SUSTAINABLE RECYCLING INDUSTRIES

Bridging the gap between the formal and informal e-waste sector in Egypt

Partnership vs. Bypass Approaches

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SRI SUSTAINABLE RECYCLING INDUSTRIES

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Turning waste into resources for development

SRI builds capacity for sustainable recycling in developing countries. The programme is funded by the Swiss State Secretariat of Economic Affairs (SECO) and is implemented by the Institute for Materials Science & Technology (Empa) and the World Resources Forum (WRF). It builds on the success of implementing e-waste recycling systems together with various developing countries since more than ten years.

Acronyms

BFR	Brominated Flamme Retardant Plastics
CEDARE	Centre for Environment and Development for the Arab Region and Europe
EEE	Electrical and Electronic Equipment
Empa	Swiss Federal Institute for Materials Science and Technology
EPR	Extended Producer Responsibility
MCIT	Ministry of Communication and Information Technology (Egypt)
MoE	Ministry of Environment (Egypt)
POM	Put on market
PCB	Printed Circuit Boards
SRI	Sustainable Recycling Industries
StEP	Solving the e-Waste Problem Initiative
WEEE	Waste Electrical and Electronic Equipment
WRF	World Resources Forum
WMRA	Waste Management Regulatory Authority

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Executive summary

Rising global affluence and consumption have led to an increase in the generation of electronic waste (e-waste). The informal sector, prevalent in low- and middle-income countries such as Egypt, plays an important role in the collection of e-waste, but poses risks to human health and the environment due to substandard recycling practices. It has low recovery rates, resulting in the loss of valuable materials, and its predominant control over most of the e-waste leads to shortages at formal recycling facilities. This hampers the nascent formal sector as it struggles with the challenge of limited availability of e-waste for processing and recycling. Informal collection networks outperform formal ones in terms of efficiency, while formal treatment processes excel at recovering more resources from e-waste. Merging these systems offers the potential to maximize the efficiency of both e-waste collection and processing.

The overall objective of this study is to establish an international benchmark for successful approaches to bridging the collection gap between the formal and informal sectors, drawing on existing literature and case studies from various developing countries. The study examines the likelihood of success of these approaches in the specific context of Egypt, involving extensive stakeholder engagement to identify key challenges and opportunities. The goal is to outline the most appropriate solution for bridging the gap between the formal and informal sectors in Egypt, to be piloted in the future as part of the Sustainable Recycling Industries (SRI) activities funded by the Swiss State Secretariat for Economic Affairs (SECO) and implemented by the Centre for Environment and Development for the Arab Region and Europe (CEDARE) and the consulting firm DSS Sustainable Solutions Switzerland (dss+).

The study recommends the adoption of an intermediary organization approach, which revolves around an intermediary entity equipped with the necessary financial resources to purchase e-waste from informal collectors and subsequently facilitate its transportation or sale to formal recycling facilities. This arrangement ensures that e-waste collected by informal workers is diverted from illicit channels and recycled in an environmentally sound manner. To discourage informal workers from selling their collected waste to informal recyclers or larger scrap dealers, the intermediary organization matches market prices and offers additional incentives such as micro-insurance and loans. For a potential pilot, fundraising would involve linking with established PROs for donations in exchange for a recycling certificate. Funds would be channelled through an independent organization overseen by a financial regulatory agency or committee. The intermediary organization, possibly the formal Egyptian Recyclers Association, would play a key role in facilitating the purchase of e-waste from informal actors. Independent storage facilities would be used for secure storage, and an auction would be held with only accredited formal recyclers participating. The proposed solution is illustrated in Figure 1.

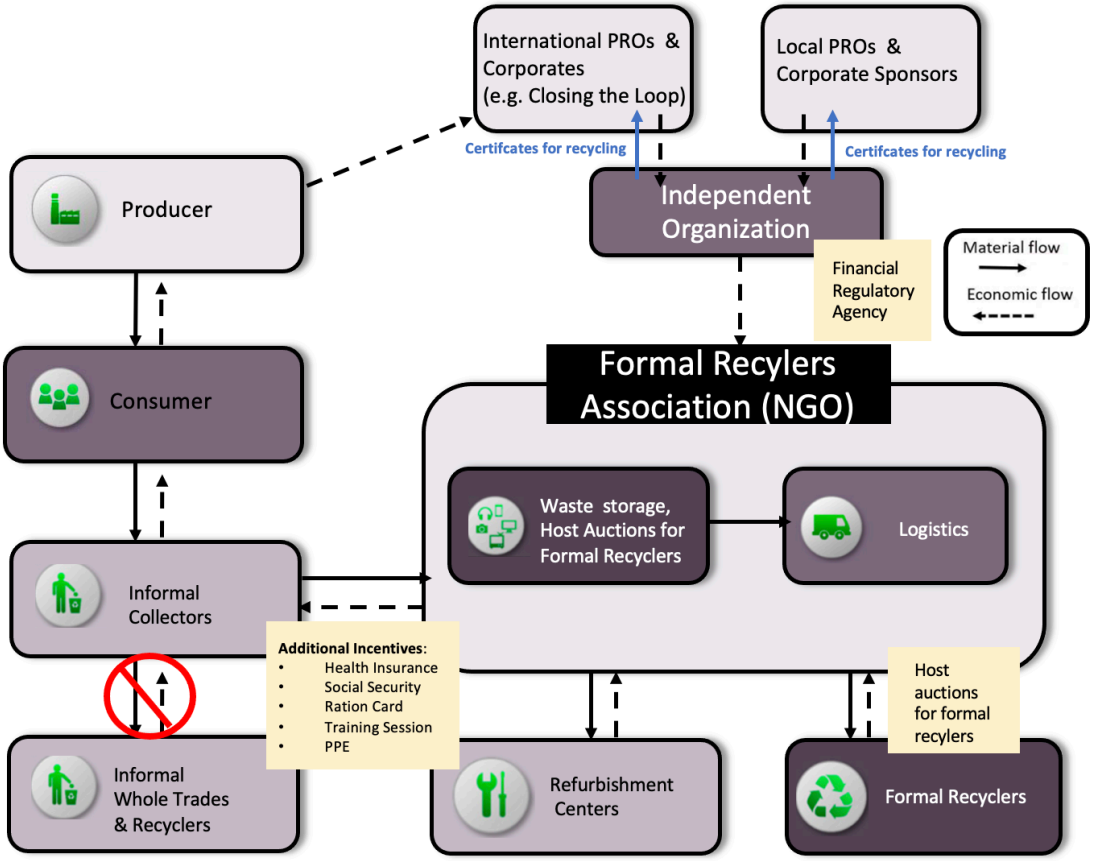

Figure 1: Overview of the Intermediary Organization Approach suggested for Egypt.

Keywords

Formal Sector, Informal Sector, Partnership Approaches, Bypass Approaches, WEEE

1 Introduction

1.1 Background

With the global increase in prosperity and consumption, there has been a corresponding surge in the generation of waste electrical and electronic equipment (WEEE or e-waste), while the corresponding waste management system could not keep up sufficiently in all regions. This challenge is particularly pronounced in low and middle-income countries like Egypt, where the informal sector plays a major role in e-waste collection and management in the country. While these informal activities provide livelihoods for many and contribute to high collection rates, the substandard recycling methods employed pose substantial risks to human health and the environment. Furthermore, they result in the loss of valuable and scarce materials. On the other hand, the formal sector is still in the process of emerging and growing, yet it faces a significant obstacle—the scarcity of e-waste available for processing and recycling. This challenge arises primarily because the informal sector collects and processes the majority of e-waste in Egypt. This issue is often termed as a "collection deficit" or a limitation in terms of access for formal recycling facilities to obtain e-waste. Presently, Egypt lacks the requisite legislation and guidelines for the proper management of e-waste and the framework for allowing formal and informal sector interplay and synergies. However, the Egyptian government is actively working to formalize the e-waste recycling sector through collaborative efforts with international organizations. Despite these endeavours, there is still much work ahead.

The Sustainable Recycling Industry (SRI) program represents one such initiative aimed at supporting Egypt, generously funded by the Swiss State Secretariat of Economic Affairs (SECO). Implemented by the Center for Environment and Development for the Arab Region and Europe (CEDARE) and the consulting company DSS Sustainable Solutions Switzerland (dss$^+$), with key partnerships including the Ministry of Communications and Information Technology (MCIT) and the Egyptian Ministry of Environment (MOE), this program is dedicated to a vital cause. Its overarching goal is to facilitate the establishment of a sustainable recycling industry for e-waste and related waste streams. Specifically, the program places emphasis on governance and technology aspects that enable the efficient recovery of secondary raw materials and the safe handling of hazardous substances. The objective of the Sustainable Recycling Industries project (SRI) is to achieve the sustainable integration and participation of small and medium enterprises, as well as the informal sector from developing and transitioning countries in the global recycling of secondary resources.

Despite the remarkable progress made by the SRI project over the years, the complex issue remains unsolved. This issue revolves around the gap between the formal and informal sectors and is of utmost importance to resolve. Its complexity arises primarily from the challenges associated with engaging informal sector workers. This issue lies at the core of the problem, influencing both the growth of the formal sector and the development of the recycling framework.

1.2 Objective & Outline

To address these critical issues, the report's primary objective is to understand the interplay and dynamics between the informal and formal sectors in the context of e-waste collection and management in Egypt. This study aims to present a comprehensive overview of approaches and existing informal-formal partnership models from different parts of the world to evaluate their relevance and potential applicability in the specific environmental context of Egypt. These partnership concepts aim to facilitate the achievement of high recycling rates and compliance with legislative requirements, often related to extended producer responsibility (EPR) or other take-back systems in low and middle-income

countries. It is crucial to explore the potential benefits and challenges associated with various partnerships and alliances between the formal and informal sectors. Such exploration can promote integrated solutions among different stakeholders, delivering social, financial, and health benefits while ensuring sustainable waste management across the entire value chain.

The second chapter of the report provides a detailed snapshot of the e-waste management landscape in Egypt as of 2023. It offers a glimpse into the physical system employed for handling e-waste and focuses on the socio-economic and legal framework that defines e-waste management in Egypt. The third chapter sheds light on the methods and techniques employed in this research. It includes an explanation of the interviews and secondary literature reviews used, providing insight into the foundation of the study. Chapter four pinpoints the most pressing issue in the context of e-waste management. A comprehensive comparative assessment of both the formal and informal sectors is conducted to better understand the challenges they face.

Chapter five takes a closer look at the various approaches available for bridging the gap between the formal and informal e-waste sectors. It examines existing approaches in depth, outlining their advantages and disadvantages when applied to the Egyptian context. A side-by-side comparison of the two most promising solutions is presented. In the final chapter, the report provides an outlook on the future work that needs to be carried out to address the identified issue. It presents recommendations for overcoming the challenges in e-waste management, considering both the formal and informal sectors. This section aims to pave the way for future actions and developments in this crucial field.

2 E-waste Management in Egypt 2023

2.1 Description of physical system

The Egyptian e-waste management system involves a multitude of stakeholders, both formal and informal. The e-waste management system can be categorized into three key phases: generation, collection, and treatment, which includes sorting, dismantling, and recycling through hydrometallurgical processes to recover valuable secondary raw materials (Figure 2). Treatment and recovery encompass crucial processes such as sorting, dismantling, and recycling through hydrometallurgical methods, aimed at the recovery of valuable secondary raw materials.

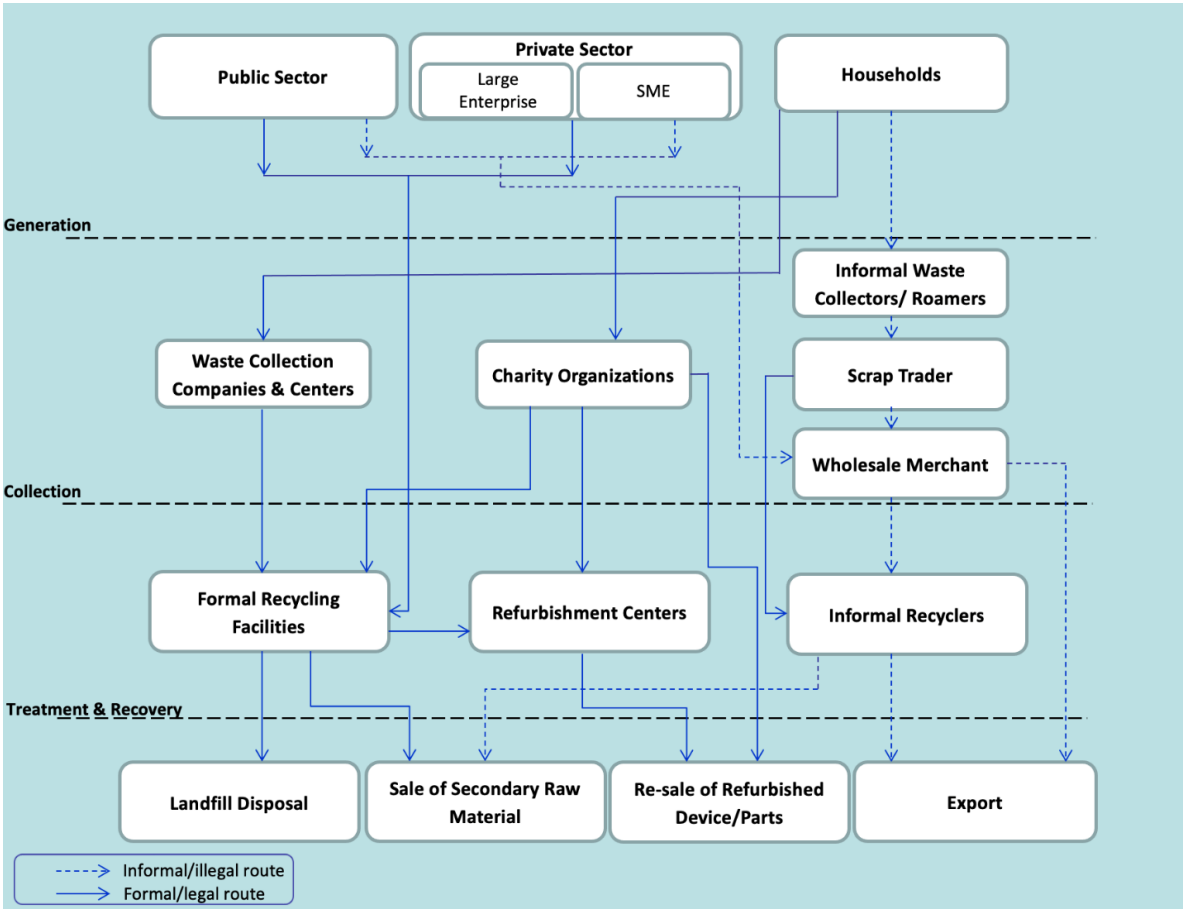

Figure 2: E-Waste management system Egypt 2023: Informal practices, considered illegal under Egyptian law but still applied, are represented by dashed arrows, while formal processes are indicated by solid lines.

2.1.1 Generation

Based on import/export statistics and lifetime profiles from the study conducted by G. Iattoni et. al. [1], Egypt introduced approximately 1.1 million metric tons (Mt) of Electrical and Electronic Equipment (EEE) to the market in 2019, resulting in the generation of 0.6 Mt of Waste Electrical and Electronic Equipment (WEEE) in the same year. These figures provide a glimpse into the substantial potential for e-waste management in the country. Notably, Egypt exhibited the highest level of EEE Put on Market (POM) in the region in absolute terms, reaching 1.1 Mt in 2019, surpassing other countries such as Saudi Arabia (758 kt), Iraq (459 kt), and Algeria (458 kt) [1]. This underscores the significant scale of e-

waste in Egypt. Furthermore, the per capita e-waste generation for Egypt stands at approximately 4.9 kilograms per inhabitant [1], indicating the considerable volume of electronic waste that can be harnessed for effective and sustainable management strategies in the country.

2.1.2 Collection

Household E-Waste

In the domain of household e-waste collection, there are three principal entities. First, the informal sector, characterized by door-to-door collectors and roamers, assumes a pivotal role in Egypt's e-waste management landscape. This sector is most notably represented by the "Zabbaleen," or Traditional Waste Collectors, who provide daily door-to-door collection services, encompassing a diverse array of waste materials, including household items. They are typically situated within designated areas in the Greater Cairo Region, often referred to as "garbage complexes." Complementing their efforts are the "Roamers" or "Sarriiha," who actively engage in street-level activities that involve the purchase, trade, and exchange of recyclable waste items, including Waste Electrical and Electronic Equipment (WEEE) [2]. These individuals possess extensive knowledge of repairing aging appliances and rudimentary machinery, and they maintain connections with professional refurbishers who may acquire these items. This route was omitted from figure 1, for the sake of clarity [2].

The collected waste follows a structured trade process and is guided through by an intermediary group known as "Scrap Traders." These scrap traders serve as middlemen and intermediary buyers/dealers, strategically positioned within and beyond the garbage collector's neighborhoods. They operate as dealers who maintain small-scale depots and subsequently supply wholesalers and significant buyers with recyclable materials [2].

The choices faced by informal wholesale merchants in this complex system are multifaceted. Wholesale Merchants play a vital role in this intricate system. They purchase recyclables in bulk from small merchants who roam the streets and from the scrap traders. These wholesale merchants are recognized for their expansive warehouses, each specializing in a distinct category of recyclable materials. Wholesale merchants have three primary options for the distribution of e-waste:

- Export: The export of e-waste is highly sought after due to the prospect of higher profits. Wholesale merchants say choose to engage in this practice, capitalizing on the international market for e-waste materials, which is currently illegal in Egypt.

- Formal Recycling Facilities: Wholesale merchants have the option to sell e-waste to formal recycling facilities. However, this choice is often hindered by the inability of formal recyclers to offer competitive prices, given their substantial overhead costs. In addition, it’s legally prohibited for formal recycler to purchase e-waste from informal actors. Formal recyclers cannot include such purchases in their cost of goods sold, given their origin from an illegal entity and the absence of proper documentation such as receipts and tax identification numbers from the wholesale trader. This route was omitted from figure 1 for the sake of clarity.

- Informal Recyclers: As an alternative, merchants may opt to sell e-waste to informal recyclers. These informal recyclers often employ environmentally substandard processes to recover precious materials more lucratively, though at the cost of environmental standards and safety.

Two other smaller players in e-waste collection are charitable organizations and private sector companies and drop off locations. Charitable organizations play a significant role, receiving substantial donations and maintaining well-established networks across different governorates (states). Private sector collection companies are actively involved, offering incentives for the drop-off of household e-

waste at designated collection points, often providing rewards for such contributions. Notably, E-Tadweer, a prominent company in this domain, will be explored in greater detail later.

Public and Private Sector E-Waste

In both public sector and the private sector (comprising small and medium enterprises (SMEs) and larger enterprises) e-waste collection, a common practice involves the use of auctions, wherein only licensed e-waste recyclers are eligible to participate. The process typically begins with an entity seeking to dispose of their e-waste, which involves contacting an appraiser office or pricing expert or e-waste consultant. The role of these experts is twofold: to classify the materials as either hazardous or non-hazardous and to prepare the necessary documents, including an Environmental Requirements Booklet and licenses such as factory operating license and inclusion in the industrial registry, which are required for participation in the auction.

In many cases, there is a lack of rigorous enforcement of the laws governing e-waste disposal. Wholesale merchants and traders who are not formal and do not possess the necessary licenses, often participate in these auctions, offering exceedingly high prices that formal recyclers struggle to match as they need to comply with social and environmental legislation, resulting in a situation where the latter do not obtain the e-waste materials they need. Consequently, there is a significant shortage of e-waste at their facilities, impeding their operations. To address this issue, a meeting was convened at the headquarters of the Egyptian Ministry of the Environment, gathering all 22 pricing specialists/consultants across the country as well as representatives from WMRA and the formal recyclers association, all of whom actively participated in the discussion. During the meeting, five issues were raised and discussed:

- **Missing Segregation of E-Waste:**

The primary issues with these auctions is that they frequently feature mixed lots of waste, such as construction waste, e-waste, medical waste, household waste and more. In many instances, the public and private sector entities do not undertake the segregation of these materials. This lack of sorting and classification further complicates the e-waste handling process.

- **Unlawful Sale of E-Waste as Used Goods:**

A significant portion of appraiser offices, also referred to as pricing offices or consultants, engage in the sale of waste materials, presenting them as used goods. This practice serves to circumvent the requirement of drafting an Environmental Requirements Booklet and specifying the licenses necessary for participation in auctions. By doing so, they exploit a legal loophole that allows anyone to participate, as no environmental licenses are needed, thus enabling the sale to scrap traders or wholesalers at higher prices to maximize profit.

Article 25 of the Egyptian Tax Authority Law No. 91 of 2005, provides specific depreciation rates for different asset categories, including computers, information systems, and data storage devices. The law dictates that these assets (e.g., computers, information systems and data storage devices) depreciate annually at a rate of 50 % of their initial value for each tax year. In contrast, all other activity assets depreciate at a rate of 25 % for each tax year. Consequently, this implies that the maximum value remaining is the salvage value of the asset, which goes to zero after four years. When an asset reaches this point, it is officially considered abandoned and is no longer in use. This legal categorization classifies it as e-waste, subject to appropriate regulations.

Furthermore, Minister of Industry and Trade Resolution No. 603 of 2007 outlines regulations regarding the import of computers, information systems, and their derivatives as used items. One key stipulation is that no more than five years should have elapsed since their production date up to the date of shipment. This regulation is designed to ensure that only relatively recent equipment is considered for import. These stringent controls are put in place to regulate the age and quality of imported items, reinforcing the need for transparency in the handling of e-waste.

- **Lack of clarity and confusion regarding liability:**

Most appraisal offices (pricing experts/e-waste consultants) do not require environmental requirements for the sale of electronic waste and other waste at auctions. They justify this by asserting that the entity requesting the sale of its waste does not wish to include it. However, the appraisal office is responsible for arranging the preparation of the specifications booklet, financial and technical points, and environmental requirements, as it is assigned to the entity (government sector, public sector, private sector) in the sale process in exchange for a sales commission. Thus, the appraisal office owner will be fully legally responsible, not the entity requesting the sale. So, it falls within their jurisdiction to ensure that the e-waste is handled by a formally accredited recycler, that meets all requirements and has the necessary licenses and certificates. Unless the entity sells itself and not through the office of an expert, it will bear full legal responsibility. This practice is in violation of Law 202 of 2020, Article 55 and Article 75, which penalizes anyone who violates the provisions of the second paragraph of Article 55 with a fine of not less than two hundred thousand Egyptian pounds and not more than one million Egyptian pounds. This law mandates compliance, and there is no choice to disregard it, as doing so would expose one to legal repercussions. This arrangement places the responsibility and liability on the consultancy firm after the contract has been signed, rather than on the company seeking to dispose of the e-waste.

- **Accept incomplete application documents and sign a promise pledge to comply with environmental requirements:**

Many expert appraiser offices routinely facilitate the sale of waste to individuals who have secured environmental approval, often without requiring the additional documentation of a factory operating license and inclusion in the industrial registry. In these cases, the offices permit participation even in the absence of essential documents and certificates, opting instead for a pledge in which bidders commit to adhering to environmental requirements and assuming full responsibility for compliance. This practice is in violation of Egyptian Law 202 of 2020, as the responsibility for accreditation of Egyptian recycling companies falls under the purview of the Waste Management Regulatory Authority (WMRA). In the process of accreditation, WMRA collaborates with a committee comprising representatives from the Ministry of Environment and the Ministry of Industry and Trade to evaluate the companies. Following this evaluation, companies that meet the necessary criteria can be approved by the WMRA to be included in the list of authorized e-waste recycling companies. Hence, it is imperative not to accept any company that is not included in this list on the day of the auction. The list can be directly obtained from the regulatory authority (WMRA) or through the formal recycler NGO association, which receives periodic list updates.

- **Selling waste directly to transport companies approved by the Ministry of Environment:**

A significant portion of expert appraiser offices engage in the practice of selling waste through auctions, although they specify selling to transportation companies that hold approvals and licenses from the Ministry of Environment. This approach is also a violation of the law, as it is legally mandated to sell waste directly to waste recycling facilities and obligate these facilities to contract and transport through transportation companies approved by the Ministry of Environment. When waste is sold to

waste transport companies accredited by the Ministry of Environment, there is a risk that it may not be delivered to waste recycling facilities and could instead be diverted to the informal sector. In situations where a contract is awarded for one of the waste recycling facilities, it is imperative that the transportation is carried out through waste transportation companies approved by the Ministry of Environment, in accordance with legal requirements.

The fruitful meeting and discussion of all involved entities led to the following conclusion:

In the near future, all expert appraiser offices (pricing experts/e-waste consultants) will be mandated to register with WMRA, complete the requisite legal documentation, and pay the prescribed fees to obtain an annual license for conducting waste sales at auctions. Non-compliance with these regulations will result in legal consequences and the revocation of the license. The Minister of the Environment and the Minister of Supply and Internal Trade emphasized the imperative for expert offices to collaborate with the WMRA. This collaboration involves submitting the specifications booklet and adhering to the instructions, requirements, and laws stipulated by WMRA when offering waste auctions. The outcome of the meeting led to the decision that waste is no longer to be sold as mixed lots. Instead, e-waste should be separated, and a distinct auction will be organized, permitting only accredited entities approved by WMRA to participate. Furthermore, there will be more frequent unannounced inspections during these auctions to ensure compliance with the established regulations.

2.1.3 Treatment & Recovery

Formal Sector

The information in this section is drawn from collaborative audits conducted by Vans Chemistry and dss^{+} under the Sustainable Recycling Industries (SRI) Programme. These audits were conducted from February to April 2023 and encompassed 12 authorized recycling facilities in Egypt, recognized by both the Ministry of Environment and the Ministry of Industry. Additionally, the section also references findings from visits to two accredited recycling facilities in Egypt in June 2023 and several interviews with members of the formal recycler's association in Egypt in 2023.

The formal e-waste recycling sector in Egypt is rapidly evolving, with new companies continuously entering the field. A common challenge within this sector is the practice of cherry-picking, where recycling companies primarily focus on processing high-value items like ICT waste (computers, tablets etc.), printed circuit boards, and copper wires, as these yield the greatest financial returns. This approach is understandable given the profit-driven nature of these businesses. Consequently, they often opt not to handle or accept other types of e-waste that may be economically unviable to recycle or yield lower returns. This selective practice is further enhanced by the absence of an Extended Producer Responsibility (EPR) fee or recycling fee in Egypt, which is typically paid by producers/consumers to support environmentally responsible recycling of such net-cost fractions (such as cooling appliances, CRT screens, lamps). The fierce competition and scarcity of materials in the market further contribute to this behavior among formal recyclers.

As of early 2023, WMRA reported a total of 12 authorized recycling facilities in Egypt:

- Energy Co
- International Company
- Al Fardous
- EERC
- ITG
- Triple REE
- Arabian WEE

- Al Amal Corporation
- Recycle Key
- German Trading
- Al-Arayshi
- Green Core

Formal recycling facilities in Egypt employ various processes to recover valuable materials from e-waste:

- **Dismantling & Component Removal:** This involves the removal and dismantling of electronic devices, as depicted in figure 3.

- **Mechanical Shredding/Separation:** E-waste is mechanically shredded and separated to isolate valuable materials, as illustrated in figure 4.

- **Cable Stripping:** Copper cable stripping is the process of removing the external insulation or sheathing from copper cables, exposing the copper wire within. This recovered copper wire can then be recycled or reused in various applications.

- **Electrolytic Copper Recovery (Electroplating):** Electrolytic copper recovery, also known as electroplating, is a purification process where impure copper (the anode) is selectively electroplated onto pure copper sheets (the cathode) within an electrolyte solution, effectively separating and refining the copper by eliminating anode impurities. This process ensures the production of high-quality, purified copper for various applications. Figure 5 shows an image of a lab-scale electroplating unit.

- **Precious Metals Recovery (Lab-scale):** Research and development efforts are centered on the extraction of precious metals like gold, silver, and palladium through leaching processes involving strong acids.

These processes yield several valuable materials from e-waste, including:

- Fiber Reinforced Plastics (FRP) Dust/Plastics
- Ferrous Metals
- Copper (typically on a relatively small scale)
- Tin/Lead (also on a small scale)
- Gold (research and development stage)
- Silver (research and development stage)

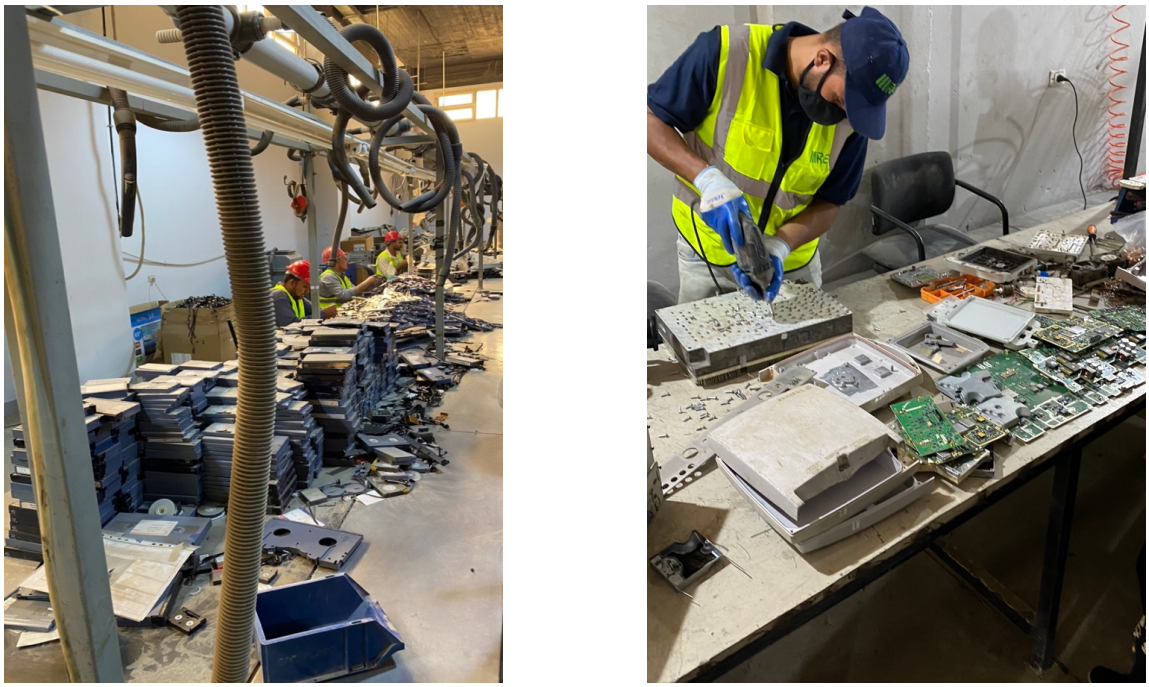

Figure 3: On the left three workers are shown dismantling old VHS cassettes and e-waste equipment. On the right a worker is depicted dismantling a PCB from communication tower equipment.

Figure 4: Shredding equipment found at Egyptian recycling facilities.

Figure 5: Electroplating device for copper recovery and refining.

As printed circuit boards represent the most sought-after e-waste fraction for formal recyclers, it's crucial to examine the recycling process commonly employed by most formal recyclers in Egypt. A typical process involves the removal of all components (e.g. capacitors) through a heat-based desoldering process. Subsequently, the boards are shredded, and using blowers, the resulting powder is propelled into the air, allowing it to fall freely and separate by weight. This means that everything containing metals falls to the bottom of the tower, while the lighter plastic components are expelled by other blowers. The fraction at the bottom of the tower consists of metals. The ferrous metal fractions are separated from the non-ferrous fractions using a magnet. Non-ferrous fractions containing copper, aluminum and other metal fractions undergo incineration in a high-temperature furnace and are further processed in an electrolytic cell through electroplating. Electrolytic copper recovery, also known as electroplating, is a sophisticated purification process for impure copper. This method utilizes two essential components: the anode and the cathode. In this process, the anode, a positive electrode, is made from the impure copper requiring purification (from high-temperature furnace), while the cathode, a negative electrode, is composed of pure copper or stainless steel. Both the anode and the cathode are immersed in an electrolyte solution containing sulfuric acid and copper (II) sulfate, which facilitates the movement of ions during the electroplating procedure. Anode plates are hung by their "handles" in electrolytic copper refining tank, as shown in figure 5. Pure copper cathode or stainless-steel sheets suspended on solid copper bars are inserted into the same tank, one sheet between each anode. As an electric current flows from the anodes through the electrolyte to the cathodes, copper ions from the anodes are transferred into the solution. Here, pure copper is selectively electroplated onto the starter sheet, serving as the cathode. This electroplating technique effectively separates pure copper from the impurities present in the anodes. This process yields copper with a purity of >99 %. Additionally, as a byproduct, a slurry or sludge containing precious metals is obtained, which undergoes further refinement with the use of mixture of nitric and hydrochloric acid, which is known as aqua regia.

However, there are challenges in the formal recycling sector. These facilities primarily operate at a lab-scale or in batch-wise processes rather than continuous industrial-scale operations. There is also a lack of knowledge about technologically advanced and environmentally friendly recycling facilities and

technologies. Most of these facilities focus on handling printed circuit boards (PCBs) and do not process other types of e-waste. Additionally, the facilities face issues such inadequate infrastructure, basic equipment shortages, and limited pollution control measures. There's a need for increased work safety and environmental awareness. It is also necessary to allocate funds for an analytical chemical laboratory to identify hazardous materials and to assess the quality and purity of refined metals. A few facilities practice dismantling, refurbishing, and reusing components or it is sold to refurbishment centers, if the know-how is not available inhouse. Most companies report a shortage of feedstock, resulting in their operations running at only 20-25 % of their capacity.

Informal Sector [2]

Activities performed by informal workers associated with e-waste pose severe health risks for dismantlers, affecting them both physically and biologically due to exposure to hazardous chemicals. Inadequate tools, machinery, and the absence of personal protective equipment contribute to an elevated risk of on-the-job accidents, potentially resulting in long-lasting disabilities or chronic injuries that significantly limit future income opportunities. The lack of safety precautions, proper tools, protective gear, separation between residential and work areas, and the use of toxic chemicals further exacerbate the health hazards faced by these informal workers. Recycling practices for selected e-waste fractions performed by informal collectors and recyclers workers are presented below:

- **Copper Cable Burning:**
  1. Process: Copper separation from cables through burning, emitting CO, CO_2, and potentially Dioxin and Furan from plastic burning.
  2. Concerns: Most workers are conducting the burning process in transfer stations.

- **PCB and Metal Recycling:**
  1. Process: Dealers send PCBs to families in rural areas for gold extraction using a chemical process.
  2. Concerns: The dismantling and recycling process involves the use of strong acids and mercury, posing risks to both workers and the environment. The process occurs without proper protection, exposing families, especially women and children, to high risks.

- **CRT (Cathode Ray Tube):**
  1. Process: CRTs are dismantled, checked for reuse, and sold to refurbishers or glass producers if non-useful.
  2. Concerns: The process may involve lead exposure during dismantling, and non-useful CRTs are sold for glass production.

- **Plastics:**
  - Process: Plastics are separated by color and hardness, washed, dried, and reused in injection mold machines.
  - Concerns: No extended producer responsibility (EPR) exists for recycled plastics, and the process generates waste dumped in municipal sites.

Residues resulting from the WEEE dismantling process, including brominated flame-retardant plastics (BFR), are being inappropriately discarded in regular municipal dumping sites. This is contrary to proper disposal procedures, as the Nasreya landfill in Alexandria governorate, is the designated facility equipped to manage hazardous waste. The disposal cost for one ton of waste is around EGP 500, and additional expenses for transportation to Nasreya further contribute to the financial strain. Considering these financial challenges, dismantlers opt for illegal dumping in municipal sites, which constitutes a clear violation of established laws and regulations.

2.2 Description of socioeconomic system

To establish effective partnerships between the formal and informal sectors, it's essential to thoroughly study and understand both sectors. This involves examining their beliefs, business strategies, and socioeconomic backgrounds. By gaining insight into these aspects, the most appropriate strategies and approaches for collaboration can be identified. This understanding is crucial for bridging the existing gap and enabling synergies between the two sectors.

2.2.1 Comparison of formal and informal recyclers

Formal Sector

In Egypt, the formal e-waste recycling sector operates with organization and a commitment to environmentally responsible practices. These companies maintain a structured setup, ensuring that their employees are insured, and their operations are compliant with established environmental regulations. They are subjected to regular audits conducted by the Waste Management Regulatory Authority (WMRA) in Egypt, which helps ensure transparency and accountability in their processes.

However, despite their formal status, these recyclers face unique challenges. One of the primary issues is the scarcity of raw materials. This scarcity is due to the prevalent practice of informal collectors who accumulate a significant portion of the country's e-waste. As a result, formal recyclers often find themselves with limited e-waste to process, hindering their efficiency and capacity. Another notable characteristic of these formal recyclers is that their processes are typically batch-oriented, as opposed to continuous industrial processes. This design can lead to relatively lower yields and material recovery rates. Formal recycler’s face challenges in optimizing the efficiency of their hydrometallurgical processes, so they often resort to wet chemical process such as acid leaching strong acids that lead to lower recovery and purity. It’s important to acknowledge that there are no smelters for e-waste in Egypt. This limitation further adds to the challenges faced by the formal recyclers, as they may need to explore alternative methods for handling specific materials. Despite these obstacles, formal recyclers in Egypt dutifully pay taxes and adhere to various environmental regulations and policies. They uphold high standards for their operations, aiming to ensure that e-waste is processed safely and sustainably. Formal recyclers primarily consist of individuals from a higher socioeconomic class who have received education in the field. This sets them apart from their informal counterparts, reflecting the diversity within Egypt's e-waste recycling landscape.

Informal Sector

In the informal sector of the E-waste industry, a legacy business has taken root, with operations spanning several generations within the same family. Despite this legacy, the lack of formal education remains a significant challenge for many. Informal stakeholders tend to be cautious but more adaptable than formal enterprises when it comes to embracing significant changes in their operations. At the core of their business model lies the pursuit of maximum profit margins and a continuous flow of materials, ensuring that money is not stuck up for extended periods. The average price of items is determined daily, based on the fluctuating prices of metals in the commodity market.

One of the key aspects of their operations is the immediate exchange of materials for on-the-spot cash, which is essential for the smooth functioning of the system. However, there is fear of legal enforcement and government regulations, prompting the creation of new clusters as a means of evading government officials. Notably, the informal sector in the E-waste industry in Egypt operates on principles of community collaboration, faith, trust, and family involvement. They often provide social security, offering support during times of illness or significant life events like weddings. These informal workers

have established a nationwide collection network, like a Hub and Spoke model, involving various relatives dispersed across the country who gather E-waste from different regions. The informal workers have a strong sense of ownership regarding their business. They strongly value independence and desired ownership of the space, business, and materials they collected and dismantled, however small their business was.

3 Methods

The information presented is derived from practical experiences, interviews, secondary literature research, meetings, and trainings, as well as on ground-field trips to formal recycling facilities.

3.1 Literature Research

A comprehensive list of secondary research papers used for preparing this work is presented in the bibliography.

3.2 Individual Interviews & Discussions

Individual interviews were conducted with multiple stakeholders. The interviews focused on understanding the Egyptian e-waste management system, in particular the role of formal and informal actors and the possibilities of partnerships between them. In addition, also the rules and laws regulating e-waste in Egypt were discussed, as well as the legal situation of informal actors and their potential to be formalized. A short description of interviewed stakeholders is presented below.

Mr. Ahmed Salem

Mr. Salem is the CEO of the Egyptian E-waste Recycling Company (EERC). Additionally, he is the Chairman of the Egyptian Recyclers Association that was established in 2023. He has more than a decade of industry experience and used to be an informal recycler before joining the first formal recycling company in Egypt which is International Technology Group (ITG).

Dr. Hossam Allam

Dr. Hossam Allam is currently the Regional Programme Manager of the Sustainable Growth Programme at the Centre for Environment and Development for the Arab Region and Europe (CEDARE). Dr. Allam has more than 20 years of international experience in the fields of utilizing environment for development. His professional experience includes managing and developing strategies and programme of work for CEDARE's Sustainable Growth Programme, which includes Sustainable Consumption and Production, Green economy, Sustainable cities, Energy, and ICT for Development themes.

Mr. Karim Dabbous

Mr. Karim Dabbous is the founder and CEO of E-Tadweer. He founded his pioneering company in 2020 dedicated to promoting environmentally responsible disposal of household e-waste, via an app by which private citizens can locate the nearest drop-off location for e-waste disposal and get rewards in form of points and discounts on purchases of electronic equipment in selected stores.

Mr. Mohamed Ahmed

Mr. Mohamed is the plant manager of the oldest Egyptian recycling company namely International Technology Group formed in 2014 in Egypt. He is a senior executive overseeing the recycling facility

and has plenty of experience in e-waste handling and recycling, as well regulatory compliance, and e-waste sourcing.

Ms. Shaima El-Sayed Mohamed Ali

Ms. Shaimaa is the director of the final disposal department and Stockholm focal point located at the Waste Management Regulatory Agency (WMRA), which is part of the Egyptian Ministry of the environment (MOE). She has plenty of experience in auditing and regulatory compliance and goes on regular audits at formal recycling facilities in Cairo.

Dr. Tarek El Araby

Dr. El Araby is the CEO and Chairman of the Egyptian Waste Management Authority in Egypt (WMRA). Dr. El Araby has more than 15 years' experience in handling all sorts of waste and setting the regulatory framework waste handling in Egypt.

Mr. Tawfik El Kheshen

Mr. El Keshen is an external consultant, that has a decade of experience in e-waste and plastic recycling with a special focus on extended producer responsibility (EPR) systems and recycling markup fees.

3.3 Meetings, Discussions & on-ground field trips

Enhancements to understanding of e-waste handling, storage, regulatory compliance, recycling, and the e-waste management system were achieved through active participation in various meetings, training sessions, and visits to formal recyclers, facilitating the gathering of necessary information and knowledge for compiling this report.

Training of Trainers for e-waste auditing

SRI Egypt held a training of trainers on E-waste Recycling Auditing and Conformity Assessment as part of the Project's activities in Egypt. The activity aimed to train a group of auditors and inspectors from various governmental entities, including the WMRA, the Egyptian Environmental Affairs Agency (EEAA), the Industrial Development General Authority (IDA), private companies, as well as independent consultants. By acquiring the E-waste Conformity Assessment TOT, the trainees became eligible to train others and transfer the knowledge to a wider base of auditors through similar training programs.

Following a series of virtual training sessions that took place, the physical training began and lasted for four days, including field visits to electronic waste recycling plants. The TOT content covered the environmental and health requirements for recycling, as well as modules on the Waste resulting from Electrical and Electronic Equipment (WEEE). The TOT also covered the establishment of a system, auditing procedures, protocols, guidelines, reports, application codes, and compliance schemes. It also included a hands-on auditing of an e-waste recycling plant.

Public and Private Sector E-Waste Actions Conference

A meeting was convened to address the participation of informal and unlicensed wholesale merchants in auctions that often leads to inflated prices, causing formal recyclers to face challenges in acquiring the needed e-waste materials, creating a substantial shortage, and hindering their operations. The meetings were held at the headquarters of the Egyptian Ministry of the Environment, gathering all 22 pricing specialists/consultants across the country as well as representatives from WMRA and the formal recyclers association, all of whom actively participated in the discussion.

Formal Recyclers Visit

In the course of this study three formal recycling facilities were visited, where access was granted to observe the entire process, from the arrival and sorting of materials to dismantling and recycling, concluding with waste disposal:

1. International Technology Group (ITG)
2. Triple REE
3. Egyptian E-waste Recycling Company (EERC)

4 Results & Discussion

4.1 Issues

The e-waste management system in Egypt is confronted with systemic challenges that extend across the entire spectrum, encompassing both formal and informal sectors. To comprehensively address these issues, it is crucial to distinguish between overarching systemic concerns and those specific to each sector. Identifying and understanding these challenges is paramount for devising effective solutions tailored to the Egyptian context. Enclosed is a figure summarizing the most critical issues plaguing the Egyptian e-waste management system. It is important to note that while this analysis is not exhaustive, it strategically focuses on the key bottlenecks. Addressing these bottlenecks has the potential to yield significant enhancements in efficiency and prosperity within the sector, making it imperative to prioritize these aspects for a more sustainable e-waste management framework in Egypt. Figure 5 offers a comprehensive overview of the issues to be discussed in the subsequent sections.

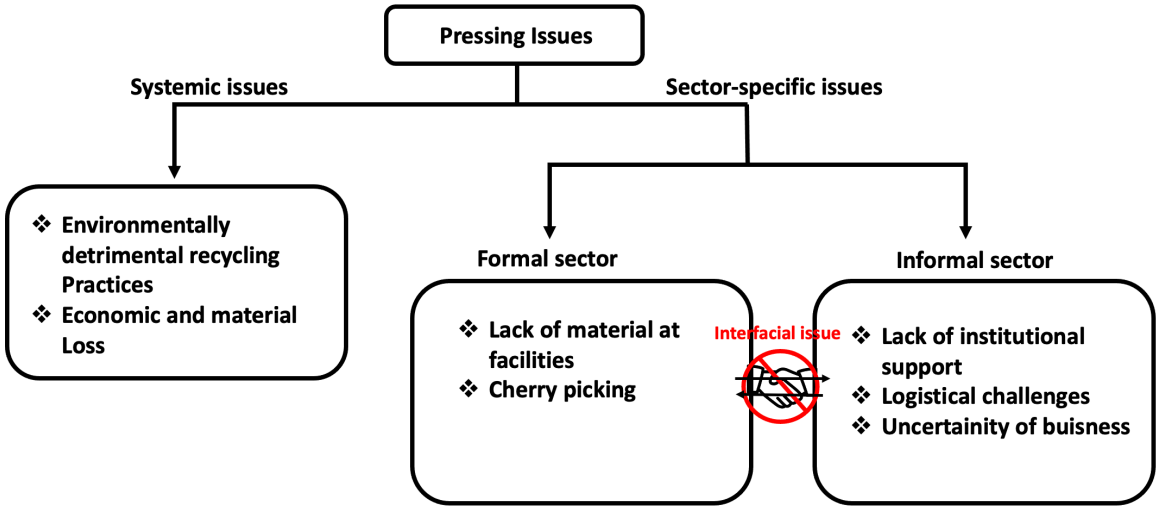

Figure 4: Overview of the most pressing issues related to the Egyptian e-waste management system.

4.1.1 Systemic issues

Although informal e-waste micro-businesses play a crucial role in supporting the local economy, generating employment opportunities for skilled, semi-skilled, and unskilled workers as service providers, their contributions are often undervalued and negatively perceived. This stems from their engagement in illegal and polluting work practices. Below are highlighted issues associated with the informal sector's control over most of the e-waste in Egypt:

Environmentally Detrimental Recycling Practices

The health impacts of e-waste dismantling and recycling for informal dismantlers lacking protective measures are severe due to exposure to hazardous chemicals. Insufficient tools, machinery, and the absence of personal protective equipment increase the risk of accidents on the job, potentially leading to long-lasting disabilities or chronic injuries that significantly limit future income opportunities. E-waste, with its mix of hazardous substances like heavy metals and organic additives, releases these

substances during the dismantling and recycling process (e.g., strong acids or mercury used for precious metal recovery, and dioxins from burning cables). The chemicals released not only affect workers directly but also have far-reaching consequences for communities and cities at large. While workers face direct exposure, their families, experience indirect exposure due to inadequate workplace hygiene, such as the absence of specific work clothes and handwashing, as well as improper separation of work and residential areas. Effects include issues during pregnancy, birth defects, hormonal imbalances, brain diseases, and impairments, leading to DNA changes and damages. Moreover, chemicals associated with e-waste dismantling and recycling can contaminate water and air.

Economic and Material Loss

The use of inefficient recycling techniques not only results in the loss of valuable resources but also diminishes the financial returns for those involved. Within the informal sector, where low-tech processes are common, the focus is often limited to extracting a handful of specific metals, leaving out materials that require more advanced recycling methods in industrial facilities. Research conducted by MeITY highlights the stark contrast in material recovery efficiency, with the informal sector achieving only 20-30 %, compared to industrial processes that surpass 80% efficiency [5].

4.1.2 Sector-specific issues

The sector specific issues can be divided into two categories, namely the formal and informal sector related issues.

Formal Sector

Lack of material at formal recycling facilities

The crucial challenge lies in the informal sector's predominant control over e-waste, resulting in a shortage for formal recycling facilities and causing harm to the environment. Despite the legal prohibitions that prevent informal workers and traders, primarily due to their lack of the necessary licenses, from participating in private and public sector e-waste auctions, they still manage to circumvent these regulations. This is largely due to the shortcomings in law enforcement, insufficient oversight, and a lack of awareness among pricing experts, consultants, and auctioneers. Traditionally, a fierce competitive dynamic unfolds at auctions, pitting formal recyclers against informal workers and traders. The informal, unburdened by overhead costs, often outbid formal recyclers to secure materials. Furthermore, formal recyclers are legally prohibited from purchasing e-waste from informal actors, and even if permitted, they face challenges offering competitive market prices due to their operational overheads. Informal workers often receive higher prices by selling to informal wholesalers and aggregators, who in turn export the e-waste and receive more favorable prices.

Cherry Picking

The practice of selectively targeting specific e-waste fractions, commonly referred to as cherry-picking, focuses predominantly on components such as printed circuit boards (PCBs), known for yielding precious metals like gold, silver, aluminum, and copper. Consequently, recyclers employing this approach exclusively pursue e-waste fractions that offer the greatest financial return and profit. However, it is imperative for recyclers to adopt a more inclusive approach, accepting all electronic waste components rather than prioritizing those with the highest monetary value. This selective strategy results in the oversight of other precious materials, including tantalum, cadmium, zinc, palladium, and more, which may not be present in PCBs but still possess significant value. Most importantly, this could result

in insufficient handling of hazardous fractions that are not economically viable for recycling, potentially leading to improper disposal and environmental harm.

Informal Sector

Lack of institutional support

The current legal framework for (e-)waste management in Egypt leaves little scope for the involvement of informal workers have brought little opportunity for them to benefit. Despite their willingness to transition into formal businesses, the complex and time-consuming formalization procedures, coupled with the high associated costs, act as formidable obstacles. Especially challenging for those unfamiliar with government procedures and lacking experience in navigating formal business processes, these entrepreneurs find themselves stuck in an illegal status. This not only exposes them to various pressures and the genuine risk of closure but also places them at a financial disadvantage, with smaller profits and minimal support available. The absence of institutional support is a significant issue for them.

Logistical Challenges

The illegal nature of their work and time restrictions on goods vehicles compel transport networks to predominantly operate at night. Informal workers often find themselves working irregular sleep cycles. The cluster benefits from cost-efficient local transporters who have honed their skills in transporting and handling e-waste over time.

Uncertainty of businesses

The uncertainty of workers is a recurrent concern within the community. Workers express the precarious nature of their businesses, with legal issues frequently casting doubt on their ability to continue working the next day.

Dependence on informal supply chain networks

Smaller micro-entrepreneurs rely on more established players to supply e-waste and handle the sale of fractions, reflecting the dynamics of the informal e-waste recycling ecosystem.

4.1.3 Interfacial issues

Legal restrictions prohibit formal recyclers from acquiring e-waste from informal collectors or aggregators. Additionally, there is no motivation for formal recyclers to engage in illicit transactions, given the necessity for a receipt, which informal workers cannot furnish. The requirement for a receipt is crucial for formal recyclers to include e-waste acquisition costs in their costs of goods sold (COGS), enabling them to deduct these expenses from their taxable income and, consequently, evade taxation on such transactions. This presents a significant impediment to interactions between these two sectors.

4.2 Solution Approaches

In essence, two types of approaches exist to solve the identified issues presented above: one that circumvents the informal sector, categorizing it as illegal and combating it through stringent law enforcement (the bypass route), and the other that emphasizes collaboration (the partnership route).

4.2.1 Partnership Approaches

The partnership route entails establishing collaborations with the informal sector to enable synergies and a framework that allows both formal and informal entities to work together effectively. It aims to leverage the strengths of each sector while considering socioeconomic factors. The forthcoming paragraphs will outline and demonstrate the various advantages and potential rewards of such cooperation for all stakeholders.

Benefits of Partnership Model

Formal recyclers [3]

Formal recyclers typically have established networks for sourcing e-waste, primarily from business-to-business (B2B) channels (as illustrated in chapter xx) that are mandated to work with authorized recyclers. However, this source provides only a fraction of the available materials, with the majority accessible through business-to-consumer (B2C) channels. As mentioned above one challenge for formal recyclers lies in accessing e-waste from B2C sources, managed mainly by informal workers embedded in local communities, facilitating extensive door-to-door collection. Collaborating with informal actors offers formal recyclers a reliable way to access more e-waste. Furthermore, by relying on more stable and higher input material flows, recyclers can concentrate on their core strength of recycling in an environmentally responsible and legally compliant manner. This strategic focus empowers them to invest in the appropriate treatment technologies without the additional burden of extensive collection responsibilities. By aggregating larger quantities of e-waste, the bargaining power towards material buyers on the international secondary raw-material markets increase, while reliable flows of materials improve the cash flow situation for recyclers.

Informal workers often possess valuable knowledge of e-waste components and their market value, aiding in the avoidance of cherry-picking practices. By collaborating formal recyclers could benefit from their expertise. However, it is crucial to ensure that producers and Producer Responsibility Organizations (PROs) do not exploit this by cherry-picking valuable fractions, emphasizing their legal obligation to manage all components, regardless of value. Despite the legal prohibitions that prevent informal workers and traders, primarily due to their lack of the necessary licenses, from participating in private and public sector e-waste auctions, they still manage to circumvent these regulations. This is largely due to the shortcomings in law enforcement, insufficient oversight, and a lack of awareness among pricing experts, consultants, and auctioneers. Traditionally, a fierce competitive dynamic unfolds at auctions, pitting formal recyclers against informal workers and traders.

The informal, unburdened by overhead costs, often outbid formal recyclers to secure materials. However, with a partnership in place, this rivalry ceases to be a threat.

Public authorities [3]

By advocating for collaborations between informal and formal actors involved in the collection, repair, dismantling, and recycling of e-waste, public authorities can encompass all stakeholders within existing

legal frameworks. This approach can help close existing avenues through which e-waste leaks into unregulated recycling facilities with crude practices that pose environmental and health hazards. Additionally, it can fortify the position of environmentally and socially sustainable alternatives.

Moreover, the inclusion of informal sector participants is likely to enhance the acceptance of the recycling system and, subsequently, reduce social risks for authorities. Promoting such partnerships aligns with the interests of both national and local authorities. In many instances, informal sector workers are already operating within established networks for e-waste collection. Therefore, encouraging partnerships between the informal and formal sectors enables public authorities to leverage the existing informal collection infrastructure and offers them the advantage of oversight, monitoring, and ultimately a possibility to formalize this sector.

Incorporating informal stakeholders into formal e-waste management systems potentially increases acceptance of legislation among the informal community. It avoids the establishment of parallel systems and eases the competitive pressure on formal actors. Furthermore, national, and local authorities can achieve substantial co-benefits, such as fulfilling national goals for employment and inclusive development while avoiding the forced displacement of informal workers and potential unrest among marginalized communities.

Regarding economic advantages, public authorities can reduce administrative burdens compared to an approach solely based on enforcement, as opposed to dialogue, incentives, and partnerships. The formalization of the informal workforce also leads to increased tax revenues and the promotion of local value chains and local income derived from e-waste collection and processing.

In terms of environmental impact, promoting partnerships between formal and informal participants helps to ensure the achievement of pollution control standards and targets for e-waste collection and recycling, as outlined in national policies, laws and international conventions. Paired with heightened monitoring and enforcement efforts, the formalization process creates opportunities for remediating contaminated sites and prevents the emergence of new contaminated areas within cities, stemming from unregulated e-waste recycling, ultimately reducing associated health risks for local populations.

Informal Sector [3]

With the growing public awareness of the adverse effects of informal e-waste recycling and the implementation of new regulations to address this issue, informal e-waste collectors and recyclers find themselves increasingly vulnerable to enforcement activities and law enforcement. This heightened scrutiny may result in their further marginalization, increased instances of harassment or demands for bribes, and ultimately, their being driven deeper into the underground economy or out of business.

However, engaging in partnerships with formal stakeholders, whether they are manufacturers, recyclers, aggregators, or non-governmental organizations, can prevent this marginalization and offer a range of opportunities. Foremost, through a process of formalization in collaboration with the stakeholders, informal workers can enhance their status by being recognized as significant participants. This recognition offers protection for at least some of their economic activities.

Moreover, such partnerships provide informal workers with access to the necessary equipment, protective gear, and training to mitigate health risks associated with their daily operations. Various case studies have demonstrated that formalized waste pickers gain increased visibility and acknowledgment as licensed collectors or dismantlers, thanks to official attire and formal identification cards. This reduces the risk of harassment and provides access to facilities that were previously off-limits. Additionally, it contributes to raising public awareness about workers' rights, a topic often overlooked in public discourse.

Formalization brings further benefits by expanding the range of e-waste materials that can be collected by informal workers. Currently, informal collectors primarily focus on valuable materials and products like PCBs, cables, computers, and mobile phones. However, with the right support and training, they can include additional items in their collection portfolio, such as lighting equipment, thereby increasing their income potential.

The more direct and tangible advantages of formalization encompass access to social security and healthcare, which are often lacking in informal economies due to slim profit margins allocated primarily to essential items, such as food for subsistence. Furthermore, having a contract with a formal entity offers a stable and dependable income. Depending on the terms of the agreement, there may also be opportunities to acquire managerial skills, expand business activities, and improve access to institutional sources of capital, thus broadening entry into formal value chains. This can increase bargaining power with industry players and government authorities, opening access to previously unavailable e-waste supply channels, including bulk disposers who are legally required to cooperate solely with formal collectors. Access to downstream formal markets can also be expanded since many buyers in the industry are bound by strict regulations, which prohibit collaboration with informal entities. Finally, being part of a formal collective can attract political attention and enable these stakeholders to actively participate in the development of e-waste legislation. In addition, there is potential for accessing financing through EPR fees once the Extended Producer Responsibility (EPR) system is implemented. EPR fees are expected to encompass collection costs, providing an opportunity for informal collectors who meet specific conditions to benefit from these fees directly or indirectly. This could involve direct compensation or payments facilitated by formal recyclers.

Challenges of Partnership Models

Establishing successful collaborations between the formal and informal sectors comes with its share of challenges. To bridge the gap between the two sectors and fully realize the benefits of the identified approaches, they must successfully overcome the following hurdles.

Trust-Issue

To begin with, formal entities often lack the acquaintance and connections necessary to engage with the informal sector. Developing trust is a fundamental prerequisite for nurturing productive relationships with informal workers, and this trust-building process must unfold gradually. However, it demands a significant investment of time and resources, which some entities, whether producers, PROs, or other intermediaries, may be reluctant to commit.

Furthermore, during the initial stages of informal-formal collaborations, information disparities can hinder the establishment of trustworthy partnerships. These disparities may relate to the reliability of stakeholders, knowledge about prevailing market prices, or the quality of collected materials. Additionally, without sustained, long-term commitment from producers, PROs, or public authorities in the form of price supports or complementary measures, informal collectors might find themselves in a difficult position. After leaving their prior informal arrangements to engage in formal partnerships, they could face existential threats if those partnerships fail. Therefore, building trust among informal and formal stakeholders, fostering a collective willingness for enduring collaboration, and implementing mechanisms that ensure relationship stability are imperative.

Price-Gap

The significant price differences between formal and informal when it comes to offering rates to collectors, is another challenge that needs to be overcome. Informal workers or traders, operating without the burden of overhead costs and frequently resorting to environmentally substandard recycling

methods, can recover materials at a significantly lower cost. This cost advantage empowers them to offer more attractive prices to collectors, surpassing what the formal sector can competitively match. Consequently, they tend to accumulate the majority of the country's e-waste and this leads to a scarcity of e-waste at formal recycling facilities.

Pivot Issue

An essential factor to consider is that the sustainability of the formalization process relies on the ability of newly formalized e-waste recyclers to consistently maintain their market share. In the absence of such market access, there is a tendency for them to revert and pivot to their informal practices as a cost-saving measure. Stakeholders seeking to engage with informal counterparts must carefully consider these challenges when embarking on collaborative endeavors.

4.2.2 Bypass route

The bypass route essentially aims to circumvent the informal sector by formally collecting e-waste from households, thus gaining access to the B2C channels. This approach requires authorities to categorize any informal e-waste collector and worker as operating illegally, subjecting them to legal consequences. This is the prevailing situation in Egypt as per the current law (Law 202 of 2020), where any informal recycler may incur fines of up to 1 million EGP or face imprisonment. A prerequisite for this approach is stringent and vigilant law enforcement and supervision. This approach might be more straightforward since it does not involve the challenges of engaging with less formally educated individuals from various socio-economic backgrounds who might have inherent reservations about collaboration. Additionally, it entails fewer stakeholders, which can streamline decision-making, reduce administrative complexity, and enhance operational efficiency. Accessing and communicating with these individuals can be exceptionally challenging, as they are widely dispersed and lack a cohesive front. Engaging them as stakeholders would require a substantial investment of time and effort. This is one of the reasons why the bypass route can be considered advantageous.

However, this approach carries significant risks:

- **Forced Displacement and Unrest**: The immediate effect would likely be the forced displacement of informal workers from their livelihoods. This could lead to unrest within marginalized communities, as people lose their means of income and social stability. This displacement can disrupt the social fabric, potentially leading to protests, conflicts, or demonstrations.
- **Political and Security Instability**: Such widespread displacement and unrest have the potential to create political and security instability in the country. Discontent and social unrest can strain the government's resources and capacity to maintain law and order. This, in turn, can lead to political tensions and, in extreme cases, security crises.
- **Economic Consequences**: There are economic consequences to consider as well. Displaced informal workers may require government assistance or intervention, incurring additional financial burdens on public resources. The loss of the informal e-waste sector, which often operates efficiently in recycling valuable materials, may also lead to economic losses for the country.
- **Social Challenges**: Informal e-waste workers often come from vulnerable and low-income backgrounds. Depriving them of their livelihood without alternative opportunities can result in increased poverty and exacerbate existing social inequalities. This, in turn, can create long-term social challenges for the country.

- **Criminal Activities**: With limited education and prospects, some individuals may resort to criminal activities to support themselves and their families. This poses both a security threat and a challenge for law enforcement agencies.
- **Environmental Impact**: Additionally, shutting down informal recycling channels without offering viable alternatives can lead to e-waste being processed in even more environmentally harmful recycling practices. This could negate environmental gains achieved through formal recycling methods.
- **Public Perception**: The government's decision to label informal workers as illegal could influence public perception and create mixed sentiments. It may lead to criticism and backlash, especially if it is seen as a heavy-handed approach that does not consider the socio-economic realities of informal workers.

In summary, making all informal e-waste collectors and workers illegal can have wide-ranging and interconnected implications affecting not only the informal workers themselves but also the community, the country's stability, and its economic and environmental well-being. Therefore, a comprehensive partnership approach, which considers the socio-economic factors and offers viable alternatives, may be more sustainable and less disruptive in the long run.

4.3 Case Studies: Partnership Approaches for formal and informal sector

4.3.1 Direct Partnership/ Subcontractor Model

This approach involves integrating the leader or chief of the informal sector directly into a recycling facility, ensuring a steady stream of materials for the recycling facility. This partnership may take the form of financial compensation, including fixed salaries or profit-sharing arrangements, for both the informal sector market leader and the informal collectors or in the form of subcontracting. Additionally, this collaboration offers the informal sector participants a stable income, insurance coverage, and the possibility of sharing profits, creating a mutually beneficial arrangement that incentivizes responsible e-waste management practices.

This approach is not without its hurdles, and overcoming these challenges is crucial to its success:

- **Access to informal Sector market leader:** Initially, establishing contact and gaining access to the leader of the informal sector can be a significant challenge. Building a bridge between these two sectors may require considerable effort and outreach.
- **Gaining Trust:** Convincing the chief of the informal sector to collaborate and trust the formal recycling facility is another crucial step. This often involves addressing their concerns and showing the benefits of the partnership, including potential economic gains and environmental improvements.
- **Negotiating Terms:** Arriving at mutually agreeable terms that satisfy both sides is vital. This involves setting clear expectations, defining responsibilities, and negotiating factors such as pricing and profit-sharing.
- **Ensuring a Constant Flow of Material:** Maintaining a consistent material flow into the recycling facility is key to the success of this model. Challenges may arise when seasonal variations or market fluctuations affect the availability of e-waste.
- **Margin Considerations:** This partnership model might result in smaller profit margins for the formal recyclers, as they need to share the profits with the chief of the informal sector. Balancing the financial aspects while ensuring the sustainability of the partnership can be a complex task.

Arguably the most pressing issue is “Negotiating Terms”. Informal workers often make more money by selling e-waste to larger wholesale scrap dealers who may engage in potentially illegal practices, such as exporting or selling e-waste to informal recyclers. As a result, the margins for the informal sector chiefs in a formal recycling partnership are typically smaller. This financial discrepancy can create a hurdle in convincing them to collaborate with formal recyclers and prioritize the environmentally responsible disposal of e-waste over immediate financial gain. A hurdle associated with regulatory compliance is the requirement for formal recyclers to apply for an additional collection license, given their involvement in the collection process. This entails an investment of both time and money. Moreover, once obtained, formal recyclers must dedicate resources to train and ensure that the collectors adhere to the prescribed rules and standards during the collection process to avoid penalties during audits and supervision. This situation presents a paradox as the intention behind this approach is to harness the efficiency of informal sector collectors without imposing additional bureaucratic constraints that might disrupt or alter their existing practices. This approach is most effective when formal and informal players collaborate to generate increased revenue. This can be achieved by enhancing quantities of waste collected and/or negotiating higher compensation, facilitated through mechanisms such as EPR fees or other types of payments by responsible businesses.

Case Study: Desco Electronic Recycling South Africa [3],[4]

A compelling case study from South Africa showcases successful collaborations between formal recyclers and informal sector workers, realized through a subcontractor model.

Desco Electronic Recyclers, established in 1992 in South Africa, initially focused on recycling obsolete IT equipment and mainframes but has since evolved into a diverse e-waste recycling company, with a specific emphasis on Printed Circuit Boards (PCBs). Desco actively involves informal workers in their business model, either supporting ex-employees or independent informal/semi-formal waste dismantlers and collectors in transitioning to become formalized independent business contractors. These contractors, in turn, collaborate with Desco as subcontractors, offering the advantage of outsourcing dismantling operations while retaining their autonomy and business management. Desco initiated its first partnership in 2000 when it facilitated the establishment of independent companies, UBISI and Selolo Recycling, which remain loyal subcontractors. The introduction of the Black Economic Empowerment (BEE) Act in 2003 further supported enterprise development within Desco's facility.

At present, Desco collaborates with ten subcontractor businesses, with five operating on its premises and five off-site. Subcontractors have two income stream options: Desco sells pre-processed e-waste to the subcontractor, who adds value through dismantling and sells the fractions back to Desco, or Desco hires the subcontractor to provide labor for dismantling on-site. E-waste outsourced for dismantling includes various electronics such as printers, photocopiers, household appliances, and more. The subcontractors are also engaged for on-site equipment dismantling at client locations.

Eligible subcontractors include:

- Desco employees with an interest in starting their own business and the necessary knowledge of e-waste handling.
- Non-employees or suppliers, such as informal dismantlers and recyclers with a trust relationship, having supplied Desco with PCBs and other fractions for over a year.

Subcontractors, while purchasing material from Desco, are free to sell certain material (e.g. aluminum) streams to other buyers but must sell all printed circuit boards back to Desco. Subcontractors at Desco commit to adhering to environmental, health, and safety regulations outlined in Desco's policy and national laws, as well as paying their employees a minimum wage. To ensure compliance with these conditions, subcontractors initially operate at Desco's site. Once they demonstrate adherence to these standards, they may work off-site but are subject to regular inspections to maintain compliance. If substandard practices are identified, the partnership is terminated. Furthermore, material is not provided to subcontractors on credit to ensure the return of materials. In addition, body searches are conducted to prevent materials from leaving the premises at the end of each day.

Desco provides substantial support to subcontractors, including administrative assistance, training, equipment, vehicles, zero interest loans, and access to tools and premises. However, the success rate of these partnerships has been about 50 %, with some partnerships failing due to disagreements or competitive pressures, where many are lured into selling to the competition for a few cents per kg more. Desco's approach has contributed to uplifting ex-employees and informal sector workers, allowing subcontractors to apply for government tenders and sponsorships to become formalized recyclers. It is essential to highlight that Desco utilized informal workers primarily for dismantling tasks, not collection. Ensuring that off-site dismantling activities meet formal standards remains a significant challenge. Moreover, ensuring the return and sale of all PCBs to recyclers is not only complex but, given their high value, also encourages selective handling, while formal recycling facilities should ideally process all e-waste comprehensively without selectivity. Critics might argue that unviable fractions are outsourced due to the high cost associated with formal recycling at dedicated facilities. Even if all of

these challenges are effectively addressed, the predominant use of informal sector workers has been in dismantling activities. Nonetheless, a particularly beneficial approach, especially in the context of Egypt, involves deploying these workers for collection rather than dismantling. The primary challenge in Egypt lies on the collection side, not the dismantling side, as formal recycling facilities face material shortages rather than a shortage of labor for processing. Figure 6 provides an overview of the subcontractor model employed by Desco.

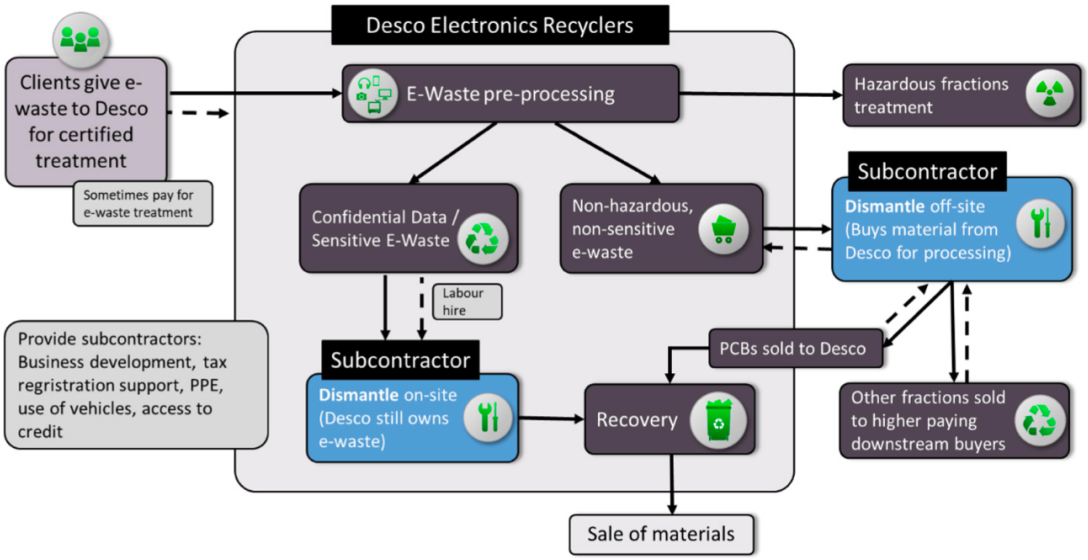

Figure 5: Overview of Desco's subcontractors model [3].

4.3.2 Subsidized Co-Working Space -E[co]work-

E[co]work introduces a pioneering co-working facility tailored to e-waste dismantlers, offering innovative and cost-effective spaces for micro-entrepreneurs in the e-waste recycling sector. The inaugural pilot space was established in 2023 and the opening ceremony took place on 17th of October 2023 in Delhi, India [5].

The core objective of E[co]work is to bridge the gap between the formal and informal recycling sector, creating a safe working environment and an alignment with legal requirements. Modeled after co-working spaces, E[co]work provides secure physical workspaces available for rent through 'pay-per-use for space' or 'pay-per-use for services' options [5, 6]. The business also equips these spaces with advanced machinery to enhance processing efficiency and ensures the adoption of safe work practices. Dismantlers utilizing E[co]work gain access to a broader market due to their formalized status, enjoy increased work efficiency, and have access to additional services like training, healthcare, insurance, and banking facilities. This pioneering E[co]work approach has the potential to significantly enhance livelihoods, improve public health, reduce environmental impact, and promote a circular economy.

The E[co]workspace is designed to cater to the needs of dismantlers while providing access to state-of-the-art and eco-friendly recycling tools. By offering shared infrastructure, E[co]work aims to shift the mindset of dismantlers from one of shame to pride in their work. This transformation enables safer work practices, elevates incomes, and enhances social mobility. Furthermore, it contributes to environmentally responsible disposal of hazardous materials and promotes closed material chains. E[co]work's commitment to proper ventilation systems, dust control, and protective equipment serves to enhance the health and well-being of dismantlers, their families, and the surrounding community [5, 6].

E[co]work encountered challenges in securing acceptance among informal micro-entrepreneurs in its design phase after discussion with multiple stakeholders. These hurdles are detailed below [5, 6]:

- **Rental model vs. ownership:**
  - Sense of ownership: Many micro-entrepreneurs highly value their independence and aspire to own the space they work in, regardless of the size of their business.
  - E[co]work's core concept is built on a rental model, which may not align with the desire for ownership.
- **Disruption of networks and clusters:**
  - Relocating from established clusters can disrupt personal networks and potentially limit access to dismantling materials. Younger micro-entrepreneurs often rely on more established players within these clusters for material supply and sales.
- **Logistical drawbacks:**
  - Indian informal e-waste clusters provide similar benefits to its members as regular industrial clusters. This includes the availability of support services such as logistics providers that have industry-specific expertise.

Addressing these challenges, E[co]work adapted its model, emphasizing its role as a stepping-stone towards achieving long-term ownership. The inclusion of long-term rental options aims to provide the community with flexibility and a sense of ownership, addressing underlying motives through an exceptional work environment and trial co-working periods. To overcome disruptions to networks and clusters, the focus is on integrating established players and targeting a mix of micro-businesses to ensure a consistent material flow. Lastly, logistical concerns of informal businesses are alleviated by offering support to Micro-entrepreneurs interested in E[co]work, helping them adapt transport networks and capitalize on scale-related benefits through cooperation [5, 6].

Despite E[co]work's persistent efforts to address the concerns of informal workers, a significant challenge remains—the financial feasibility of the approach. The rent/pay-per-use model may not generate sufficient income to sustain operations, and the introduction of a profit-sharing mechanism with informal workers could further deter their participation. To overcome this funding challenge, the recommendation is for E[co]work to explore avenues such as collecting funds from PROs, EPR fees, or donations from international corporations dedicated to e-waste recycling.

Another substantial issue, echoing concerns raised by informal workers in both India and Egypt, revolves around the strategic location of the co-working space. Placing it in proximity to areas where informal e-waste recycling occurs is essential to prevent disruptions to logistical chains, nodes, and clusters crucial for material flow. A cost-effective solution to test this concept involves establishing modular co-working spaces in the form of 20 to 40 ft containers near garbage collection areas. This approach ensures easy transportation, setup, and adaptability, allowing for relocation as needed while maintaining proximity to informal workers.

Implementing such an approach in Egypt could be transformative, bridging the gap between formal and informal sectors and fostering synergies. However, it does not address the challenge of the insufficient material flow to formal recycling facilities. While enhancing productivity, improving living conditions, and providing formal status to the informal sector, it significantly reduces the environmental impact of recycling activities. Despite these positive aspects, the majority of the material continues to be handled by informal workers.

4.3.3 Informal Workers Association

The approach involves the establishment of a society or association specifically dedicated to the informal sector within the e-waste recycling industry. This society or association serves as a platform that aims to formalize and structure the operations of informal e-waste collectors and aggregators. The core idea is to create a bridge between the formal and informal sectors by understanding and adapting the processes of the informal sector to ensure the proper flow of materials to formal recyclers, all while offering fair prices to the informal sector. Importantly, this approach seeks to achieve these goals without enforcing drastic changes or introducing a significant bureaucratic burden on the informal sector. The concept revolves around the notion that by uniting within an association, informal e-waste collectors can collectively pool their quantities, enabling them to negotiate better prices. This, in turn, paves the way for smaller collectors to access fair pricing or compensation. Moreover, the association can extend a range of benefits tailored to the daily lives of informal workers, including the provision of ration cards, micro-insurance, education, and training programs aimed at improving their overall well-being. The informal workers' union can acquire legal accreditation, allowing them to legally sell the e-waste to recyclers and provide formal recycling facilities with official receipts.

Case Study: Informal Workers Association Nigeria [3],[7]

In Nigeria, the e-waste recycling landscape is primarily informal, with most activities taking place outside the formal sector. This informal recycling has led to severe health and environmental issues. Informal workers, who are highly organized and connected through extensive national networks, are involved in these activities, often collaborating with wholesalers exporting e-waste to countries like China, sometimes without the necessary permits.

The informal sector in Nigeria also plays a pivotal role in managing the significant influx of used electronics, many of which are classified as e-waste. These used electronics are often imported and arrive in large quantities, with approximately 19 % of the estimated 60'000 tons of goods brought into the country in 2016 considered e-waste upon arrival. Within the informal sector, scavengers and dismantlers focus on extracting specific materials in demand by wholesalers, while less valuable components such as leaded glass from CRTs, broken LED screens, and large volumes of BFR plastics are often discarded. This sector requires development, and informal collectors would benefit from protective measures, such as training, provision of personal protective equipment (PPE), and access to health insurance. Informal workers also face difficulties obtaining bank accounts, and the prices they receive for their collected e-waste can vary significantly depending on their location.

Nigeria has put in place certain legislative measures to manage e-waste, such as the National Environmental (Electrical Electronic Sector) Regulations. The Nigerian Environment Standards and Regulations Enforcement Agency (NESREA) has provided operational guidelines for the implementation of an EPR program. A PRO was established in 2018. However, the full implementation of EPR principles outlined in the legislation has been delayed, leading to a lack of funds for the proper execution of EPR responsibilities.

Despite these legislative delays, some private sector players in Nigeria, such as Hinckley Recycling, have adopted a proactive approach to address the challenges associated with informal e-waste recycling. Hinckley Recycling established an e-waste recycling facility that operates in line with international standards. The facility is equipped with a significant manual dismantling team and aims to collaborate with the informal sector.

Hinckley Recycling has initiated training workshops and medical check-ups for informal collectors, promoting awareness of good practices and safety. This initiative has evolved into a trade partnership as more informal collectors express their interest in working with Hinckley. In 2018, Hinckley assisted in

forming an association of informal e-waste collectors, attracting around 40 members by year-end. As part of this association, collectors benefit from training on safe e-waste collection and dismantling, support in opening bank accounts, access to medical assistance, and assurance of receiving a fair price for their collected e-waste.

To prevent cherry-picking practices, Hinckley encourages collectors to bring whole units or complete products, rather than pre-dismantled parts, offering higher prices for this approach. This not only saves time and money for the collectors but also ensures a more valuable and efficient recycling process.

While these agreements with informal collectors are currently somewhat informal, they are evolving, with plans to introduce a more formal application process. As Nigeria progresses toward the implementation of the EPR system, Hinckley will serve as both a recycler and an off taker for collectors. Both recyclers and collectors will be required to register with NESREA to participate in the EPR system. Hinckley's proactive engagement has equipped informal collectors with essential prerequisites for the EPR system, including training, bank accounts, and personal data, ensuring a smoother transition for them. Figure 7 illustrates how the informal workers association interacts with the formal recycler Hinckley Recycling.

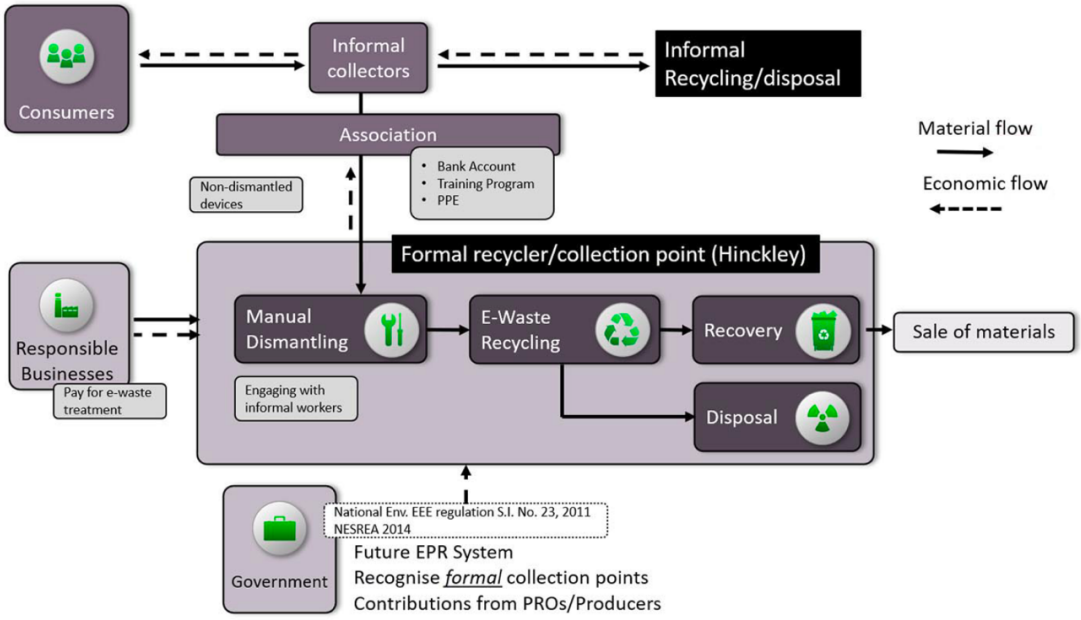

Figure 6: Overview of the collaboration of Hinckley Recycling with the informal sector [3,7].

Despite offering compelling incentives such as protective gear, training, and bank accounts to informal workers, this approach falls short of addressing the most pressing challenge, which is the substantial price gap between what formal recyclers can afford to pay and the higher prices offered by informal recyclers and large scrap dealers. This disparity inevitably drives informal workers to sell their e-waste through these more lucrative channels, leading to e-waste entering illegal routes. For this approach to succeed, the presence of an Extended Producer Responsibility (EPR) program that compensates recyclers for processing unfeasible fractions is crucial. Furthermore, it is essential that the EPR fee incorporates access-to-waste costs, allowing formal recyclers to provide competitive prices to informal workers and ensuring a steady supply of e-waste for responsible recycling.

4.3.4 Intermediary Organization Approach

The intermediary organization approaches revolve around an intermediary entity equipped with the necessary financial resources to purchase e-waste from informal collectors, subsequently facilitating its transportation or sale to formal recycling facilities. This arrangement guarantees that e-waste, collected by informal workers, avoids illicit channels and undergoes environmentally responsible recycling. To discourage informal workers from selling their collected waste to informal recyclers or larger scrap dealers, the intermediary organization offers supplementary incentives.

Case Study: PRO Karo Sambhav India [3],[8]

A compelling case study from India showcases successful collaborations between formal recyclers and informal sector workers, realized through an intermediary PRO, named Karo Sambhav.

Karo Sambhav has embraced the participation of informal workers to boost e-waste collection, aggregation, and dismantling. In light of India's 2016 E-Waste Rules, which mandate producers to meet e-waste collection targets proportionate to the products they introduce to the market, Karo Sambhav recognized the need for engaging the informal sector. Although the E-Waste Rules do not explicitly mention such engagement, the informal sector currently manages over 95 % of India's e-waste, making it crucial for attaining ambitious collection targets.

Karo Sambhav's innovative approach, built upon insights from previous pilots and stakeholder experiences, strives to enhance collection in collaboration with informal e-waste aggregators, waste pickers, and repair shops on behalf of multiple producers across various Indian cities. Distinguished from prior initiatives, this approach benefits from substantial financial resources that effectively bridge the price gap between informal and formal recyclers, facilitated by partnerships with producers making financial contributions in line with their obligations under the 2016 E-Waste Rules.

To optimize the collection process, Karo Sambhav targets key nodes within the informal collection networks, focusing on lower-level aggregators specializing in specific e-waste categories. More prominent players with a steady stream of buyers can command higher prices, while smaller aggregators, being less established, may sometimes offer materials at more competitive rates. These aggregators, crucial components in the e-waste value chain, accumulate substantial quantities of obsolete products before redirecting them downstream for further processing. Some aggregators may also take on dismantling roles, specializing in specific materials and components. While meeting the pricing expectations of smaller aggregators is essential, additional measures are implemented to build trust, solidify trade relationships, and enhance the value proposition for informal workers. Since most informal sector transactions are cash-based, smaller aggregators are susceptible to receiving lower payments or, at times, not receiving the final cash payment due.

Karo Sambhav has succeeded in engaging partners through dependable financial transactions. After initial small trades, the organization persuaded some workers to transition to digital payments and assisted them in establishing bank accounts and registering their tax information, marking the first steps toward formalization. Digital payments have become preferable for some workers after experiencing the immediate deposit of funds into their bank accounts, mitigating concerns over security risks and bribes associated with carrying large sums of cash. Simultaneously, the engaged aggregators benefit from business development support to expand their operations, becoming advocates for the partnership based on the evident benefits.

Given the substantial regional differences in the Indian e-waste landscape, diverse collection and partnership strategies are required. Most e-waste is transported north of Delhi to Moradabad for end-processing by informal recyclers. Additionally, Karo Sambhav collaborated with NGOs skilled in improving the livelihoods of waste-pickers, organizing them into collectives and self-help groups. In Patna,

Bihar's capital city, characterized by lower e-waste volumes and limited collection compared to other urban centers, the absence of a robust aggregator network presents opportunities for waste-pickers to take on e-waste collection. Beginning in October 2017, Karo Sambhav partnered with an NGO in Patna to engage over 1'000 waste-pickers in e-waste collection. The model revolves around a community group initiative, forming self-help groups of 4-5 women who can access credit from banks. The outreach campaign identified 112 slums for weekly collection during fixed time periods and the NGO assisted waste pickers in acquiring electric rickshaws for e-waste collection from small vendors and repair shops.

Aggregators are required to adhere to a code of conduct established by Karo Sambhav, mandating compliance with the organization's standards. Checks and balances are in place to ensure accountability throughout the e-waste collection chain. Electronic documentation of transactions and material flows guarantees that materials exiting the informal sector do not re-enter informal recycling channels. Within its initial two years of operation, Karo Sambhav has successfully engaged over 5'000 aggregators and collectors, collecting more than 3'000 tons of e-waste. The organization continues to expand and enhance its operations. Figure 8 provides an overview of the approach employed by Karo Sambhav.

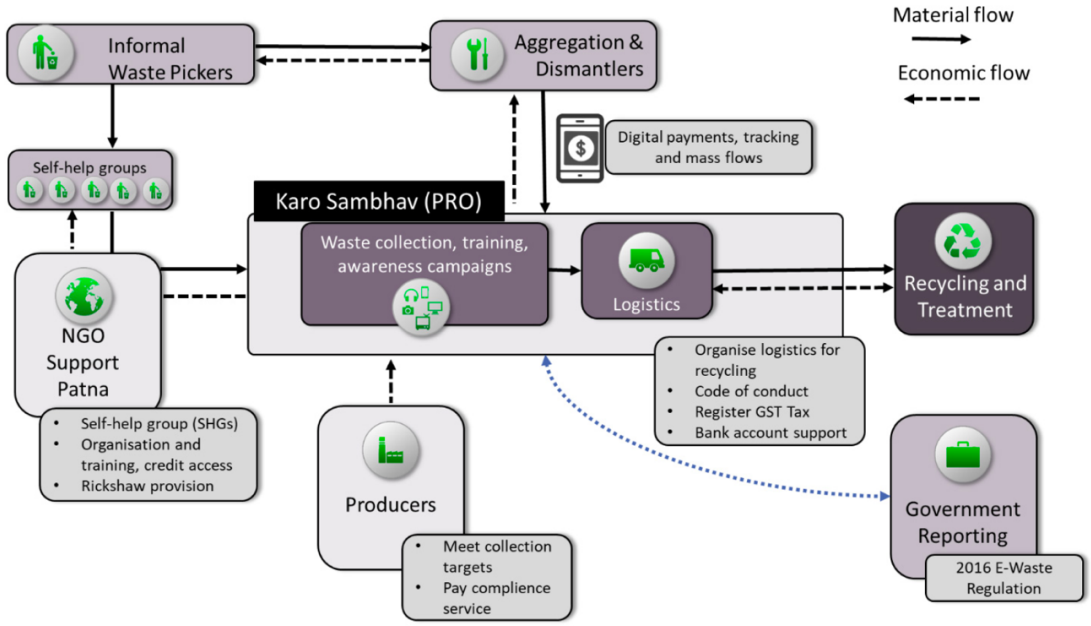

Figure 7: Overview of Karo Sambhav's role in bridging the gap between formal and informal sector. [3,8]

In light of the PROs and EPR programs in Egypt, this approach may need to be adapted to align with the specific conditions and requirements of the Egyptian context.

Intermediary Organization Approach for the Egyptian context

This approach adjusted to the Egyptian context involves the establishment of an intermediary organization or company equipped with the financial means to purchase e-waste from small collectors and aggregators at market prices, thus preventing this e-waste from being channeled into illicit pathways, such as selling to larger wholesale aggregators or informal e-waste dismantlers and recyclers. Subsequently, this organization conducts an auction or bidding process, exclusively open to formally accredited recyclers by WMRA. The formal recyclers typically offer lower prices due to their operational overheads, in contrast to the informal sector. This pricing discrepancy could potentially result in business loss as e-waste is purchased from the informal sector at a higher price and sold to formal recyclers at a lower rate.

The funding required to bridge the price difference is sourced from international PROs or large private sector companies situated outside Egypt, in regions like Europe, Asia, or America. Their motivation often stems from their commitment to providing carbon-neutral equipment. This means for every new device introduced to the market, they collect and recycle a scrap device, ensuring that electronics like phones and laptops become 'waste neutral.' They can accomplish this by contributing to an Egyptian organization that serves as the vital link connecting the formal and informal sectors, guaranteeing that e-waste collected by informal collectors is managed and recycled in an environmentally responsible manner through accredited formal recyclers. In return, these donor organizations receive carbon credits and comprehensive reports on e-waste collection and recycling activities. These reports and certificates can be employed as marketing tools to acquire customers and to apply for grants or incentives.

To receive foreign donations, the intermediary organization must hold the requisite licenses and security clearance. Additionally, the revenue generated from selling e-waste to recyclers should ideally cover operational expenses; however, if it falls short, a transaction fee may be imposed on donations to ensure the organization remains financially viable. This approach effectively addresses the primary challenge previously mentioned, namely the pricing disparity between the formal and informal sectors. To address the additional obstacle of trust, it is imperative to offer supplementary incentives beyond higher prices to attract informal waste collectors and aggregators. These additional incentives can manifest in various forms, such as access to micro-insurance, opportunities for worker training, a point-based system for ration cards, and shared co-working spaces for informal collectors. Registration as formal participants is a requirement to access these supplementary benefits and obtain an e-waste collector identification card. The trust-building process is of utmost importance since it will be lever in preventing the collectors and aggregators to sell their materials to informal recyclers or wholesale sellers.

Furthermore, this approach addresses another significant obstacle, which is that formal recyclers are legally prohibited from purchasing e-waste from informal collectors or aggregators. There's also no incentive for formal recyclers to do so illicitly, as they require a receipt (which informal workers cannot provide) to incorporate it into their costs of goods sold (COGS) and subsequently deduct it from their taxable income, thereby avoiding taxation on these transactions. This organization then bridges this gap between formal and informal sector to ensure that collected e-waste is adequately handled by accredited recyclers.

In the realm of intermediary organizations, the Dutch company 'Closing the Loop'[9] serves as a notable example. Committed to promoting sustainable consumption in the global tech industry, Closing the Loop offers a waste compensation service operating on a 'One for One' principle. For each new device introduced to the market, they collect and recycle a scrap device, aiming to achieve 'waste neutrality.' This service has gained recognition and is embraced by various public and private organizations. Collaborating with the tech industry, civil society, and local communities, Closing the Loop is actively involved in research on circular procurement, waste reduction, and empowering informal communities. Closing the Loop sources e-waste from African countries due to insufficient electronic

waste collection and recycling infrastructure. This collection plays a vital role in preventing uncollected and improperly recycled waste, contributing to increased waste reduction and offsetting the environmental impact of electronic devices.

One notable collaboration involves Closing the Loop and Vodafone Germany. Vodafone Germany, aiming to be a preferred choice for customers, incorporated Closing the Loop's waste compensation service into its Circular Mobile Strategy, branded as 'One for One.' This commitment pledges that, for each mobile phone purchased, an end-of-life mobile device is collected and recycled. The collection occurs in countries with inadequate waste management systems, overseen by Closing the Loop. This initiative significantly impacts the industry, emphasizing the potential for sustainable services to appeal to a broad customer base. The approach fosters trust during customer purchases, illustrating a commitment to practical circular solutions. Customers can manage their phone's lifecycle sustainably by utilizing Vodafone's circular services, including repair and return options. Closing the Loop's service involves collecting and recycling one discarded phone in Africa for each new device sold by Vodafone in Germany."

Implementing this approach presents several challenges. Initially, gaining access to informal collectors and building trust is a significant hurdle, as they are often resistant to changes in their culture and way of working, lacking flexibility. The requirement for formalization when dealing with the organization poses a threat, as informal collectors, upon formalizing, become subject to taxes that can erode their profit margins. This might discourage their participation and lead to a return to their informal activities. Furthermore, maintaining competitive pricing against large wholesale traders is complex. These traders frequently export e-waste illegally, enjoying high margins and low costs, making it difficult for the organization to match their prices. Consequently, preventing e-waste from entering illicit channels is challenging. During auctions with formal recyclers, the potential for collusion or cooperation among them to drive prices down is a concern. This could impact the organization's financial viability, making it non-self-sustaining.

4.4 Bypass Approaches

The bypass route takes a different path, avoiding the informal sector and directly reaching out to households, essentially making it a Business-to-Consumer (B2C) approach. There are two main categories of bypass routes. In one scenario, individual consumers proactively visit designated collection centers to deposit their e-waste. This practice is already in place in Egypt, with E-Tadweer being the company that follows this model. The second approach involves providing a door-to-door collection service, eliminating the need for private consumers to commute, facilitating the process for them. In both scenarios, there is typically some form of compensation for the consumers, which can take the shape of reward programs, points, vouchers, price reductions, or other incentives.

According to Mr. Ahmed Salem, who serves as the Head of the NGO representing formal recyclers in Egypt, the establishment of a door-to-door collection system presents significant challenges. Previous attempts were made in this direction, including the launch of a mobile application that allowed private individuals to sign up, provide details about their e-waste, and schedule pickups via cars, trucks, or motorcycles. However, this approach proved to be cost-prohibitive due to the high number of orders and the small quantities of e-waste collected during each pickup. These collections could not cover the transportation costs. To find an alternative solution, Mr. Salem explored partnerships with shipping companies. Unfortunately, this too proved to be financially unsustainable as these companies charged based on the weight of the e-waste. Given the limited number of orders and the relatively small weight of the donated e-waste per order, this approach remained unfeasible. Setting up a door-to-door collection system that can compete with the existing informal sector is expensive.

4.4.1 Private Sector Collection System: E-Tadweer

The information provided was gathered directly from an interview with Mr. Karim Dabbous, the founder and CEO of E-Tadweer.

E-Tadweer, founded by Mr. Karim Dabbous in 2020, is a pioneering company dedicated to promoting environmentally responsible disposal of household e-waste. The company achieves this by offering a smartphone application. Users can sign up, complete the requisite information, and photograph their old electronic devices. The application then guides them to the nearest collection point. E-Tadweer primarily concentrates on communication and IT-related e-waste and has successfully secured contracts with major corporations like Vodafone, showcasing a wide spectrum of accepted e-waste types. Private users who bring in their old devices receive compensation in the form of vouchers or rewards for the purchase of new equipment. However, E-Tadweer does not provide cash compensation; instead, Vodafone undertakes the collection of these items and promptly informs E-Tadweer once a critical volume has been accumulated. The company then coordinates with e-waste recyclers to collect the materials from the designated location. Within this collaborative framework, Vodafone receives a share of each transaction, creating a mutually beneficial revenue structure for E-Tadweer. Figure 9 provides an overview of E-Tadweer business operation.

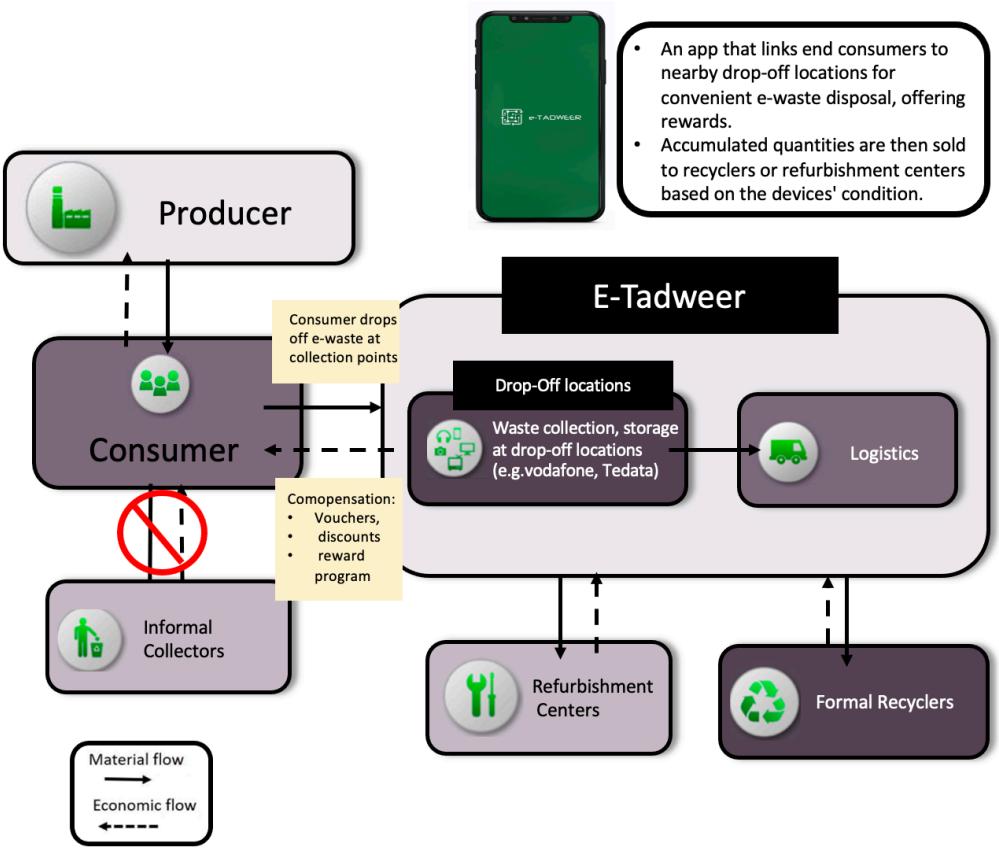

Figure 8: Overview of E-Tadweer's business operations.

Challenges

While companies like Vodafone have an extensive network of branches across Egypt, a major challenge lies in the limited awareness and willingness of individuals to make the effort to drop off their e-waste. Only specific Vodafone branches equipped for e-waste storage are part of this initiative, and their numbers remain limited. This limitation contributes to the reluctance of people to undertake long commutes solely for the sake of obtaining a voucher. The preference for cash over vouchers is common among the Egyptian population.

The process of accumulating a sufficient quantity of e-waste for recycling can be protracted since it is unfeasible for recyclers to collect smaller amounts. This situation has led to increased overhead costs, mainly because Vodafone requests higher shares per transaction (almost around 10 % of each transaction). Due to the public's unwillingness to drop off their e-waste and increasing overhead costs, the service was closed in certain less frequented Vodafone stores. Expanding the number of participating stores and other collection points however are a prerequisite to make e-waste disposal more convenient for the public.

New Direction

In addition to its traditional E-Tadweer model, the company diversified its offerings by providing consultancy services to ensure its survival and adapt to changing market demands.

E-Tadweer now serves as a consultancy firm for private sector companies, aiding them in the sale of their e-waste materials. They specialize in optimizing the sale process, ensuring their clients secure

better prices and generate more revenue. In return for their services, E-Tadweer charges consultancy fees, effectively handling the entire process on their clients' behalf. As an additional layer of assurance, they offer certificates and QR codes equipped with tracking capabilities. These measures verify that the e-waste has been sold to a formal recycler, enhancing transparency and accountability.

It's important to note that E-Tadweer doesn't purchase e-waste directly but operates as "e-waste agents" facilitating the selling process on behalf of their clients. Moreover, E-Tadweer aspires to calculate and trade CO2 certificates; however, this endeavor faces challenges in the Egyptian context. These challenges primarily stem from a lack of expertise and transparency. Notably, even formal recyclers encounter difficulties in quantifying their efficiency, material yield, and resource consumption—essential factors for precise carbon calculations.

4.4.2 Charity Organization Approach

The "Charity Organization Route" is an approach that capitalizes on the extensive network and established connections of charitable organizations present in every governorate across Egypt. These organizations routinely receive a wide array of donations, encompassing various items, including electronic devices. The central idea of this approach is to empower these charitable entities to collect and then segregate e-waste or electronic devices in substantial quantities. If the necessary expertise is available in-house, these charitable organizations can further categorize the electronic equipment into groups for refurbishment and e-waste, optimizing the potential for environmentally responsible disposal and economic recovery. Once a significant volume has been gathered, these organizations can organize auctions for these items or collaborate with formal recyclers, inviting them to collect the e-waste. In this collaborative model, the charity organizations play a pivotal role in the e-waste management process and, in return, are compensated with a share of the profit generated from the recycling of these materials. This approach not only streamlines the collection process but also leverages the extensive reach of charitable organizations to contribute positively to e-waste management, all while benefiting from the financial aspects of the recycling operation. It presents a mutually beneficial opportunity that can significantly enhance e-waste management in Egypt. Figure 10 presents an overview of this approach.

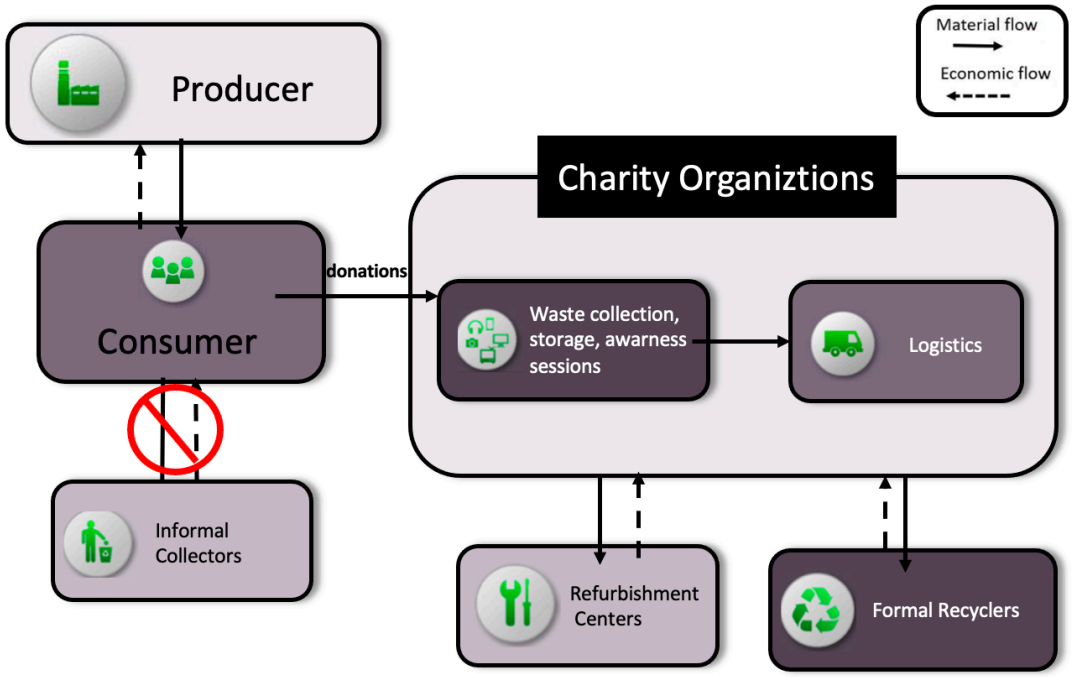

Figure 9: Overview of the Charity Organization Approach.

Advantages

The "Charity Organization Route" offers a range of distinct advantages. One of its key benefits is the elimination of the need for constructing new infrastructure or establishing extensive networks. Since these charitable organizations are already firmly rooted in every governorate in Egypt, the necessary connections and a vast network are readily available. This inherent infrastructure negates the requirement for additional marketing efforts and the need for substantial additional investment or resource allocation. Moreover, the existing reputation and credibility of these organizations can significantly expedite the process, as they are already established and trusted entities within their communities.

This existing framework not only simplifies the logistics of e-waste collection but also enhances the overall efficiency of the recycling process.

From a legal perspective, this approach operates within a gray area, as these charity organizations are receiving donations of old electric and electronic equipment, which are not necessarily classified as hazardous e-waste. This classification provides the benefit of not having to apply for licenses to collect and store electronic and electrical equipment from WMRA, which are time-consuming and costly to obtain.

Disadvantages

The Charity Organization Route comes with a set of challenges that need to be acknowledged and addressed. The process of collecting, segregating, and refurbishing electronic equipment can be intricate and demands a well-organized system. Properly storing this equipment until a sufficient quantity is amassed for auction or pickup can also be a logistical challenge. The market demand for refurbished or recycled electronic equipment is another aspect to consider. Success relies on a steady market for these products, and competition with newer devices can affect pricing and profitability. Additionally, regulatory compliance is essential, as even though these donations may not be classified as waste, environmental regulations must still be adhered to. Ensuring that the handling and disposal of electronic equipment align with legal standards can be demanding.

Furthermore, the issue of revenue sharing requires careful negotiation between charity organizations and formal recyclers. Determining equitable profit-sharing terms can be a complex process, with potential for disputes or hesitations in the partnership. Finally, data security is a crucial concern. Handling donated electronic equipment carries the risk of data breaches if data is not properly wiped or destroyed. This poses privacy and security risks that need to be addressed effectively. Recognizing and addressing these challenges is essential for the successful implementation of the Charity Organization Route in e-waste management in Egypt.

4.5 Comparison of Approaches

Key performance indicators to evaluate collaboration solutions between the formal and informal sectors in Egyptian waste management include:

- **Price Gap:**
  - Bridging the price gap between formal offerings and informal sector expectations.
- **Material Supply at Formal Facilities:**
  - Addressing the problem of insufficient material at formal recycling facilities.
- **Alignment of Interests and Self-Sustaining:**
  - Ensuring mutual interests and assessing the long-term sustainability of the collaboration.
- **Building Trust:**
  - Implementing trust mechanisms and fostering synergies between formal and informal actors.
- **Minimal Disruption to Informal Operations:**
  - Assesses the approach's success in minimizing changes to the existing operations of informal sector participants, ensuring a seamless collaboration without significant disruption to their established workflows and practices.

To establish a sustainable and mutually beneficial collaboration in the Egyptian waste management context, a successful solution needs to effectively address key indicators. A pivotal factor for success is bridging the price gap, given that workers and involved parties prioritize immediate financial needs over additional benefits like insurance, health, a good working environment, protective gear, training sessions, or access to ration cards. While these aspects are crucial for their well-being, securing a regular income remains the top priority.

Informal collection networks are better than formal ones in terms of efficiency, while formal treatment processes excel at recovering more resources from e-waste. Merging these systems offers the potential to maximize efficiency in both collecting and processing e-waste.

A comparative analysis of possible approaches, provided in table 1, indicates that the direct partnership approach is financially infeasible due to compensation challenges. Informal actors will always have the chance to sell their e-waste and get higher reward rather than being subcontracted and getting a collection fee or salary or in the best case a profit share. Forming an informal workers association, while improving the overall situation of informal workers, does not address the price gap issue. Formal recycler will still struggle to match prices offered by informal wholesaler and aggregators.

The E[co]work approach, while beneficial in improving informal workers lives, encounters significant logistical drawbacks for informal workers. The requirement to operate in a different co-working space, away from their established nodes and networks, poses challenges in accessing materials and disrupts their way of operating. Additionally, concerns arise regarding the long-term financial sustainability of the E[co]work business model. Furthermore in India, the dismantled material by informal actors at the co-working space does not channel to formal recyclers; instead, it is still sold to other informal actors. Consequently, this approach does not effectively address the crucial issue of the lack of materials at formal recycling facilities. But it offers an excellent entry point to understand and gain the trust of informal workers. This can lead to successful collaborations in the future in which they sell their materials to formal workers if the price gap is bridged via the EPR fee or other financial mechanisms.

The intermediary organization approach emerges as the most sensible choice, addressing critical aspects such as overcoming the price gap and minimizing disruption to existing informal operations. This approach provides additional incentives (insurance, awareness session, access to ration cards etc.) and

directly tackles the challenge of insufficient raw materials at formal recycling facilities. This approach has the highest likelihood of success and can be combined with the other approaches presented. Informal workers could potentially secure better prices by collaborating with intermediary organizations. These entities have the capacity to amass larger quantities through pooling and conducting auctions, leading to higher selling prices. This approach is particularly advantageous for roamers and small microentrepreneurs, as intermediary organizations can sell the aggregated quantities and distribute the proceeds based on the agreed-upon split. This approach can be seamlessly integrated with the E[co]Work model, allowing informal workers to sell their dismantled e-waste to the intermediary organization. With sufficient funds, the intermediary can purchase the e-waste at market prices. This collaboration not only establishes trust between both entities but also provides valuable insights into the needs of informal workers. This understanding becomes a pivotal entry point for tailoring additional incentives that further strengthen trust. The autocatalytic mechanism is set in motion, fostered by word-of-mouth recommendations from informal workers. As a result, this collaboration lays the groundwork for informal actors to potentially form a united front in the future, possibly evolving into a workers' association.

Bypass approaches, like a door-to-door collection system, are considered impractical due to high transportation costs and low e-waste volumes per order. However, the charity organization network is seen as a promising approach, to be pursued alongside the intermediary organization approach. Careful negotiation is required to address drawbacks, such as handling and storing e-waste by these organizations and issues related to revenue sharing. Determining equitable profit-sharing terms may be complex, necessitating careful consideration for a successful partnership.

Table 1: Comparison of partnership approaches for bridging the gap between formal and informal sector. Green, yellow and red denote excellent, moderate and below average efficacy.

		Approaches			
		Direct Partnership Model/Subcontractor Model	Subsidized Co-Working Space (E[co]work)	Informal Workers Association	Intermediary Organization Approach
Key Performance Indicator (KPI)	Material Supply at formal Recycling facilities	Informal workers are subcontracted by formal recyclers to collect for them directly.	No material flow towards formal recycling facilities	Informal collectors pool e-waste and sell to formal recyclers through informal workers association	Informal collectors sell their e-waste individually to the intermediary organization which hosts an auction for formal recyclers
	Bridging Price Gap	Not applicable	Not applicable	Price gap still exists	Price gap is bridged via donations from international corporations and PROs
	Self-Sustaining	Minimal; Profit of selling the collected e-waste to aggregators and wholesalers is larger than any compensation (salary or profit share)	Medium; Need for ensuring the feasibility of such a co-working space to self-sufficient and cover its own expenses	Not-Self-Sustaining; leverages position of informal workers, so that these can sell for even higher prices to formals, nothing prohibits them from selling to informal wholesalers and aggregators	Self-Sustaining as long as price gap can be bridged and additional incentives are in place to gain informal workers trust
	Trust Building incentives	insurance, steady salary or compensation in form of profit shares	Awareness sessions, trainings, protective gear, tools, equipment, storage space, prayer room, sanitary work environment	Insurance, awareness sessions, ration card	Insurance, ration card, awareness sessions, loans
	Disruption of Informal Operations	Informal workers will have to slightly adjust since they must adhere to collection regulation of formal collection license	Medium-high; informal dismantlers work in co-working space with tools and equipment wearing protective gear	Minimal; informal workers will operate like before	Minimal; informal workers will operate like before

5 Conclusion & Outlook

In summary, the overarching goal of this study was to establish an international benchmark for successful approaches in bridging the collection gap between the formal and informal sectors in waste management, drawing insights from existing literature and case studies across various developing nations. Further investigation into the likelihood of success for these approaches within the specific context of Egypt, involving extensive stakeholder exchanges were conducted to identify key challenges and opportunities.

Looking ahead, the study strongly advocates for the implementation of the intermediary organization approach, deeming it as the most promising strategy. This innovative approach bridges the price gap, facilitating the purchase of collected e-waste from informal workers through auctions that connect informal sellers to formal recyclers. The financial bridge is primarily established through foreign donations from established Producer Responsibility Organizations (PROs) and international corporations. In return, these entities receive valuable carbon credit certificates or equivalent documentation, validating the extent of environmentally sound recycling achieved. While this approach serves as a valuable short-term solution, it's crucial to emphasize that the ultimate goal should be the establishment of a national Extended Producer Responsibility (EPR) system in Egypt.

A key advantage of this approach is its minimal disruption to the operations of highly efficient informal collectors. Informal collection networks are more effective than formal ones, while formal treatment processes can recover more resources from the e-waste. By bringing these two systems together, the collection and end-processing efficiency of the e-waste value chain can be maximized. This intermediary organization approach is a short-term bridging solution until the introduction of the Extended Producer Responsibility (EPR) system in Egypt.

For a potential pilot of this ground-breaking approach, fundraising efforts can be initiated by establishing connections with well-established companies, such as Closing the Loop in the Netherlands or local PROs which in return would receive recycling certificates. The raised funds could be channelled through an independent organization, which possesses the necessary security clearances, documents, and auditing capabilities for receiving foreign funds. A financial regulator agency or independent committee can meticulously oversee transactions and operations. The intermediary organization, possibly the formal Egyptian recyclers association or another independent committee with connections to the informal sector, plays a pivotal role. Leveraging the fact that many formal recyclers were once part of the informal sector, these people, as members of the formal recyclers union, can establish connections to facilitate the purchase of e-waste from informal actors. Independent storage spaces can be rented, serving as secure locations for the storage of e-waste. An auction, featuring formal recyclers accredited by the Egyptian Waste Management Authority, can be conducted by an appraiser office. The data gained from such a pilot project are invaluable, providing crucial insights to validate the accuracy of the EPR markup fee estimated as part of the SRI project. Figure 11 presents an overview of the proposed solution approach.

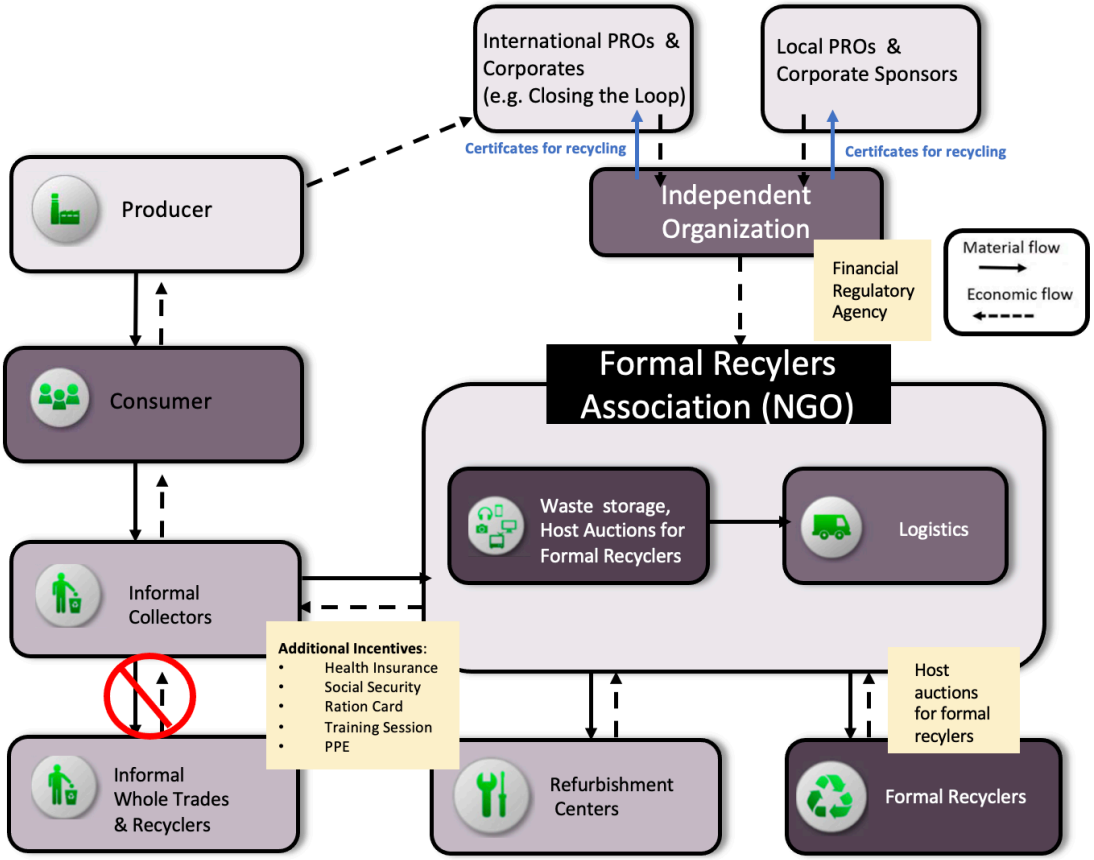

Figure 10:Overview of the proposed intermediary organization approach for Egypt.

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