastic items consistently dominate. This pattern is closely associated with urban lifestyles and inefficient waste management systems (Cordova et al., 2024; Lebreton & Andrady, 2019; Lebreton et al., 2017). These findings suggest that mismanaged plastic waste (MPW) contributes more significantly to riverine plastic transport than hydrometeorological factors (Pinto et al., 2024; Ulum et al., 2024).

Indonesia, as a large archipelagic country, exhibits similar conditions. Urban rivers such as the Ciliwung River function not only as transport routes for plastic waste to the ocean but also as major accumulation zones. This situation is influenced by public behavior, high consumption of single-use plastics, and limitations in waste management infrastructure, such as limited landfills (TPS) and waste collection fleets. Inadequate management has resulted in increasing plastic accumulation in river bodies, negatively affecting water quality and public health in riparian areas (He et al., 2024).

Recent studies have emphasized the role of multi-actor governance in addressing plastic pollution in urban rivers. The complexity of plastic waste management extends beyond policy issues and is strongly influenced by weak coordination among government institutions, local communities, the informal sector, and private stakeholders. Collaborative and participatory governance approaches have been shown to improve plastic waste management effectiveness by integrating the roles of multiple actors. Research conducted in Vietnam shows that community participation and collaboration between government and private institutions can improve the effectiveness of plastic waste management (Cleveland et al., 2025).

Despite extensive research on plastic sources, distribution, and mitigation in river systems, limited attention has been given to the systematic analysis of actor relationships at the local level. This includes the mapping of actor networks, influence positions, and coordination mechanisms. Such analysis is essential for strengthening river governance as a complex social–ecological system. Therefore, this study aims to analyze the relationships among key actors and their respective roles in plastic waste management along the Ciliwung River corridor to support more effective and sustainable collaborative strategies.

MATERIALS AND METHODS

This study applied the Matrix of Alliance, Conflict, Tactics, Objectives, and Recommendations (MACTOR) method using the software developed by Godet (1991, 2006). The MACTOR approach enables the analysis of actor influence, interests, and interactions within complex management systems, including plastic waste management in riverine environments.

This research began in August-December 2025 with the identification of key actors and management objectives related to plastic waste along the Ciliwung River corridor that passes through the DKI Jakarta area through in-depth interviews and a literature review. A Matrix of Direct Influence (MDI) was constructed to assess the level of direct influence among actors, while a Matrix of Actor–Objective (MAO) was developed to describe actors' positions and attitudes toward each objective. Both matrices were completed based on expert judgments. The MDI matrix was used to evaluate influence and dependence among actors, whereas the MAO matrix described actors' preferences and priority objectives (Fauzi, 2019; Rees & MacDonell, 2017).

Data were collected through in-depth interviews with experts from academia (Sahid University and Pancasila University) and key informants representing various stakeholders, including the central government (Balai Besar Wilayah Sungai Ciliwung Cisadane), local government agencies of East Jakarta City (Dinas Sumber Daya Air, Dinas Lingkungan Hidup), local government agencies of

Kramatjati and Tebet sub-districts), representatives of the private sector, non-governmental organizations (Ciliwung Community), local communities, and the informal sector (scavengers) in Jakarta. The number of informants and sources was 20 people.

RESULTS

Based on in-depth interviews with key informants and experts representing various stakeholders, the actors involved in plastic waste management along the Ciliwung River corridor were identified and are presented in Table 1. Furthermore, based on in-depth interviews, the objectives of plastic waste management along the Ciliwung River corridor in the Special Capital Region of Jakarta were formulated, as presented in Table 2.

Table 1. Identification of actors involved in plastic waste management along the Ciliwung River corridor in the Special Capital Region of Jakarta

Identified actor	Description	Code
Balai Besar Wilayah Sungai Ciliwung Cisadane (BBWS Ciliwung Cisadane)	Acts as the manager of large-scale river infrastructure under the authority of the Kementerian Pekerjaan Umum Republik Indonesia.	BBWS
Dinas Sumber Daya Air Provinsi DKI Jakarta	Functions as the regional technical agency responsible for implementing local policies related to river body management.	SDA
Dinas Lingkungan Hidup DKI Jakarta	Directly involved in urban waste management, including waste collection, transportation, processing, management of 3R waste facilities (TPS 3R), and environmental education	DLH
River management technical unit	Directly involved in day-to-day river conditions, including routine removal of floating waste, riverbank maintenance, and river condition reporting.	UPTD
City/ district/ sub-district government	Serves as the implementing body for administrative and coordinative activities, bridging provincial government policies with local communities.	Pemda
Local communities and non-governmental organizations	Act as agents of social change, including environmental education, public campaigns, and community-based river conservation activities.	Community
Neighborhood volunteers and local waste banks	Involved in community-based waste management by promoting waste separation and plastic recycling, as well as strengthening social control at the community level.	Public.
Private sector/ corporate social responsibility (CSR)	Contributes through Corporate Social Responsibility (CSR) programs, such as providing waste management facilities, financial support, and technical assistance	Private sector
Universities and academic institutions	Act as knowledge-based supporting actors through research activities, policy analysis, community engagement, and technical assistance related to plastic waste management	Campus
Waste pickers and the informal sector	Act as environmental economic actors that directly contribute to plastic waste reduction through waste sorting and the collection and sale of recyclable materials.	Informal

Table 2. The aim of managing plastic waste on the banks of the Ciliwung River in DKI Jakarta

Objective	Key issues
Reducing the volume of plastic waste entering the river	High leakage of plastic waste from domestic sources due to low levels of waste separation at the upstream level.
Increasing waste separation and recycling rates at the community downstream level	Low public awareness and lack of consistency in practicing household waste separation.
Reducing illegal dumping sites along the riverbanks	Limited monitoring and law enforcement against illegal waste disposal, as well as the persistence of dumping waste into rivers as a common practice among some communities.
Improving environmental awareness and pro-environmental behavior of residents	Environmental education programs are not sustained and tend to be ceremonial, resulting in a gap between environmental knowledge and daily practices.
Creating plastic waste–based livelihood opportunities	Plastic-based economic activities remain informal and vulnerable, and the informal sector (waste pickers) has not

Objective	Key issues
	been fully integrated into the formal waste management system.
Improving water quality and river habitat	Plastic waste contributes to the decline in water quality and degradation of river ecosystems, and the policy focus is still predominantly on flood control, not river ecological restoration.
Strengthening institutional capacity and community-based governance	Community institutions still rely on short-term projects and there is weak coordination between communities, local governments and technical institutions.
Ensuring sustainable funding for waste management programs	There is a high dependence on CSR funds and temporary project assistance and the absence of a long-term funding scheme integrated with the APBD.
Increasing the participation of school children and the younger generation	Environmental education activities in schools are not yet connected to real action on riverbanks and there is little space for creative participation for the younger generation in waste management.
Reducing public health risks related to waste on riverbanks	Plastic waste accumulation increases the risk of environmental-based diseases (dengue fever, diarrhea) and there is minimal collaboration between the environmental sector and the public health sector.

MDI	BBWS	SDA	DLH	UPTD	Pemda	Community	Public	Privt_Sect	Campus	Inform
BBWS	0	4	4	4	4	4	4	3	2	1
SDA	3	0	4	4	4	2	3	2	2	1
DLH	3	3	0	4	4	2	3	2	2	1
UPTD	2	2	2	0	3	2	3	1	1	3
Pemda	2	2	3	3	0	3	3	2	1	3
Community	1	2	2	2	2	0	3	1	0	3
Public	0	2	2	2	2	3	0	0	1	3
Privt_Sect	2	2	2	2	2	2	2	0	0	0
Campus	0	2	2	2	2	2	2	2	0	0
Inform	0	0	0	0	0	0	0	0	0	0

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Figure 1. Inter-actor relationships in plastic waste management along the Ciliwung River corridor in the Special Capital Region of Jakarta

2MAO	Vol.pls	recycling	exha_sour	envrn_cons	livelihood	wat_qualty	institute	CSR	youth part	pblc healt
BBWS	3	1	3	1	0	4	1	0	1	2
SDA	3	0	2	1	0	3	1	0	0	2
DLH	4	4	3	3	2	3	4	3	2	4
UPTD	4	3	3	1	1	2	2	0	0	3
Pemda	3	2	4	3	2	2	4	3	2	4
Community	4	4	3	4	3	2	4	2	3	3
Public	4	4	4	4	3	3	4	4	3	3
Privt_Sect	2	3	1	2	3	1	1	4	1	1
Campus	1	1	1	3	2	2	2	1	3	2
Inform	4	4	2	1	4	1	2	2	0	2

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Figure 2. Relationships between actors and the objectives of plastic waste management along the Ciliwung River corridor in the Special Capital Region of Jakarta

The results of actor and objective identification were evaluated by expert informants through the completion of the Matrix of Direct Influence (MDI) (Figure 1). To illustrate the relationships

between actors and the objectives of plastic waste management along the Ciliwung River corridor, the 2MAO matrix was completed and is presented in Figure 2.

The MACTOR interpretation of the MDI completed by expert informants resulted in the Matrix of Direct and Indirect Influences (MDII), consisting of two indicators: IMaxi (Influence) and DMaxi (Dependence). The IMaxi value represents the net direct and indirect influence of an actor and reflects its capacity to influence the actions of other actors. In contrast, the DMaxi value represents the net direct and indirect dependence of an actor on others (Godet, 1991, 2006) (Figure 3).

MDII	BBWS	SDA	DLH	UPTD	Pemda	Community	Public	Privt_Sect	Campus	Inform	Ii
BBWS	13	19	21	23	23	20	23	13	9	15	166
SDA	13	18	20	22	22	19	21	13	9	14	153
DLH	13	18	19	21	21	19	21	13	9	14	149
UPTD	10	14	15	15	15	16	16	11	9	14	120
Pemda	12	16	16	17	17	17	19	11	9	15	132
Community	10	12	12	12	12	13	13	9	8	13	101
Public	9	11	11	11	11	12	12	9	7	12	93
Privt_Sect	11	14	14	14	14	14	14	10	9	11	115
Campus	11	14	14	14	14	14	14	10	7	10	115
Inform	0	0	0	0	0	0	0	0	0	0	0
Di	89	118	123	134	132	131	141	89	69	118	1144

Figure 3. Levels of direct and indirect influence and dependence among actors in plastic waste management along the Ciliwung River corridor in the Special Capital Region of Jakarta

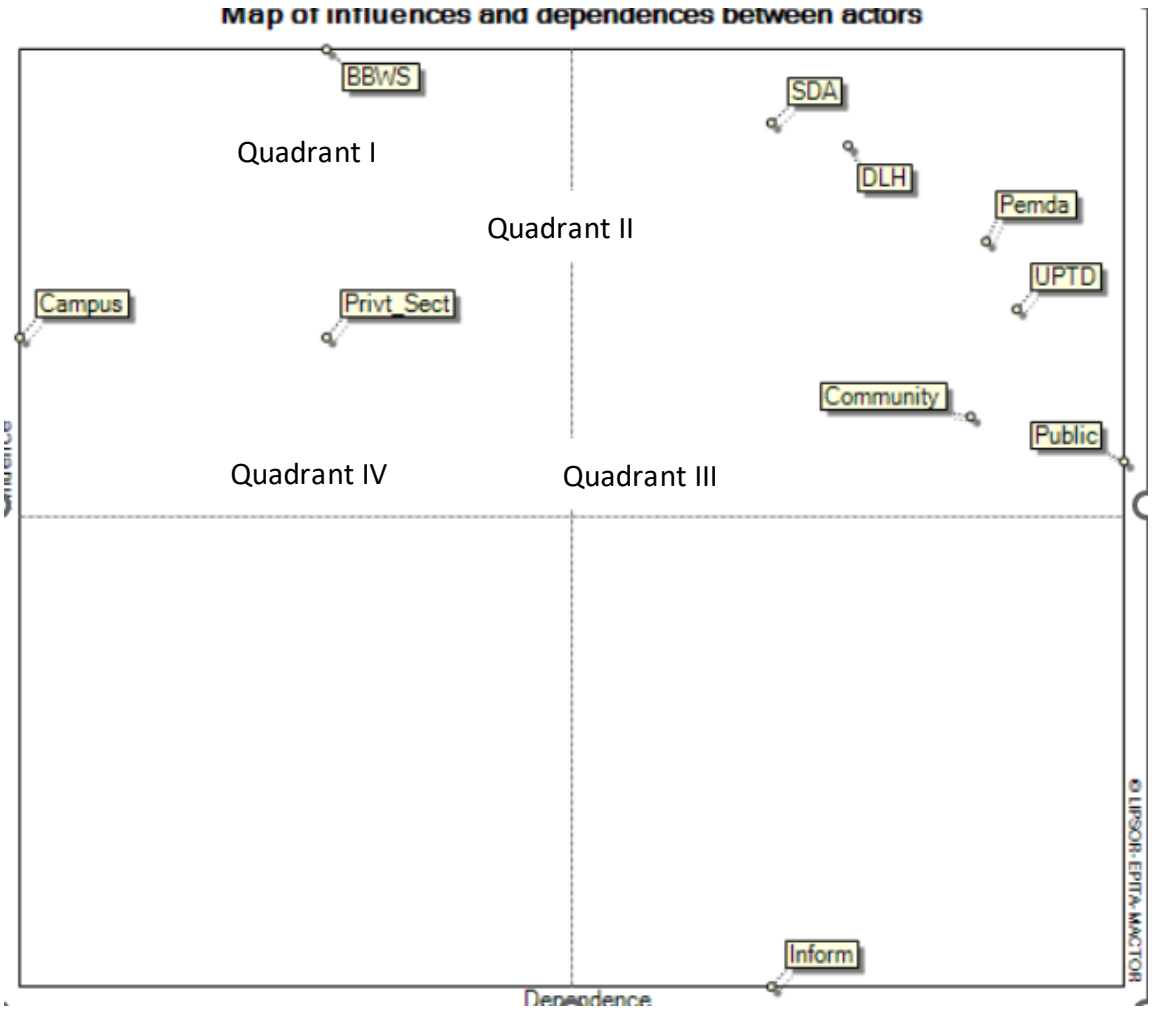

Figure 4. Map of influence and dependence among actors in plastic waste management along the Ciliwung River corridor in the Special Capital Region of Jakarta

Actor mapping using the MACTOR software generated a Map of Influences and Dependences between Actors, illustrating the relative levels of influence and dependence of each actor in river management (Figure 4). Actor competitiveness in the MACTOR method is represented by the Ri value (Figure 5). The Ri value indicates the level of actor competitiveness by considering direct and indirect influence, dependence, and feedback interactions among actors.

	Ri
BBWS	1.81
SDA	1.38
DLH	1.29
UPTD	0.90
Pemda	1.04
Community	0.69
Public	0.58
Privt_Sect	1.07
Campus	1.22
Inform	0.00

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Figure 5. Actor competitiveness in plastic waste management along the Ciliwung River corridor in the Special Capital Region of Jakarta

The net distances between actors graph illustrates the degree of proximity and positional differences among actors based on similarities and differences in their stances toward the strategic objectives analyzed in the MACTOR matrix (Figure 6). Overall, the objectives of plastic waste management are presented in Figure 7 and the net distance graph between objectives (Figure 8).

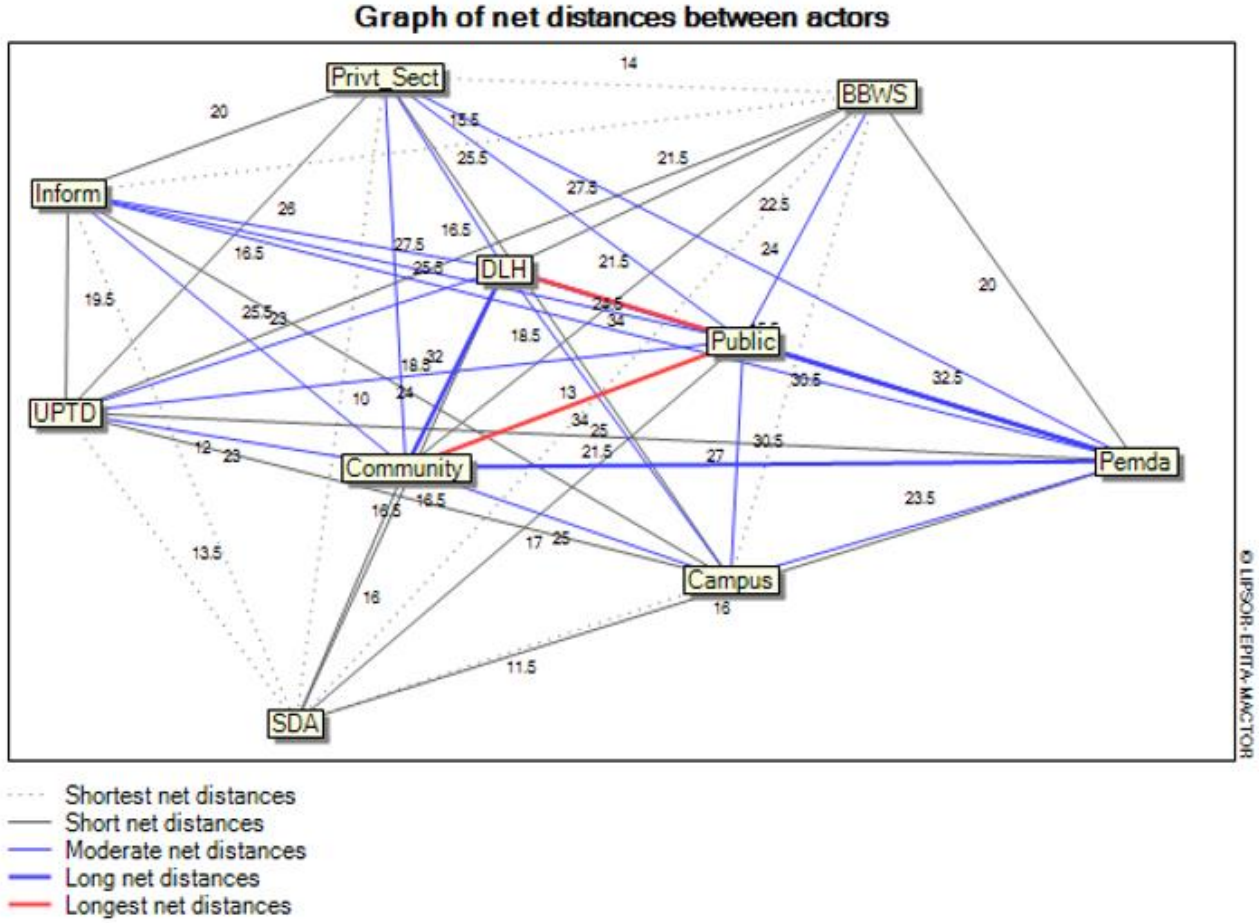

Figure 6. Net distance map between actors

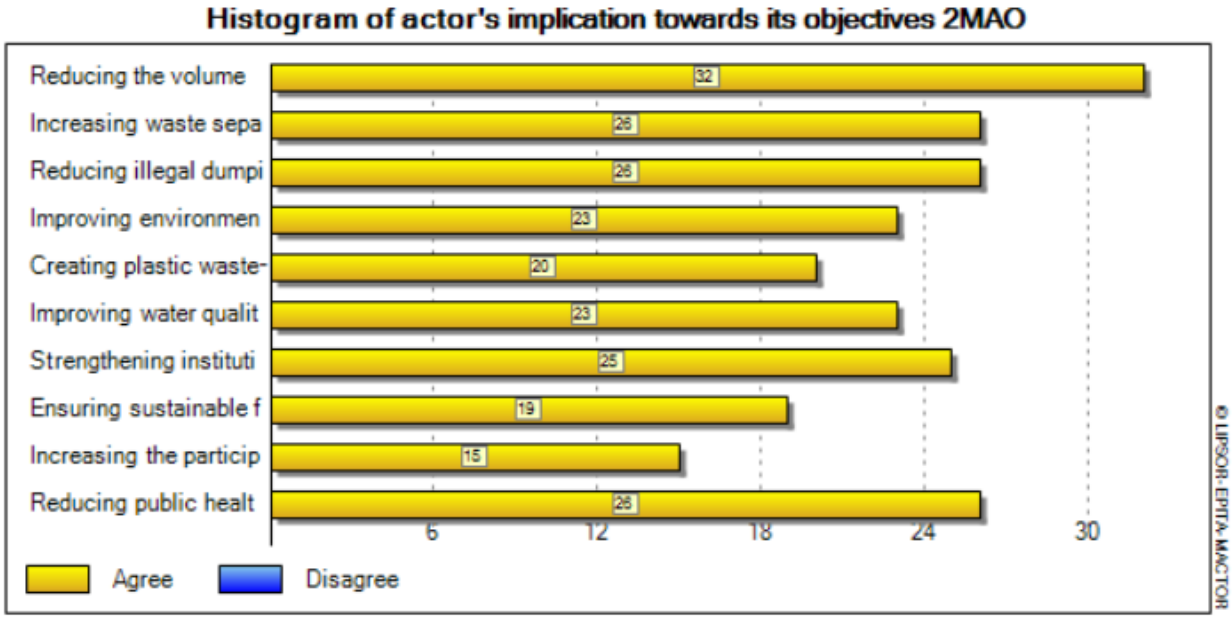

Figure 7. Actor mobilization in achieving management objectives

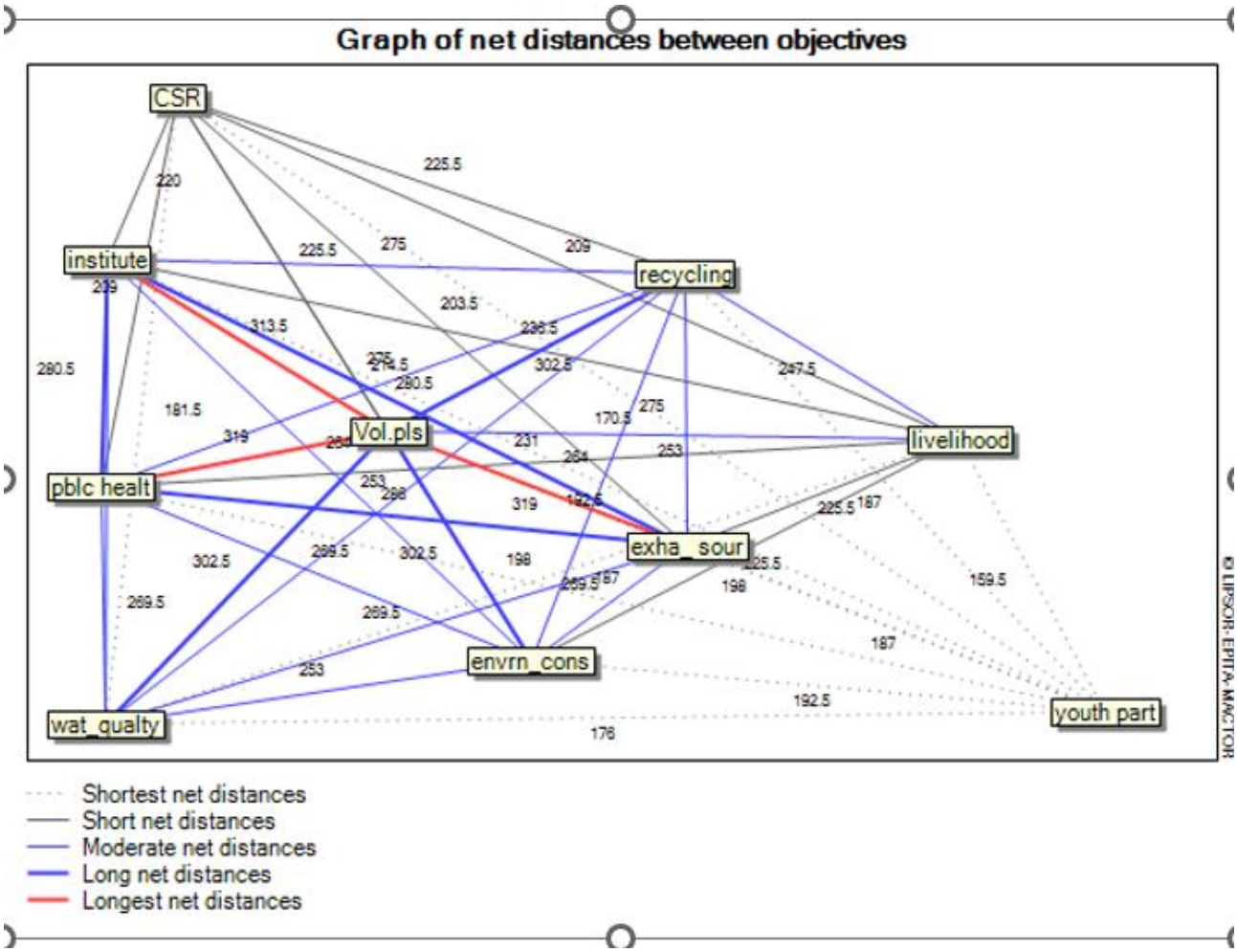

Figure 8. Net distance graph between objectives

DISCUSSION

In this study, the MACTOR method can be used to analyze the complexity of stakeholders in plastic waste management programs along the Ciliwung River corridor, as it enables an in-depth examination of alliances, conflicts, and strategic objectives among the actors involved. The

MACTOR framework facilitates the mapping of relationships and dependencies, which is essential for understanding how diverse stakeholder objectives align or conflict with one another (Fetoui et al., 2023).

The results indicate that the actors with the greatest influence in plastic waste management along the Ciliwung River corridor in the Special Capital Region of Jakarta are central government institutions, represented by the Balai Besar Wilayah Sungai Ciliwung Cisadane (IMaxi= 32) and the Dinas Sumber Daya Air Provinsi DKI Jakarta (IMaxi= 29). In contrast, the informal sector, particularly waste pickers, exhibits the highest level of dependence on other actors (DMaxi= 25), followed by local communities, community organizations, city/district/sub-district governments, and the River Management Technical Unit (UPTD), each with a DMaxi value of 23. This pattern reflects a pronounced imbalance in power and dependence within the plastic waste management system.

Actor mapping using the MACTOR software produced the Map of Influences and Dependences between Actors (Figure 4), which positions actors based on the combination of their influence and dependence levels. This map classifies actors into four quadrants, each representing distinct roles and characteristics within the river management system. Actors located in Quadrant I (BBWS, universities, and the private sector) function as dominant actors or drivers, possessing a high capacity to shape policy directions and resource management structures. In actor analysis literature, this position is commonly associated with actors holding formal authority, resource control, or scientific legitimacy. The dominant role of BBWS aligns with the concept of state-led environmental governance, in which central government institutions play a key role in managing transboundary river systems. Meanwhile, universities and the private sector, although not always vested with formal authority, are categorized as dominant actors due to their knowledge capacity and financial capital, which enable them to exert significant influence over other actors.

These findings are consistent with the study by Widiyanti et al. (2024) in Madiun Regency, which highlights that in complex waste governance systems, actors with strong institutional affiliations—such as government agencies and formal institutions—tend to dominate decision-making processes, while other actors face constraints due to limited access and structural legitimacy. This conclusion is further supported by Mukhlis et al. (2025), who conducted research in Tulungagung Regency and found that actors with strong institutional positions and leadership roles play a critical role in directing strategies and operational frameworks in peri-urban waste management, corresponding to the characteristics of Quadrant I actors.

Actors positioned in Quadrant II (Dinas Sumber Daya Air, Dinas Lingkungan Hidup, local governments, UPTD, community organizations, and local communities) represent key relay actors. These actors play strategic roles in policy implementation but are highly dependent on cross-actor coordination. In the literature, such actors are often referred to as intermediary or boundary actors. In the context of urban river management, local government agencies and communities are directly involved in field-level implementation; however, their effectiveness is strongly influenced by policy support, budget allocation, and regulatory frameworks established by dominant actors. The high dependence levels observed among Quadrant II actors reflect the inherently complex, multi-actor nature of urban river governance.

Studies in the Krueng Aceh watershed have shown that despite substantial resources held by government stakeholders, management effectiveness remains limited due to weak coordination among actors (Mulyawan et al., 2022). Whitley (2024) further emphasizes that both endogenous and exogenous actors may actively participate in decision-making processes, yet remain constrained by institutional affiliation and collective capacity. Research by Muchtar (2025) on the Tallo watershed reinforces these findings, demonstrating that collaboration among government, communities, and the private sector is crucial for effective implementation, thereby affirming the importance of Quadrant II actors as essential yet highly dependent implementers.

The informal sector, positioned in Quadrant III, represents actors with tangible contributions but limited bargaining power. A study by Whitley (2024) shows that the informal sector is often categorized as dependent stakeholders—actors directly affected by policy outcomes but with limited involvement in decision-making processes. Despite their low influence, informal actors play a crucial

role in waste reduction and strengthening circular economy practices. Their high level of dependency suggests that the sustainability of their contributions is largely determined by policy recognition and support from dominant actors. This position aligns with the informal sector in Quadrant III, which is characterized by low influence and high dependency. Recent studies have also shown that neglecting peripheral actors can exacerbate inequalities in resource access and representation in watershed governance, underscoring the need to address structural barriers to optimize their contributions (Issac & Newell, 2025).

In the MACTOR quadrant map, no actor is found to significantly occupy Quadrant IV. This condition indicates that the Ciliwung River management system is highly interconnected, with most actors exhibiting some degree of influence and dependence. Recent studies on stakeholder engagement in water governance confirm that in complex systems, truly marginal actors are rare due to dense interconnections within governance networks (Whitley, 2024).

Actor competitiveness within the MACTOR framework is represented by the Ri value (Figure 5). BBWS demonstrates the highest competitiveness score (Ri*= 1.81), indicating a strong capacity to influence other actors while maintaining its strategic interests. This dominance can be attributed to the institution's structural authority and formal legitimacy in water resource management. These findings are consistent with studies suggesting that actors with technocratic authority and regulatory control tend to exhibit the highest competitiveness in multi-actor environmental governance systems (Whitley, 2024). Other actors with relatively high competitiveness include the Dinas Sumber Daya Air (1.38), Dinas Lingkungan Hidup (1.29), and universities (1.22). These actors can be classified as non-dominant strategic actors, possessing the capacity to influence the system while remaining dependent on other actors. Technical agencies play important roles in sectoral policy formulation and environmental oversight, while universities derive competitiveness from scientific legitimacy and knowledge production capacity. This supports literature emphasizing the role of knowledge-based actors as sources of soft power in environmental governance (Sianggaputra et al., 2022; Widiyanti et al., 2024).

The private sector and local governments exhibit competitiveness values close to the neutral threshold (Ri*≈ 1), reflecting dual roles as actors with potential policy influence while remaining highly dependent on regulatory frameworks and decisions made by other actors. The literature refers to this position as adaptive policy followers, who adjust economic and administrative interests in response to prevailing environmental policies (Widiyanti et al., 2024). Competitiveness values for community organizations (0.69) and local communities (0.58) indicate limited structural capacity to advocate for their interests, despite their critical roles in on-the-ground waste management practices. Limited access to resources, information, and institutional legitimacy remains the primary factor constraining the bargaining power of these groups (Widiyanti et al., 2024).

The informal sector records the lowest competitiveness value (Ri*= 0.00), indicating an almost complete lack of capacity to compete within formal policy arenas. Within the MACTOR framework, high dependence coupled with low influence positions the informal sector as a peripheral actor in the governance network, consistent with findings by Widiyanti et al. (2024). The net distances between actors graph illustrates the degree of proximity and positional differences among actors based on similarities and differences in their stances toward strategic objectives. Shorter net distances indicate convergence of interests and perceptions, while longer distances reflect divergent orientations, priorities, and role capacities (Mukhlis et al., 2025). The analysis reveals a core cluster of actors with relatively short to moderate distances, particularly among the Environmental Agency, local governments, community organizations, and UPTD, indicating shared policy orientations and functional interdependencies in plastic waste management implementation.

The Dinas Lingkungan Hidup appears centrally positioned within the network, with numerous short and moderate-distance connections, highlighting its role as a bridging actor linking government, community, and non-governmental stakeholders. In contrast, technical actors such as BBWS and the Dinas Sumber Daya Air exhibit relatively greater distances from social and informal actors, reflecting a more sectoral and infrastructure-oriented focus. Nevertheless, the absence of extreme net distances

suggests substantial potential for consolidating all actors within collaborative governance schemes through strengthened cross-sector coordination.

CONCLUSION

The actors exerting the greatest influence in plastic waste management along the Ciliwung River corridor in the Special Capital Region of Jakarta are central government institutions, represented by the Balai Besar Wilayah Sungai Ciliwung Cisadane and the Dinas Sumber Daya Air Provinsi DKI Jakarta, particularly in their capacity and role in shaping policy direction and resources management structure, especially in its capacity and key role in shaping policy direction and resource management structures. The informal sector exhibits the highest level of dependence on other actors, followed by local communities, community organizations, city/district/sub-district governments, and the River Management Technical Unit. Actor mapping indicates that BBWS, universities, and the private sector function as dominant actors, while the Dinas Sumber Daya Air, Dinas Lingkungan Hidup, local governments, UPTD, community organizations, and local communities serve as key relay actors, and the informal sector operates as dependent stakeholders. Collaborative actor mobilization is therefore essential to achieve shared objectives, including reducing plastic waste accumulation along the Ciliwung River corridor, minimizing public health risks, improving river water quality, and decreasing sources of plastic waste entering the river system.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the institutional support provided by Universitas Indraprasta PGRI Jakarta and the Regional Government of the Special Capital Region of Jakarta (DKI Jakarta), Indonesia.

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