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Making state circular economy parks work for Indian states (Part 1): An emerging story of Rajasthan

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MAKING STATE CIRCULAR ECONOMY PARKS WORK FOR THE INDIAN STATES (PART 1): AN EMERGING STORY OF RAJASTHAN

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JUNE 2024

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WORKING
PAPER

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Abstract

As global e-waste streams rise, recycling efforts remain insufficient, as does the willingness to promote recycling. This insufficiency is primarily due to the perception of ‘waste’ as ‘disposable,’ which has hindered its consideration as a business opportunity. Over time, this perception has negatively impacted the development of the recycling sector. To counter this prevailing notion, this working paper promotes the idea of ‘e-waste as a commodity’ and argues that recycling can stimulate economic growth and support the primary supply of critical minerals used in manufacturing electronic equipment.

Acknowledging the potential impact of e-waste, it is necessary to recycle it to minimize loss and maximize profit. To achieve this, the working paper proposes and evaluates the concept of e-waste-focused industrial parks called “E-Waste Recycling Parks” or ERPs. This concept is an extension of eco-industrial parks and aims to boost the recycling industry, making the recycling business more economically viable. Furthermore, the paper develops a framework outlining five critical factors for the development of ERPs in India. These factors include understanding the demand for ERPs, reviewing legislative and regulatory frameworks, financing and operationalizing ERPs, and post-establishment monitoring.

In India, several states increasingly acknowledge the concept of ERPs, including Maharashtra, Rajasthan, and Delhi. This working paper focuses on the state of Rajasthan and details how the state plans to implement a recycling project within a waste recycling park. The paper explains how factors such as waste flow dynamics, the location of the park, and other elements can be leveraged to benefit the recycling park.

Keywords: E-Waste, E-waste Recycling Park (ERP), Regional analysis

JEL classification: Q53, Q58, R58

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Making State Circular Economy Parks Work for the Indian States (Part 1): An Emerging Story of Rajasthan

Amrita Goldar¹, Tarun², Malay Kotal³ and Ritika Verma⁴

1. Urban Mines and Industrial Parks

In the last few decades, the global urban population has increased significantly. The impact of greater urbanisation and associated lifestyles is evident; while it has enhanced the delivery of goods and services, it has also led to an excessive reliance on electrical and electronic equipment. Due to this dependence, the electronics industry has become one of the fastest-growing sectors, projected to reach USD 1028 billion in 2023 (Statista, 2023). However, this growth brings a harsh reality: all electrical equipment eventually becomes obsolete and turns into a waste stream known as 'e-waste.' E-waste is often referred to as 'urban mines' because it contains many precious metals. If recycled, these metals can serve as secondary materials, thereby reducing the production of greenhouse gases associated with primary mining and production.

The global e-waste generation has risen multi folds over the year; in 2019, the world generated a striking 53.6 Metric Tons (Mt) of e-waste, which has grown by 9.2 Mt since 2014 (UNITAR, 2022). Given the increased generation of e-waste around the globe, global e-waste recycling is also rising sharply. In 2019, the formal collection and recycling of e-waste was 9.3 Mt, which has grown by 1.8 Mt since 2014 (UNITAR, 2022). The growth, however, was reported mainly by the high-income countries, and the progress in low and middle-income countries is still lagging (Srivastava & Pathak, 2020).

Given the importance of e-waste recycling, the global relevance of these urban mines has gradually increased. Various interventions, including the implementation of legislation and efforts to motivate consumer participation, are being introduced at both international and national levels. Additionally, the introduction of Eco-Industrial Parks (EIPs) at regional and local levels is becoming more common to strengthen the circular economy concept. The

eco-industrial approach was introduced to further reinforce the circular economy, improve resource and energy-efficient management, and promote organic industrial collaboration (Geng et al., 2016).

The idea of EIPs was initially presented at the 1992 United Nations Conference on Environment and Development in Rio de Janeiro (UNIDO, 2021). The EIP concept has evolved to address a number of societal problems, including environmental pollution and climate change, promoting resource efficiency and improved management of resources through its deployment globally. In addition, they also aim at achieving a number of Sustainable Development Goals (SDGs), including SDG 5 (Gender Equality), SDG 6 (Clean Water and Sanitation), SDG 7 (Affordable and Clean Energy), SDG 8 (Decent Work and Economic Growth), SDG 9 (Industry, Innovation and Infrastructure), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action) (UNIDO, 2021). Establishing EIPs would facilitate the attainment of the specified SDG objectives through diverse aspects such as sustainable production and consumption patterns, generating employment, etc.

The concept of EIPs is analogous to an ecological system, i.e., where different systems organically interact with each other (Gibbs & Deutz, 2005), and the by-products of one case will become the feedstock of another (Elabras Veiga & Magrini, 2009). Thus, EIPs are a mix of both industrial ecology and cleaner production, where the waste of one is input to the other. As a result, there is zero production of waste making the process more environmentally friendly. However, the success of developing such industrial parks is mainly dependent on the emergence of innovative network governance that enable different companies to find common ground and find ways to reuse and recycle industrial by-products (Mathews et al., 2018).

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This working paper is intended to analyse the concept of industrial parks and their suitability in the management of e-waste in India. As the working paper reveals, the development of EIPs in India is still at a very nascent stage, and going ahead, a lot of progress is needed. The structure of the rest of the paper is as follows. Section 2 will outline the global scenario of EIPs. Section 3 examines the factors that need to be considered for establishing an industrial park focusing on recycling e-waste in India. Section 4 explains the case study of Rajasthan. Lastly, Section 5 discusses potential recommendations for e-waste management across Indian states while establishing E-waste recycling parks (ERPs) based on the fieldwork and stakeholder consultations in Rajasthan.

2. Eco-Industrial Parks (EIPs) in the Global South

EIPs were initially designed to streamline industrial development by applying the principles of industrial ecology in a specific location through efficient resource sharing (information, materials, energy, and infrastructure), leading to economic gains (Lambert and Boons, 2002; Gibbs and Deutz, 2007). Over time, the scope of EIPs has broadened to address climate change concerns and promote green growth through

innovative solutions (e.g., technological, economic, social) and by minimizing waste generation (OECD, 2009). The use of pollution reduction technologies within EIPs allows countries to safeguard the environment and enhance the competitive advantage of supply chains by reducing production costs (Chertow and Lombardi, 2005; Yuan & Shi, 2009).

The development of EIPs was initially more concentrated in developed countries. In the USA, the federal government promoted EIPs in multiple locations through the President's Council for Sustainable Development. Similarly, Europe, Canada, Germany, and the Netherlands also encouraged their development (Tian et al., 2014). However, in recent times, EIPs have gained more traction in the Global South, i.e., in countries such as China, Indonesia, and Vietnam (please refer to Table 1). Recognizing the potential of EIPs to promote economic development and address environmental concerns, national and regional governments in these countries have introduced various industrial policies to promote EIPs (Gibbs and Deutz, 2007; Song & Zhou, 2021). Some of these initiatives have led to the development of parks, while others have established zones, industrial towns, or eco-development areas for a similar purpose (detailed in Table 1).

Table 1: Few EIP Initiatives across the Global South

| S.N. | Countries | EIP Initiatives | Details |
|------|-----------|--|---|
| 1. | China | Shenyang Economic technological development area (SETDA) | It was established in 1988 as a greenfield industrial park and promoted to a national-level industrial Park in 1993. The Park consists of multiple industrial clusters, such as those of chemical products, of metal products, of machinery, traffic, electric equipment, and electronic manufacturing, and of food and beverage processing (Liu et al., 2014). |
| | | Shanghai Chemical Industry Park (SCIP) | The industry park was established in 1996 as a greenfield park. It is one of the largest integrated petrochemical bases in China. In the year 2002, the scope of the park was broadened to provide integrated water supply and wastewater treatment services for industrial customers in SCIP. ⁵ |
| | | Sino-Swiss Zhenjiang Ecological Industrial Park (SSZEIP) | SSZEIP was established in 2012 as a greenfield park based on a bilateral initiative between the Ministry of Commerce of the People's Republic of China (Mofcom) and the State Secretariat for Economic Affairs of the Swiss Confederation (SECO). It aims to accommodate a wide variety of laboratories and R&D centres, which facilitate the testing and certification of raw materials and technology development. ⁶ |
| | | Dalian Hi-Tech Zone (DHTZ) | DHTZ is one of China's first national-level high-technology industrial zones, founded in 1991. It was established as a greenfield park to promote software and information technology outsourcing, featuring network and e-commerce. In addition, it provides a platform for scientific and technological innovations. ⁷ |

⁵ Available at: <https://www.suez-asia.com/en-cn/our-offering/success-stories/our-references/integrated-water-treatment-service-in-scip>

⁶ Available at: <https://www.swisscham.org/link/investment-zones/sino-swiss-zhenjiang-eco-industrial-park/>

⁷ Available at: <https://www.dlhitech.gov.cn/english/introduction/intro/content.html>

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|----|--------------|-------------------------------|---|
| 2. | Indonesia | MM2100 Industrial Town | MM2100 Industrial Town is one of the most comprehensive business destinations in Indonesia. It was established in 1990 under the Global Eco-Industrial Parks Programme (GEIPP) to promote a wide range of industrial services such as production, distribution and warehousing (IIED, 2018-19). |
| | | Batamindo Industrial Park | The economic cooperation agreement between the governments of Singapore and Indonesia led to the conception of Batamindo Industrial Park in 1989. The Park was established to host many international brands with their regional manufacturing presence in Indonesia. The Park offers a choice of ready-built factories for businesses to choose from to accommodate various manufacturing processes (IIED, 2018-19). |
| | | Kabil Industrial Estate (KIE) | The Kabil Industrial Estate (KIE) was established in 1990 with a thorough master plan that included Batam's first self-sustaining water reservoir and water treatment facility. The Park continued to grow and include new activities, like power plants, port facilities, natural gas supply and telecommunication. ⁸ |
| 3 | Philippines | Carmelray Industrial Park-I | Carmelray Industrial Park-I was developed in 1990 as a Special Economic Zone (SEZ) by the Philippine Economic Zone Authority (PEZA). The Park specialised in the food, chemicals, and electronics industries. ⁹ |
| 4 | Brazil | Paracambi Eco-industrial park | The Paracambi EIP was established as a greenfield park in 2002 to promote large and medium industries within the Rio de Janeiro Metropolitan area (Veiga and Magrini, 2008). |
| 5 | South Africa | Automotive Supplier Park | The Automotive Supplier Park ¹⁰ is a greenfield industrial park comprising mainly of component manufacturers and suppliers to original equipment manufacturers. |
| 6 | Vietnam | Deep C Industrial Park | The Deep C Industrial Park ¹¹ is a greenfield industrial park with industrial clusters of automotive parts and spare parts, petrochemicals, logistics, and services. |
| | | Khanh Phu Industrial Park | The Khanh Phu Industrial Park is a greenfield industrial park established in 1996 with a total area of 1.686 Hectare (ha). The companies in the industrial park are operating in food, textile, and paper sectors. ¹² |
| | | Hoa Khanh Industrial Park | The Hoa Khanh Industrial Park is a diverse greenfield industrial park consisting of multiple industrial clusters of food, textile, electronic products, automobile, paper, and others. |

Source: Authors' Compilation

This comparative analysis of EIPs across the Global South highlights that they host diverse industries, ranging from the IT sector to automobile manufacturing, logistics, and more. Historically, many of these parks were established with a focus on single sectors; however, over time, they have diversified based on local demands. For the development of EIPs in the Global South, the Global Eco-Industrial Parks Programme (GEIPP) has played a significant role wherein major emphasis was given to scaling up resource productivity and improving

economic, environmental, and social performances of businesses.¹³ Our analysis further highlighted that most EIPs are production-based greenfield initiatives focused on waste reduction.¹⁴ However, recycling of the generated waste has been a fairly less explored area. This is because the majority of market players responsible for recycling in the Global South belong to the informal sector. However, given the fact that the quantum of e-waste is rising sharply, there is a greater need for focusing industrial development aimed towards management of the e-waste.

⁸ Available at: <http://www.chinagoabroad.com/en/contributor/kabil-industrial-estate>

⁹ Available at: <https://directorsdirectory.com/carmelray-industrial-park-i/>

¹⁰ Available at Automotive Supplier Park – AIDC Accessed 11 April 2023

¹¹ Available at Deep C Industrial Park (Dinh Vu) - Hai Phong - Hai Long JSC Accessed on 11 April 2023

¹² Available at Hoa Khanh Industrial Zone (eipvn.org) Accessed on 11 April 2023

¹³ Available at: <https://www.greenindustryplatform.org/initiatives/global-eco-industrial-parks-programme/about>

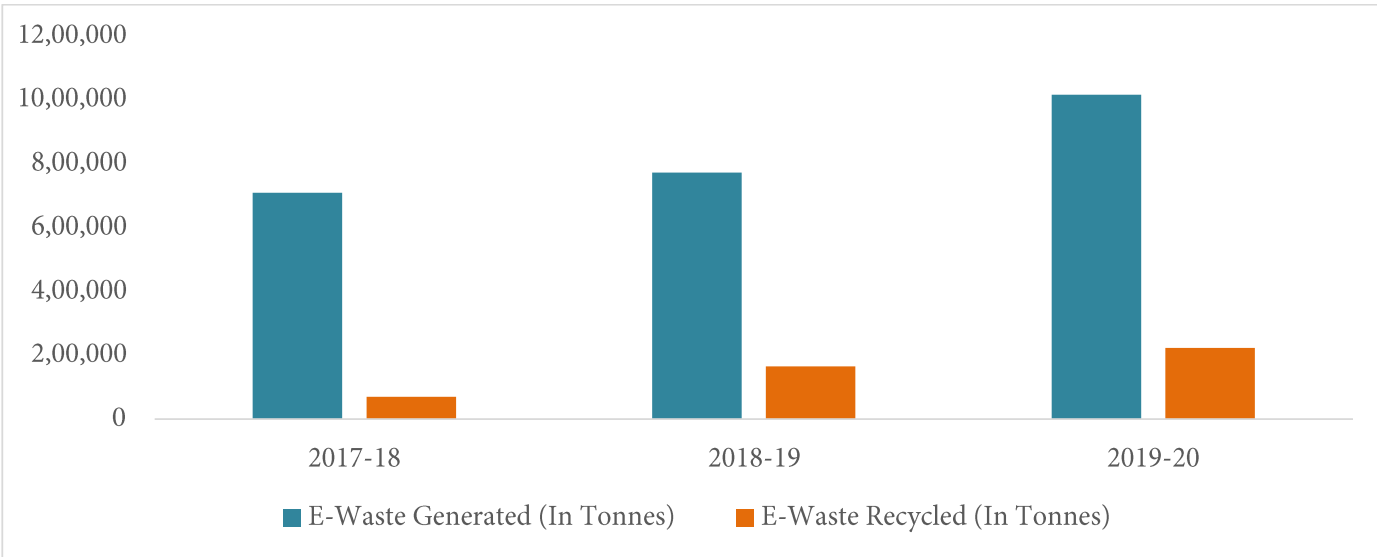
¹⁴ Greenfield is defined as any land that has been developed from the outset.

3. Transitioning from EIPs to ERPs in India

India is one of the largest e-waste producers in the world. According to the data provided by the Central Pollution Control Board (CPCB), the estimated e-waste generation from 21 types of notified e-waste raised from 708445 tonnes in 2017-18 to 1014961.2 in 2019-20 (CPCB, 2021). The quantity of e-waste recycled and dismantled during these years were

69413.61 tonnes and 222436.34 tonnes, respectively (CPCB, 2021). However, there is a lack of consistency in various data sources regarding the total amount of recycled waste, with reported recycling rates ranging from as low as 2 percent to a maximum of 22 percent (Awasthi et al., 2018; CPCB, 2021; Garg & Adhana, 2019). In addition to the formal sector, the informal sector also plays an important role in e-waste recycling.

Figure 1: Status of E-Waste Management



Source: CPCB, 2021

The lagging development of the recycling sector is primarily due to the perception of waste as an externality rather than a business opportunity. This perception has led to fewer recyclers entering the market despite its economic potential (Jain & Gidwani, 2023). However, the conventional portrayal of ‘waste’ as ‘throwaway’ is changing, revealing it as a growing business opportunity (Jain & Gidwani, 2023). As the market expands and the social stigma around waste diminishes, many entrepreneurs and larger businesses are gradually venturing into the sector. In light of this, we argue for promoting ‘e-waste as a commodity’.

Historically, the regional flows of commodities have resulted in development of many economic hotspots. For instance, in agriculture, higher sugarcane production led to a proliferation of sugarcane industries and vice versa (Solomon, 2014). In the similar vein, the gargantuan production of e-waste could lead to the organic growth of e-waste industries in India as well. The role of recycling supplementing the primary supplies in addition to environmental safeguarding can’t be ignored. In the context of China, a study by Liu et al. (2023) highlights that

recycling has the potential to meet 27 to 42 per cent of the demand, and the amount of energy, metal, greenhouse gas and toxicity can be reduced by 146.76 per cent by 2050. However, the potential of recycling to aid the primary supply is subjective to available recycling technologies and their efficiency (Asokan et al., 2023).

One obstacle to the organic development of e-waste recycling is the limitation of environmental governance. India was one of the few countries to introduce rules to distinguish e-waste from other waste back in 2011, which was later updated in 2016 and then in 2022. The latest rules emphasize the introduction of Extended Producer Responsibility (EPR), where producers are responsible for the ultimate disposal of their waste. Additionally, a significant amount of waste is collected and recycled by the informal sector, making it more challenging for the formal sector to collect waste in significant quantities. While some progress has been made in establishing a governance framework, much work is needed in areas such as improving collection and optimizing waste flows. To address this problem, traditional e-waste management strategies, which are

often technologically inefficient, should be replaced with more effective alternatives (Ikhlayel, 2018).

The required efficiencies can be gained with the implementation of the concept of inclusive and sustainable business parks. Industrial parks have been in the news recently mainly because of the alarming concern of climate change, environmental degradation and the rising need for business models based on green growth and a circular economy (UNIDO, 2017). Two typical industrial parks, Tianjin Economic-Technological Development Area (TEDA) and Qingyuan City Waste Disposal & Resource Utilisation Centre, have proved extremely efficient in dealing with waste. While waste management is the primary role of such established parks, it also has other positive spill overs, like generating jobs and economic growth.

The literature highlights the role of Eco-Industrial Parks (EIPs) in various sectors, addressing the escalating issue of e-waste generation and the necessity of recycling. Building on this concept, we propose the idea of 'E-Waste Recycling Parks' (ERPs), derived from the concept of 'industrial symbiosis' in the context of e-waste management (UNIDO, 2017). ERPs can address the existing problems of e-waste management in multiple ways:

1. The symbiotic relationship of different types of e-waste under a single roof will make the recycling process more environmentally friendly and help achieve the zero-waste target.
2. ERPs will make the recycling process cost-effective through infrastructural cost-sharing, reducing transportation costs, and establishing inter-industrial linkages.

3. As e-waste consists of diverse materials, according to CPCB and State Pollution Control Board (SPCB) reporting, standalone recycling of each item may not be economically viable. However, establishing ERPs can facilitate collective recycling.
4. ERPs can stimulate regional economic development by creating new jobs, localizing production and consumption, and promoting collaboration between the formal and informal sectors.
5. ERPs have the potential to encourage industry recycling by introducing state-of-the-art technology and incentivizing private sector participation in the recycling business.

Additionally, the co-location of recyclers can foster technological innovations, mutual learning, and can be used to create public awareness and build capacity.

4. Preparatory Analysis for the Establishment of ERPs

The development of a blueprint for the successful establishment of an economic park is not uniform across the globe. After a thorough analysis of existing literature, international standards, and interviews with stakeholders, we have identified five factors critical to the development of ERPs in India. The proposed framework distinguishes between five phases: understanding the demand for ERPs, reviewing the existing legislative and regulatory frameworks, financing the ERPs, operationalising ERPs, and post-establishment monitoring. Table 2 below elaborates on the proposed framework in detail.

Table 2: Five critical factors towards the establishment of ERPs in India

| S.N. | Factors to Consider | Details |
|------|--|--|
| 1 | Understanding the demand for ERP | <ul style="list-style-type: none"> • Mapping the existing e-waste inflow and outflow network and recycling value chain. • Calculating the existing quantum of e-waste generated in the state where the park is located as well as adjoining regions. • Estimating the quantum of waste that will be generated in the near future. • Understanding the gap between the installed e-waste recycling capacity and the required capacity. • Identifying the existing stakeholders involved or in the e-waste recycling loop. |
| 2 | Reviewing of the legislative, administrative and regulatory frameworks | <ul style="list-style-type: none"> • Reviewing the existing legislations that deal with e-waste management and handling (i.e., E-waste Management and Handling Rules, Battery Waste Management Rules), including regulations for land acquisition. • Reviewing the existing policy guidelines that indirectly deal with the e-waste generation and management (i.e., National Policy on Electronics, National Telecom Policy, Faster Adoption and Manufacturing of Hybrid and Electric Vehicles, State level EV policies, Battery Swapping Policy, etc). |

| | | |
|---|------------------------------|--|
| | | <ul style="list-style-type: none"> Analysing the existing regulatory framework that promotes spatial economic development (e.g., industrial park, special economic zones, export processing zones, industrial clusters etc.). Identifying the suitable location for establishing ERP through locational analysis. Conducting feasibility study for establishing the ERP. Preparing the master plan for the establishment of ERP, which could be undertaken in two steps, i.e., (a) conceptual master planning (including activities and broad layout of the park), and (b) planning and preparation of a detailed project report.¹⁵ |
| 3 | Financing the ERP | <ul style="list-style-type: none"> Reviewing the existent public revenue streams available for financing green growth on a national level (i.e., budgetary allocation at the central level, <i>Gati Shakti</i> scheme, Production Linked Incentives (PLI) scheme) needed for the development of ERP. State-level public revenue streams and incentive schemes. Loans from public and private sector banks. Alternative financing sources (e.g., International Finance Corporation (IFC), Green Bonds, Carbon Credits). |
| 4 | Operationalising the ERP | <ul style="list-style-type: none"> Reviewing the existing land related legislations (i.e., land acquisition/pooling act, land disposal act) to make land available for ERP. Allotment of land for establishing ERP through public notification. Identifying/setting-up authority responsible for the establishment of ERP. Provision of infrastructural and administrative services to the ERP. Examination of project suitability based on the submitted proposal and identification of best available technology for e-waste recycling by a technical committee in consultation with entrepreneurs. Streamlining the application procedure by implementing single-window clearances. Preparing a standard operating procedure for smooth functioning of the park and identify common facilities required for facilitating recyclers. Deciding on the governance models of the park, i.e., private, government, and/or cooperative model like public-private partnership (PPP). |
| 5 | Post-establishment mentoring | <ul style="list-style-type: none"> In the early phases, handholding and troubleshooting is an important factor for the success of park. Efforts should be made for integrating local informal waste channels into the formal ones, to ensure adequate supplies of raw material to entrepreneurs locating their plants in the park. Monitoring of the local environmental factors after the establishment of the park to safeguard the local environment. Monitoring the social considerations for the proposed ERPs. |

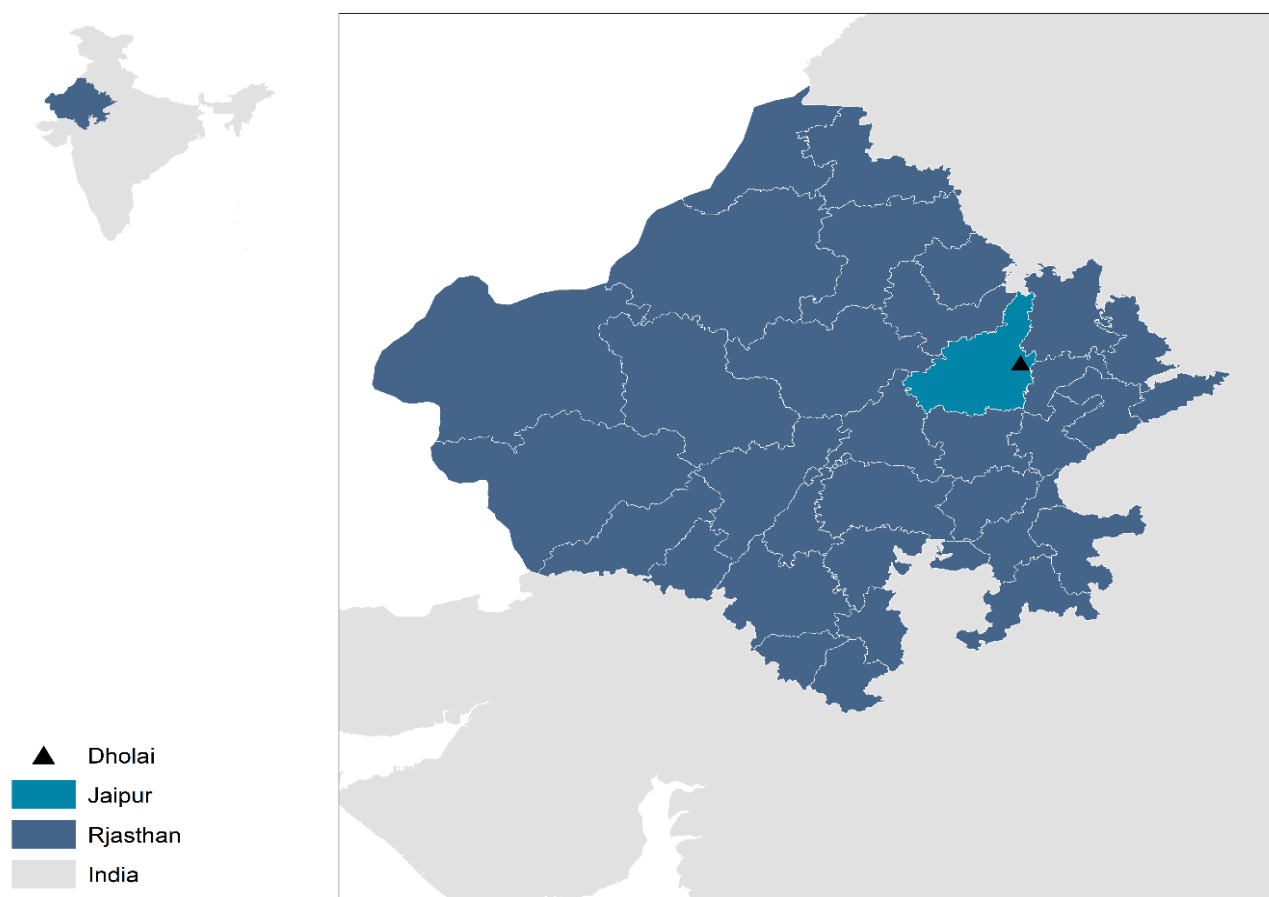
5. State of Progress in Rajasthan

In order to increase e-waste recycling capacity within the state, Rajasthan government is planning to establish a recycling park in Jaipur. A number of Indian states like Maharashtra, Delhi, and Rajasthan have started the discussion around establishing waste recycling parks. Moving ahead, Rajasthan is one of the early-mover states to further the concept

of industrial parks to explore waste as a commodity, including e-waste. The state plans to establish e-waste recycling park (as indicated in Figure 2). This section, thus takes a closer look at the state of Rajasthan and the development of waste recycling park, on the lines of the framework discussed previously. While the park will be focused on different waste categories, we limit ourselves to recycling of e-waste.

¹⁵ A detailed project report contains a thorough breakdown of all the components required to complete the project.

Figure 2: Location map of Tholai (envisaged site for establishing E-Waste Recycling Park in the state of Rajasthan)



Note: This is a thematic map designed for representation. Thus, the map is not to scale and without prejudice of national and international boundaries.

Understanding the existing waste collection and management

The rise in the use of electronic equipments and electric vehicles due to rapid urbanisation, industry development and decarbonisation of the transport and energy sectors has increased the amount of e-waste generated in India and in the state of Rajasthan. Rajasthan is a forerunner in installed solar capacities and had an installed capacity of 16,405.75 MW¹⁶ by 2023, nearly double of India's second-largest solar installed capacity. The proliferation of solar panels will also lead to an enormous amount of waste production once they reach end-of-life.

To avoid the environmental damages caused by the ever-increasing volume of e-waste and promote its effective disposal, the Government of India put in place the national 'E-waste Management Rules, 2016, further superseded in 2022, to promote a circular economy and create awareness among people for the

effective management of e-waste (GoI, 2016, 2022). The rules emphasise the concept of EPR and further highlight the need for manufacturers and producers to take responsibility for the produced e-waste. These rules were followed by a number of local e-waste collection drives by the state government of Rajasthan to encourage the recycling of e-waste (The Times of India, 2021).

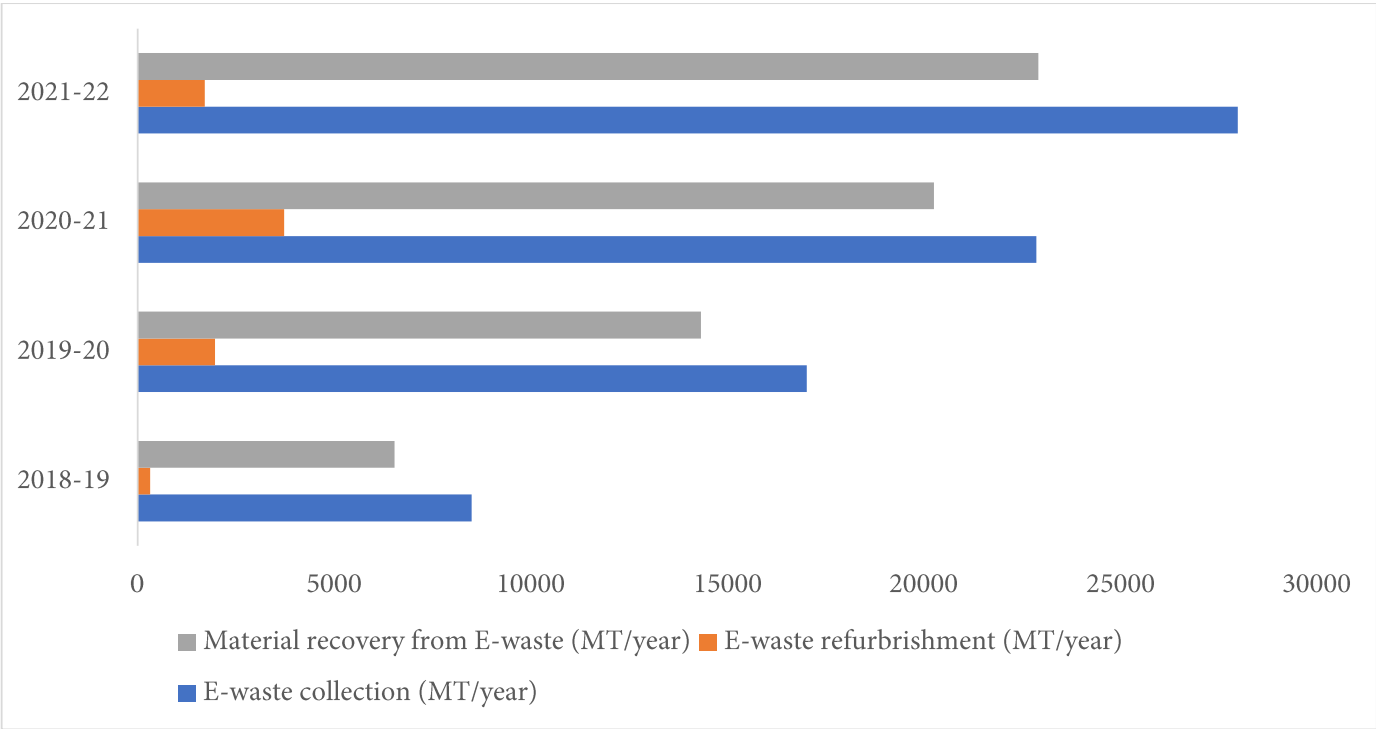
As a result, the amount of e-waste collected formally within Rajasthan augmented almost three times over the last four years, from 8498.28 MT/year in 2018-19 to 27997.44 MT/year in 2021-22 (as indicated in Figure 3). The rise in the quantum of e-waste collection has resulted in increased recycling and recovery of materials like ferrous metals, non-ferrous metals, plastic, glass, printed circuit boards, battery scraps, and many other items from end-of-life e-waste (as indicated in Figure 4). It also indirectly affects the increase in the re-use of some of the e-waste material after the refurbishment (as indicated in Figure 4).

¹⁶ Available at https://nsefi.in/figures_statistics/ (Accessed on 31 March 2023)

The newer rules, however, don't talk about the role of the informal sector in e-waste management. Literature, on the other hand, confirms that much of the e-waste recycling across Indian states is largely undertaken by informal actors by using

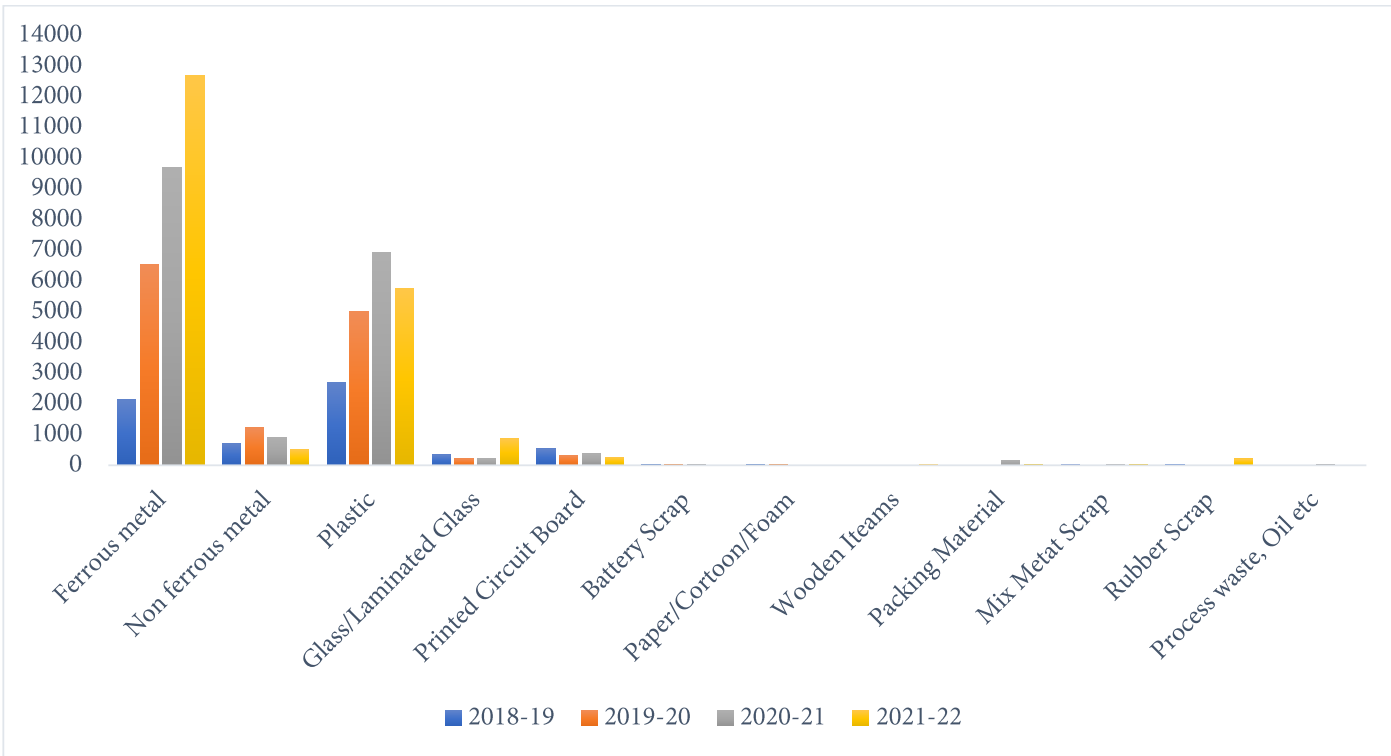
primitive techniques and methods, making it both an environmental and health hazard (Khatriwal, 2019; Dutta and Goel, 2021). The Rajasthan storyline is no different, and in fact, the state has a very well-established informal recycling industry.

Figure 3: E-waste collection, refurbishment and material recovery in Rajasthan



Source: Rajasthan State Pollution Control Board

Figure 4: Material recovery (MT/year) from the E-waste in Rajasthan



Source: Rajasthan State Pollution Control Board

Informal Recycling of e-waste in Rajasthan

Based on our fieldwork, we found that informal recycling of e-waste in Rajasthan is vertically organised at multiple levels. At the bottom, numerous informal e-waste collectors (known as *kabadiwalas*) collect e-waste and other types of waste from households

and then sell it to informal waste retailers. Next, the retailers sort the e-waste materials from other forms of waste and sell them to informal e-waste wholesalers. Waste segregation is an essential step of the waste management process, and it contributes a higher economic value of the waste (Kihila et al., 2021).

Figure 5: Manual Segregation of Waste



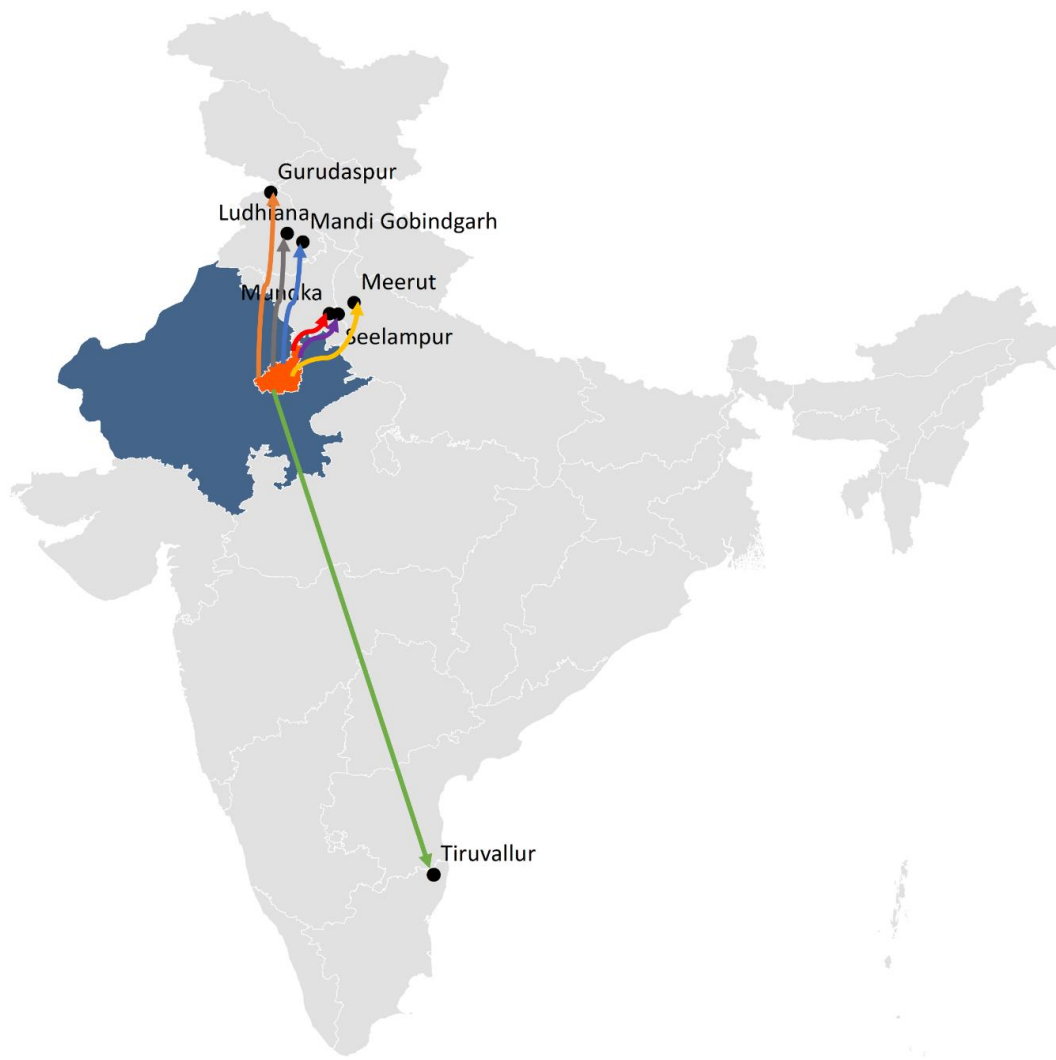
Source: Authors

Similarly, sorting e-waste from other waste types (Figure 5) helps retailers earn money by selling the e-waste materials at a higher price in Rajasthan. The wholesalers use their personal contacts to sell the sorted e-waste materials to recyclers in Rajasthan and in neighbouring states like Delhi, Punjab, Haryana, and Uttar Pradesh for material recovery. For instance, battery wastes are sent to Tamil Nadu, electronic scrap materials are sent to Delhi and Meerut (Uttar Pradesh), ferrous materials are sent to Gurudaspur, Govindpur, and Ludhiana (Punjab), and plastics are sent to Mundka (Delhi) (as indicated in Figure 6).

This informal network for the recycling of e-waste is a narrative that has been introduced previously; even in the case of China, when the formal recycling

industry was still in the developing phase, there was already an established informal recycling network (Chi et al., 2011). Since the informal network is already very well established, Chi et al. (2011) argues that abrupt abolishment of the network might be counterproductive. In addition, the informal e-waste management industry is an important avenue for unskilled local and migrant labours (Zhang et al., 2012). Therefore, establishing the ERP must be undertaken through integration of the informal e-waste management industry. In the context of Rajasthan, the state is in its initial phase of establishing an ERP. It is expected that the state initiative might streamline the working of informal recycling network through the collection, transportation, and waste segregation routes.

Figure 6: E-Waste flows from Jaipur



Note: This is a thematic map designed for representation. Thus, the map is not to scale and without prejudice of national and international boundaries.

Conceptualisation of ERP

According to the state's E-waste disposal (draft) policy of 2022, the recycling park will put together e-waste recyclers alongside other types of waste recyclers, including end-of-life vehicles (ELV), batteries, plastic and other hazardous waste. It will help the state government to promote circular economy and facilitate the private actors to set up recycling plants that use state-of-art technology for recycling of e-waste. Additionally, the park will contain facilities like testing labs, a market for refurbished goods, facilities for employees engaged in processing e-waste to expand their skills, an awareness centre, and facilities for private recyclers to buy e-waste from the informal actors like *kabadiwalas*, retailers, and wholesalers (Government of Rajasthan, 2022).

The discussion with government officials revealed that the location for the recycling park in Tholai,

Jaipur has been decided in consideration of multiple factors. First, Jaipur has a locational advantage. It is situated nearby to two major urban centres, i.e., Gurgaon in Haryana, and Delhi; thus, the e-waste flow from these regions can serve as a supply to the park, in addition to the e-waste generated within the state itself. Moreover, these regions can also play a role in the market for reselling recycled materials. Second, the park has robust road connectivity. It is located along the Agra-Delhi-Jaipur highway, which helps to minimise the cost of e-waste transportation. Third, the availability of state-owned land on the outskirts of Jaipur. The state industrial development department, Rajasthan State Industrial Development and Investment Corporation (RIICO) previously acquired a large portion of land for industrial development purposes and helped the state government to streamline the process by reducing the time required for land acquisition. Fourth, the availability of public utilities, i.e., source of water and

regular supply of electricity in the state capital, makes it a suitable site for the recycling activity.

Role of state government bodies and financing of the ERP

Multiple state government departments are involved in the establishment of the e-waste recycling park in Rajasthan. RIICO is supplying the land parcel. It has identified 48 ha of land parcel at Tholai, Jaipur, for the establishment of the park. In addition, it is also responsible for the provision of infrastructure and basic services. While the Rajasthan State Pollution Control Board (RSPCB) is acting as the main nodal agency, which is not only communicating with different stakeholders but is also formulating the guidelines on how to establish a recycling park in alignment with the environmental guidelines. The discussion with the RSPCB officials revealed that the department has contacted one bilateral agency for providing technical support and helping in the preparation of the master plan for the park. In addition, it also came to light that the RSPCB is in talks with several private recyclers (like Tatas, Mahindra, GEPIL and RAMKY) to set up their recycling plant inside the park with the expectation that they will bring in state-of-art technology as well.

Establishing the recycling park involves a high upfront cost for creating a world-class infrastructure facility. In order to address this problem, the state government has explored multiple sources of funding opportunities. For instance, it has reached out to the central government and secured INR 50 Crore of grants under the *Gati Shakti* program.¹⁷ In addition, the state government will be providing a financial package under the Rajasthan Investment Promotion Scheme (RIPS) of 2022 to incentivise the recyclers, in the form of investment subsidies, exemption of stamp duty, electricity duty, market fees, land tax and conversion charges, interest and capital subsidies (Government of Rajasthan, 2019). It will help recyclers to subsidise the cost of recycling and channelise the e-waste generated within the state and neighbouring states to the e-waste recycling park (Government of Rajasthan, 2022).

Operationalising and addressing environmental concern

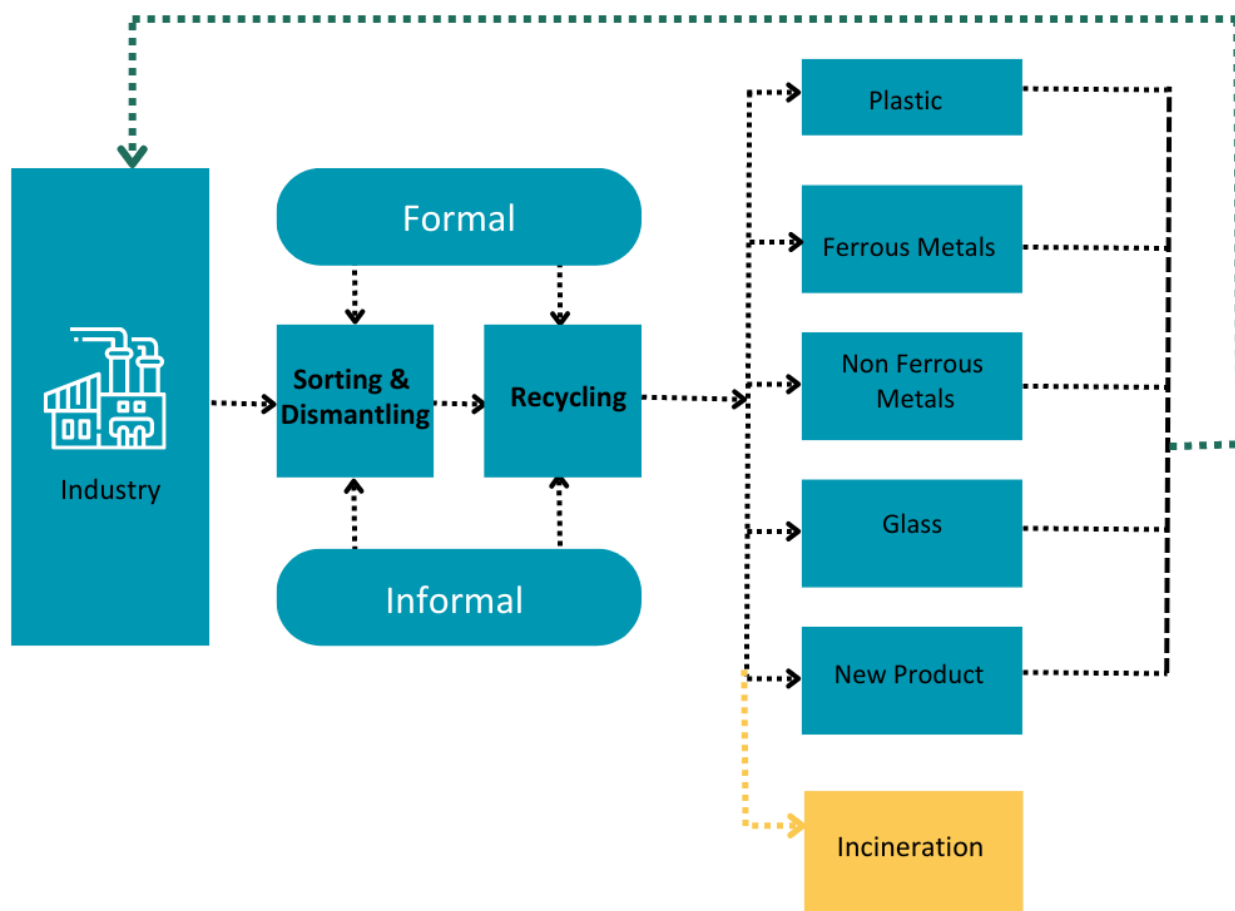
To promote the ERP, the Government of Rajasthan, on one hand, is encouraging state departments not to dispose of e-waste with other scrap items under the “condemnation and disposal policy for e-waste” (Government of Rajasthan, 2022). On the other hand, it strengthens the informal sector to sell its waste within the formal sector. These efforts are anticipated to increase the collection of e-waste and promote its environmentally sound management. As the recycling park is being conceptualised in accordance with the eco-industrial concept, the park will be established following an environmental-neutral pathway to achieve end-to-end recycling goals.

E-waste is a complex waste and difficult to categorise due to its diversity and differential life cycles (Rathore, 2020). Thus, the co-existence of different recycling industries under one roof will facilitate the process of recycling each other’s generated waste (as depicted in Figure 7). Further, the produced waste of one industry could be used as input to the other industry creating mutualistic synergies. The entire process will be monitored under the larger umbrella of environmental guidelines published under the E-waste (Management) Rules, 2022 to address the environmental concerns involved with the manufacture, sale, transfer, purchase, refurbishing, dismantling, recycling and processing of e-waste (Government of India, 2022). In addition, the Rajasthan E-Waste Disposal (draft) policy of 2022 aims to provide specialised training to workers to create awareness about the negative impacts of unsafe handling of e-waste on health and the environment.

Figure 7 depicts the schema for ERP, which involves various essential steps required for setting up ERPs. It provides a basic overview of how a waste processing facility might sort, dismantle, and recycle different materials. Major e-waste is primarily generated by industries from various backgrounds. The collected waste goes through sorting and dismantling, where different materials are separated. This process involves two streams: formal and informal. Post the sorting, the materials are recycled to obtain various metals, as shown below. However, incineration forms the final step to destroy the waste.

¹⁷ *Gati Shakti* – National Master Plan for Multi-modal Connectivity was launched in October 2021. It is a multi-modal connectivity programme with a vision of providing integrated and seamless connectivity for the movement of people, goods, and services from one mode of transport to another (GoI, 2021).

Figure 7: A Schema for ERP



Source: Author's compilation

6. Conclusions and Recommendations

The development of ERP offers an enormous opportunity for industrialisation, economic growth, and environmental safeguarding. However, capitalising on the opportunity requires planning and implementation of ERPs. This working paper has overlined a set framework to assist policymakers in planning and implementation of new ERPs. In order to establish ERPs, several broader aspects of consideration will include:

Operationalizing Strategies: Turning Policy into Action

- Understanding feasibility is one of the earliest steps in establishing ERPs. This step helps identify the factors that require more focus to build ERPs. For instance, in the case of Rajasthan, we identified that the availability of land parcels, financing, and proximity to the market played critical roles in the park's inception.
- The park's long-term success depends on the state's e-waste collection capacity (Moerenhout et al.,

2022). While the existing policies are ambitious, an equally stronger waste collection chain needs to be established to ensure the success of ERPs.

Legislative Assessment: Centralizing Management Efforts

- Identifying government bodies and mapping the existing stakeholders responsible for recycling is essential to establishing ERPs. In the case of Rajasthan, the state pollution control board is playing the role of principal nodal agency, which is the contact point between government bodies and private actors. In addition, the board could also help operationalise environmental guidelines.
- State governments will need to identify incentives to attract private investors to the park. The state of Rajasthan is offsetting the initial cost of setting up the infrastructure facilities and also providing financial incentives to attract investors. This will also encourage symbiosis between recyclers, resulting in efficiency and profit gains.

Integrating with the Informal Sector: Harnessing Local Expertise

- The development of ERPs must consider the well-established informal e-waste recycling network. The sudden abolishment of the informal network can prove counterproductive since they are already deep rooted and function efficiently. Thus, the development of ERPs must also be cognisant of the informal sector and should be inclusive by design.

Technological Innovations: Advancing Sustainable Solutions

- The success of ERPs is also dependent on the recycling of diverse sets of e-waste and industrial symbiosis between the industries recycling them.

This step is critical to achieving economies of scale as the waste and recycled product from one industry could be used as input by other industries resulting in cost-sharing between industries.

- Another critical factor for the success of ERPs is the adoption and availability of state-of-the-art recycling technologies. The latest technologies have made it possible to recover metals with high efficiency and in an environmentally sound manner.
- ERPs should be an integrated facility, inclusive of a testing lab, raw material storage, training, and skill development facilities. It should be built using environmentally sustainable principles promoting the use of renewables and water harvesting, and aimed towards zero waste production.

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