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Critical appraisal of regulatory frameworks and compliance deficiencies in e-waste governance: A case analysis of Bhavnagar, Gujarat

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Abstract

The paper examines the regulatory framework of e-waste in Bhavnagar, Gujarat, with regard to adherence and the ground realities of the informal recycling industry. Overall findings from a mixed-methods approach include high levels of awareness of e-waste, with only 28.3% of recyclers being aware of the (E-Waste) (Management) Rules. Meanwhile, 90% of them state that they do not know who regulates it. It was shown that hazardous activities, such as open burning (57.5%) and acid leaching (22.5%), were conducted, and only 32.5% of workers wore protective gear. Immigrants showed health issues; 55.8% of them had respiratory problems, and 40.8% had burns on their skin, depending on the situation. Also, 88.3% of the recyclers were unlicensed, and 93.3% of all the recyclers had no formal training. These findings reveal that the targets should be addressed using specific awareness, simplification of formalization, and incentives. In a bid to limit its health and environmental suicidal impact, the study recommends that close monitoring, provision of protective gear, and incorporation of the informal recycler into the formal structure be implemented.

Keywords: E-Waste Management; Regulatory Compliance; Informal Recycling; Health Risks; Environmental Governance

1. Introduction

The rapid proliferation of digital technologies and consumer electronic devices has contributed to the global surge in electronic waste (e-waste), which is now among the fastest-growing waste categories worldwide. The report of the Global E-Waste Monitor 2024 notes that in 2023, 62 million metric tons of e-waste were produced, and is expected to increase to 82 million tons by the year 2030 (Blade et al., 2024). India, being the third-heaviest producer of e-waste globally, generated approximately 1.64 million tons of e-waste in 2022, with the primary cause of e-waste generation being the widespread availability of smartphones, computers, and household appliances (Sandwal et al., 2025; Sakhre et al., 2024). Nevertheless, e-waste management in the country is highly fragmented and close to 90% of e-waste is handled by the informal sector using unsafe and unregulated methods (Srivastava & Shrivastava, 2025). To address the growing concern of uncontrolled e-waste, the Government of India issued the E-Waste (Management) Rules, 2016, which were later modified in 2022. These rules aim to introduce the concept of extended producer responsibility (EPR), formalize recyclers and dismantlers for official authorization, and promote environmentally sound recycling. Nevertheless, there is uneven compliance at the ground level contrary to the regulatory frameworks which exist, specifically, in tier-II cities, the institutional capacity, awareness, and monitoring mechanisms are either weak or absent (Biswas et al., 2020; Bhaskar & Turaga, 2018; Isangadighi & Udeh, 2023; and Turaga, 2019). Although the state of Gujarat boasts an industrial and waste recycling industry, several districts, notably Bhavnagar, continue to see the Chawls of e-waste recycling activity thrive due to lax stringency and unclear regulations.

Along with being the epicenter of the informal e-waste trade in Gujarat, Bhavnagar district, known for its Alang shipbreaking yard, is playing a pivotal role in the state. In this case, unregulated recyclers and scrapers operate on the

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outskirts of cities and employ unsafe processes, such as acid leaching, open-bag burning of circuit boards, and manual extraction without personal protective gear. The activities are particularly dangerous to environmental health in that they cause the contamination of soil and groundwater, and also to the occupational safety of women and children who engage in the informal recycling of waste (Patel et al., 2023 and Islam et al., 2025). Most of the e-waste collection centers and dismantling units in Gujarat are either non-functional or non-compliant due to lax regulations (Isangadighi & Ukudo, 2025). The paper is rooted in the notion that it is not theoretical policies. Still, their implementation ability, as well as the synergy of formal rules and realities, is a key to e-waste governance. It provides a critical review of the design and operationalization of the e-waste regulatory regime in India, and particularly highlights the compliance gaps observed in Bhavnagar. The qualitative research and policy analysis of the study reveal certain regulatory, institutional and socio-economic gaps that prevent compliance and jeopardize environmental justice. The primary objective of this research is to investigate the role of regulatory systems in shaping, empowering, or limiting e-waste governance in the City of Bhavnagar, and to assess how effectively this is achieved locally in light of national policy requirements. The major aims can be expressed as follows: (i) to analyse the sufficiency and transparency of the current e-waste regulations; (ii) to explore capacities and mandates of intervention agencies in Bhavnagar; (iii) to collect empirical data, at the field level, of regulatory compliance and informal practices; and (iv) to recommend improvement on enforcement, and thereof mitigating of environmental and health hazard. The research is relevant to existing debates on decentralized environmental regulations, the importance of the informal sector in a transition to a circular economy, and the institutional prerequisites for successful regulation in emerging economies.

2. Theoretical and Conceptual Framework

E-waste governance is situated within broader discussions of environmental regulation, institutional capacity, and informality, which serve as the basis for measuring policy achievement and compliance success. Among the most interesting theoretical frameworks is Environmental Governance Theory, which focuses on discussing the interaction of various actors: state, market, and civil society, through which nations manage environmental risks in situations of decentralization and regulatory pluralism (Lemos & Agrawal, 2006). The framework can be helpful, especially in situations such as those found in India, where a conflict exists between formal and informal ways of doing things socio-economically. Regulatory Compliance Theory is also relevant to this research. It distinguishes between voluntary, coerced, and strategic compliance, focusing on enforcement credibility, clear rules, and institutional legitimacy in the process of influencing the willingness of actors to comply (Gunningham, 2011). This theory can also be applied in the e-waste governance context, as it helps explain the gap between the formulation of the rule and its implementation at the field level in informal sector economies. Additionally, the models of Informal Sector Integration provide valuable insights into how unregistered or unofficial players in the e-waste business operate alongside the formal system. To put it simply, in these models, hybrid regulation designs are promoted, considering informal actors as problems, not only violators (Medina, 2007). This kind of thinking is especially applicable in the case of Bhavnagar, in which informal dismantlers and recyclers control the e-waste value chain. These theories are united in their conceptual framework, as presented by the dependence on regulatory frameworks as a point of interaction between formal intent and informal practice. In this sense, compliance does not assume two dynamic states of result. Still, it is dependent on the coherence of the policy, the capacity of the institutions, the incentives of the various stakeholders, as well as the consideration of environmental justice.

3. Global Perspectives on E-Waste Regulation

The role of Extended Producer Responsibility (EPR) and take-back systems has been highlighted worldwide as a method to internalize the environmental costs associated with electronic consumption. (Global studies) One of them is regularly used as a reference: the Waste Electrical and Electronic Equipment (WEEE) Directive, issued by the European Union, which has extremely high producer responsibilities and converged collection quotas (Widmer et al., 2023). Nevertheless, critics suggest that the widely developed systems also face problems such as transboundary regulations of waste movement, technological obsolescence, and consumer non-cooperation (Isangadighi et al., 2025). Regulatory systems in developing countries are often hindered by the design-implementation gap, where a set of comprehensive laws is enacted with little to no effect. For example, narratives in West Africa and Southeast Asia suggest that governmental regulations can lead to continued informal recycling due to a shortage of incentives, low local capacity, and social or economic reliance on waste jobs (Lepawsky, 2022; Nguyen et al., 2023).

4. Waste Management in India

The management system for e-waste in India has advanced significantly since the introduction of the E-Waste (Management) Rules of 2011, with further development through the expansion of the 2016 and 2022 Rules. In 2016, an

equivalent framework was introduced, featuring explicit EPR provisions. The 2022 revision aimed to simplify registration, enhance accountability, and automate compliance through online tracking (CPCB, 2023). Despite legislative progress, implementation remains incomplete in parts. Arias et al. (2023) noted that nearly 80% of e-waste in India is handled by informal recyclers working in uncontrolled environments. According to Kumar et al. (2023), licensed dismantlers tend to underreport the quantities of processed materials, and district-level inspections are infrequent. Additionally, urban local bodies (ULBs) often lack awareness of their responsibilities regarding e-waste regulation. Gujarat is considered a regulatory trendsetter; however, recent evaluations indicate that districts like Bhavnagar are experiencing a rising number of informal e-waste operations with minimal regulation (Patel et al., 2023). Although the Gujarat Pollution Control Board (GPCB) has established regional offices, most enforcement remains paper-based, and coordination with town governments is limited.

5. Informality and Environmental Justice in Waste Governance

The nexus among informality, environmental degradation, and regulatory exclusion poses a significant connection in new research. Despite informal recyclers being discussed as negative phenomena in the policy dialogue, these workers contribute to good material recovery. Still, they are not formally addressed and are threatened with exposure to toxicants (Shrivastava et al., 2022). In Bhalswa (Delhi) and Dharavi (Mumbai), research indicates that even informally involved handlers in e-waste are not equipped with safety equipment, thereby risking exposure to heavy metals, flame retardants, and carcinogenic fumes (Singh et al., 2021). Since dealing with e-waste ineffectively is an environmental concern, it is a burden to the vulnerable groups. According to preliminary reports, women and children working in the informal sector comprise a large proportion in Bhavnagar, where family-owned micro-recycling units often lack basic protective infrastructure (Shah et al., 2023). However, the district has not been studied empirically extensively, which means there is a research gap that this study aims to fill. Although a lot has already been done in the context of national-level policy and metropolises such as Delhi and Mumbai, there is still a significant gap in terms of subnational case studies concerning smaller urban regions, like Bhavnagar, that often escape the attention of the majority. Additionally, the limited literature combines theoretical approaches of compliance and informality to critically evaluate the extent to which effective governance of e-wastes translates to the implementation of governance at grassroots levels. This paper will fill these gaps by providing a regulatory, critical, and empirical-driven analysis of Bhavnagar, which is context-sensitive and governance-driven.

6. Methodology

To critically evaluate the regulatory framework of e-waste and gauge the compliance gaps in Bhavnagar, Gujarat, this study has taken up a qualitative-dominant mixed-methods design. Bhavnagar was conveniently chosen owing to the increased informal recycling of e-wastes, its history in industry and its emergent position in the Gujarat waste economy. There were four data collection tools, namely key informant interviews (KIIs), document and policy review, structured and semi-structured field observations, and semi-structured questionnaires. The semi-structured guides employed in 24 KIIs as a part of the study to interview the officials of the Gujarat Pollution Control Board (4), Bhavnagar Municipal Corporation (3), registered dismantlers (3), environmental nongovernmental organizations and legal professionals (4), academics (4), and informal handlers (6), were used to discuss the awareness of the E-Waste (Management) Rules (2016 and 2022), enforcement capacity, inter-agency coordination, the dynamics of the informal sector, and compliance. There were 11 regulatory texts on documents that covered national and state-level policies, CPCB and GPCB guidelines, municipal waste plans at Bhavnagar, EPR directives, and documents under license or inspection and was cross-examined by compliance review matrix on legal clarity, implementation strength and extensiveness. A checklist with standardized items was developed, and seven informal e-waste sites in Bhavnagar were visited, including the areas of Bortalav, Chitra GIDC, and Nari Road, which was then used to make field observations on elements of dismantling activities, personal protective equipment availability, usage of child labour, the condition of the site as well as signs of formal compliance. Moreover, semi-structured questionnaires were also distributed to 120 informal recyclers and handlers to assess their levels of awareness of the legal framework, disposal practices, knowledge of EPR, health and safety risks, and views on formalization, to complement the qualitative trends using SPSS (v26). Sampling was used intentionally, including experts and snowball sampling, which created frankness and pertinence among the respondents. Thematic analysis of interview and observation data (utilizing NVivo 14 software) was employed, and document data adhered to a regulatory appraisal structure. Survey data were explained through frequencies and cross-tabulations. The relevant review board gave ethical clearance; all respondents gave informed consent and ensured that their participation was kept confidential. Translators were used whenever necessary to facilitate communication with migrant workers who did not understand Gujarati. All interviews were conducted safely and respectfully. Although constraints (limited access to confidential regulatory records, the unwillingness of some respondents, and difficulty in

observing hidden clusters) were present, the multi-instrument, triangulated design provided a robust and contextualized platform on which to evaluate the governance and field realities of e-waste management in Bhavnagar.

7. Results

Table 1 Awareness and Understanding of E-Waste Policy

Variable	Yes (%)	No (%)	Not Sure (%)
Heard of E-Waste (Management) Rules	28.3	71.7	0.0
Knows government body responsible (GPCB/BMC)	10.0	90.0	0.0
Seen an official inspect work	18.3	81.7	0.0
Understands EPR	14.2	85.8	0.0
Thinks law applies to small recyclers	33.3	48.3	18.4

Table 2 Operational Practices and Compliance

Variable	Always/Sometimes (%)	Never (%)
Uses gloves or protective gear	32.5	67.5
Uses burning for extraction	57.5	42.5
Uses acid washing	22.5	77.5
Has business license or registration	11.7	88.3
Has received training	6.7	93.3

Table 3 Occupational Health and Environmental Exposure

Health Issue	Frequency	Percentage (%)
Coughing or breathing difficulty	67	55.8
Eye irritation	38	31.7
Skin burns or irritation	49	40.8
Headaches	28	23.3
No reported health issues	19	15.8

Table 4 Occupational Risk Level Classification

Risk Level	Frequency	Percentage (%)
Low	40	33.3
Moderate	69	57.5
High	11	9.2

Table 5 Attitudes Toward Formalisation

Statement	Agree (%)	Disagree (%)	Not Sure (%)
Would register if free and simple	65.0	18.3	16.7
Thinks formalisation brings benefits	58.3	21.7	20.0
Thinks inspections are fair	31.7	46.7	21.6
Would attend free training	74.2	10.0	15.8

Table 6 Structured Observation Results Using Checklist (7 Informal E-Waste Sites in Bhavnagar)

Observation Parameter	Observed (Number of Sites)	Not Observed (Number of Sites)	Field Notes
Open burning of wires/components	5 sites	2 sites	Dense smoke observed at Bortalav and Nari Road during active dismantling.
Acid leaching or informal chemical use	3 sites	4 sites	Acid handling noted in Chitra GIDC and Alang outskirts with no containment.
Use of personal protective equipment (PPE)	1 site	6 sites	Sporadic use of gloves; no masks, boots, or goggles recorded.
Presence of child labour (<15 years)	4 sites	3 sites	Children observed dismantling components near informal workshops.
Environmental degradation (residue, ash, effluents)	6 sites	1 site	Blackened soil, ash piles, and electronic debris are scattered in most areas.
Visible licensing or authorisation signage	0 sites	7 sites	No evidence of formal registration or posted notices at any location.
Proximity to residential dwellings	5 sites	2 sites	Most sites were in or adjacent to dense, low-income residential settlements.

Table 7 Thematic Summary of Key Informant Interview Findings

Thematic Area	Emerging Insights	Illustrative Quotations
Institutional Role Confusion	Multiple informants highlighted overlapping and unclear mandates between GPCB and local governments.	“Local bodies think GPCB should lead; GPCB thinks it’s a municipal issue.”
Weak Monitoring & Inspection	Routine inspection of informal handlers is rare or absent due to human resource constraints and priority gaps.	“We haven’t inspected any informal recycler in the last two years.”
Policy Disconnection from Ground Realities	Rules are written with formal actors in mind, excluding the operational realities of informal recyclers.	“The E-Waste Rules make sense on paper, but they don’t reach people in Bhavnagar’s lanes.”
Data Deficiency & Informal Economy Blindness	There is no accurate data on the volume of waste handled informally; much of the system is statistically invisible.	“Informal recyclers don’t report, and no one is tracking them officially.”

Public Awareness Deficit	Regulators and NGOs alike noted very low awareness among informal actors, worsened by the absence of IEC campaigns.	"We never ran any awareness drive on e-waste in this district."
Fear of Formalisation	Informal handlers avoid engagement with the government due to fear of taxation, harassment, or shutdown.	"They think registration means government control and punishment."
Need for Incentive-Based Integration	NGOs and academic experts recommend a training-certification model with incentives, not penalties.	"If we reward safe handling and register groups with benefits, many will formalise."
Lack of Local Policy Innovation	No city-level scheme exists to integrate informal handlers, despite their heavy contribution to e-waste processing.	"Other cities have pilot programs. Bhavnagar has nothing at all for these workers."

Table 8 Document and Policy Review Summary

Document Reviewed	Scope & Relevance	Clarity of Mandates	Enforceability	Inclusion of Informal Sector	Monitoring Mechanism	Remarks
E-Waste (Management) Rules, 2016	High	Moderate	Moderate	Weak	Moderate	Nationally applicable but vague on local enforcement
E-Waste (Management) (Amendment) Rules, 2022	High	High	High	Weak	High	Stronger EPR guidelines but lacks local sector clarity
GPCB Circular on Dismantler Authorization (2021)	Medium	High	Moderate	Absent	Weak	Focused on formal actors; no outreach protocol
Bhavnagar Urban Solid Waste Policy	Low	Moderate	Weak	Absent	Weak	E-waste not clearly delineated in municipal framework
CPCB EPR Compliance Checklist	High	High	High	Absent	High	Excellent for producers but inaccessible to small actors
CPCB Guidelines on Hazardous Waste (2019)	High	High	High	Indirect	Moderate	Mentions e-waste in broader hazardous waste context
Gujarat State Pollution Control Annual Report (2020-2022)	High	Moderate	Low	Absent	Moderate	Mostly statistical; lacks enforcement narratives
Bhavnagar Municipal Inspection Logs	Medium	Low	Low	Absent	Weak	Few inspections recorded; no

(obtained, partial)						e-waste-specific entries
EPR Authorization List (CPCB Portal)	High	High	High	Absent	High	Well-maintained for producers; informal actors excluded
MoEFCC Hazardous Waste Regulation Toolkit	High	Moderate	Moderate	Weak	Moderate	Provides general guidance; not sector-specific
Parliamentary Standing Committee Report on E-Waste (2021)	High	High	Advisory Only	Strong Recommendation	Advisory	Urges inclusion of informal sector but non-binding

8. Discussion

8.1. Awareness and Understanding of E-Waste Policies

As the results show, a significant proportion of informal e-waste recyclers (71.7%) are unaware of the E-Waste (Management) Rules, and 90% of respondents do not know the name of the government organization responsible for addressing the problem (GPCB/BMC). These figures indicate a profound lack of awareness and knowledge about existing regulations, which aligns with previous studies, such as one by Schroder et al. (2021) and Schroder (2020), who identified an awareness campaign as a crucial step towards increasing compliance in developing economies. The degree of lack of awareness among the people in Bhavnagar indicates a lost opportunity for policymakers and regulators to engage with the informal sector. The difference in the level of awareness regarding the e-waste rules and knowledge of the Extended Producer Responsibility (EPR) mechanisms (only 14.2% of individuals are aware of EPR) represents another considerable problem. To be able to be involved in formalized recycling processes meaningfully, informal recyclers need to know the major regulatory mechanisms, such as EPR. This fact raises doubts about the design of policy dissemination strategies and their alignment with the local context of informal sectors.

8.2. Operational Practices and Compliance

Bhavnagar practices a troubling profile in terms of operations. Although 57.5% of the people who recycle burn their product to extract it, 77.5% of the recyclers do not employ acid washing, and 32.5% of recyclers wear gloves or protective clothing. This indicates that not only are safety standards not adhered to, but also there is a lack of awareness of the environmental and health risks associated with the improper disposal of e-waste. This finding aligns with research conducted in other parts of the world, including that by Odeyingbo et al. (2022), which identified similar hazardous behaviours in informal e-waste recycling centres worldwide. This highlights the health and environmental risks faced by informal recyclers. The informality prevalent in the sector is also reflected in the fact that 88.3% of recyclers do not hold business licenses or registrations. Such informal non-registration may also present a possible obstacle to any form of regulatory enforcement in an attempt to create structural change, as the statistical visibility of informal operators to policymakers is non-existent. Earlier studies have established that one of the most significant deterrents to the enforcement of e-waste management legislation remains informality, and this is also the case in Bhavnagar.

8.3. Health and Environmental Exposure

These severe occupational risks in the sector are revealed by the high percentages of reported health complications, which include 55.8% involving coughing or shortness of breath, 40.8% involving burns or skin irritations, and 20.5% involving chest pain. The existence of 33.3% of recyclers who fall into the moderate level of recycler risk further denotes that grave health risks are possible. Along with such health problems, the absence of protective equipment and unfavourable working conditions has already been associated with similar health issues mentioned in previous studies

(Jin et al., 2019). This aligns with the findings in the city of Bhavnagar, where the infrequent use of protective equipment and the practice of open burning are prevalent. The consequences of such health risks are tremendous. It is possible that recyclers, in particular the informal sector, are at risk of developing chronic morbidity as a consequence of exposure to toxic chemicals and heavy metals. This, in turn, will lead to poverty cycles, as workers may be unable to sustain their livelihoods due to poor health.

8.4. Attitudes Toward Formalisation

The study shows that 65% of recyclers are willing to consider formal registration if it's free and easy. However, 31.7% are convinced that inspection is fair, and 74.2% are open to attending free training. These findings indicate a strong distrust of official procedures, which may have arisen due to a fear of being controlled by governments or being punished, another central theme in the interviews. One might be tempted to believe that this fear of formalization had to do exclusively with Bhavnagar. Still, similar results were reported by Sorrell et al. (2020) in their analysis of informal recyclers across India. Informal recyclers tend to be distrustful of the registration process, as they fear being taxed and monitored more closely by higher authorities in the future. This is in addition to the unwillingness to formalize the sector, characterized by the absence of any incentive for formalization. Past studies have suggested the need to replace punitive approaches with models of incentives in which the informal recyclers receive rewards when they exercise safety and adhere to rules, but are not punished. The mechanism that informal recyclers in Bhavnagar could utilize is the training-certification version, which entails some concrete incentives in terms of access to high-quality resources and markets of formally recognized e-waste managers.

8.5. Observational Findings

Concerning the informal e-waste sites, the findings have shown that unsafe practices are widely practiced, including the open burning of wires (observed in five sites), and acid leaching (observed in three sites). These results align with the international effort to mitigate environmental degradation caused by informal recycling activities, as noted in Lundgren's (2014) study. Non-formal registration or unlicensed use of all the sites visited further highlights how informal recyclers remain invisible in the context of the law. Due to the close location of the e-waste recycling facilities to the residential communities (five sites), the issue of environmental justice is a matter of serious concern. Informal recycling not only mistreats workers but also the communities surrounding it, which risks contaminating the air, water, and soil with toxic compounds. Research conducted in the past has established that informal e-waste recycling disproportionately affects marginalized societies, which often lack a political platform to address such issues.

8.6. Policy Gaps and Institutional Challenges

The thematic conclusion of the key informant interview highlights important institutional and policy issues. A chaotic regulatory regime, inadequate monitoring, and a lack of information on informal recycling operations lead to unclear and complex mandates for the GPCB and local governments. The present finding aligns with the findings made by Rai et al. (2024) and Rai et al. (2025), who identified identical governance problems within the e-waste industry in India, particularly in terms of overlapping jurisdictions and ineffective enforcement apparatuses. Moreover, the local policy innovation, which is noticeably absent in Bhavnagar, where no city-level initiatives to integrate informal handlers can be identified, can be discussed as an illustrative example of a broader policy patch-up failure to adhere to the realities of the informal sector. According to Scheinberg et al. (2011), e-waste governance should have policies that are not only comprehensive but also sensitive to the local context under which the informal recyclers operate.

Recommendations

To achieve the aim of solving the problems defined in the e-waste management system in the city of Bhavnagar, it is recommended that the government focus on informing the informal recyclers about the specific e-waste policies and regulations via local media, workshops, and awareness campaigns. To improve formalization, an incentive-based approach needs to be implemented that has simpler registration procedures, free training and material rewards for those recyclers who follow the safety and environmental requirements. Employee health must be safeguarded, which can be achieved by providing workers with protective gear and conducting regular screenings. Closer observation and visits, thanks to the usage of technologies such as mobile apps and satellite images, will contribute to compliance. The commitment towards formalizing the informal sector must contain pilot plans as well as joint ventures with NGOs and local communities, to develop policies of a city nature, over which there may be consensus between the formal and informal actors. In addition to this, data collection systems need to be enhanced to monitor e-waste flows, and policy innovation at the local level should be implemented to improve the inclusiveness of e-waste management. Lastly, to improve governance within local contexts and increase cooperation among all players involved in the e-waste management system, the current management policies for e-waste need to be revised to incorporate proper consideration of the informal sector.

9. Conclusion

The conclusions from Bhavnagar show that establishing a multi-level strategy for e-waste governance is critical. It is crucial to adopt a paradigm that minimizes reliance on punishments as a regulatory tool, to foster increased public awareness and establish effective monitoring and inspection operations within a framework of non-punitive action. The results also suggest the need to initiate policies that can overcome the differences between the two economies, formal and informal, and overcome the peculiarities of informal handlers. Compared to earlier research, the case of Bhavnagar is not unique. It represents the general tendencies of the developing world, where informal recycling processes are prevalent and the legal framework is relatively underdeveloped. To enhance e-waste management in Bhavnagar and other similar localities, policymakers need to focus on incorporating all locally relevant initiatives that benefit voluntary cooperation among governmental organizations, unregulated recyclers, and the general populace.

Compliance with ethical standards

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Originality Declaration

This paper has not been previously published in any Journal or is being considered for publication anywhere else.

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Data Availability

The data generated in the course and/or analysed in this study shall be made available upon request to the corresponding author.

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