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System-wide assessment of plastic pollution in Indonesia: external stakeholder mapping

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Abstract
Recent global initiatives, such as the Global Plastics Treaty, highlight the urgency for a systems-based approach to address the risks associated with plastic pollution. However, the implementation of such initiatives is often hindered by the absence of clear criteria for what constitutes a systemic approach and who is included within it. This study offers a comprehensive analysis of external stakeholders, those who are not directly engaged in the physical flow of plastics, contrasted with internal stakeholders, who play direct roles in the physical production, consumption and waste generation and management. While internal stakeholders have traditionally received increased attention in value chain studies, external stakeholders remain largely overlooked. To address this gap, this research introduces a novel approach, embedded in the systems-based method, called Complex Value Optimisation for Resource Recovery (CVORR), to identify, map and categorise external stakeholders in the plastics value chain in Banyuwangi, Indonesia, based on organisation type, activities, and interest. The study reveals a complex system of 111 external stakeholders consolidated into 11 groups that are engaged across various operational stages and spatial levels. By integrating stakeholder theory and analytical tools such as the Mendelow matrix, the study uncovers underlying power dynamics and significant lock-ins that arise where the emphasis on downstream waste management overshadows preventive upstream measures. The findings highlight the importance of fostering communication and collaboration among stakeholders and creating partnerships within and across stakeholder groups to drive systemic change. Engaging effectively throughout the plastics value chain can pave the way for tailored solutions to local challenges, thereby enhancing sustainability and facilitating alignment with the Sustainable Development Goals. Ultimately, this study advocates for coordinated efforts, ensuring that policy interventions and local actions support a comprehensive, circular approach to effective plastics management.

Keywords Stakeholder mapping · Indonesia · System analysis · Plastics value chain · Sustainability · Circular economy · CVORR

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1 Introduction

Indonesia, a dynamic and developing country of over 270 million people and one of the largest ASEAN economies, is facing a severe plastic pollution problem (UNEP 2020; Jambeck et al. 2015). Indonesia has dispersed populations, continuous population growth, and lacks well-established governmental and structural frameworks to manage waste effectively (Becerra 2021; Nurdiana et al. 2021). According to our estimates (Iacovidou et al. 2025), on average, 10% of Indonesia's total plastic waste is recycled, 20% is disposed of in controlled landfills, 9% is discarded in uncontrolled dumpsites, 20% is dumped, and a staggering 41% is openly burned, highlighting an alarming global pollution crisis. This includes emissions of greenhouse gases and other toxic airborne pollutants, including microplastics, that are a potential risk to human health (Wilson 2023).

Human health impacts associated with plastic waste mismanagement are in addition to the enormous economic costs (estimated 1.3 billion USD pa in the Asia–Pacific region) associated with, for example, the loss of revenue from tourism, clean-up and infrastructure repair activities and ecosystem degradation (UNEP 2014). Whilst knowledge of the environmental, economic and social impacts of plastic pollution is increasing, much less is known about those who are responsible for the production, consumption, and management of plastic waste and their in-between dynamics (UNDP 2022), inhibiting progress on efforts towards achieving a circular plastics economy.

Given this context, a comprehensive identification and mapping of stakeholders involved in the Indonesian plastics value chain is essential for understanding the systemic causes of the plastic pollution issue (Nurdiana et al. 2021; Rimantho et al. 2023; Prabawati et al. 2023). In our systems-based approach, called Complex Value Optimisation for Resource Recovery (CVORR), identifying and mapping stakeholders involved in a resource recovery system is a key step in analysing the drivers and barriers to circularity. This analysis, guided by stakeholder theory (Freeman 2010), can shed light on stakeholders' interests, priorities, and roles that orchestrate the flows of resources in a system, in this case, plastics. Based on this theory, stakeholders can be broadly divided into *internal* and *external* categories. *Internal* stakeholders, also known as primary, are those directly involved in the mass flow of plastic materials, components and products, for example, manufacturers, retailers, consumers and waste handlers, who physically interact with the plastics as they move through the chain. In contrast, *external stakeholders*, also known as secondary, influence the plastics system without participating in material handling (Fearne et al. 2012). These include, for example, regulatory bodies, community-based organisations, financial institutions and research organisations that influence the system through funding, monitoring, and other functions, such as policy-making, governance, financing, activism, environmental concerns, and research (Gerassimidou et al. 2022).

Distinguishing between internal and external stakeholder groups is fundamental to a systemic approach to circularity. It allows for a complete understanding of the drivers, barriers, and leverage points that exist across the entire system. By identifying who is "in" or "out" of the direct material flow and why, we can clarify roles, uncover power dynamics, and design targeted engagement strategies that are appropriate to each stakeholder's influence and interest. This approach goes beyond traditional linear analyses by recognising that indirect (external) stakeholders, although often overlooked, can significantly shape system trajectories. As such, our method supports a "systemic approach," one that integrates both direct and indirect influences across environmental, social, economic, technical and political domains to enable coordinated and effective interventions in the plastics value chain. For an overview of the main stakeholder categories and their descriptions, see (Gerassimidou et al. 2022).

At present, there has been limited attention given to the role of external stakeholders as opposed to internal stakeholders (Ratnawati et al. 2020; IPEN 2022; Putri et al. 2018; NPAP 2020; Iacovidou et al. 2025). While there are studies that distinguish stakeholders into internal and external (Prabawati et al. 2023) and recognise the involvement of external stakeholders in plastic waste management across various developing countries (Ferronato et al. 2024), the emphasis tends to be on describing what actions are being undertaken, with less exploration of how and why stakeholders participate or are constrained. Yet, their role is particularly influential in creating multidimensional value (i.e., positive environmental, economic, social, political and technical impacts) within the plastics system, and hence, it must not be overlooked. External stakeholders are responsible for information exchange and building relationships, offering essential infrastructure, regulations, and social contexts that contribute to value creation (Fearne et al. 2012). Furthermore, although circular economy principles are acknowledged, a holistic systems-based analysis is often lacking, hindering a comprehensive understanding of the interdependencies between external stakeholder dynamics, material and financial flows, and systemic barriers to circularity. Key aspects such as power imbalances, differential benefits, and the financial leverage influencing stakeholder behavior remain under-explored.

To address this knowledge gap, this study maps and classifies the external stakeholders involved in Indonesia's plastics value chain, using Banyuwangi Regency as case study, providing insights into their roles, interactions, and

expectations regarding the transition towards a circular plastics economy, one that prevents pollution and promotes efficient plastics production and consumption. This selection is based on Banyuwangi's involvement in the PISCES (Plastics in Societies) project, its high levels of community engagement and political will, and the acute problem of plastic waste pollution (PISCES 2024). These features make Banyuwangi a compelling critical case (Flyvbjerg 2006) for understanding stakeholder dynamics and enabling conditions for system-change interventions, i.e., actions and strategies designed to fundamentally transform underlying structures, policies, or practices within a system to create lasting improvements, offering transferrable insights to other regions in Indonesia and comparable contexts facing similar governance, environmental and social challenges.

To achieve the objectives of this study, a 'top-down' and 'bottom-up' approach was used to identify and analyse the stakeholders indirectly involved and influencing the plastics value chain. The 'top-down' approach refers to the identification of stakeholders that operate at the national–international interface, whose activities focus on the development and implementation of the national framework for promoting and improving plastics circularity and solid waste management. The 'bottom-up' approach refers to the identification of stakeholders that operate at the national-local or regional-local interface, whose activities focus on improving solid waste management at a local or regional level, preventing plastic pollution and safeguarding the natural environment and communities' livelihoods.

This integrative approach is an essential component of a systems-based analysis as it is instrumental in establishing a shared terminology for describing the stakeholder networks and providing the depth and insights needed to drive research, innovation and action needed to solve Indonesia's plastic pollution problem (Patton and Li 2021). In this context, the 'system' refers to the plastics value chain that is commonly distinguished into two main parts: the upstream part, which includes the initial stages from raw material acquisition and plastic materials, components and products manufacture, distribution and consumption by end-users; and the downstream part, which encompasses the post-consumer stage, including disposal, collection, sorting, and waste processing. These insights could inform wider policies, strategies and decision-making processes related to stakeholder engagement in Indonesia.

The study is organised into five sections. Section 2, Methodology, outlines the approaches used to address the research objectives (Sect. 2.1) and details the process of stakeholder identification and data collection (Sect. 2.2). Section 3, Results, provides a preliminary systems-based analysis of external stakeholder roles and interactions in plastics value chain in Banyuwangi Regency (Sect. 3.1), an overview of the abundance and distribution of external stakeholders in the plastics value chain in Banyuwangi (Sect. 3.2), a stakeholders' analysis based on their activities (Sect. 3.3) and priorities (Sect. 3.4), and an analysis of the power dynamics within the system, including a detailed mapping of these stakeholders (Sect. 3.5). Section 4, Discussion, addresses research limitations, main challenges, and proposed mitigation measures aimed at fostering a more sustainable system. Finally, Sect. 5, Conclusions, encapsulates the main findings and conclusions drawn from the study.

2 Methodology

A detailed description of the stakeholder analysis as part of the CVORR system-based approach can be found in the Supporting Information (SI) (*Section A*; Fig. A1). Briefly, CVORR includes two main tools: 1) the CVORR baseline analytical tool and 2) the CVORR complex value flow evaluation tool (Iacovidou et al. 2020). Stakeholder analysis is one of the main components of the CVORR baseline analytical tool, which integrates material and monetary flow analysis, stakeholder mapping and analysis, and analysis of system dynamics using the five levels of information (5LoI) framework. While a standalone stakeholder analysis is feasible, it does not fully capture stakeholders' roles, interactions and influence. Conducting this analysis within the CVORR framework addresses these limitations, offering a comprehensive and integrated approach. To maintain the focus of this study, a description of the CVORR baseline analytical approach is provided elsewhere (Iacovidou et al. 2020; Ebner and Iacovidou 2021).

The CVORR approach evaluates the multidimensional value of materials, components and products within systems by identifying inefficiencies and opportunities across environmental, economic, social, technical and political dimensions. Unlike conventional tools such as Life Cycle Assessment (LCA), which focus predominantly on environmental impacts, or Material Flow Analysis (MFA), which quantifies physical flows, CVORR adopts a holistic, systems-based lens that integrates multiple dimensions of value and stakeholder perspectives to support systemic change. Its successful application in the UK plastics value chain (Iacovidou et al. 2020) and the PISCES project in Indonesia demonstrates its suitability for informing evidence-based, context-sensitive interventions in complex socio-technical systems.

Furthermore, Iacovidou et al. (2021) emphasise its unique capacity to facilitate deep, transformational change by uncovering dynamic interactions and power asymmetries within value chains, features that are critical in addressing persistent systemic challenges like plastic pollution, and in

facilitating deep, transformational change (Iacovidou et al. 2021).

2.1 External stakeholder identification: tools and approaches

In CVORR's stakeholder mapping and analysis stage, there are four distinct steps: (1) classification of stakeholders into internal and external, (2) categorisation of stakeholders based on their legal status to aid the identification of the main groups of stakeholders (stakeholder typology), (3) categorisation of stakeholder types based on organisational objectives and focus areas (activities) along the value chain to aid the identification of all stakeholders involved at the national–international, national-regional, and regional-local levels, and (4) classification of stakeholders according to their level of *interest* and *power* following the *Mendelow matrix* (Mendelow 1991). The latter step helps to generate insights into their in-between relationships and dynamics. This study outlines steps 2–4 a s Step 1 has been addressed in an earlier study that accompanies this work (Iacovidou et al. 2025).

According to the Mendelow matrix, *power* refers to stakeholders' ability to influence decisions and actions, whereas *interest* indicates their concerns and focus areas regarding their main activities and the way these help to address plastic pollution in Indonesia. Although the Mendelow matrix provides a simplified representation of stakeholder power dynamics (Cuofano 2023), it offers useful insights into which stakeholders should be actively engaged and involved in decision-making processes and which stakeholders require careful management (UNDP 2022). Table 1 presents the four categories of external stakeholders, each characterized by their key potential influence in catalysing systemic change within global value chains (e.g., through the development or implementation of action plans). These categories are difeerentiated by two key dimensions: the stakeholder's level of power to drive systemic change and their level of interest in how these changes are realised. This classification draws on established project management frameworks (Cuofano 2023; Mendelow 1991), and is contextualized here to support efforts in addressing complex challenges such as plastic pollution.

As shown in Table 1, stakeholders vary in their levels of influence and interest, which in turn shapes how they engage with systemic transformation processes. While not all stakeholders have equal power, each can play a meaningful role in shaping outcomes. Effective systemic change requires differentiated stakeholder engagement strategies, particularly for key players with high influence, who are crucial for enabling or obstructing transitions. Tailoring engagement efforts to reflect each stakeholder's potential impacts enhances the legitimacy of interventions, reduces opposition and resistance, and can reveal underutilised opportunities. Robust stakeholder management, therefore, depends on aligning engagement approaches with the specific roles, motivations, and leverage points of diverse stakeholders within the system.

External stakeholders in the plastics value chain were identified using the top-down and bottom-up approach to policy development and implementation, and additional initiatives and efforts to address plastic pollution and promote a circular economy. To manage the large number of external stakeholders operating at the national-regional and regional-local interface, we used the Banyuwangi Regency, the largest in Java, as a case study. While external stakeholder analysis ideally spans multiple spatial and temporal scales, focusing on Banyuwangi Regency enables a detailed understanding of stakeholder dynamics within a manageable scope. This provides a foundation for future scaling and replication at national or comparative sub-national levels. Temporally, this study captures a snapshot aligned with ongoing PISCES interventions, providing timely insights for immediate application. The regency scale was chosen because it captures both top-down influences from national strategies and bottom-up community-level actions, making it ideal for analysing the cross-scale coordination and identifying intervention points that reflect both policy intent and local realities.

2.2 External stakeholder identification: typology development and management

A preliminary system analysis was carried out to identify the range of relevant stakeholders, particularly those with a clear presence in Banyuwangi. A structured data extraction

Table 1 The four groups of external stakeholders and their characteristics according to Mendelow matrix

Power	Interest	Description	Characteristics
High	High	*Key Players*	They need close engagement, collaboration, and regular communication to address their concerns and leverage their influence effectively
High	Low	*Influencers*	They should be kept satisfied with relevant information and supportive relationships to ensure their indirect support and advocacy
Low	High	*Informed*	They need to be engaged in dialogue and involved in relevant activities to align with their interests and concerns
Low	Low	*Low priority*	They require minimal effort and basic awareness and providing information provided as needed, without significant resource allocation

protocol was applied, informed by principles of qualitative content analysis. Key themes and stakeholder attributes (e.g., influence, interest, sector, legal status) were systematically coded using a deductive-inductive approach: pre-defined codes were based on stakeholder theory and sustainability transition literature, while emergent codes were identified through iterative review. This process allowed us to validate the classification and strengthen the reliability of the stakeholder mapping, leading to a deep understanding of the complex power dynamics and engagement potential across national and local levels.The roles and operational activities of all categories of external stakeholders operating within the Banyuwangi Regency, as well as how they execute these roles, were analysed using the following criteria:

- *Spatial level*: assesses the scale of stakeholders' operations across different levels (e.g., international, national and local, i.e., province, regency, city or district).
- *Stage of the value chain*: examines whether stakeholders focus on upstream activities (from production (P) to consumption (C)), downstream activities (from consumption (C) to waste management (M)), or across the entire value chain, encompassing production (P), consumption (C) and management (M).
- *Type of activities*: analyses stakeholders' roles in the plastics value chain and how they perform these roles. It is based on their alignment with organisational missions and visions, as seen on their websites, personal communication, and publications.

Some stakeholders may fit into multiple categories (as shown in Table 3, Sect. 3.1) and may engage in various activities (listed in Table 4, Sect. 3.1), which can complicate the classification process. This is especially the case if they address both professional and societal issues. To address this complexity, we categorise stakeholders based on their primary focus and mission, as determined through our preliminary analysis, ensuring a sufficient description of their role in this complex network.

To understand the role of different stakeholder categories within the Indonesian plastic value chain, we examined their activities through five key value dimensions: environmental, economic, social, technical, and political, the description of which is given in Table 2. These value dimensions reflect stakeholders' primary interests, hereafter referred to as *priorities*.

Each stakeholder activity aligns with one or more value dimensions, allowing us to assess the cumulative priorities of each stakeholder category based on the number of activities they engage in. By mapping primary value dimensions to each stakeholder's activities—an approach informed by our preliminary systems analysis—we quantified stakeholders' priorities according to their roles and activities within the value chain.

For instance, consider a stakeholder group engaged in five (5) activities: If these five activities were all aligned with environmental and economic dimensions, three aligned with social, two aligned with technical, and none aligned with political dimensions, the cumulative scoring for this stakeholder category would be:

- Environmental: 5
- Economic: 5
- Social: 3
- Technical: 2
- Political: 0

To normalise these scores and assess the distribution of priorities, we divided each cumulative score by the total number of activities (in this case, five). For instance:

- Environmental and Economic: 1 (score of 5 ÷ 5 activities)

Table 2 External stakeholder priorities identification template based on value dimensions

Value dimension	Description
Environmental	This refers to the impact of plastics value chain on ecosystems and resources, including sustainable sourcing, energy use, waste management, pollution reduction, and biodiversity protection. Organizations prioritize environmental value to minimize ecological footprints and promote environmentally responsible practices
Economic	This refers to the financial performance and economic benefits of plastics value chain, including profitability, cost-efficiency, ROI, job creation, funding, and overall contribution to economic growth. Organizations focus on economic value to optimize resources, improve financial practices, and maintain competitiveness
Social	This refers to the impact of plastics value chain on communities and society, including labor practices, community engagement, equitable access, and contributions to public health and education. Organizations prioritize social value by ensuring fair treatment, supporting community well-being, and promoting positive social outcomes throughout the value chain
Technical	This refers to the effectiveness and efficiency of processes, technologies, and methodologies within plastics value chain, including innovation, quality control, capacity, and technological adoption. Organizations focus on technical value to enhance performance, logistics, and reliability across their operations
Political	This refers to the influence of decision-making processes on plastics value chain, including the roles of regulations, leadership, governance, advocacy, financial leverage, and organizational Power. Organizations prioritize political value to navigate regulatory frameworks, foster collaboration, and align practices with standards, shaping both strategies and sustainability outcomes

- Social: 0.6 (score of 3 ÷ 5 activities)
- Technical: 0.4 (score of 2 ÷ 5 activities)
- Political: 0 (score of 0 ÷ 5 activities)

In this example, the stakeholder group exhibits high priority in environmental and economic dimensions (scores of 1.0), moderate priority in the social dimension (0.6), low priority in the technical dimension (0.4), and no priority in the political dimension (0.0). In the context of the Mendelow matrix, a score of 0.5 or higher in the political dimension indicates high power, while a score of 0.5 or higher in the environmental dimension denotes high interest. Therefore, this stakeholder group has low power and a high interest in addressing plastic pollution. We applied this analysis to all stakeholder groups, using the remaining value dimensions as proxies to determine whether their power and interest levels are strong, moderate, low, or marginal, according to the four quadrants of the Mendelow Matrix. This approach was applied across all stakeholder groups, providing a systematic and quantitative assessment of their interests and influence within the plastic value chain, presented in Sect. 3.5.

2.3 Data collection

To identify the main categories of stakeholders based on their legal status and role in systemic change, we used several primary sources, including peer-reviewed literature, government databases, and official websites of relevant organisations. We also incorporated secondary sources, such as workshops and personal communications, facilitated through the PISCES partnership. Personal communications were conducted virtually or in person with a diverse group of key informants selected based on their expertise and involvement in the plastics value chain in Indonesia. These informants ensured representation from government agencies (e.g., officials from the Coordinating Ministry for Maritime and Investment Affairs), collaborative projects in Banyuwangi such as Project STOP (e.g., SYSTEMIQ and local government agencies), non-governmental and non-profit organisations (e.g., Emvitrust, Enviu), and actively engaged community stakeholders (e.g., from local initiatives and women organisations).

To ensure the rigour and verifiability of information obtained from grey literature and personal communications, a multi-faceted approach to triangulation was implemented. This involved: (1) comparing information from different sources (primary, secondary, grey literature, and personal communications) to identify consistent themes and patterns; and (2) cross-referencing information across different informant types (e.g. comparing perspectives of government officials with those of NGO representatives).

Furthermore, the expertise and credibility of key informants and the methodologies used in grey literature reports were also carefully assessed based on the informant's experience and position in the sector. While the use of grey literature inherently comes with potential biases due to the lack of peer review, its inclusion was crucial for capturing up-to-date insights into the dynamic and rapidly evolving landscape of stakeholders within the system. The potential for such biases, and the steps taken to mitigate them through triangulation, are important to consider when interpreting the findings presented in this manuscript. This approach enabled us to identify their organisational objectives and focus areas (activities) in the plastics value chain and to assess their interrelationships and influence on the plastics value chain through their operations.

3 Results

3.1 Preliminary analysis of external stakeholders from a systems-based perspective in Banyuwangi Regency

Using the plastics value chain processes—production (P), consumption (C), management (M)—as a guiding map, we examined stakeholders' roles and interactions proceeding from upstream to downstream parts of the value chain and highlighting key entities at local and national levels.

3.1.1 Stakeholders operating upstream: P-C

Empirical evidence of upstream interactions among stakeholders at the local level remains largely under-documented, with most documented interactions occurring nationally. The national government engages with stakeholders upstream in the plastics value chain by fostering collaborative initiatives with internal stakeholders (Iacovidou et al. 2025), such as the polymer industry, plastic manufacturers, traders and consumer goods producers, and external stakeholders such as trade associations (TAs) and research institutions (RIs), to enhance the procurement process (BRIN 2022; LKPP 2017). Through these collaborations, the government develops and implements procurement regulations while promoting the local sourcing of petrochemical inputs, exemplified by the USD 31 billion investment from the Ministry of Industry to support the petrochemical sector (USAID 2022). The National Public Procurement Agency (LKPP), Ministry of Environment and Forestry (MoEF) and former Coordinating Ministry for Maritime and Investment Affairs (CMMAI) collaborate with RIs, and particularly, the Indonesian National Research and Innovation Agency (BRIN), to integrate Green and Sustainable Public Procurement

(GPP/SPP) for recycled and reusable plastics. This involves developing policy frameworks, defining standards for recycled content in packaging, and building institutional capacity to ensure effective implementation of these initiatives. BRIN's contribution centers on research and development to inform these processes (GIZ 2023).

Six TAs operate upstream in the value chain with key activity focusing on *Product manufacturing.* These TAs are responsible for overseeing the entire plastic supply chain (USAID 2022) and act as intermediates between the national government (NG) and businesses. Through, this role, TAs have the potential to significantly influence the sector by promoting circular economy models, advocating for relevant policies, implementing sustainability initiatives, and improving waste management and resource efficiency (USAID 2022). Their activities include raising industry awareness, analysing policy impacts, and fostering collaboration within the recycling sector.

Non-profit organisations (NPOs) are mainly found involved in the downstream of the plastics value chain (see Sect. 3.1.2). There is only one NPO that focuses exclusively on upstream activities, specifically focusing on scaling innovative reusable and refillable plastic packaging solutions in Banyuwangi, in partnership with PISCES, to promote collaborations with consumer goods producers and retailers (PISCES 2024). PISCES is an international and interdisciplinary partnership that connects UK and Indonesian RIs with key stakeholders, such as government agencies, businesses, industry and NGOs, to develop evidence-based solutions for plastic waste impacts in communities, using Banyuwangi as a case study (PISCES 2024). Within this initiative, the PISCES project has been funded by financial institutions (FIs), i.e., the UK Research and Innovation's (UKRI) Global Challenges Research Fund (GCRF), and partnered with government agencies to provide system-change interventions focusing on the East Java Province by setting up and running the 'Living Lab Initiative', i.e., an infrastructure to enable the development, experimentation and testing of design solutions to the plastic packaging problem (PISCES 2024).

Several Banyuwangi government agencies may engage in activities not explicitly related to the plastics value chain, though these activities significantly influence the upstream plastics value chain through various mechanisms (e.g., policy enforcement, infrastructure development, and awareness campaigns). Local government (LG) agencies, such as the Environmental Agency (DLH), exert regulatory oversight by enforcing environmental regulations. Strategic planning efforts led by the Village Community Empowerment Agency (DPMD) focus on village development plans, while the Regional Financial and Asset Management Agency (BPKAD) collaborates on regional plans. These local initiatives often align with national plastic pollution prevention goals, as seen in the financial management efforts coordinated with the Ministry of National Development Planning (BAPPENA). Permitting processes sit with the Office of Agriculture and Food Security (Dispertan), which is responsible for agricultural permits. Additionally, the Office of Communication and Informatics (Diskominfo) facilitates access to information and technology adoption, further enhancing local capacity. In addition, the MoEF issued the Extended Producer Responsibility (EPR) regulation (No. 75/2019), holding producers responsible for reducing single-use plastics, although it has faced resistance from plastic manufacturers due to challenges associated with regulatory changes (Becerra 2021) and bureaucratic complexities (Arisman and Fatimah 2023). Collectively, these actions by both NG and LG indirectly shape the business environment for upstream stakeholders, impacting their operations and investment decisions.

3.1.2 Stakeholders operating downstream: C-M

Most stakeholders' interactions predominantly occur downstream of the plastics value chain as part of their efforts to implement changes in plastic waste collection and management. This tendency arises from greater opportunities for interventions downstream, where lobbying power is less concentrated (Gerassimidou et al. 2022). The stakeholders' interactions downstream of the system reveal both the efforts made and the barriers encountered in addressing the issue of plastic pollution at local and national levels. Like the P-C level, some government agencies and organisations may engage in activities not explicitly related to the plastics value chain. However, their roles significantly influence the broader resource recovery system, including plastic waste collection, transport, and management services, and the cleanliness of public spaces, rivers, and roadsides.

As part of the national commitment to reduce marine plastic pollution by 70% by 2025, Banyuwangi Regency has developed and implemented its Solid Waste Master Plan, referred to as Banyuwangi Hijau. This initiative is a collaborative effort involving several programs, including the Clean Oceans through Clean Communities (CLOCC) program (CLOCC 2021) and Project STOP (STOP 2022). The CLOCC program is an initiative funded by Norad (the Norwegian Agency for Development Cooperation) and its partnering with various NPOs, the main being the InSWA (Indonesia Solid Waste Association) (CLOCC 2021). Project STOP, launched by Borealis (a plastic manufacturer) in collaboration with SYSTEMIQ (an enterprise) and government agencies at the national and local levels, aims to create effective circular waste management systems. The project focuses on providing technical expertise to prevent waste

leakage, enhance recycling efforts, build economically sustainable programs, create new jobs, and mitigate the harmful impact of mismanaged waste on public health, tourism, and fisheries (STOP 2022; Borealis 2022), including participation in national policy planning discussions with the MoEF (Patton and Li 2021).

Despite these initiatives, plastic waste management in Banyuwangi still faces significant challenges, particularly in rural areas, which are excluded from the Solid Waste Master Plan (CLOCC 2021). This has resulted in limited integration between the regency government and rural villages, with many villages managing waste independently and often failing to implement the required waste service fees outlined in regulations (CLOCC 2021). The lack of integration and weak regulatory enforcement has led to financial constraints, transparency issues in monitoring and evaluating waste data, and ultimately, a low prioritisation of waste management (CLOCC 2021).

In Banyuwangi Regency, waste collection responsibilities are shared between the regency and the community organisations (Rukun Warga: RW), often through the establishment of waste banks (Maryanti 2017). However, LG agencies create regional and governor regulations through delegation and attribution, facilitating the governance and autonomy of local areas (Purba and Erliyana, 2020). This has led to the lack of standardised practices, leading to overlapping roles between operators and regulators, unclear procedures, coordination problems among waste sector agencies (Wikurendra et al. 2024; Systemiq 2021a) and delays in policy implementation (Ratnasari et al. 2023). Currently, the synergies between different levels of government are sub-optimal, which poses challenges in developing a reliable SWM system and, in turn, hampers private investment and corporate social responsibility (CSR) (Wikurendra et al. 2024).

Community-based organisations (CBOs) engage residents and empower them to make decisions about income generation, employment, and environmental and cultural preservation (Taufik 2022) by coordinating activities and building social networks among members (Kristanto et al. 2022). CBOs are responsible for collecting domestic waste at the source and transporting it to temporary disposal sites (TPS) using waste carts or tricycles (CLOCC 2021). The regency government oversees the TPS, managing the collection and transport of waste from these sites to formal disposal facilities (TPA) using trucks (Systemiq 2021a; CLOCC 2021). However, the regency's waste management efforts primarily focus on urban areas (CLOCC 2021). CBOs who advocate for the informal recycling sector (IRS), such as the Indonesia Scavengers Association (IPI) and the Indonesia Scavengers and Waste Collectors Association (APPI), leverage social capital in scavenger communities to foster unity, promote sustainable activities, and connect members with external partners through strong social networks (Fathy 2019). However, public participation in these CBOs remains low in Banyuwangi. The local government has the potential to collaborate with waste pickers and environmental organisations, such as Waste4Change (an enterprise), to implement initiatives like a recyclable waste mapping system that can improve waste collection efficiency and create more income-generating opportunities for waste pickers, thereby facilitating their integration into the waste management sector (Hasugian et al. 2019).

Environmental NPOs are actively involved in the plastics value chain in Banyuwangi Regency, facilitating environmental sustainability efforts by supporting waste management facilities and practices (Systemiq 2021a; Becerra 2021). In 2020, six major consumer goods producers and plastic manufacturers established the Indonesia Packaging Recovery Organization (IPRO) (an NPO) to promote EPR aimed at funding SWM services and enhancing recycling by implementing a take-back program for post-consumer packaging recycling (Becerra 2021, Arisman and Fatimah, 2023, Patton and Li 2021, Systemiq 2021b). Initially targeting East Java (including Banyuwangi) and Bali, IPRO seeks to expand its reach but currently faces limitations due to plastic waste collection and sorting hindrances (Systemiq 2021b).

Global environmental awareness in Indonesia, has been fostered through a combination of international environmental campaigns (e.g., Earth Day initiatives and UN-led plastic pollution campaigns), curriculum integration in schools and universities, and nationally endorsed programs such as Adiwiyata, an environmental education initiative led by the Ministry of Environment and Forestry. These efforts have supported the adoption of long-term environmental strategies, such as the National Action Plan for Marine Debris (2017–2025), and have contributed to growing public and institutional recognition of environmental challenges and the need for waste reduction (Latanna et al. 2023). The Indonesian government, represented by the former CMMAI and the MoEF, collaborates with the National Plastic Action Partnership—an intergovernmental body (IGB)—to develop strategies for reducing plastic pollution in coastal areas (Arisman and Fatimah, 2023). NPAP play a critical role in addressing this challenge. NPAP unifies civil society, industry, and academia to aim for a 70% reduction in ocean plastic pollution by 2025 and seeks support from various international funders (Patton and Li 2021). It emphasises that combating ocean plastic waste demands a holistic approach integrating regulations, infrastructure development, education, and behaviour change (Patton and Li 2021).

Despite having dedicated ministries for waste management and plastic pollution, the division of responsibilities among these entities remains unclear (UN-ESCAP 2021). Additionally, the lack of continuity in leadership within the waste management system, exacerbated by the frequent rotation of government officials across agencies and departments, further complicates the issue (Systemiq 2021a). RIs make efforts to collaborate with the IGB and FIs through structured agreements, enabling the implementation of joint research programs involving national and local governments (IGES 2024). For instance, the PISCES partnership and the Institute for Global Environmental Strategies (IGES), IGBs, such as the World Bank and United Nations Economic and Social Commission for Asia and the Pacific (UN-ESCAP), and FIs, such as the Asian Development Bank, provide support to the local and national governments in promoting waste management interventions in Banyuwangi (GIG 2018; UN-ESCAP 2021).

TAs focusing downstream of the plastics value chain and industry groups collaborate with the government to develop industry standards, share best practices, and address common challenges. For example, the Indonesia Plastic Recyclers (IPR)—a TA comprising 70 plastic recycling manufacturers—collaborates closely with key government ministries, particularly the Ministry of Industry and MoEF, to drive initiatives that promote sustainable plastic recycling practices (USAID 2022). In addition, the Packaging and Recycling Association for Indonesia Sustainable Environment (PRAISE) has actively supported waste reduction initiatives such as the Banyuwangi Project STOP (Arisman and Fatimah, 2023). TAs such as the Plastic Recycling Association of Indonesia (ADUPI), IPR, and the Indonesian Association of Waste Entrepreneurs (APSI) collaborate extensively within Indonesia's plastic recycling and waste management sector (USAID 2022). ADUPI emphasises improving the quality of domestic post-consumer plastics to boost recycling rates, while APSI focuses on enhancing recycling capacity through expanded waste collection and stakeholder collaboration (USAID 2022). With over 500 members, including plastic manufacturers and waste banks, ADUPI advocates for plastic recyclers across the waste value chain (Becerra 2021; USAID 2022). APSI, with 268 members representing waste entrepreneurs, complements these efforts by managing waste collection, sorting, processing, and recycling operations at local and national levels (USAID 2022). IPR, a key technical advisor in plastic recycling, collaborates with both ADUPI and APSI to source plastic waste from APSI members, ensure quality standards, and develop market opportunities for recycled plastics (USAID 2022).

In Banyuwangi, the BINTARI Foundation (NGO) support national and local governments in developing policies. For instance, through collaborative efforts, Semarang DHL, located in Central Java, agreed to draft policies integrating waste banks into market-based recycling systems, fostering collaboration with informal waste traders, enhancing male participation, and providing support to waste bank members through training and equipment provision for sustainable operations (Patton and Li 2021). Another initiative is initiated by Sungai Watch (NGO) to mitigate marine plastic pollution and recover river waste—aiming to clean up the Mangroves of Banyuwangi (Sungai Watch 2022). Sungai Watch also aims to involve LG, businesses and the community in its mission, contributing to better stakeholder support (Sungai Watch 2022). Additionally, Emvitrust, a prominent NGO engaged in waste management in Banyuwangi, serves as a delivery partner for the PISCES project (PISCES 2024), providing critical evidence on local content and highlighting the synergies that can be achieved through collaboration between RI and NGOs.

The Global Reporting Initiative (GRI), an NPO, promotes transparency and sustainable practices in the plastics value chain through GRI's Sustainability Reporting for Responsible Business (SRRB) program, encouraging Indonesia's plastic industry to disclose their environmental, social, and governance (ESG) impacts (GRI 2022). Interactions also take place between NPOs and CBOs. For instance, the Indonesia Waste Bank Association (ASOBSI), an NPO established in 2017 by waste bank operators (Becerra 2021), encourages CBO collaboration, offering insights into waste bank operations and their broader impact on Indonesia's waste and materials market (Becerra 2021). Collaborative research projects involving CBOs, NPOs, and NGOs can effectively implement behavioural interventions like awareness campaigns, incentive programs, design improvements (e.g., water dispensers), and stakeholder partnerships (Appleby et al. 2024), as exemplified by the PISCES collaboration.

3.2 External stakeholder identification and categorisation based on roles and activities

Based on the analysis in Sect. 3.1., we identified **111** external stakeholders currently or potentially involved in the plastics value chain, mapped against the criteria outlined in the methodology section, including their legal status, operational spatial levels and their respective stages within the value chain, and their activities (*SI;* Table B1). Specifically, these stakeholders were consolidated into 11 types of organisations, as shown in Table 3.

Notably, the local government serves as a hybrid stakeholder, encompassing both internal (direct responsibility for waste collection and management) and external (functioning as a local representation of the national government) roles.

Table 3 Categories of external stakeholders involved in the plastics value chain based on their legal status

Category	Description
Local government (LG)	Stakeholders of local government including elected authorities, councils, and agencies at province, regency and city level
National government (NG)	Ministries of national government
Intergovernmental bodies (IGB)	Entities that involve the participation of multiple national governments aiming to facilitate cooperation, coordination, and communication among sovereign states to address common issues, pursue shared goals, and make collective decisions
Community-based organisations (CBO)	Organizations consisting of members of a specific community driven by a shared interest or goal within the community they serve—they can be either guided or sponsored by the Indonesian government or not
Non-governmental organizations (NGO)	Organisations that operate independently of government control and are typically larger and more structured compared to CBOs, exhibiting a higher level of professionalization and operating at multiple levels
Trade associations (TA)	Organizations formed by businesses, companies, or entities within a particular industry sector aiming to represent their interests
Research institutions (RI)	Institutions of several disciplines, including higher education institutions, universities and government-led research agencies, that are involved in research projects
Financial institutions (FI)	Institutions that provide financial services in the form of loans and investments (institutional investors)
Non-profit organizations (NPO)	Professional organisations with social and environmental credentials for purposes other than making a profit consisting of members who share a common field of expertise or professional interest—other than industry—working in a specific profession or occupation
Enterprise	For-profit businesses, corporations, and company entities for purposes other than plastic manufacturing and consumer good production
Media	Channels transmitting information, messages, or content to a wide audience

As internal stakeholders, local governments are tasked with implementing policies aimed at preventing plastic pollution and managing household waste, including plastic waste. As external stakeholders, local government bodies encompass interactions and responsibilities that extend beyond their internal functions, including decision-making processes, community engagement, collaboration with stakeholders, enforcing environmental regulations and monitoring compliance, facilitating regional development, supporting sustainability initiatives and other responsibilities seemingly outside the plastics value chain that can considerably impact SWM services, as well as the cleanliness of public spaces, rivers, and roadsides.

Understanding the roles and potential challenges of various stakeholder categories (see a detailed description in SI; Table C1) serves as a foundational reference for assessing their in-between interactions and how their key activities contribute to enhancing improvements in the system (Gerassimidou et al. 2022).

The operational activities of the 11 categories of external stakeholders in both the upstream and downstream parts of the plastics value chain within the Banyuwangi Regency, as well as how they execute these roles, are listed in Table 4. We identified 21 distinct activities within the plastics value chain that explain the roles and activities of the 11 categories of stakeholders (Table 4**)**. Although some activities may seem unrelated to the plastics value chain (e.g., financial management, religious affairs, other public services), our analysis indicates that stakeholders involved in these activities play an important role in driving transformative changes within the system. This emphasises the necessity of a holistic and integrated approach to effectively address the multifaceted challenges of plastic pollution. Table 4 also presents these activities in alignment with one or more value dimensions that reflect stakeholder priorities. These classifications are validated through the preliminary system analysis (Sect. 3.1).

Table 5 presents the distribution of 111 stakeholders across the 11 categories and provides insights into their spatial level of operation, position in the plastics value chain and the activities they partake in. The stages of the value chain and activities are indicated by letters and numbers, respectively, to facilitate easy navigation of the table, with further guidance provided in the table footnotes.

Among the 11 stakeholder categories, LG has the highest representation, with 24 entities (i.e., departments/bodies/organisations), while media has the least, represented by a single entity, encompassing all media channels (Table 5). Additionally, all stakeholder categories engage across the entire plastics value chain (P-C-M), with 84 out of 111 entities engaging in activities that influence the entire system. Four stakeholder categories—IGBs, FIs, RIs and Media—comprise a total of 18 entities operating exclusively across the entire value chain. Three stakeholder categories—NG, TAs, NPOs—comprise a total of eight entities operating exclusively upstream, while seven stakeholder categories—LG, NG, CBOs, NGOs, TAs, NPOs, and Enterprises—comprise a total of 19 entities operating exclusively downstream. This highlights the emphasis on the downstream part of the value chain, as opposed to the upstream part. This is further supported by examining the percentage of entities relative to the total number of entities within each category.

Table 4 Categories of activities performed by external stakeholders involved in the plastics value chain and alignment with value dimensions

No	Activity	Description	Value dimension
1	Leadership	Activities that guide and govern a community, region, or nation	Social Political
2	Decision-making	Processes or activities undertaken by individuals, groups, and organizations with power and influence to evaluate options and shape strategic decisions, significantly impacting the creation and implementation of legislation at the national, regional, and local levels	Technical Political Economic
3	Community well-being	Activities aimed at enhancing the happiness and prosperity of a community, thereby improving overall quality of life and satisfaction. This includes efforts focused on community empowerment, family welfare, advocacy for working and living conditions, human rights, and cultural well-being	Social Environmental
4	Regional development	Activities focused on strategic planning, long-term development and coordination, to create comprehensive plans and projects that address the unique challenges and opportunities of a specific area. This includes specific activities such as infrastructure improvement, economic diversification, agriculture development, job creation, social inclusion, and environmental sustainability. Overall, these activities aim to promote balanced and sustainable growth, enhance community resilience and boost regional competitiveness	Economic Political Social
5	Infrastructure development	Activities involved in the design, construction, and improvement of essential structures such as facilities and systems, that support economic, social, and environmental functions within a region or country	Technical Economic Political
6	Environmental conservation	Activities focused on conserving and preserving natural resources to prevent extinction, restore damaged habitats, protect biodiversity and tackle climate change. This broader context of resource preservation includes land, energy resources and forests. While **Waste management**, **Water resource management** and **Marine conservation** are related, these are addressed separately when stakeholders specialize in these specific areas	Environmental Social
7	Waste management	Activities related to waste collection, transportation, sorting and end-of-life (EoL) management options, such as recycling (limited to sorting for further reprocessing, but not the reprocessing itself, as stakeholders involved solely in **Plastic reprocessing** are classified separately), recovery and disposal methods	Environmental Technical Economic Political
8	Pollution control and reduction	Activities aimed at tackling pollution caused by resource and waste mismanagement in various environmental compartments (water, land, air) via clean-ups, awareness campaigns and other targeted projects	Environmental Technical Social Political
9	Water resources management	Activities related to the planning, development, distribution, and use of water resources within a specific region or watershed. These activities aim to ensure the availability, quality, and equitable distribution of water, including water supply planning, water quality management, water allocation and rights	Environmental Technical Social
10	Marine resource conservation	Activities aimed at conserving marine ecosystems, including fisheries management, addressing marine pollution, protecting marine biodiversity, and promoting sustainable tourism practices in the marine environment. While there is overlap with **Pollution control and reduction**, **Marine resource conservation** focuses more broadly on the overall health of marine ecosystems. Stakeholders involved in both **Marine resource conservation** and **Pollution control and reduction** may address marine plastic pollution, but their overall focuses differ	Environmental Economic
11	Environmental health	Activities focused on maintaining public cleanliness to prevent the spread of communicable diseases, ensure food safety, and uphold sanitation responsibility and accountability. While there is a connection with **Pollution control and reduction**, **Environmental health**, specifically addresses sanitary issues that impact human health, whereas **Pollution control and reduction** focuses on mitigating pollutants and waste	Environmental Social
12	Financial management	Activities involved in managing financial resources, including budgeting, taxation (e.g., retribution fees), and investment management	Economic Political
13	Educational training	Activities aimed at acquiring knowledge, skills, and competencies in a specific subject, field, or job role, including those focused on behavioural change. When combined with environmental activities, such as **Waste Management**, **Pollution control reduction**, and **Marine resource conservation**, these activities often target behaviour changes across the value chain (e.g., altering consumption or disposal practices)	Social, Economic Technical
14	Tourism development	Activities related to the growth of tourism in a particular destination, such as marketing, services, cultural heritage and environment	Economic Social Political
15	Research & Development (R&D)	Activities focused on creating and advancing technologies across various sectors, including industry, research, and environmental sustainability. These activities aim to leverage knowledge to design, develop, and implement innovative technological solutions	Economic Technical Environmental
16	Religious affairs	Activities related to religion including the administration, management, and regulation of religious practices, institutions, and issues within a specific jurisdiction or community	Social Political

Table 4 (continued)

No	Activity	Description	Value dimension
17	Other public services	Activities other than waste management and water supply, typically funded through taxation and provided by the government to meet essential societal needs, such as education, healthcare and transportation services	Social Political
18	Communication	Activities focused on raising awareness and disseminating information about a specific topic through social media, national/international forums and platforms	Social Environmental Political
19	Science and Innovation (S&I)	Activities aimed at minimizing environmental, social, and economic impact of goods and services throughout their lifecycle. Stakeholders develop and introduce innovative solutions related to the design, manufacturing and/or use of materials, components and products, with a focus on enhancing their sustainability performance	Economic Technical Environmental Social
20	Plastic reprocessing	Activities involved in reprocessing plastic waste (e.g., washing, shredding, extruding, compounding, etc.) to produce secondary plastic material and recycled polymer resins	Environmental Technical Economic Political
21	Product manufacturing	Activities related to materials, components and products manufacturing, including capability building and advocacy for the industry and related businesses, such as retailers	Technical Economic

Table 5 Distribution of the 111 external stakeholders across 11 categories and their roles within the plastics value chain

Category	Number of stakeholders	Spatial level*	Stage in the value chain*	Activities
Local government (LG)	24	Local (24)	P-C-M (22) C-M (2)	1, 2, 3, 4, 5, 6, 7, 8, 9, 12, 14, 16, 17 1, 2, 6, 7, 11
National government (NG)	15	National (15)	P-C-M (13) P-C (1) C-M (1)	1, 2, 4, 5, 6, 8, 10, 11, 12, 14, 15, 17 1, 2, 21 1, 2, 7
Intergovernmental bodies (IGBs)	4	International (4)	P-C-M (4)	2, 4, 5, 6, 7, 8, 10, 12, 15
Community-based organisations (CBOs)	9	National (2) Local (5) National (2)	P-C-M (2) P-C-M (5) C-M (2)	1, 3, 8, 10, 13 1, 3, 9, 11, 13, 14 1, 3, 7, 13
Non-governmental organizations (NGOs)	13	National (10) Local (3)	P-C-M (9) C-M (1) P-C-M (2) C-M (1)	3, 6, 10, 13, 16, 19 8, 13 3, 6, 7, 14 7, 8
Trade associations (TAs)	11	National (11)	P-C-M (2) P-C (6) C-M (3)	7, 14, 19 13, 19, 21 7, 20
Research institutions (RIs)	7	International (4) National (3)	P-C-M (4) P-C-M (3)	6, 8, 13, 15, 19 13, 15, 16, 19
Financial institutions (FIs)	6	International (5) National (1)	P-C-M (5) P-C-M (1)	4, 5, 6, 12, 15, 19 5, 12, 19
Non-profit organizations (NPOs)	16	International (5) National (11)	P-C-M (3) P-C (1) C-M (1) P-C-M (7) C-M (4)	4, 6, 7, 8, 13, 18, 19, 20 19, 21 7, 8, 10 3, 4, 6, 7, 11, 13, 18, 19 7, 8, 13, 18
Enterprise	5	International (2) National (3)	P-C-M (1) C-M (1) C-M (3)	6, 7, 8, 10, 15 8, 13, 19 7, 8, 13, 18, 20
Media	1**	National (1)	P-C-M (1)	18

*The number in parenthesis indicates the number of stakeholders for the specific spatial level and/or stage of the value chain; **Includes all media channels

Upstream (P-C): three stakeholder categories, eight entities—TA with six entities, accounting for 55% of all entities within its category, followed by NG and NPO, each with one entity, representing 7% and 6% of their respective categories.

Downstream (C-M): seven stakeholder categories, 19 entities—NPOs with five entities, representing 31% of their category, Enterprises with four entities, accounting for 80% of their category, followed by TAs with three entities (27%), CBOs with two entities (22%), NGOs with two entities

(13%), LG with two entities (8%) and NG with one entity (7%).

Entire system (P-C-M): eleven stakeholder categories, 84 entities—LG with 22 entities, accounting for 92% of all entities in this category, NG with 13 entities (86%), NGOs with 11 entities (87%), NPOs with 10 entities (63%), RIs with seven entities (100%), CBOs with seven entities (78%), FIs with six entities (100%), IGBs with four entities (100%), TAs with two entities (18%), Enterprise with one entity (20%), Media with one entity (100%).

Among those operating downstream (C-M), the majority operate at the national level (14 entities at the national level, followed by three at the local level and two at the international level). Conversely, stakeholders that operate across the entire plastics value chain (P-C-M) do so at varying spatial levels: 38 entities at the national level, 29 entities at the local level and 17 at the international. For those working upstream (P-C), their operations occur at the national and international level, with seven and one entities, respectively.

3.3 Analysis of stakeholders' participation across all activities

Figure 1 illustrates the activities of all entities across the 11 stakeholder categories. This figure highlights the interconnected roles of stakeholders across various activities within the system. While some stakeholders may engage in activities that are not be directly related to plastic pollution prevention and reduction—or if they are, they may not be involved in activities such as such as *Waste Management (7)* and *Pollution Control Reduction (8)*—their interactions with other stakeholders create opportunities for sharing information, aligning priorities, and creating coalitions to strengthen collaboration and leverage synergies that can enhance efforts to address plastic pollution more effectively. A detailed description of potential synergies is provided in the SI (*Section C:* Table C2).

As shown in Fig. 1, *Leadership (1)* and *Decision-making (2)* feature the highest levels of participation, with 48 and 39 entities involved, respectively, primarily due to the large number of entities within the LG (24 entities) and NG (15 entities), along with contributions from other stakeholder categories. *Waste Management (7)*, *Educational Training (13)*, and *Regional Development (4)* follow, each involving between 21 and 25 entities distributed across various stakeholder categories. *Science & Innovation (19)*, *Environmental Conservation (6)*, *Pollution Control and Reduction (8)*, and *Community well-being (3)* engage between 15 and 20 entities. All remaining activities involve fewer than 15 entities.

Based on stakeholder participation by stakeholder category, *Environmental Conservation (6)*, *Waste Management (7)* and *Pollution Control and Reduction (8) are* the activities with the highest stakeholder participation, *each* involving eight stakeholder categories. Specifically, LG, NG, IGBs, NGOs, RIs, FIs, NPOs, and Enterprise are engaged

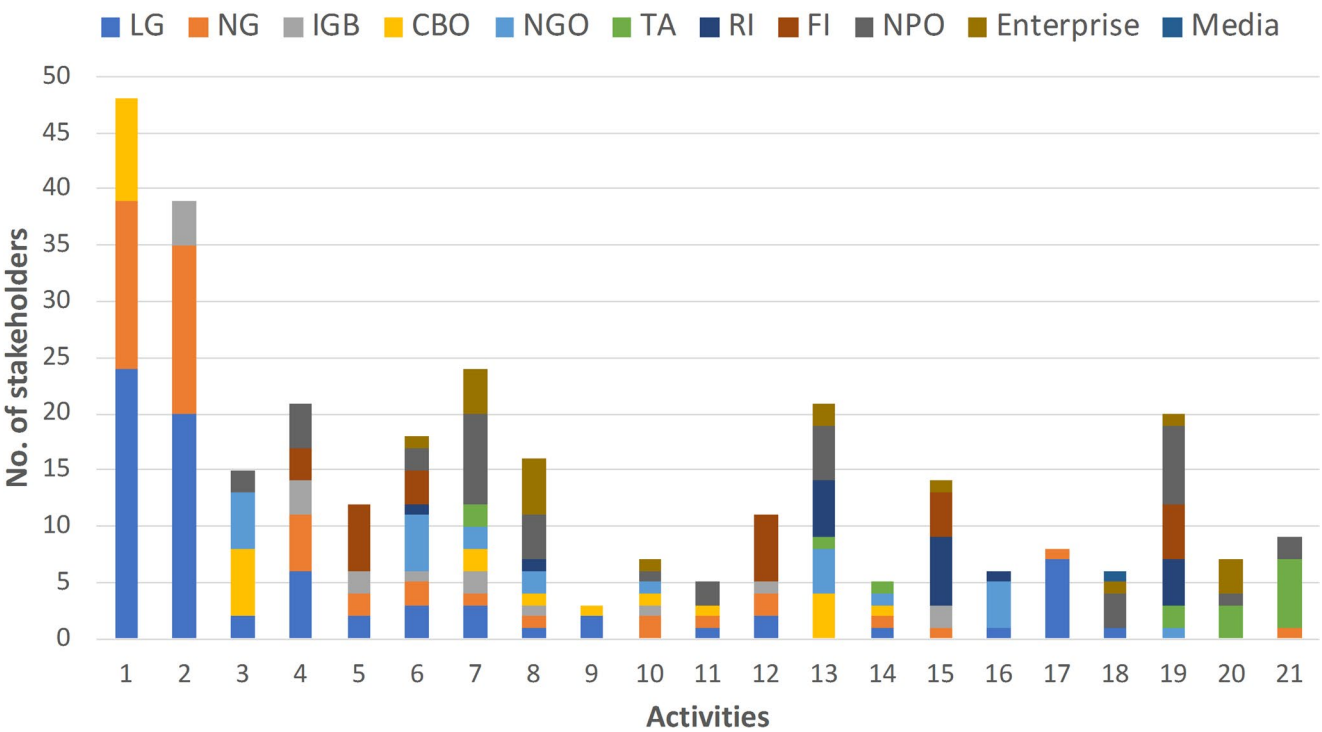

Fig. 1 Key activities of external stakeholders in the plastics value chain in Banyuwangi regency, showing the number of entities participating in each activity, categorised by stakeholder type

in *Environmental Conservation (6)*, with NGOs being the most prominent stakeholders (5 entities), followed by FIs, and LG, each contributing significantly (3 entities each), followed by FIs and LG. *Waste management (7)* is led by NPOs (8 entities) and involves LG, NG, IGBs, CBOs, NGOs, TAs, and Enterprise. *Pollution control and reduction (8)* is primarily driven by enterprises (5 entities), with NPOs (4 entities) also playing a crucial role. Other involved stakeholders include LG, NG, IGBs, CBOs, NGOs, and RIs, albeit to a lesser extent.

The second-highest level of stakeholder engagement by category (6 categories) is observed in *Marine resource conservation (10)*, *Science & Innovation (19)* and *Educational Training (13)*. Specifically, in *Marine Resource Conservation (10),* NG leads the efforts with the involvement of IGB, CBO, NGO, NPO, and Enterprise. *Science & Innovation (19)* is primarily led by NPOs, followed by FIs and RIs, and less by NGO, TAs, and Enterprise, while *Educational Training (13)* is mainly driven by RIs and NPOs, followed by NGOs, CBOs, TA and Enterprises.

In the third rank, four activities involve five stakeholder categories as follows: *Regional development (4)*—LG, NG, IGBs, FIs, NPOs; *Tourism development (14)*—LG, NG, CBO, NGO, TA; *Research & Development (R&D) (15)*—NG, IGBs, RIs, FIs, Enterprise. The rest goes as follows:

- Four stakeholder categories involved in: *Community well-being (3)*—LG, CBOs, NGOs, NPOs; *Infrastructure development (5)*—LG, NG, IGBs, FIs; *Environmental health (11)*—LG, NG, CBO, NPOs; *Financial Management (12)*—LG, NG, IGB, FIs; and *Communication (18)*—LG, NPO, Enterprise, Media.
- Three stakeholder categories involved: *Leadership (1)*—LG, NG, CBOs; *Decision-making (2)*—LG, NG, IGBs; *Religious affairs (16)*—LG, NGOs, RI; *Plastic reprocessing (20)*—TAs, NPO, Enterprises; and *Product Manufacturing (21)*—NG, TAs, NPOs
- Two stakeholder categories involved in: *Water resources management (9)*—LG, CBO; and *Other public services (17)*—LG, NG.

3.4 Analysis of stakeholders according to priorities

To understand stakeholders' roles in the system, we analysed their priorities and how these priorities shape the plastics value chain. Each activity corresponds to one or more value dimensions—environmental, economic, social, technical, and political—as outlined in Table 3. This alignment allows us to assess the cumulative priorities of each stakeholder category based on their engagement across various activities. By mapping primary value dimensions against their activities, we quantified stakeholders' priorities according to their roles within the value chain.

Figure 2 visualises stakeholders' priorities, providing valuable insights into how they influence the plastics value chain through their activities.

All stakeholder categories exhibit priorities spanning all value dimensions due to their engagement at various spatial levels. This dynamic involvement necessitates shifts in priorities to address evolving needs and challenges. As shown in Fig. 2**,** LG has the strongest focus on the political dimension, with its activities accounting for 30.6% of its priorities, followed by NG at 15.1%. Other stakeholders, including FIs (11%), NGOs (10.2%), NPOs (9.3%), Enterprise (6.4%), IGBs (5%), CBOs (4.5%), TAs (4.4%), RIs (2.2%) and Media (1.3%) also emphasise political priorities, albeit to a lesser extent. The relatively high emphasis on the Political dimension highlights the critical role governance plays in shaping the environmental and economic landscape regarding plastics.

LG again takes the lead in the social dimension with 28.6% of their priorities focusing on social impact, followed by NGOs (15.7%), NPOs (15.1%), CBOs (12.6%) and the NG (10.4%), reflecting their commitment to delivering positive social impacts. In contrast, stakeholders such as RIs (5%), Enterprises (4%), FIs (3.7%), TAs (2.1%), IGBs (1.8%), and Media (1.1%) show very minimal involvement, highlighting areas where social initiatives may be lacking.

NG takes the lead in the Economic dimension with 15.4% of their priorities concentrating on this specific domain, followed closely by FI (15.2%), TAs (13.4%), NPOs (12.5%) and LG (12%), which indicates their active role in economic development, including issues related to the plastics value chain. Other stakeholders, such as IGBs (7.6%), Enterprises (6.8%), RI (6.4%), NGOs (5.5%), and CBOs (5.2%), exhibit lower engagement in this dimension.

Environmental priorities are quite diverse, with varying degrees of engagement across the stakeholders. Specifically, NPOs (20.7%) exhibit the highest degree of priorities in the environmental domain, followed by LG (14.4%). CBOs also contribute meaningfully (13%), followed by NGOs (11%) and Enterprises (10.45%), highlighting a collective priority for environmental efforts among various organisations. The remaining stakeholder groups, such as NG (8.7%), FIs (6%), RIs (5.9%), IGBs (4,6%), TAs (3.8%) and Media (1.4%) have a lower degree of environmental priorities.

TAs show a higher emphasis on the Technical dimension (15.9%), with notable involvement by LG (15.6%), which demonstrates the importance of technical expertise in plastic management. Other stakeholders, such as NPOs (14.5%), FI (10.2), Enterprises (9.32%), NG (9.1%), and RI (9.1%), also engage in technical activities, though not as prominently. The remaining stakeholder groups, such as CBOs (6.7%),

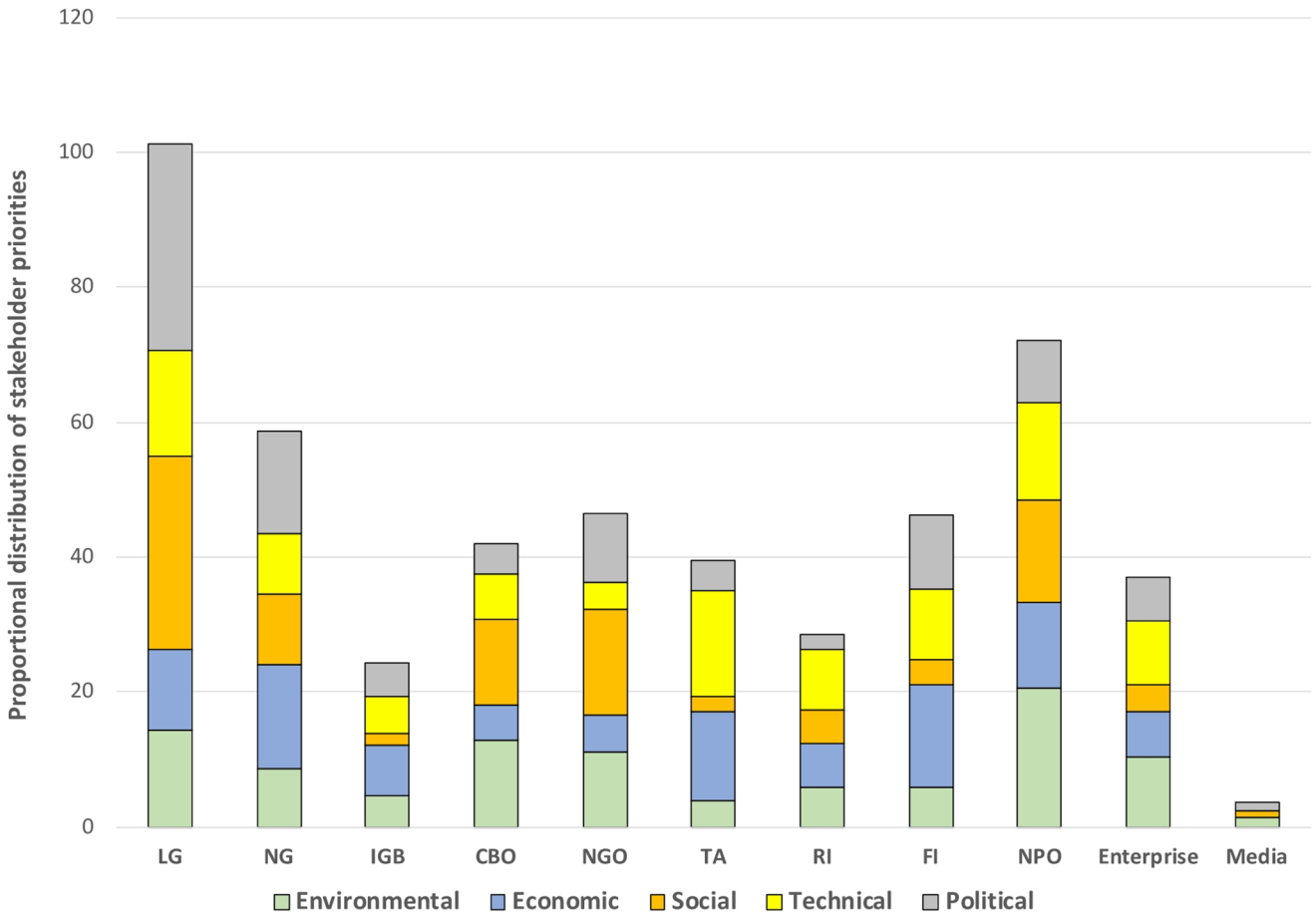

Fig. 2 Key priorities of external stakeholders involved in the plastics value chain in the plastics value chain across all levels based on the five defined value dimensions related to their activities

IGBs (5.5%) and NGOs (4%) have a lower degree of technical priorities.

In summary, the distribution of stakeholder activities illustrates diverse engagement levels across the value dimensions, with LG and NPOs demonstrating a strong emphasis on political and environmental priorities, respectively. In contrast, Media and IGBs show limited participation, indicating potential areas for increased collaboration and engagement to enhance the effectiveness of the plastics value chain management.

3.5 External stakeholder interest and power: the Mendelow matrix

In the context of categorising stakeholders using the Mendelow matrix, interest (high versus low) is determined by the extent to which stakeholders prioritise environmental concerns (aka, priorities). This evaluation is based on activities related to the environmental dimension, particularly in addressing pressing environmental issues, such as plastic pollution reduction and mitigation, which is the scope of this system analysis. However, stakeholders with lower interest classification in the environmental domain do not imply a lack of concern, as evidenced by Fig. 2. It rather indicates that these stakeholders prioritise other areas due to their operational focus, internal mandates or strategic goals set by themselves (for small organisations), their shareholders or members (e.g. TAs), and by those from whom they want to attract funding to fuel their activities.

Conversely, stakeholder power is evaluated by the extent to which stakeholders prioritise political concerns, reflecting their involvement and role in regulatory authority, financial leverage, and organisational influence. This dual assessment emphasises the relationship between stakeholders' that are driven by environmental benefits and those who prioritise political influence, providing insight into how their priorities shape the policies and practices within the plastics value chain.

Using the scoring technique detailed in the methodology section, we quantified stakeholders' priorities based on their activities (*SI;* Table D1). Stakeholder categories with a high political value score of 0.5 or higher were classified

Fig. 3 Grouping of external stakeholders involved in the plastics MCPs value chain in Banyuwangi regency according to the Mendelow matrix. *Note* Ent. refers to Enterprises

as having high power, while those with an environmental value score of 0.5 or higher were classified as having high interest. Figure 3 presents the Mendelow matrix of external stakeholders, providing insights into their respective levels of power and interest within the plastics value chain in the Banyuwangi regency.

Figure 3 shows that *key players* (high power, high interest) within the external stakeholders' network vary depending on the spatial level in which they operate and whether they operate across the entire system or focus on downstream activities. The *influencers* (high power, low interest) are mainly government agencies operating at the national level and the upstream part of the value chain, as well as national FI. The *keep informed* (low power, high interest) are mainly national and local CBOs, national NGOs, RIs, national NPOs and international Enterprises operating across the entire system, who strive for change, but their power, and hence political influence, is limited. In addition, international NPOs and enterprises operating upstream and downstream, respectively can be considered influencers. Finally, the *low priority* (low power, low interest) are those that have minimal involvement or interest in the plastics value chain, in this case, national TAs operating upstream of the plastics value chain, that primarily represent the interests of key internal stakeholders (e.g. petrochemical industry); however, their engagement could still be leveraged to ensure an inclusive approach to driving transformative change.

Key players: At the international level, the main *key players* are IGBs, NPOs, and FIs due to their decision-making power that influences global advocacy and financial backing, respectively, which shapes local and national government activities and facilitates cross-broader collaboration, promoting research and innovation and supporting sustainable infrastructure development; key prerequisites for economic stability and growth, and social development in Indonesia. At the national level, *key players* are the media channels (traditional and contemporary platforms) and the TAs that represent the interests of the industry. These stakeholders can significantly influence policy by raising awareness and

educating the public on the environmental impacts of plastic pollution (Henderson 2023) and facilitating industry collaboration across the entire plastics value chain. At the local level, NGOs are also *key players* in the plastics value chain, as their proximity to communities enables them to implement tailored sustainability approaches and focus on capacity-building efforts whilst gaining access to important information that shapes political discourse and investments.

At the downstream end of the plastics value chain, LG is a *key player* due to its direct involvement in waste management, decision-making authority and access to local knowledge. These functions enable LG to drive changes in the system; however, financial constraints and political interests often limit their ability to implement effective solutions. While not all LAs across Indonesia prioritise plastic pollution mitigation, Banyuwangi's LG has demonstrated a strong commitment to addressing this challenge. Other *key players* at the downstream part of the plastics value chain include CBOs, TAs, NPOs (national and international), NGOs (local and national) and Enterprises (national). Because of their focus on the downstream activities demonstrated through a strong implementation capability, these stakeholders can mobilise community participation and community-driven initiatives that focus on waste reduction and well-being, facilitate collaboration across sectors, build capacity and implement practical solutions to tackle plastic pollution, thereby raising awareness and enhancing local environmental health and sustainability (Prabawati et al. 2023). They can also provide leadership and educational training to community leaders, waste pickers and collectors, enhancing waste management practices. Their influence stems from their ability to leverage international funding (NPOs), control downstream activities (TAs) and their access to important information (CBOs and NGOs), which allows them to shape waste management strategies and drive systemic improvements.

Influencers: These are mainly government agencies operating across the value chain as well as national FI. Specifically, NG and LG exhibit high power due to their authority, policy implementation and service provision at the regional level (UNDP 2022; Irianto et al. 2022); however, their low interest in specific elements of the plastics value chain may stem from resource constraints, competing priorities, broader governmental focus, dependence on local governance, administrative complexities and a focus on politically favorable projects. While some agencies may prioritise initiatives related to plastics, others might focus on different policy areas or industries, leading to divergence between environmental and industrial groups (Irianto et al. 2022). This dynamic can lead to a disconnect between their potential for influence and their actual engagement in addressing pressing environmental challenges. National FIs have high power due to their financing capabilities and authority in infrastructure development, but their low interest in the plastics value chain arises from a broader focus on general infrastructure goals, dependence on partnerships, and limited direct involvement in specific environmental issues.

Keep informed: These are national and local CBOs, national NGOs, international NPOs and Enterprises, and RIs that are committed to advancing sustainability, confronting environmental challenges and advocating for community rights and environmental conservation, driven by grassroots mobilisation and local engagement. Despite their active involvement in environmental conservation and development of innovative solutions for addressing social and environmental challenges, their influence is limited compared to those operating downstream of the system due to their reliance on partnerships and external support to implement their initiatives, market constraints, regulatory frameworks, and their role in R&D often limit their ability to enact significant systemic changes independently (Gerassimidou et al. 2022), as opposed to those operating exclusively on the downstream end of the value chain. While they can drive grassroots engagement and influence behavior, their ability to enact broader policy changes or establish systemic transformations is limited, as they depend on collaboration with governments and other stakeholders for regulatory support and resource allocation.

Low priority: These entities are not directly impacted by or engaged in the system with minimal involvement or interest; however, their engagement could still be leveraged to drive positive change. Specifically, TA in the upstream plastics industry often display low power and low interest (*low priority* stakeholders) due to their limited decision-making authority, a focus on specific manufacturing concerns, dependency on member engagement, resource constraints, and a reactive operational stance.

4 Discussion

The plastics value chain in Indonesia is shaped by a complex external stakeholder network that influences decision-making, resource allocation, and sustainability. This network is governed by power dynamics, financial capabilities, governance structures, and collaborative mechanisms that either enable or hinder effective interventions. Our analysis reveals that the influence of external stakeholders is shaped by the nature of their activities and interactions, which can be political, hierarchical, decentralised, market-driven or hybrid, depending on their distinct roles and degrees of influence. As a result, there is a pronounced asymmetry of power both between and within stakeholder

categories (entities), influenced by their position within the spatial level —global, national, and local— and the plastics value chain stage they operate.

Our findings suggest that dominant stakeholders (e.g., NG, LG, IGBs, International FIs, TAs) usually operate across all stages of the plastics value chain and, therefore, have the greatest potential to control resources, regulatory frameworks, and market access. In Indonesia, where economic stability and growth often depend on external financial resources, technical expertise, and international partnerships, the prominent role of international stakeholders is unsurprising. All remaining external stakeholders face power disparities that can be attributed to variations in financial leverage, the capacity to mobilise communities and drive grassroots initiatives, and access to critical information that informs and shapes policy and governance decisions. For instance, stakeholders with the capability to implement solutions and invest in capacity-building efforts do not necessarily possess the greatest influence unless they can secure financial backing and establish strong collaborations with key internal or external stakeholders. This hints at the pivotal role of financial capital, information and strategic alliance in acquiring influence.

At the national level, a diverse range of entities engages in activities related to the plastics value chain, often balancing multiple and sometimes competing interests. While these entities, especially those within the same stakeholder category, may align based on shared interests (e.g., sustainability initiatives, regulatory compliance) and overarching goals, the competition for financial resources and institutional support leads to diversification of activities, which in turn affects their access to resources and their overall influence.

At the local level, government institutions and organisations focused on community well-being and social development play a central role in decision-making, a dynamic that is particularly pronounced in Indonesia's political and social landscape. Foreign external stakeholders, despite their intention and potential to deliver valuable expertise and financial resources, often struggle to exert influence due to barriers related to trust, cultural differences, competition for funding, and political recognition. This may lead to fragmentation of efforts within the stakeholder network, further exacerbated by overlapping roles and conflicting priorities, which, in turn, impede cohesive action and mutual benefit. While financial contributions can temporarily mitigate relational barriers, their influence is often short-lived once funding is exhausted. This cyclical reliance on external resources weakens long-term impact, leading to short-term interventions with limited capacity to drive systemic change within the plastics value chain.

Addressing these challenges requires both local and national governments to recognise that political legitimacy and resource security and stability depend not only on relationships with influential internal stakeholders, such as industry players, but also on fostering strong inter-stakeholder relationships to shape strategic direction and address environmental challenges. This recognition provides a solid foundation for developing proactive policies, strong institutions, financial sustainability, and enhancing digital readiness—critical components for driving systemic change in the waste management (Patton and Li 2021; UN-ESCAP 2021).

Stakeholders' alignment can be achieved through shared interests (e.g., sustainability initiatives, regulatory compliance), leading to the formation of partnerships that strengthen advocacy and implementation capacity. For such alignment to emerge, the following preconditions must be met:

1. *Governance structures*. *Strengthening institutional mechanisms for systemic coordination across complex and fragmented value chains to mitigate and balance power asymmetries and ensure equitable participation.*
   LG leaders are susceptible to political shifts, which leads to fragmented responsibilities between governmental bodies, external stakeholders and communities (Systemiq 2021a). This results in the inadequate enforcement of regulations and slows progress toward waste-related goals (Systemiq 2021a). Establishing a robust governance structure at the regency and city levels is essential for fostering dialogue, building trust, and enabling shared decision-making; it can ultimately catalyse coordinated transitions, balancing power asymmetries while promoting interventions across the plastics value chain, focusing on place-based realities (Systemiq 2021a). Moreover, political transitions can significantly impact the delivery of essential resources and facilities, as new administrations may prioritise different initiatives.
   Achieving change requires consent from the highest levels of government, underscoring the political dimensions of such transformations (Latanna et al. 2023). In October 2024, Indonesia underwent a government transition, resulting in several administrative changes that may affect the current system. For example, the operation of the CMMAI has ceased, and the future landscape remains unclear, highlighting uncertainties in how these changes may influence existing initiatives and priorities. Therefore, establishing resilient governance structures that transcend political cycles is crucial for ensuring continued progress towards achieving Sustainable

Development Goals (SDGs) related to waste management and circular sustainability.

2. *Leveraging the role of key stakeholders at the local level. Developing a multi-scale approach that links national strategy with local action is pivotal in ensuring progress towards addressing the plastic pollution issue.* Local stakeholders provide technical capacity and support communities in waste management through educational training and tourism development. Hence, enhancing their capacity to deal with the real-world complexity of value chains, such as fragmented infrastructure, competing interests, and behavioural barriers, enables more resilient and adaptive value chains and mitigates inequalities in access to resources and decision-making power. However, barriers such as lack of transparency, financial constraints, data withholding, or political interests can disrupt information flow and reinforce power imbalances, impeding the effective implementation of local waste management strategies (Arisman and Fatimah, 2023).

   To overcome these challenges, external stakeholders who have greater adaptability in response to systemic changes should empower key local stakeholders through establishing interdisciplinary training programmes, comprehensive waste management databases (Hannon 2020), and partnerships among technology startups for innovating plastic waste management solutions (Patton and Li 2021). Such efforts should be compounded by financial or political capital to maintain or expand their influence, aimed at enhancing waste management practices while improving the economic and social conditions of marginalised or under-resourced groups (e.g., waste pickers) that often struggle to adapt. This is especially critical in regions where informal recycling stakeholders play a central role in orchestrating plastic material flows, yet these are often overlooked in formal governance processes.

   Integrating the IRS into the formal solid waste management system is essential for promoting circularity in countries like Indonesia, as it can improve livelihoods and working conditions, increase recycling rates, and reduce waste management costs for local governments (Wilson 2023). In turn, this can promote economic resilience of vulnerable populations, contributing to decent work and economic growth (SDG 8) while simultaneously empowering key local stakeholders and effective partnerships (SDG 17). Ultimately, it can provide a concrete pathway for achieving multiple SDGs related to poverty reduction (SDG 1), reduced inequalities (SDG 10) and responsible production and consumption (SDG 12).

3. *Money is power. Empowering stakeholders through sustained financial investment and supportive policy frameworks to foster long-term commitments to systemic change.* Public–private partnerships (PPP), known locally as *Kerjasama Pemerintah dengan Badan Usaha*, have emerged as a mechanism to promote shared responsibility across communities, local governments, and the private sector (Patton and Li 2021; Systemiq 2021a). These PPPs can mobilise private capital for infrastructure development, improved service provision, and facilitate effective risk management in resource governance systems (Systemiq 2021a). Increased and sustained producer funding is particularly crucial for ensuring the effective plastic waste collection and sorting, both under the present and future regulatory schemes. These efforts must be supported by strong governmental oversight to ensure transparency, cost-effectiveness, and compliance.

   A comprehensive financial model—drawing on diverse sources including government allocations, extended producer responsibility (EPR) fees, recycling revenues, private sector investments, donor grants, and concessional loans—will be essential for scaling up circular economy infrastructure (Systemiq 2021b; NPAP 2022). However, the development and implementation of such financing mechanisms and accompanying technical guidelines face significant challenges, such as enforcement capacity, equitable contribution and distribution of funding, control mechanisms, and the need to ensure participation and accountability across all stakeholders (Systemiq 2021b).

   Therefore, sustained and strategic financial investment is an important driver for the accomplishment of the SDG goals 12, 11 (Sustainable Cities and Communities) and 9 (Industry, Innovation, and Infrastructure). Specifically, it can foster circular economy interventions with the creation of new infrastructure that can enhance recycling operations with low capital (SDG 9), provide clear management, waste reduction policies (SDG 12), and improve community engagement in economic activities (SDG 11) with strong participation of public stakeholders (SDG 17).

4. *Inclusive stakeholder network. Establishing inclusive, multi-stakeholder platforms can foster constructive dialogue, build trust, and enable shared decision-making, ultimately serving as catalysts for coordinated transitions, while promoting interventions across the plastics value chain, focusing on place-based realities.* Such coordination mechanisms are essential for building legitimacy and long-term system resilience, and in aligning diverse perspectives and pooling resources. When viewed as a transformative outcome, coordination

reflects a fundamental shift in the underlying 'rules of the game' embedded in technologies, markets, policies, and cultural norms that shape stakeholder behaviour (Shepsle 2010; Ghosh et al. 2021). By embedding shared responsibility, transparency and accountability into stakeholder interactions, coordinated platforms can promote inclusive and sustainable solutions capable of driving transformative systemic change (Nurdiana et al. 2021; Kurniawan et al. 2023).

To improve stakeholder engagement within the context of a circular economy, the UN Development Programme recommended actions such as organizing webinars, participating in associations or communities promoting circular practices, offering public training, creating collaborative units for waste-related discussions, partnering with various business sectors, hosting stakeholder forums, leveraging social media for education, conducting outreach, implementing supportive regulations, and providing incentives for businesses adopting circular practices (UNDP 2022). These inclusive stakeholder networks are crucial to support SDG 17 with the aim to enable goals of sustainable waste management and economic development (SDG 12, SDG 11, SDG 9) at the local, regional and national levels.

Despite progress in organising stakeholders over the past 40 years, fundamental barriers persist. The four institutional weaknesses noted here were also highlighted in the World Bank's initial assessment of MSW management projects in developing nations between 1974 and 1988 (Wilson, 1991., pp 1766–67). A 1990 World Bank analysis identified three of these weaknesses as critical factors in MSW project failures. These issues led to the rise of Integrated Sustainable Waste Management (ISWM) in the 1990s, which addressed the fourth weakness as well. Arlosoroff (1991) noted that most MSW management investments faced delays due to poorly defined institutional structures, inadequate cost recovery, and insufficient technical and managerial expertise (Arlosoroff, 1991). While there has been much progress since then, the key challenges remain largely unchanged.

In Indonesia, which comprises 514 cities and regencies across 34 provinces, SWM challenges cannot be solved with a one-size-fits-all approach. Variations in population density, budget allocations, and industrial landscapes dictate unique SWM priorities for each city (Patton and Li 2021). Policymakers must assess these diverse waste challenges to develop effective strategies (Patton and Li 2021).

In Surabaya, recognised as a 'Smart City', the planning process involves multiple stakeholders from health and education sectors, including CBOs, NPOs, RIs, TAs and LG, through the annual MUSRENBANG forum (UN-ESCAP 2021). This inclusive process allows stakeholders to voice local challenges and identify priorities, leading to consensus-based development priorities and budget allocations (UN-ESCAP 2021). If this inclusive approach is paired with a tailored systems-based perspective in stakeholder analysis, it can foster customised waste management solutions that address local demands and empower communities in shaping their development agenda (UN-ESCAP 2021).

4.1 Limitations and future research direction

This study offers a comprehensive analysis of external stakeholders within the Indonesian plastics value chain; however, several limitations must be acknowledged as they may affect the interpretation and generalizability of the findings. First, the geographical focus on Banyuwangi Regency inherently limits the extent to which results can be extrapolated to other regions in Indonesia or to international contexts. Second, obtaining comprehensive and reliable data on plastic waste flows, stakeholder activities, and policy outcomes in Indonesia posed significant challenges. To address these constraints, we employed a mixed-source approach drawing on the best available data sources; nonetheless, gaps and inconsistencies may remain.

For instance, the qualitative components, based on literature review, workshop data, and personal communications, are subject to interpretive bias and offer limited scope for quantitative validation. Moreover, the informant selection process, which prioritised active PISCES project participants and actively engaged community stakeholders, may have inadvertently excluded marginalised perspectives. Future research should therefore seek to diversify stakeholder representation and perspectives and validate qualitative findings through quantitative approaches, such as network analysis.

Additionally, the analysis of stakeholder priorities relied on self-reported activities and stated objectives. Future research could further examine the alignment between these stated priorities and their actual practices, using observational methods or behavioural experiments. The use of the Mendelow matrix necessarily simplifies complex dynamics. A global value chain analysis could yield an in-depth, granular understanding of stakeholder influence (Dallas et al. 2019; Gereffi et al. 2005). Finally, future research should investigate governance mechanisms for cross-stakeholder coordination, assess the impact of specific policy interventions on both stakeholder behaviour and environmental outcomes, and examine how technology and innovation can reshape stakeholder relationships to drive systemic change.

5 Conclusions

The application of stakeholder mapping and analysis within the CVORR framework contributed to a comprehensive systems-based assessment of Indonesia's plastics value chain. In contrast to traditional stakeholder mapping methods that focus narrowly on influence-interest matrices, CVORR integrates material and monetary flow analysis, stakeholder mapping and analysis, and analysis of system dynamics, providing a multidimensional, iterative and inclusive design that captures interdependencies, systemic inefficiencies and leverage points for transformation. As such, CVORR supports the co-creation of targeted, context-specific interventions while it functions as a dynamic decision-support tool for advancing evidence-based, long-term systemic change in complex resource governance contexts.

Indonesia's plastic value chain is shaped by a complex and asymmetric external stakeholder network, where financial leverage, governance structures, and strategic alliances concentrate power among a few dominant stakeholders. These stakeholders often operate across multiple levels and stages of the value chain but possess limited insight into local realities and needs. Conversely, smaller, local or marginalised stakeholders face significant systemic lock-ins related to resource constraints, limited access to information, and fragmented governance that hinder their capacity to act. These imbalances weaken system resilience and constrain the potential for transformative change, underscoring the need for coordinated engagement that is inclusive, context-specific, and can address power imbalances and foster long-term financial stability.

A key barrier is that the Indonesian system, like most systems, remains locked in a linear model that prioritises material throughput over long-term sustainability. To overcome this, it requires aligning strategic oversight with grounded action across local, regional and national levels, ensuring that stakeholder coordination is context-specific. One-size-fits-all approach fails to capture this complexity or to adequately reflect Indonesia's socio-cultural diversity and geographic realities, and to fine-tune stakeholder priorities and needs within and across value chains. Interventions must therefore be tailored, adaptive, systems-oriented, and responsive to local dynamics while remaining aligned with overarching national sustainability goals.

Fostering partnerships among internal and external stakeholders can generate synergies that address both upstream production and downstream waste management challenges. Such collaborations enable goal alignment, joint problem-solving and shared accountability, acting as catalysts for system-wide transitions. An incremental approach to inclusive stakeholder engagement, starting with those holding high levels of power and interest at the local level, can lay the foundations for stable, long-term change. Combining radical and incremental approaches within collaborative frameworks strengthens communication and engagement between stakeholders, regulatory coherence, and resource allocation responsive to needs. This could pave the way for sustainable, just, and effective resource mobilisation, leading to resilient outcomes in introducing plastics and managing plastic waste for people and planet. Realising these outcomes depends on establishing institutional mechanisms that promote multi-level collaboration, ensure regional and national policy alignment, and empower local stakeholders; mechanisms that are crucial for integrated governance, effective resource mobilisation, and long-term resilience in orchestrating the plastics value chain.

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Declarations

Conflict of interest The authors have no competing interests to declare that are relevant to the content of this article.

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