

The Changing Landscape of E-Waste Management in Chennai: A Comparative Study of 2016–2026 Trends, 2026–2036 Projections and Sustainable Reuse and Recycling Strategies

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Abstract: This study tracks the changes in e-waste management in Chennai, one of the major e-waste-generating metropolitan cities in India. This paper examines the evolution of e-waste management over the past decade (2016–2026) in Chennai and estimates the trend for the upcoming decade (2026–2036). There is a lack of Chennai-specific data, which limits precise assessment and highlights gaps in efficient management, creating space for informal-sector involvement and unregulated practices. Hence, this paper answers a few major questions: How have e-waste collection and management in Chennai changed over time? How effective is the present system? And how can e-waste be reused, recycled, and disposed of effectively in the upcoming decade? Chennai, being a major e-waste-generating metropolitan city in India, has been reported to generate substantially different quantities of e-waste depending on the study and methodology used. The city's major manufacturing corridors, OMR technology hub, and seaport logistics are among the factors contributing to e-waste generation in Chennai. Tamil Nadu is also among the leading e-waste-generating states in India, and Chennai contributes a dominant portion to it. Since there is a gap in Chennai-specific historical data, this paper compares the increasing e-waste generation trends at the state and national levels. Keeping in mind that Chennai is a key stakeholder in this sector, these trends are used as supporting indicators for understanding its likely trajectory. The paper therefore assesses whether e-waste generation is likely to increase during the upcoming decade. As the Chennai database is limited, the paper assesses national and state trends and integrates graphs representing the trends over the past decade. Later, with respect to these trends, an estimation model is used to show possible changes in the upcoming decade. It presents three possible situations: low, under controlled circumstances; base, continuation of the current trend with no major changes; and high, rapid growth in e-waste generation. A major concern is the continued role of the informal sector in e-waste collection and processing. Gaps in the formal sector, lack of awareness, limited accessibility to authorized facilities, economic incentives from selling e-waste, and inadequate monitoring of informal activities can weaken Chennai's e-waste management. Increasing dependence on informal sectors is therefore a major obstacle to effective e-waste management. Hence, this study suggests ways to upgrade the formal sector and integrate a monitoring system for informal collectors to reduce the environmental burden. A survey was conducted among 110 residents of Chennai to assess public awareness of e-waste management, the proportion of people using formal disposal channels, and possible reforms they expect.

Keywords: E-Waste Generation, E-Waste Management, Chennai, Trend, Past Decade, Upcoming Decade, Formal Sector, Informal Sector, Estimation Model, Reuse and Refurbishment, Public Awareness, Environmental Burden, Reforms.

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I. INTRODUCTION

Electronic waste (e-waste) represents one of the rapidly expanding waste categories globally. The Global E-waste Monitor 2024 reports that approximately 62 million tons of e-waste were produced worldwide in 2022, with projections

indicating an increase to 82 million tons by 2030 (Baldé et al., 2024). In 2022, only 22.3% of this e-waste was collected and recycled through formal channels, emphasizing the potential environmental hazards of inadequate handling of these materials and the consequent loss of valuable resources.

India ranks among the largest e-waste generators globally, producing around 4.1 million tons in 2022 (Baldé et al., 2024). Estimates from the CPCB also reveal a significant upward trend, based on a different methodology and product coverage (PIB, 2023a, 2023b). India's regulations regarding e-waste have progressed with the implementation of the E-Waste Management Rules in 2016 and 2022; however, the processes for formal collection and recycling remain underdeveloped, with the informal sector still playing a significant role (MoEFCC, 2016; MoEFCC, 2022; Sengupta et al., 2022).

These issues are particularly evident in Chennai, the primary urban hub of Tamil Nadu. Nevertheless, there is a gap in ongoing, city-specific data concerning e-waste generation and management, despite the city's considerable population, consumption, and activity related to electronics. While historical estimates are available, there is no consistent time series specific to Chennai from 2016 to 2026. Data from Tamil Nadu likewise indicate significant e-waste collection and processing, but variations in reporting systems and the lack of a continuous generation series hinder establishing long-term trends. This situation highlights the necessity for a comprehensive evaluation.

This research therefore investigates e-waste production, collection, recycling, reuse, and management in Chennai from 2016 to 2026, assesses key changes throughout the decade, and forecasts potential production trends for 2026 to 2036 under various growth scenarios. It also suggests a holistic strategy that enhances formal-sector management, oversees and channels informal collectors, and emphasizes repair, reuse, refurbishment, and authorized recycling efforts. Because Chennai-specific data is lacking, city-level figures are modeled estimates rather than direct measurements.

➤ *The following Hypotheses Guide the Study.*

- H1: Given the increasing trend in e-waste generation at the national and Tamil Nadu levels and Chennai's significant role in the state's electronic consumption and waste generation, Chennai's e-waste generation is likely to increase during 2026–2036.
- H2: Gaps in formal e-waste collection and monitoring increase dependence on informal collection and processing, while upgrading the formal sector and monitoring the informal sector could improve e-waste recovery and reduce its environmental burden.

II. LITERATURE REVIEW

➤ *Global Context*

Electronic waste is among the fastest-growing solid waste streams worldwide. The *Global E-waste Monitor 2024* estimates that 62 million tonnes of e-waste were generated globally in 2022, an increase of 82% compared with 2010, and projects this figure to reach 82 million tonnes by 2030 (Baldé et al., 2024). Only 22.3% of the 2022 total was documented as formally collected and recycled. The report expects this share to fall to about 20% by 2030, as e-waste

generation is growing faster than formal recycling capacity (Baldé et al., 2024).

➤ *Generation and Formal Capture in India*

In India, the Central Pollution Control Board (CPCB) estimates e-waste generation nationally using producer sales data and the average life of notified electrical and electronic equipment (PIB, 2023a). On the 21-item basis used under the E-Waste (Management) Rules, 2016, estimated generation rose from 708,445 tonnes in 2017–18 to 1,601,155 tonnes in 2021–22 (PIB, 2023a, 2023b), representing a compound annual growth rate of approximately 22.6% (CEEW, n.d.).

Formal capture has improved but remains partial. CPCB data showed that approximately 3.5% of estimated generation was collected in 2017–18 and 10% in 2018–19 (Down To Earth, 2020). By 2021–22, 527,131.57 tonnes, roughly one-third of the estimated generation, were collected and processed (PIB, 2023a).

From 2023–24, CPCB moved to portal-based reporting using an expanded product list.

It reported that 61.94% of generated e-waste was formally handled in 2023–24 and 70.71% in 2024–25 (PIB, 2025). Because the methodology and product coverage changed, these figures are not directly comparable with the earlier series. The government has also stated that consistent state-wise generation estimates are not available (Down To Earth, 2024). Sub-national trend analysis therefore has to rely on available inventories, collection and processing data, and other regional indicators.

➤ *Policy Evolution*

Policy has progressively moved from regulating disposal towards greater producer responsibility. The E-Waste (Management) Rules, 2016 extended obligations to producers, consumers, bulk consumers, collection centers, dealers, refurbishers, dismantlers, and recyclers (MoEFCC, 2016). The E-Waste (Management) Rules, 2022, which came into force on 1 April 2023, require producers, refurbishers, and recyclers to register on a central CPCB portal. They also introduced environmental compensation and provisions for verification and audits (MoEFCC, 2022; PIB, 2023a). The 2022 framework further introduced tradable EPR certificates (IMPRI, n.d.). However, policy analysts have cautioned that registration alone does not demonstrate compliance with EPR targets or confirm that e-waste reaches authorized recyclers (IMPRI, n.d.).

➤ *Formal and Informal Sectors*

A recurring theme in Indian literature is the continuing role of the informal sector in e-waste collection and processing. Sengupta et al. (2022) examine household e-waste management in India through the integration of formal and informal sectors within a circular-economy framework. For Tamil Nadu, a Toxics Link study supported by the Tamil Nadu Pollution Control Board (TNPCB) found that a large proportion of e-waste was recycled informally in the back lanes of Chennai, while formal recycling remained limited and awareness levels were low (Toxics Link, n.d.). Mahanth

et al. (2023) further examine barriers to the adoption of circular-economy practices in e-waste management in Tamil Nadu.

➤ *Research Gap*

The current body of research reveals three significant gaps. Firstly, there is a lack of a unified and comparable time series for e-waste production in Chennai from 2016 to 2026; the existing estimates specific to Chennai are sparse and differ greatly in their methodologies. Secondly, there is an absence of a consistent annual series for state-level generation throughout the study period, necessitating the reconstruction of Tamil Nadu's long-term trend from various official inventories and reporting systems.

Lastly, despite the growth of registered recycling facilities, the formal collection and processing data for Tamil Nadu exhibit variations post-2021–22, a trend that warrants further investigation.

This research fills existing gaps by gathering national, state, and Chennai-specific data from 2016 to 2026, projecting the potential e-waste trends for Chennai from 2026 to 2036, and evaluating how the rise in e-waste production and deficiencies in formal collection and monitoring align with the proposed hypotheses. Additionally, it incorporates findings from primary surveys to enhance the secondary data available and offers recommendations to bolster formal management, oversee informal collection networks, and enhance repair, reuse, refurbishment, and resource recovery efforts.

III. METHODOLOGY

➤ *Research Design*

This research employs a mixed-method approach, incorporating longitudinal-comparative and scenario-based designs, to investigate e-waste management in Chennai. It integrates secondary quantitative data, qualitative policy analysis, previous studies, and primary survey data. The study compiles existing evidence to assess shifts in e-waste production, collection, recycling, reuse, and the roles of both formal and informal sectors. Due to the lack of continuous data specific to Chennai, the study utilizes national and Tamil Nadu indicators alongside available estimates for Chennai, while clearly noting the differences in data sources and methodologies.

➤ *Secondary Data Collection*

Secondary data were collected from:

- Central Pollution Control Board (CPCB)
 - Tamil Nadu Pollution Control Board (TNPCB)
 - Ministry of Environment, Forest and Climate Change (MoEFCC)
 - Press Information Bureau (PIB)
 - Government reports and policy documents
 - Peer-reviewed journals and research papers
 - Reports from credible research and environmental organizations
- The data cover:

- E-waste generation
- Collection and processing
- Recycling and recovery
- Number and development of authorized facilities
- Formal and informal-sector participation
- Government policies and initiatives
- Changes in e-waste management practices between 2016 and 2026

➤ *Comparative Analysis*

Available evidence from 2016–2026 was organized chronologically to identify major changes in:

- Generation and collection
- Formal recycling and processing
- Government regulations
- EPR implementation
- Informal-sector participation
- Repair, reuse, and recovery practices

Where comparable numerical data were available, they were presented through graphs.

➤ *Primary Data Collection*

A structured online questionnaire was used to collect primary data from 110 respondents in and around Chennai.

• *The Survey Examined:*

- ✓ Awareness of e-waste
- ✓ Disposal practices
- ✓ Use of formal or informal collection channels
- ✓ Awareness of authorized recyclers
- ✓ Attitudes towards repair, reuse, and recycling
- ✓ Willingness to use improved collection systems

The survey findings are used to complement secondary data and understand consumer behavior and awareness.

➤ *Estimation and Prediction*

Because a continuous official Chennai-specific e-waste generation series is unavailable, Chennai's historical and future generation was modeled using available national and state-level indicators.

• *For the Projection Period 2026–2036, three Scenarios were Considered:*

- ✓ Low-growth scenario: assumes stronger repair, reuse, refurbishment, and improved management.
- ✓ Base-growth scenario: assumes continuation of current broad growth trends.
- ✓ High-growth scenario: assumes continued rapid growth in electronic consumption and replacement.

The basic projection is calculated using compound growth:

$$E_t = E_{2026}(1 + r)^{t-2026}$$

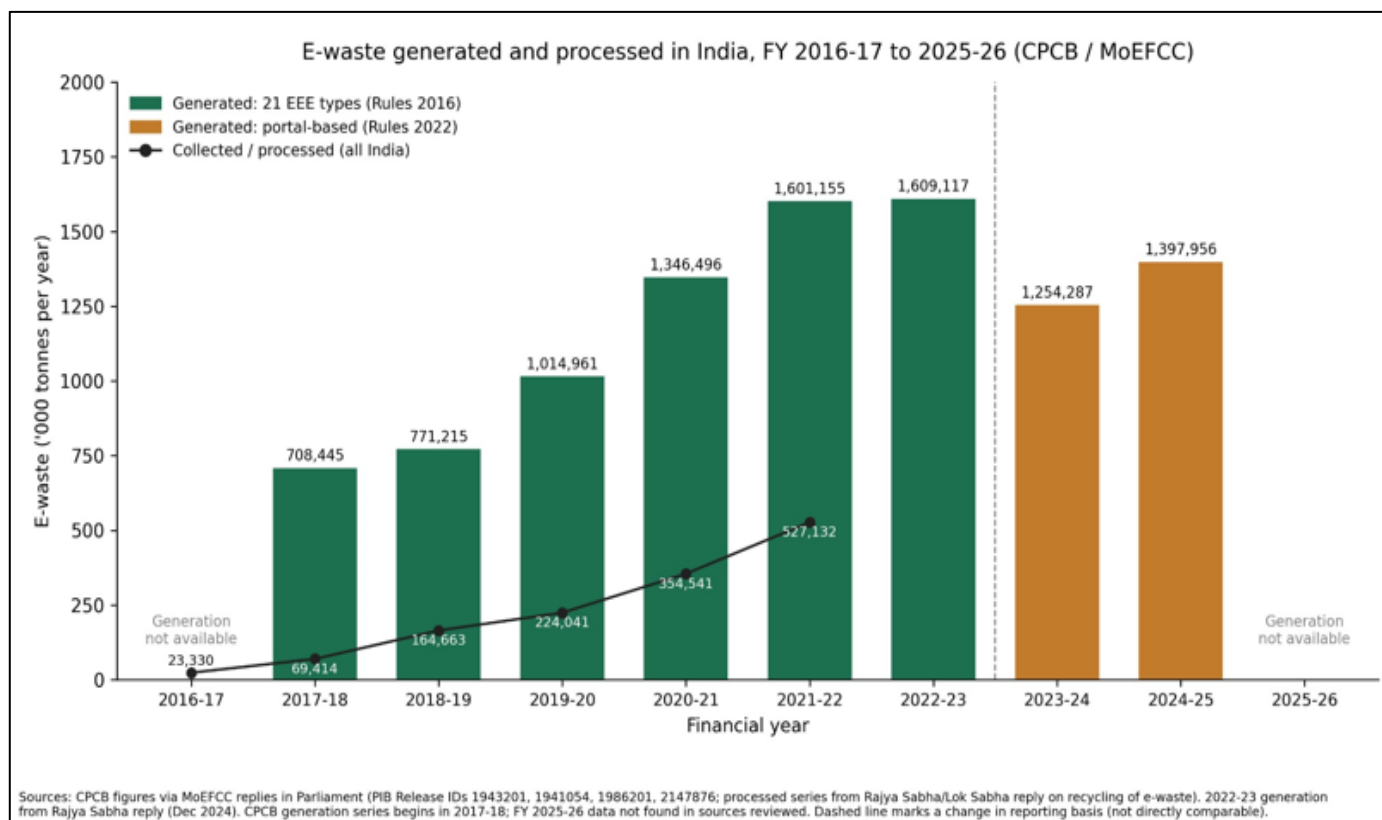
Where E_t is projected e-waste generation, E_{2026} is the modelled 2026 baseline, and r is the annual growth rate for each scenario. The resulting estimates are treated as modelled projections rather than official measurements.

➤ Data Limitations

- Ongoing data on e-waste generation in Chennai is limited.
- Historical estimates vary in methodology, making direct comparisons challenging.

- Alterations in CPCB reporting and the scope of products covered impact long-term comparisons.
- Chennai's modelled estimates are based on assumptions and carry a degree of uncertainty.
- Survey results reflect only the surveyed participants and might not accurately represent the whole population of Chennai.
- Quantifying informal-sector activity is challenging due to the absence of formal records for much of it.

IV. DATA ANALYSIS



Graph 1 E-waste generated and processed in India, FY 2016-17 to 2025-26 (CPCB / MoEFCC)

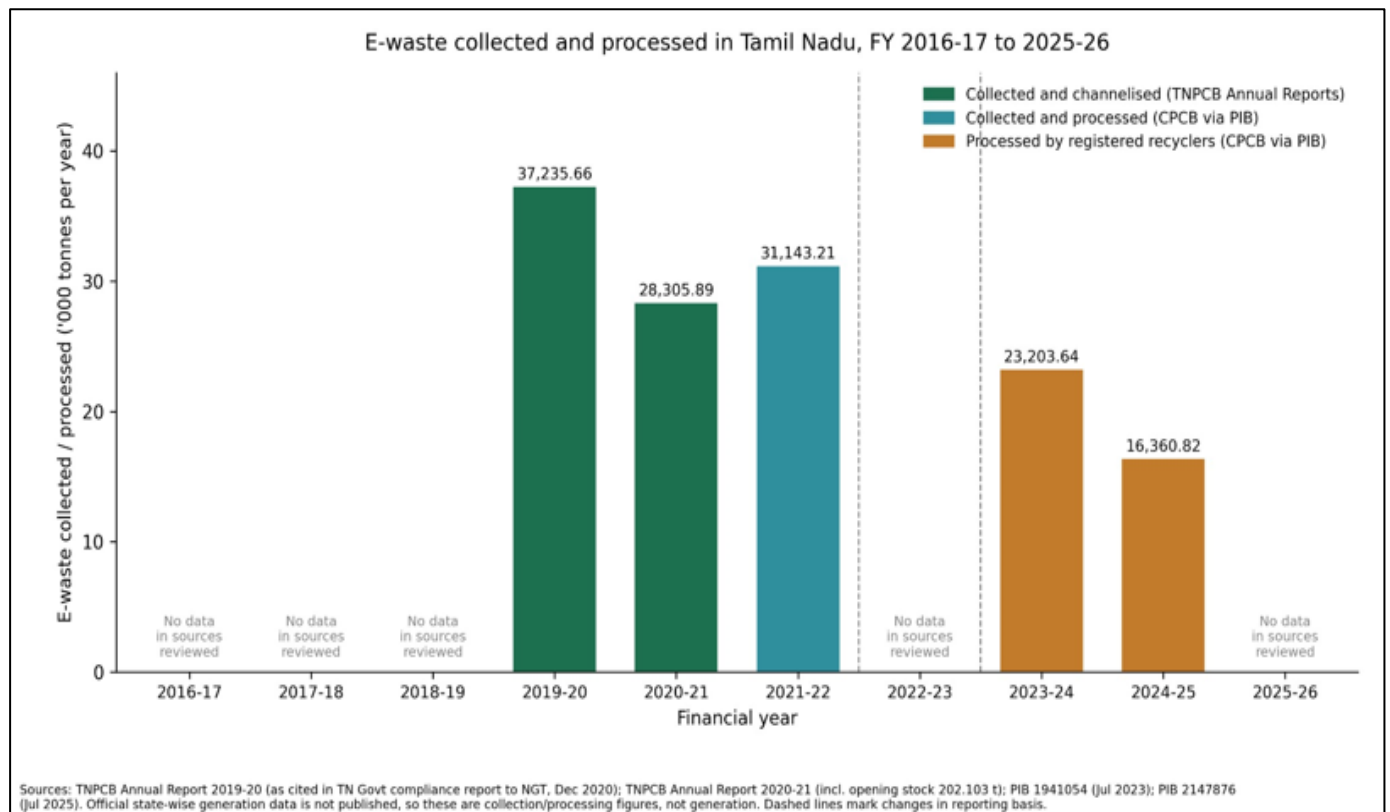
➤ Interpretation

- Estimated generation on the 21-product basis rose from 708,445 t (2017-18) to 1,609,117 t (2022-23), an increase of about 127%, or roughly 2.3 times.
- That is a compound annual growth rate of about 17.8% over 2017-18 to 2022-23. The last step was almost flat (+0.5%, from 1,601,155 t to 1,609,117 t).
- Formal collection and processing grew faster than generation: from 69,414 t (2017-18) to 527,132 t (2021-22), about 7.6 times, against 2.3 times for generation.
- The processed share of generation rose from about 9.8% (2017-18) to 21.4%, 22.1%, 26.3%, and 32.9% (2021-22).

- About 1.07 million t (67%) of the 2021-22 estimate was not formally processed, so the gap in absolute terms is still large.
- On the portal-based basis, generation was 1,254,287 t (2023-24) and 1,397,956 t (2024-25), a rise of 11.5%.

➤ Limitations to state

- The 2023-24 drop is a change in reporting basis and not a real decline, so the two series must not be read as one trend.
- The line combines "collected" and "processed" definitions, and the sources do not give 2016-17 generation or any 2025-26 data.



Graph 2 E-Waste Collected and Processed in Tamil Nadu, FY 2016-17 to 2025-26

➤ Interpretation

- Reported collection or processing was 37,235.66 t in 2019-20 and 28,305.89 t in 2020-21, a fall of 24.0%.
- It recovered to 31,143.21 t in 2021-22 (+10.0%).
- On the latter basis, processing by registered recyclers fell from 23,203.64 t (2023-24) to 16,360.82 t (2024-25), a fall of 29.5%.
- Between 2021-22 and 2024-25, the reported figure fell by about 47.5%, and between 2019-20 and 2024-25 by about

56.1%. No data were found for 2016-17 to 2018-19, 2022-23, and 2025-26.

➤ Limitations to State

- Each bar measures something different (collected, collected and processed, processed), and dashed lines mark the changes.
- The 2020-21 value includes an opening stock of 202.103 t.

➤ Policy Timeline

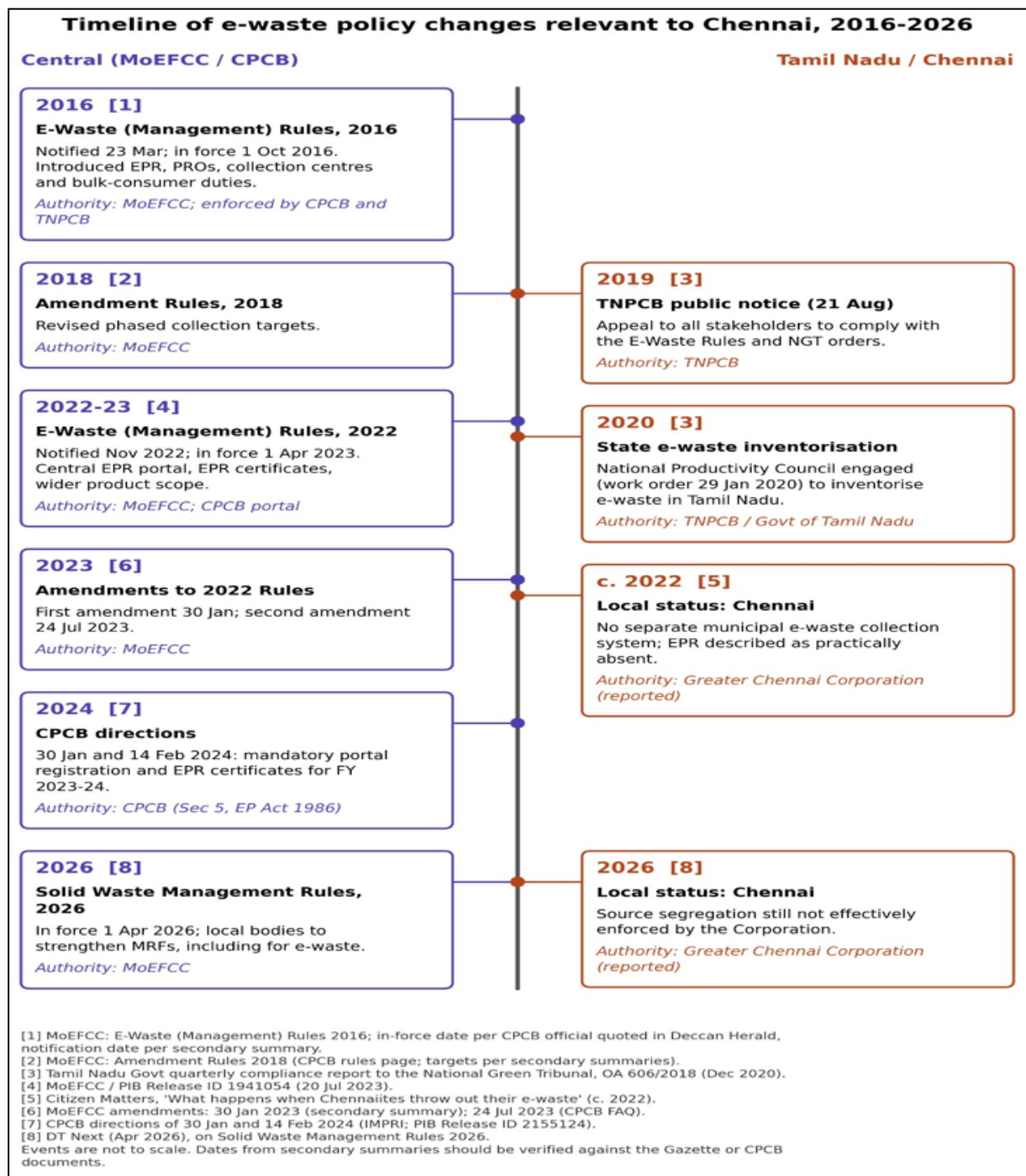
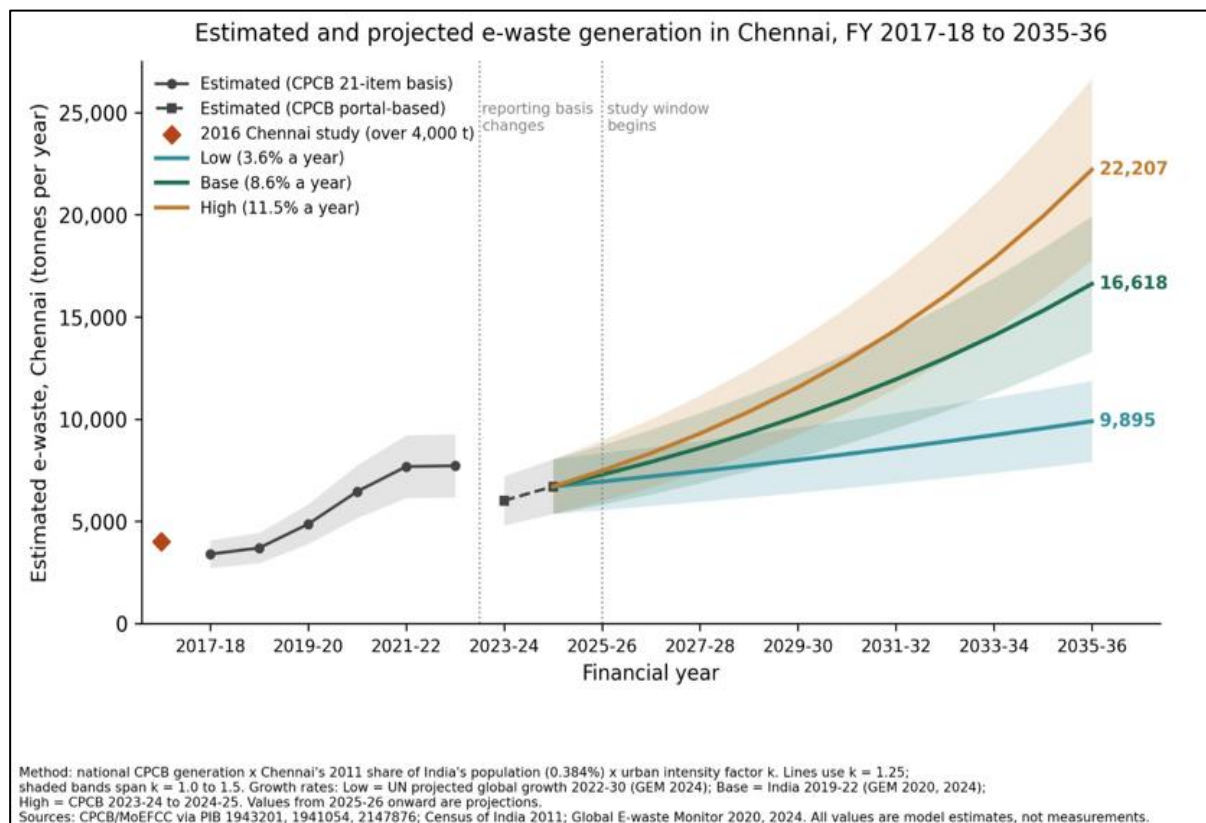


Fig 1 Timeline of E-Waste Policy Changes Relevant to Chennai, 2016-2026

➤ Interpretations

- 2016: Formal e-waste regulation began with the E-Waste Management Rules and EPR.
- 2018–2022: Regulations were strengthened, increasing responsibilities for producers and recyclers.
- 2022–24: The system shifted towards centralized registration, EPR certificates, and digital monitoring.
- Informal sector: Continued involvement suggests that formal collection systems may not be reaching all e-waste generated in the city.

- Monitoring gap: Registration and EPR systems improve accountability but do not automatically ensure that all e-waste reaches authorized recyclers.
- Overall: The decade shows stronger policies but continuing implementation and collection gaps in Chennai.
- Relevance to this study: These gaps support the need to strengthen formal systems and monitor and channel informal collectors into authorized recycling networks.

➤ *Estimated and Projected E-Waste Generation*

Graph 3 Estimated and Projected E-Waste Generation in Chennai, FY 2017-18 to 2035-36

➤ *Interpretations*

- The historical estimate rises from about 3,400 t (2017-18) to about 7,700 t (2022-23), using the central factor $k = 1.25$. The range for $k = 1.0$ to 1.5 is 2,719 to 4,078 t in 2017-18.
- The 2016 Chennai study (over 4,000 t) lies at the top of the 2017-18 range. This reflects how K was calibrated, so it is not an independent check.
- In 2025-26, the three scenarios start close together (about 6,900 to 7,500 t) and spread out over time.
- By 2035-36, the central estimates are 9,895 t (Low), 16,618 t (Base), and 22,207 t (High).
- These are increases of 42%, 128%, and 197% on 2025-26 (indices of about 142, 228, and 297). In absolute terms, that is about 2,900, 9,300, and 14,700 t of additional e-waste a year.
- By 2035-36, the low range (7,916 to 11,874 t) does not overlap the base range (13,295 to 19,942 t), while the base and high overlap.

➤ *Limitations to state*

- The step down between 2022-23 and 2023-24 (about 22%) comes from the change in national reporting basis, not a real fall.
- Chennai values are scaled from national data using a constant 2011 population share (0.384%).
- K is calibrated to one data point, and growth rates are held constant for ten years even though real growth may slow.

✓ *Note Under the Figure:*

$\text{Chennai estimate} = \text{national CPCB generation} \times 0.384\% (\text{Chennai's 2011 population share}) \times k$. Lines use $k = 1.25$; bands show $k = 1.0$ to 1.5 .

✓ *Growth Rates:*

Low 3.6% (UN global projection 2022-30), Base 8.6% (India 2019-22, Global E-waste Monitor), High 11.5% (CPCB 2023-24 to 2024-25). Values from 2025-26 are projections, and all values are estimates, not measurements.

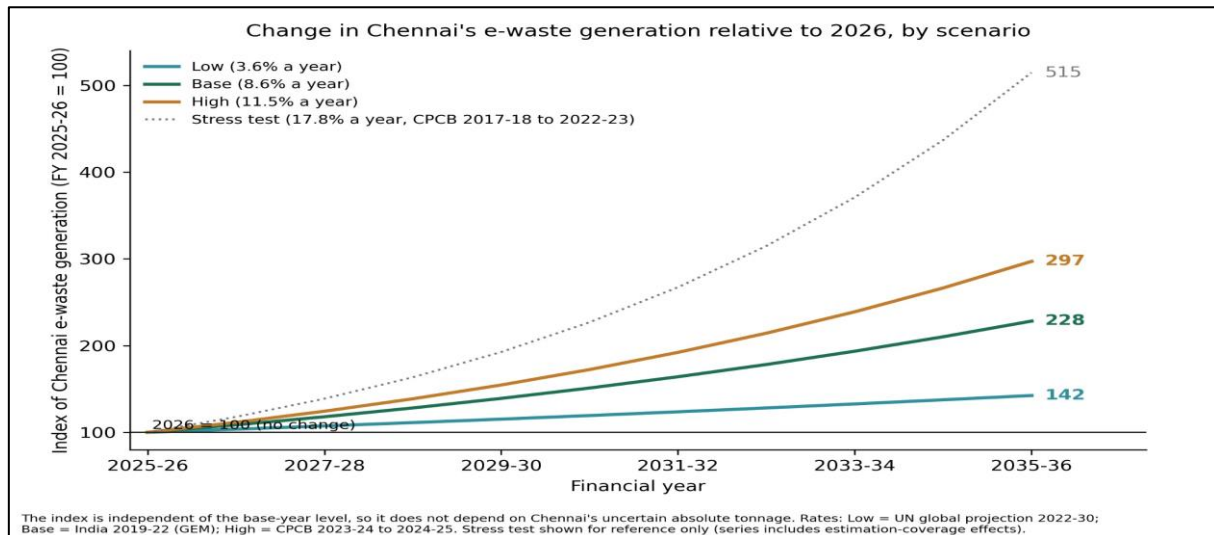


Fig 2 Change in Chennai's E-Waste Generation Relative to 2026, by Scenario

➤ Survey



Fig 3 Have You Heard of Authorized E-Waste Collection/Recycling Centers?

➤ Awareness of Authorized E-Waste Centers

- 54.5% of respondents are aware of authorized e-waste collection/recycling centers.

- 45.5% are either unaware or unsure, indicating a significant awareness gap.

This suggests that accessibility and public awareness could be barriers to formal e-waste disposal.

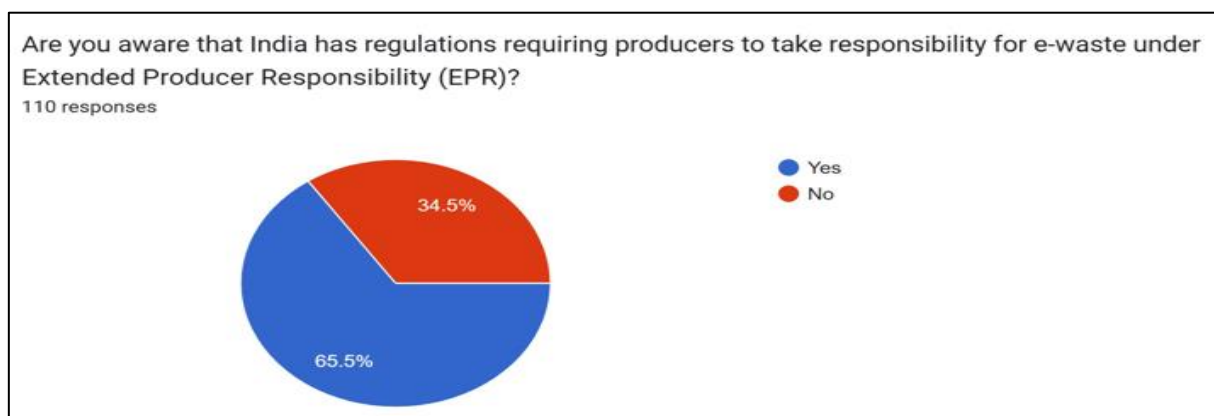


Fig 4 Are You Aware that India has Regulations Requiring Producers to Take Responsibility for e-waste under Extended Producer Responsibility (EPR)?

➤ *Awareness of EPR*

- 65.5% are aware of India's EPR regulations.
- 34.5% are unaware of EPR

Awareness of EPR is higher than awareness of authorized collection centers, suggesting that knowing about the policy does not necessarily translate into knowing where to dispose of e-waste formally.

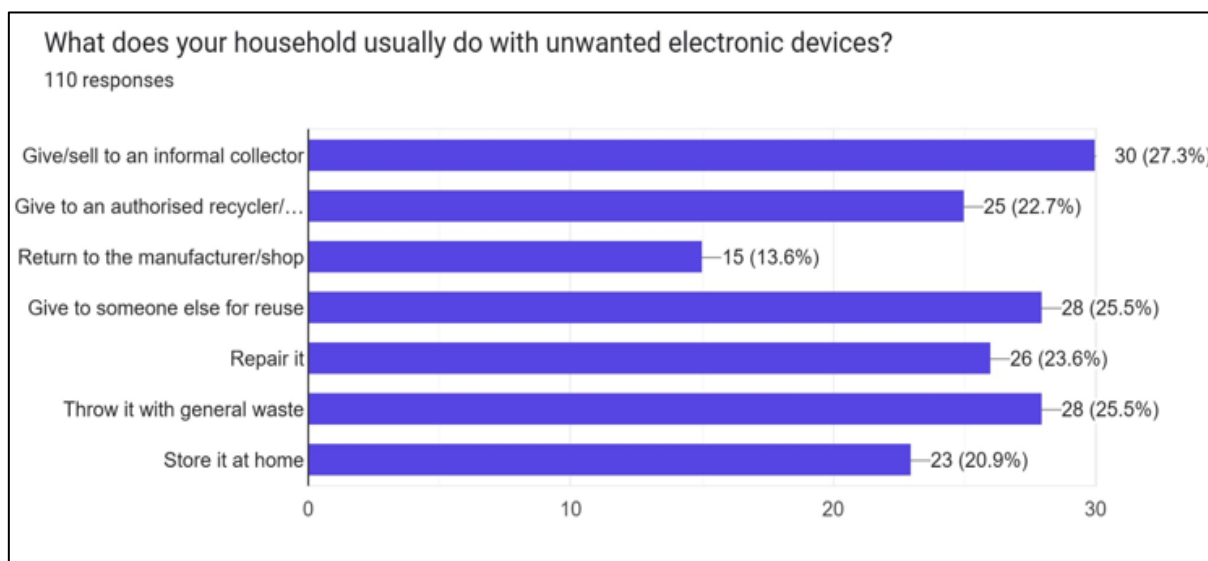


Fig 5 What Does Your Household Usually do with Unwanted Electronic Devices?

(Respondents can choose more than one option)

➤ *Household Disposal Practices*

- 27.3% give or sell e-waste to informal collectors—the most common single option.
- 22.7% use authorized recyclers/collection centers.
- 25.5% give devices to others for reuse, while 23.6% repair them.

- 25.5% dispose of electronics with general waste, indicating a significant improper-disposal risk.
- 20.9% store unwanted devices at home, suggesting delayed disposal or uncertainty about proper channels.
- Overall, the responses show mixed disposal practices, with informal and potentially improper routes remaining significant.

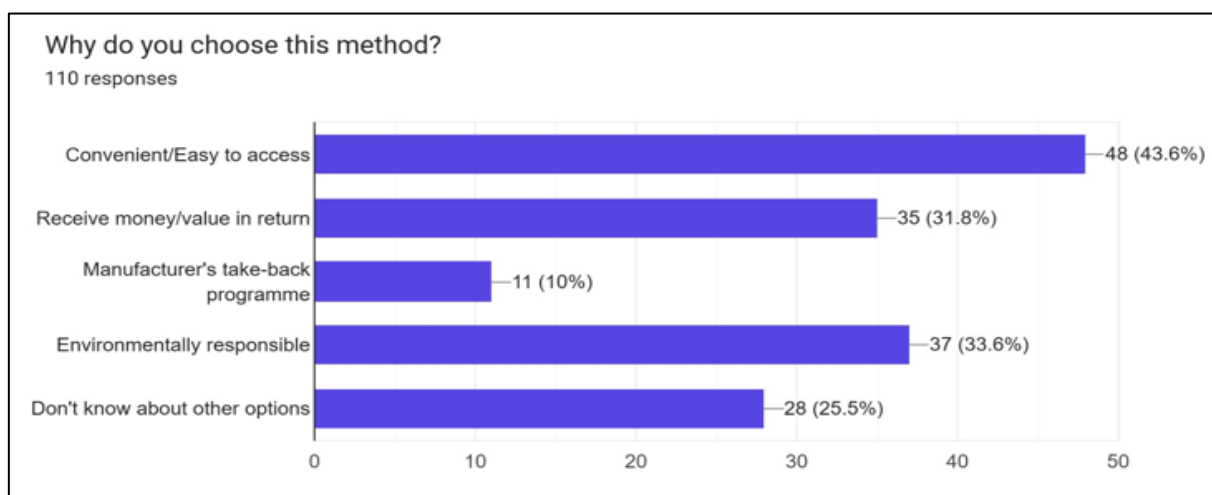


Fig 6 Why do You Choose this Method?

(Respondents can choose more than one option.)

➤ *Reasons for Choosing the Method*

- 43.6% choose their method mainly because it is convenient/easy to access.
- 33.6% consider environmental responsibility important.

- 31.8% are motivated by receiving money/value in return.
- 25.5% do not know about alternative disposal options.
- Only 10% use manufacturers' take-back programs.
- This suggests that accessibility and economic incentives may influence disposal behavior more strongly than formal take-back systems.

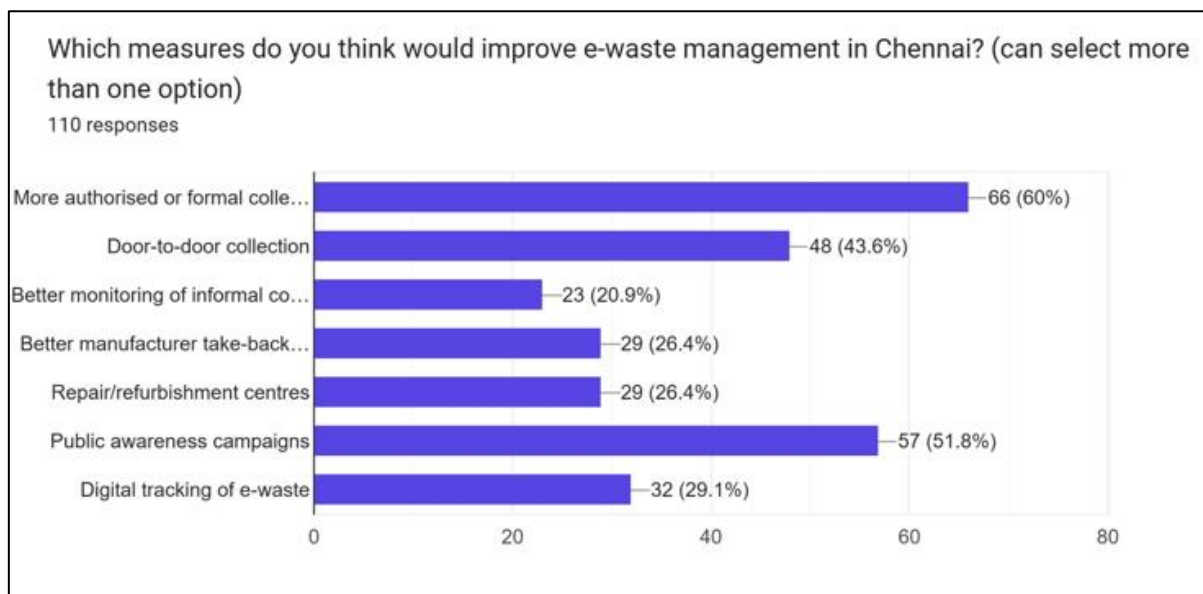


Fig 7 Which Measures do you Think Would Improve e-Waste Management in Chennai? (Can Select More than one Option)

(Respondents can choose more than one option.)

➤ Interpretation

- 60% preferred more authorized/formal collection centers—the strongest response.
- 51.8% supported public awareness campaigns, showing a clear need for better awareness.
- 43.6% preferred door-to-door collection, suggesting accessibility is important.
- 29.1% supported digital tracking of e-waste.

- 26.4% supported better manufacturer take-back systems and repair/refurbishment centers.
- 20.9% supported better monitoring of informal collectors.
- Overall, respondents mainly favor expanding formal collection and improving public awareness, while monitoring and digital tracking can complement these measures.
- These results recommend strengthening the formal sector while introducing monitoring and channelization mechanisms for the informal sector.

V. RESULTS

Table 1 Results

Hypothesis	Evidence	Assessment
Chennai's e-waste generation is likely to increase during 2026–2036.	The national generation rose in every reported year on the 21-product basis; Chennai's modelled estimate is higher in 2036 than in 2026 in all three scenarios, all k values, and all ± 2 -point sensitivity runs.	Supported. Direction is robust; the size of the increase (+42% to +197%) and the absolute tonnage are uncertain.
Upgrading the formal sector and monitoring the informal sector could improve e-waste recovery and reduce its environmental burden.	No municipal collection system is documented for Chennai; the survey: 60% want more authorized centers, and 51.8% want awareness campaigns; only 20.9% want back monitoring of informal collectors.	Partly supported. Consistent indirect evidence, but Chennai's informal share was not measured Directionally supported for formal upgrading; not tested. No intervention data exist, so the effect on recovery is a recommendation, not a finding.

- E-waste generation shows a clear upward trend at the national level, which provides supporting evidence for the projected increase in Chennai.
- Although the amount varies greatly, all three projection scenarios indicate that e-waste creation will be larger in 2036 than in 2026.
- The information that is currently available for Chennai shows a disconnect between local collection infrastructure and formal policy formulation.

- According to survey data, just 22.7% of households reported utilizing approved recyclers or collection facilities, while informal collection, general-waste dumping, and storage continue to be important household activities.
- Respondents expressed a high need for door-to-door collection (43.6%), public awareness (51.8%), and more official collection facilities (60%).

- Overall, the results highlight the need for more robust formal procedures and improved integration/monitoring of informal collecting networks by showing that growing generation and deficiencies in collection infrastructure are the main obstacles.

VI. CONCLUSION

The first premise of the study is supported by the likelihood that e-waste creation in Chennai would rise over the next ten years. Chennai needs a dedicated database to track the production and management of e-waste because it is a significant stakeholder. Chennai's official monitoring and collection systems, however, have not advanced far enough to handle the mounting demand. Official departments like the GCC should be reinforced and reorganized, and formal sectors must be enhanced. E-waste management might be improved by incorporating a monitoring system for the unorganized sector and digitally tracking e-waste. The results of the poll offer a number of strategies for increasing the general public's access to efficient and sustainable disposal, reuse, and recycling choices. However, raising public awareness and making appropriate disposal alternatives available are crucial steps in improving e-waste management. All things considered, Chennai's increasing e-waste load needs not just stricter laws but also improved execution, trustworthy data, easily accessible collection, public involvement, and synergy between official and informal institutions. Over the next ten years, a combination of these actions may assist Chennai in developing a more effective and sustainable e-waste management system.

RECOMMENDATION

- Expand the number and accessibility of authorized collection centers, especially in high-density residential and commercial areas. Improve coordination between GCC, TNPCB, CPCB, producers, and authorized recyclers.
- Establish a monitoring and traceability system for informal collectors. Instead of attempting to eliminate the informal sector, the system would integrate and monitor it.
- Informal sectors can be registered through a local identification system.
- Digital tracking of those registered facilities can be tracked and monitored.
- Chennai's Integrated E-Waste Collection and Traceability Model
- In order to improve formal management and integrate the current informal collection network, the study suggests an Integrated E-Waste Collection and Traceability Model for Chennai.
- While the e-waste they gather is tracked and sent to approved recyclers, refurbishers, or dismantlers, informal collectors may be registered, trained, and observed.

- To increase traceability and accountability, a straightforward digital tracking system might document the origin, amount, and destination of e-waste.
- The E-Waste (Management) Rules, 2022, which address registration, Extended Producer Responsibility (EPR), verification, and channeling the unorganized sector into formal recycling, are in line with this strategy.



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