



JOBS & SKILLS IN THE CIRCULAR ECONOMY

WITH FOCUS ON PLASTIC, ELECTRONIC, AND ORGANIC WASTE

— IMPRINT

Jobs and Skills in the Circular Economy

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AI DISCLOSURE

Selected visual materials and graphical illustrations were generated with the support of artificial intelligence and reviewed by the editorial team.

Background and Purpose of the Study

The concept of **Circular Economy (CE)** is gaining increasing attention in international cooperation, yet its exact meaning and its potential are often less clear. While there are numerous publications discussing CE concepts and models, less information is available on how the shift to CE can contribute to the creation of decent employment and specifically, what skills are needed. This paper, based on desk studies and selected interviews with circular businesses, has **three main purposes**:

- Providing an overall description of the concepts of CE and the different CE approaches;
- Exploring the potential and challenges of circular business models in selected CE sectors in the context of low- and middle-income countries;
- Elaborating on the demand for qualifications and skills for CE in selected sectors.

While elaborating on the general concepts of CE that are applicable globally, the paper has a clear focus on developing country contexts, with case studies originating mostly from Sub-Saharan Africa and South Asia. Given the significance of the waste management sector the bias of the study is on CE practices that address, in relation to waste management, the “downhill” part of the circularity model, i.e. the extraction of reusable materials and recycling of waste. Specific consideration has been given to the informal sector and small to medium enterprises in the context of CE.

The paper is primarily aimed at development practitioners. It is divided into two parts: **Part I** addresses CE concepts, the analysis of selected CE sectors, and explores the demand for skills and jobs in these sectors. **Part II** illustrates case studies of countries as well as of individual businesses and initiatives in the CE.

This paper has been self-financed by **FAKT**. It is primarily based on a review of literature available as open sources and case studies, some of which have been directly conducted in the form of interviews and field visits.

We thank all the contributors to this paper, which is considered a **living document**, to be enriched by further insights from practitioners.

Disclaimer

This publication has been prepared by FAKT Consult for Management, Training and Technologies gGmbH and is based on a review of publicly available literature, reports, databases, and online resources, as well as selected interviews and field visits conducted by the authors.

Part I of this study is primarily based on desk research. Part II includes case studies based on field visits, interviews, and desk research. All data, figures, statistics, and statements derived from external sources are referenced accordingly. As a living document, this publication may be revised and updated to reflect new evidence, case studies, developments, and feedback from practitioners.

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List of Abbreviations

ACEF	Africa Circular Economy Facility
ACEN	Africa Circular Economy Network
AfriCGE	African Centre for Green Economy
AI	Artificial Intelligence
BMUV	German Federal Ministry of Environment, Nature Conservation and Nuclear Safety
BMZ	German Federal Ministry for Economic Cooperation and Development
CBM	Circular Business Model
CE	Circular Economy
CIRCO	Dutch NGO 'Creating Business through Circular Design'
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DC	Development Cooperation
EEE	Electrical and Electronic Equipment
EPA	Ghanaian Environmental Protection Agency
EPR	Extended Producer Responsibility
E-Waste	Electronic Waste
FAO	Food and Agriculture Organisation
GHG	Greenhouse Gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
ICT	Information and Communication Technology
ILO	International Labour Organisation
IoT	Internet of Things
LMIC	Low- and Middle-income Countries
MESTI	Ghana Ministry of Environment, Science, Technology, and Innovation
MSW	Municipal Solid Waste
NQF	National Qualifications Framework
OECD	Organisation for Economic Co-operation and Development
PET	Polyethylene Terephthalate
SMEs	Small and Medium-Sized Enterprises
TVET	Technical and Vocational Education and Training
UN	United Nations
UNDP	United Nations Development Programme
UNIDO	United Nations Industrial Development Organisation
UNITAR	United Nations Institute for Training and Research

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Part I – Circular Economy Concepts, Sector Analysis and Demand for Skills and Jobs

1 The Concept of Circular Economy (CE)

1.1 Definitions and Characteristics

The term "Circular Economy" (CE) implies many definitions and interpretations. The EU Commission broadly defines CE as a **development strategy** that brings economic growth without increasing resource consumption, profoundly changing production chains and consumption habits and redesigns industrial systems at system level (Lehmacher & Bödecker, 2023). Other sources go further and define CE as an **alternative economic model** that aims to **decouple economic growth from resource consumption** by designing out waste and keeping products and materials in use for as long as possible (Ellen MacArthur Foundation, 2019; Kreutzer, 2023, pp. 5-6).

Though the scopes of the various definitions may vary, they generally have a similar conceptual foundation. The CE relies on the **re-use, shared use, product use extension, recycling and retention** of material goods as an alternative to the linear model of extraction, manufacture, single use, and disposal. It maintains products, components, and materials at a high level of utility and value by altering the incentive structure for businesses that promote the production of more durable goods and goods that serve as inputs into other production streams when they are no longer usable. Thus, it is a **closed-loop economic model** that, in contrast to a linear one, enables the regeneration of natural ecosystems, greatly decreases waste and pollution, and decouples economic growth from greenhouse gas (GHG) emissions. Therefore, the promotion of CE strategies is seen as a key strategy for mitigating climate change. The EU Circular Economy Action Plan (2020) links the CE directly to the European Green Deal (European Commission (EC), 2020a).

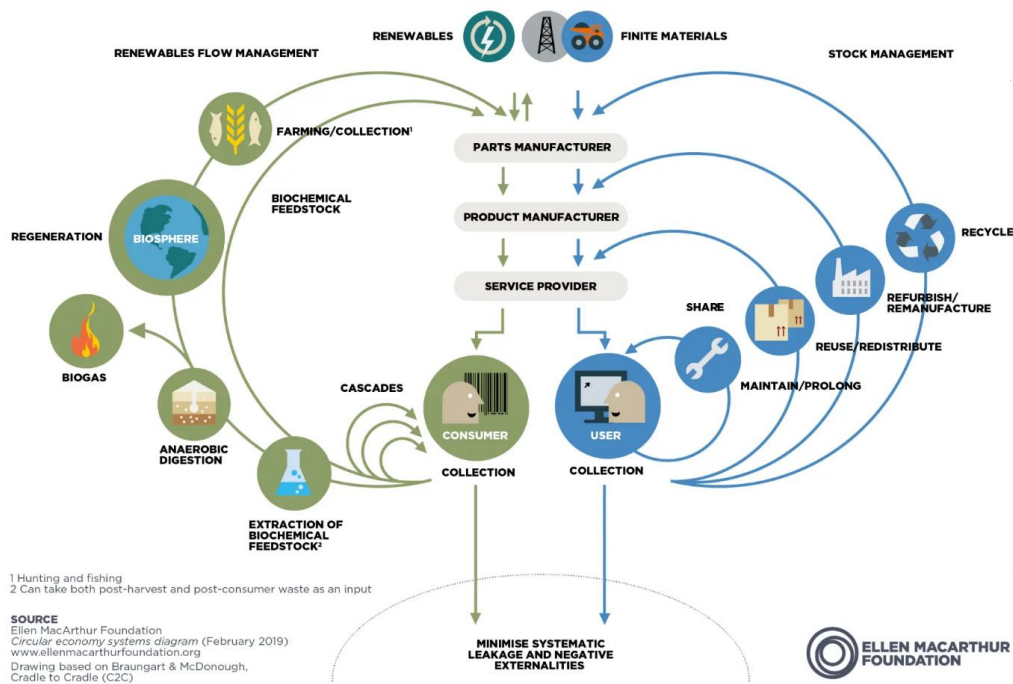
Conventional economic growth strategies mainly adhere to the linear economy model, where resources are utilised once and discarded, often termed a disposable economy, following the "cradle to grave" approach. The linear economy principle is summarised as "**take, make, use, dispose**". Conversely, the CE promotes the "**cradle to cradle**" principle, aiming to prolong resource utilisation to minimise resource consumption.

In the following, we describe different models for CE.

The "**10R Framework**", for example, breaks down each step of a CE, with a focus on minimising the consumption of materials and resources along the manufacturing chain and beyond. This model is a more comprehensive and extensive variation of the initial model, referred to as the "**Three R principle**", which was coined as "Reduce, Re-use, Recycle", dating back to the 1970s (Pantheon Enterprises, 2016).

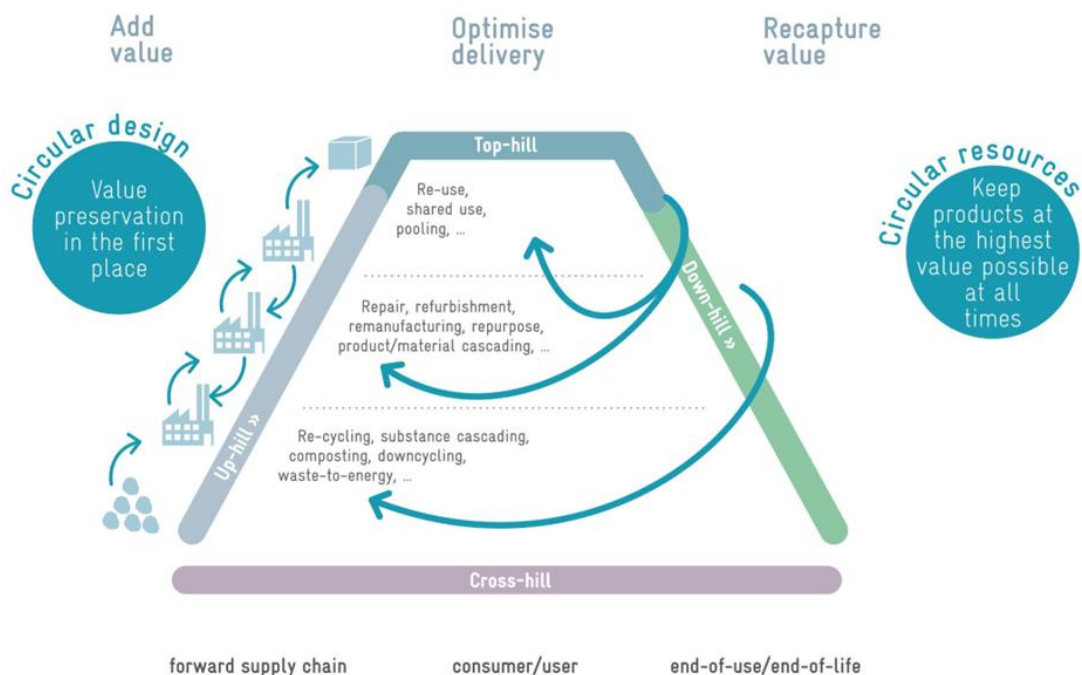
The Ellen MacArthur Foundation's CE model is built on three core principles: (1) Eliminate waste and pollution, (2) circulate products and materials at their highest value, and (3) regenerate nature. The model emphasises designing products and systems that enable re-use, repair, remanufacturing, and recycling, while also ensuring that natural systems are restored rather than depleted. It is a transformative concept that argues for a major shift of economic practices (Ellen MacArthur Foundation, 2019b; 2024; 2025).

Figure 1: Circular Economy Systems Diagram (Ellen MacArthur Foundation, 2019a)



For this study we take a deeper look at the so-called “**Value hill model**”, which is a conceptual framework used to illustrate how economic value changes along a product’s lifecycle and to show where circular strategies can preserve or regenerate value. The activities are categorised into four sections, each representing different stages of the production cycle of goods. **Figure 2** and **figure 3** both illustrate the circular and linear economy in a comparable way, highlighting the differences (Achterberg et al., 2016, pp. 4–5):

Figure 2: Simplified Value Hill Model Illustrating the Circular Economy (Menzel-Hausherr et al., 2022a, p. 9)

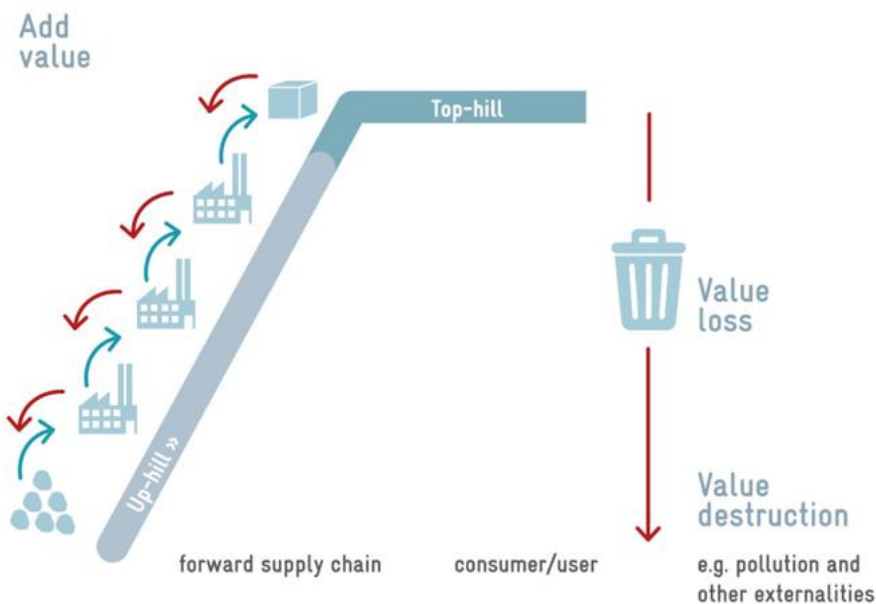


Circular design and production (uphill): This pertains to the pre-use phase, involving the development and distribution of reusable, recyclable, or compostable materials as alternatives to virgin materials.

1. **Circular use (top-hill):** This focuses on the optimal use phase, emphasising product re-use and extended product lifecycles. Examples of circular business models (CBM) include product-service-system models organised through renting, pay-per-use, leasing, and sharing economy initiatives.
2. **Circular value recovery (downhill):** This addresses the post-use phase, encompassing activities such as separate collection of waste, repair, refurbishing, remanufacturing and recycling. The resource recovery model, extended product value initiatives, and waste value models serve as examples.
3. **Circular support (cross-hill):** This includes tools, applications, and services facilitating the CE (Menzel-Hausherr et al., 2022b: 8).

For comparison, **figure 3** shows the linear economy using the **Value Hill model**. The **downhill** and **cross-hill** areas that can be found in **figure 2** only exist to a limited extent or not at all.

Figure 3: Simplified Value Hill Model Illustrating the Linear Economy (Menzel-Hausherr et al., 2022, p. 9)



By highlighting the **sectors of plastic, electronic and organic waste**, this study focuses on the **downhill** part of the model.

Criticism of the Circular Economy Concept

The varied definitions and interpretations of the CE concept are a key issue in its criticism. Over the recent years the CE has gained popularity in academic, policy, and business audiences. According to Rizos et al. (2017), however, its diverse interpretation and application can cause confusion and hinder international cooperation (p. 7).

According to Kirchherr et al. (2017a), most definitions of the CE focus on **reduce, re-use, and recycle** activities, but they often overlook the need for a **systemic shift**. Few definitions explicitly connect the CE to sustainable development. The primary focus is on economic prosperity, then environmental

quality, with little mention of social equity or future generations. Additionally, business models and consumers are rarely discussed as facilitators of the CE.

In addition, it is generally criticised that many studies on the topic of the CE largely relate to the Global North. Others point out that the rest of the world can learn a lot from circular approaches in low-income countries of the global South, especially from Africa: “Indigenous and ingenious approaches to keeping scarce materials are already more circular than those of industrialised countries in the North (Footprints Africa, 2021).

Political Impediments to the Shift towards CE Policies

Despite its environmental and economic benefits, the circular economy faces political resistance due to several interrelated factors. Incumbent industries—especially those dependent on linear models such as extractives, fast fashion, and plastics—often lobby against regulation that threatens their current business models. Policy fragmentation and lack of coordination between ministries (e.g. environment, industry, finance) hinder coherent CE strategies. There is also resistance from local governments, businesses and workers who may perceive CE reforms as costly, complex, or threatening to jobs. Additionally, short-term political cycles disincentivise long-term investments in CE infrastructure. In some contexts, vested interests, regulatory inertia, and low public awareness contribute to a lack of political will to enact or enforce ambitious CE policies.

1.2 Waste Management in the Circular Economy Concept

In general, waste management **holds significant importance in the transition to a CE**. For numerous countries, especially those undergoing development, addressing waste management is often the entry point to circular approaches (European Commission (EC), 2020b, p. 13). Literature analysis shows a “predominance of case studies at the lower end of the circularity hierarchy, focusing on the use of waste materials” (Footprint Africa, 2021, p. 7). On the other hand, it is argued that resource scarcity and poverty have always been a driving force for “up-hill” circular practices in low-income countries, especially with regard to extending the use phase of products.

The world annually consumes approximately 100 billion tonnes of materials, with cities estimated to produce up to 10 billion tonnes of solid waste per year (CGR, 2024; UNEP, 2015). Rapid global economic and population expansion leads to escalating waste volumes. Projections from the World Bank indicate a 70% surge in global solid waste generation by 2050. Municipalities in Low- and Middle-income Countries (LMIC) allocate approximately 20% of their budgets to waste management, yet over 90% of waste is still disposed of through open dumping or burning (Kaza et al., 2018).

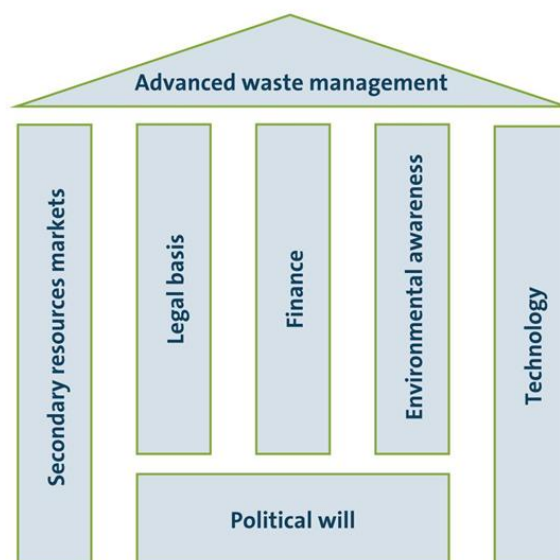
In this context, the establishment of functioning **waste management systems** – covering collection, sorting, and treatment of waste, including plastics – is of primary importance. Their aims are twofold: to recover resources and to safeguard the environment. It is crucial to recognise that countries have diverse waste management systems at varying stages of development and resource availability. This calls for tailored strategies and technical assistance to support technology transfer, development and the creation of enabling policies that address their specific needs. These efforts are essential to improving waste management efforts, particularly regarding plastic recycling schemes (Berger, 2023, p. 2).

An effective waste management system requires well-equipped entities responsible for safe disposal. Larger facilities are usually more cost-efficient through economies of scale, but they require appropriate organisational structures and catchment areas. In resource-constrained contexts (e.g. poor residential areas or rural areas), waste management practices are often inadequate as local authorities do not have the means or political will to build and operate facilities. Alternative solutions such as forming local

associations, engaging private-sector companies (including informal sector) or public-private partnerships can address this issue. (GIZ & BMUV, 2016, p. 12).

The graphic below shows the basic pillars of a functioning entity of advanced waste management.

Figure 4: Establishment of Entities in Charge of Waste Management (GIZ & BMUV, 2016, p. 12)



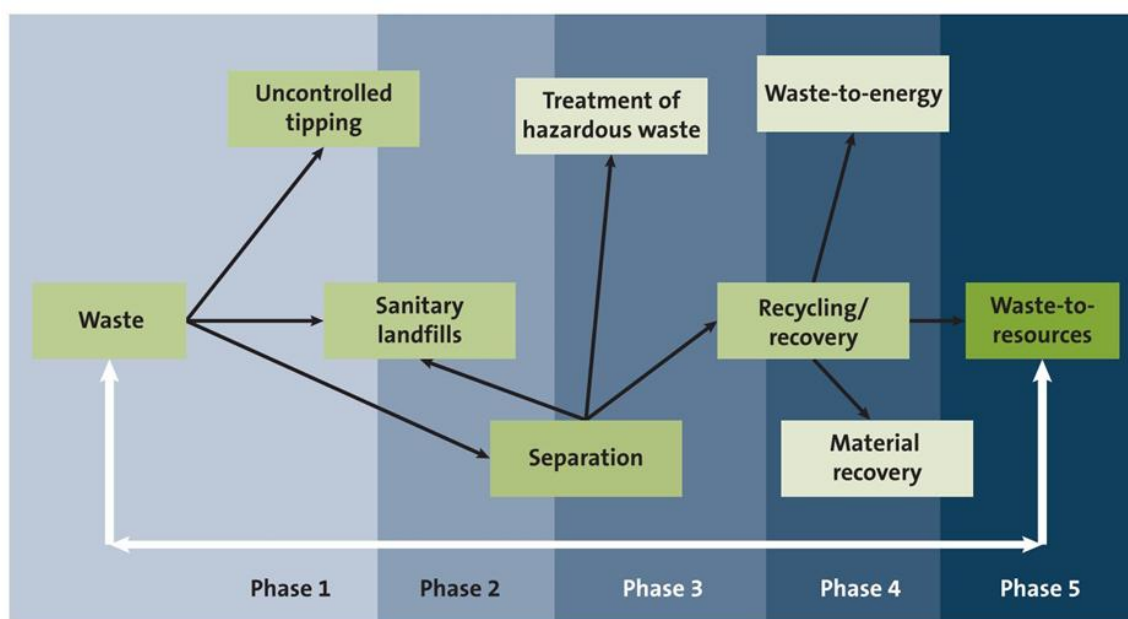
A robust waste management or CE system, e.g. for plastic and other wastes, relies on **secure markets for recycled materials**. Government support through tax relief, import duty exemptions, investment funding, subsidies, and producer responsibility requirements can ensure the economic viability of the recycling industry. Involvement of the informal sector not only contributes to capacity building and training but also promotes equality and poverty reduction. Local or national buyers of recycled products are essential for a CE, as they drive the demand for high-quality recycled materials, enabling the emergence of industrial buyers and suitable production processes (GIZ & BMUV, 2016, p. 20).

Strategy papers emphasise the importance of supporting **technological innovation and scale-up** through political frameworks and **private sector engagement** (European Commission (EC), 2020a). For instance, public-private partnerships (PPP) in industrialised countries are used for supporting the development of advanced recycling processes and facilities (**see case studies, Part II**). However, developing countries often lack the necessary human and financial resources in both public and private sector to develop and upscale technical innovations. Both, financial and technical assistance play a key role in transferring technical innovations to developing country contexts where applicable or in supporting the development of “home-grown” solutions.

To understand the role of technologies, it is helpful to use the concept of the **five phases of waste management** as shown in **figure 5** below.

For **more information** on the different phases of waste management, we recommend reading the **GIZ & BMUV** handbook "Modern waste goals and paths: Germany's expertise for an advanced circular economy" (Source: [GIZ & BMUV, 2016](#)).

Figure 5: Five Phases of Waste Management (GIZ & BMUV, 2016, p. 5)



Experience demonstrates that optimal outcomes for recycling and environmental preservation are achieved through **segregated collections**. Keeping waste fractions separate at the source and collecting them individually is the initial step toward recovering secondary resources. Efficient and effective recycling necessitates distinct processes for each material (GIZ & BMUV, 2016, p. 5).

Waste collection is much more comprehensive and organised in urban areas: 49% of the waste generated in urban areas in sub-Saharan Africa is collected, while only 9% is collected in rural areas. As a result, open dumping and burning have become the norm in rural areas as a means to get rid of waste, including plastics. (Elsaid & Tsonang, 2022, p. 3).

Waste composition varies with income levels, reflecting consumption patterns. Industrialised, high income countries produce comparably less organic waste, whereas in Africa, about 57% of waste is organic, with 13% being plastic. Organic waste, largely untapped in Africa, can be a valuable resource (see section on organic waste, **chapter 4.4**). Separately collected organic waste can undergo biological treatment, suitable for material recovery. Depending on its composition, it can be composted or used to generate biogas in fermentation plants. (Elsaid & Tsonang, 2022, p. 2).

Less than half of the waste generated in Africa is collected formally. Therefore, when developing waste management systems, socioeconomic factors such as informal sector involvement must be taken into account (Menzel-Hausherr et al., 2022b, p. 48).

1.3 Just Transition in the Context of Circular Economy

A **Just Transition** refers to the process of shifting toward a more sustainable economy in a way that is fair, inclusive, and equitable for all people, particularly those whose livelihoods are affected by the transition (ILO, 2016). In the context of **circular economy**, this means ensuring that the move away from a linear "take-make-dispose" model toward a regenerative, resource-efficient system creates new opportunities for businesses and decent jobs without reinforcing social inequalities or excluding vulnerable populations. A Just Transition in the circular economy requires proactive measures to support workers and businesses in affected sectors through business development aimed at creating new employment opportunities, reskilling, and social protection, and to ensure that new economic

opportunities—such as recycling, repair, and remanufacturing—are accessible to all, including women, youth, and rural communities (ILO, 2016, 2023b).

Considering the significance of the waste and recycling sectors, one key dimension for Just Transition is to improve the working and business conditions of informal sector businesses and informal workers as well as to integrate these marginalised actors into formal value chains (see section on informal sector in CE, **this chapter** below). A Just Transition also entails participatory governance and global resource justice, ensuring that the benefits and burdens of the circular transition are fairly distributed across societies and countries (McCauley & Heffron, 2018). In international cooperation, embedding Just Transition principles into circular economy initiatives enhances both environmental and social sustainability, aligning climate and resource efficiency goals with inclusive development.

The extent to which the shift to CE practices leads to net growth in employment is subject to discussion (see section on impact of CE scenarios, **chapter 5.1**). While the ILO study on “Skills for a greener future” (ILO, 2019) predicted substantial net job growth (see section on CE conclusions and recommendations, **chapter 6**), other studies are more cautious, with some predicting an initial “dip of net employment”, especially during the transformation period, due to the potential for both job creation and disruption. While the transformation does not necessarily lead to a net decline in employment, there are risks of job losses in certain industries, especially if social and labour policies do not accompany the transition. These losses are predicted especially for countries depending on mass manufacturing reliant on inputs of virgin raw materials, as well as resource extraction industries (Laubinger et al, 2020). If not supported by clear and reliable Just Transition policies, businesses and workers may fear job and income losses, which contributes to political movements aimed at maintaining the status quo or reversing trends going toward linear, resource-intensive economic models and practices.

The Role of the Informal Sector in the CE

According to 2023–ILO statistics, approximately 58% of the world’s population, equating to over 2 billion workers, are engaged in informal sector employment. In Sub-Saharan Africa, 83% of employment is considered informal, while the informal sector accounts for an estimated 38% share of the GDP. Approximately 90% of waste management in Africa is handled by informal workers. In the global context ILO estimates between 15 to 20 million informal waste pickers world-wide.

Most of the informal sector engagement in the context of CE falls under re-use, repair, refurbish, recycling, and value recovery. Given the scale of informal employment in these fields the role of **informal sector** businesses and informal employment in the context of CE in the Global South is significant. In 2016, the informal waste sector collected 27 million metric tonnes of plastic waste globally, accounting for approximately 59% of all globally collected plastic material destined for recycling (Chen, 2023). A similar picture emerges in the electronic waste (e-waste) sector (see chapter 5.3, **text box 3** “Ghana’s E-Waste Challenge”). Traditionally, informal businesses provide the bulk of repair services for a variety of goods, including household appliances, electronic devices, garments and automobiles. Since this paper focuses on plastic and electronic waste (e-waste) the activities related to CE are not further discussed in this paper.

Informal sector workers in recycling and value recovery are highly exposed to activities that are harmful to both human health and the environment. Poor or non-existing standards, particularly in the rapidly growing e-waste sector, are a major cause of pollution. Promoting **informal sector businesses** and improving working conditions in the CE in low- and middle-income countries is vital for inclusive development, scaling circular practices, and ensuring sustainable resource management and environmental protection. Informal actors – such as waste pickers, repair workers, and small-scale recyclers – often originate from the most marginalised societies of a country and face harsh livelihoods. They often lack representation, social protection, awareness of environmental hazards, technical skills and access to resources. As the case studies explored in this paper show, government actions aimed at improving waste management, such as reducing environmental and health hazards in this industry,

can have immediate impacts on the livelihoods of the poorest, if not accompanied by socio-economic mitigation measures (see case study “Ghana”, **Part II**).

Strategies to promote and support informal sector businesses within the CE include:

- Skills upgrading or reskilling of informal workers (e.g. for better handling of hazardous waste, improved repair techniques, or safe dismantling)
- Formalization of informal workers through recognition of skills and business status, including support for establishing formally registered cooperatives or integrating them into public recycling systems and procurement
- Linking informal sector businesses to formal industry as suppliers that seek circular sourcing of recyclable materials (e.g. via mobile apps and reliable and transparent pricing systems).

In the context of **Just Transition**, it is therefore imperative to ensure that informal businesses and their workers are not displaced but rather included or supported through adequate compensation measures, such as up- and reskilling, that enable transitions to more decent and sustainable employment opportunities.

Gender Equality in a Just Transition

In low-income countries, the share of women’s total employment that is informal (92%) is higher than that of men (87%) (ILO, 2023, p. 17), with women especially working in waste management, recycling, and resource recovery. As discussed above, creating a sustainable and all-inclusive circular economy requires female workers in the informal sector to be addressed directly. To enable a just transition, gender equality and the inclusion of women, especially given their high representation in informal work, play a critical role. Furthermore, integrating women’s knowledge and perspectives into CE processes and implementation can significantly enhance the development and effectiveness of circular practices. This inclusion promotes more inclusive, innovative, and sustainable economic practices, ultimately benefiting society as a whole. Multiple studies suggest that women’s values often more closely correlate with an environmentally responsible behaviour, and women tend to express greater concern about environmental issues and place higher value on CE principles compared to men. As business directors or member on the board, women also engage more actively in sustainability reporting and emphasise sustainable management practices. (Palm et al., 2024).

A circular economy offers an opportunity to challenge these inequalities by promoting inclusive policies that empower women to participate in green and circular industries. Gender-responsive policies can address the specific needs and challenges that women face, such as unequal access to education, technology, and financing, while simultaneously promoting their involvement in leadership roles related to the design, implementation, and scaling of circular solutions. By ensuring equal access to training, technology, and decision-making processes, the transition toward a circular economy can become a powerful vehicle for advancing gender equality.

2 Barriers and Framework Conditions for the Circular Economy

Although the idea of the CE has existed since the 1980s, the CE concept has gained popularity on the global level especially in the last decade (Stahel, 2020). According to the 2024 Circularity Gap Report, only about **7.2%** of the global economy is considered **circular** in terms of material use that is cycled. Indeed, this marks a decrease of 21% in the period 2018- 2023 (CGR, 2024, p. 8).

This chapter briefly analyses the framework conditions and barriers for CE, including economic, regulatory, and technological factors.

For **more information**, we recommend reading the documents quoted as resources.

2.1 Macro-Economic Barriers to the Circular Economy

From an economic perspective, there are many barriers to the CE. The significant investment requirements for circular initiatives worldwide face substantial obstacles due to **market imperfections** (Menzel-Hausherr et al., 2022b; Kirchherr et al., 2017b):

- **Lack of internalisation of externalities:** Costs for resource extraction, processing and waste disposal, including environmental degradation through mining, greenhouse gas emissions and pollution, are not adequately reflected in market prices. Products made from virgin materials often cost less than recycled alternatives. This disconnect means that the social and environmental costs of extraction, production and disposal are borne by society rather than being incorporated into the cost structures of conventional (linear) businesses and industries.
- Linear practices are often subsidised, leading to **price disparities** (e.g. government subsidies for fossil fuels make plastic production cheaper than recycled alternatives).
- Lacking **financial incentives:** High upfront costs for circular investments (e.g. redesigning products for recyclability) discourage businesses from transitioning.
- **Fragmented or instable value chains** make it challenging to implement circular practices effectively, as coordination among various stakeholders is required. Business cases have shown that economic shocks, e.g. during the COVID-19 pandemic, caused interruptions of supply chains for recyclable materials, leading to business bankruptcies.
- **Regulatory and policy gaps:** Inadequate as well as inconsistent policies and regulations fail to provide the necessary stable framework to support circular economy initiatives.

Capital markets tend to perceive CE businesses as highly uncertain and risky. Causes include:

- Many circular economy solutions require **significant initial investments** (e.g. for technology innovations, product redesign, market development)
- Circular business ideas are often new and **lack a proven track record**, in comparison to linear businesses that have existed for a long time
- Investors **focus on short-term results**, while circular economy businesses may not generate immediate profits
- Lack of **customised financial solutions:** Innovations in leasing or product-as-a-service models may require financial solutions that are not available in the capital market. Green finance is underdeveloped or subject to reverse political developments that favour the old “linear economy”

- **Influential market actors** (e.g. buyers of semi-recycled products or individuals gaining control over waste management processes) can dominate value chains, making it challenging for circular businesses to be financially viable or to sustain their operations.

Lacking awareness for circular practices in the business community and in the population (customers) can make it difficult for circular businesses to capture a market.

To address macro-economic barriers, research recommends the following measures:

- Policy interventions that aim at internalising environmental externalities
- Development of financial instruments that are tailored to CE business models
- Shifting investment practices towards long-term sustainability

These topics are further discussed in the following section.

2.2 Enabling Policies and Economic Environment

Policy instruments typically fall into two main categories: market instruments and regulatory instruments:

- **Market instruments** are tools and mechanisms used to influence the behaviour of individuals, businesses, and organisations by leveraging market signals such as prices, costs, and incentives. In the context of CE, they primarily aim at reducing the economic and market barriers (see section on macro-economic barriers to the CE, **chapter 2.1**) by internalising environmental costs, thus promoting resource efficiency.
- **Regulatory instruments** encompass a range of measures including recycling targets, product standards, requirements for recycled content, mandates on product reparability, recyclability requirements, lifetime warranties, bans and restrictions, as well as deposit-refund systems (Menzel-Hausherr et al., 2022b, pp. 26–27).

Financing the Development of a CE – the Policy Dimension:

Financing the development of a CE heavily depends on policies and national regulatory frameworks. Investment in a CE-enabling framework involves developing sector-specific regulations, assisting in policy formulation for regulators and financial institutions, conducting demand analysis, supporting technological development and developing expertise and skills. These framework conditions dictate the necessary financial and technical resources and the timeframe required for implementation. Systematically incorporating environmental damages associated with linear activities into pricing mechanisms could potentially stimulate CE growth by providing appropriate price signals (Menzel-Hausherr et al., 2022b, p. 15).

Grant Financing and Policy-based Lending:

Grant funding and policy-based lending are crucial for establishing an enabling framework for the CE. Non-reimbursable grants, typically provided as one-time payments or upfront instalments, cover a portion of capital investment costs and fund non-revenue-generating aspects such as research, development and technical assistance. Grant financing also supports soft cost investments, such as creating a conducive regulatory environment, which is essential for enabling commercial financing to deploy technologies (Menzel-Hausherr et al., 2022b, p. 27).

Strategies for covering differential costs:

The financing of investment costs is usually not sufficient for the financial sustainability of CE practices. "Differential costs" arise when transitioning from linear economy practices (e.g. take-make-dispose) to circular economy practices (e.g. reduce-re-use-recycle). They arise due to differences in processes, materials, technologies, and infrastructure required for circular activities compared to traditional ones. For instance, using recycled or secondary materials can sometimes be more expensive than sourcing virgin materials due to collection, sorting, and processing requirements. Repairing, refurbishing, or remanufacturing products often involves more labour-intensive processes compared to mass production in a linear model. Circular models require efficient collection systems for used products or materials, which can increase transportation and handling costs. Meeting circular economy standards and regulations, such as Extended Producer Responsibility (EPR), can increase costs. Additionally, obtaining circular product certifications requires investment in audits and assessments.

Without credible policies and suitable policy instruments, CE often lacks financial sustainability, discouraging private sector investment. Typically, over two-thirds of the total cost comprises ongoing running costs, which necessitate a continuous revenue flow. Reliance solely on user fees is often impractical. Potential funding sources include purpose-linked levies, general tax revenues, and Extended Producer Responsibility (EPR) (GIZ & BMUV 2016, p. 19), which is discussed in the next section.

Extended Producer Responsibility (EPR)

Extended Producer Responsibility (EPR) is a policy approach that makes producers responsible for the entire lifecycle of their products, especially for take-back, recycling, and final disposal. It shifts the responsibility – financial and/or physical – for waste management from governments and consumers to producers, encouraging more sustainable product design and waste reduction (OECD, 2016).

EPR schemes function under the polluter-pays principle, ensuring that producers bear the financial and operational responsibility for the end-of-life management of their products. Their aim is to incentivise producers to assume responsibility for the environmental impacts linked to their processes and products. These schemes cover various materials like packaging, electronics, batteries, tires, vehicles, furniture, and textiles, and help cover collection and recycling expenses. Producers are required to contribute, typically based on a per-unit or per-weight fee structure:

For more information on this approach, we recommend reading the GIZ report "Financing Circular Economy – Insights for Practitioners" (Source: [Menzel-Hausherr et al., 2022b](#)).

3 Circular Business Models (CBM)

A driving force for the transition to a CE is the emergence of new and innovative **Circular Business Models (CBM)**. A circular business model is a framework for creating value by aligning or establishing business operations with the principles of the CE, which focuses on reducing waste, maximising resource efficiency, and promoting sustainability. Unlike traditional linear business models, which follow a "take-make-dispose" approach, circular business models aim to keep resources in use for as long as possible through CE strategies such as recycling, re-using, refurbishing, and sharing. Although there is no uniform definition of CBMs, a key condition is that they operate in an environmentally and climate sensitive manner, i.e. ensuring that activities do not deplete or degrade natural resources ("ecosystem health") and minimise energy use, greenhouse gas emissions, and pollution (**low-climate impact process**).

Most CBMs involve a combination of the following strategies (Atasu et al., 2021):

- **Product life extension (PLE)**: This strategy focuses on designing products to last longer and/or to be easily repaired and re-used.
- **Design for recycling (DFR)**: Companies applying this strategy redesign their products and manufacturing processes to maximise recoverability of the materials involved for use in new products or to **substitute** raw materials, e.g. replacing plastic packaging with non-plastic degradable alternatives.
- **Retain Product Ownership (RPO)**: A producer rents or leases its products to the customer. Ownership is replaced by access, where customers pay for the use of a product rather than purchasing.
- **Sharing economy**: Services that promote sharing of products among consumers to reduce the need for individual ownership (also called "intensifying use of products" such as car rental, phone leasing, agricultural equipment cooperatives).

In developing country contexts, CBMs are typically small to-medium-sized businesses that do not have a wide market reach and have lower levels of production capacity and product sophistication. **Most CBMs discussed in this study operate in the space of circular value recovery** (the down-hill side of the CE concept) and typically address a combination of **waste management** issues, **resource scarcity**, or **high costs** of raw materials by:

- **Utilisation of waste**, i.e. turning waste into usable resources (e.g. use of organic waste into bio energy or fertiliser)
- **Substitution** of expensive or non-available raw materials, e.g. collection and processing of precious metals
- **Repair and refurbishing services** that extend the lifetime of products (often of second-hand products such as cars, electrical appliances, or clothing)

A study in India showed that businesses extending product lifetimes through repair, re-use, and recycling of waste were most prevalent while businesses intensifying use of products (e.g. car or equipment sharing, phone or office equipment leasing) were notably less common (Dhodapkar et al., 2023, p. 54). Most businesses in repair and waste recycling in developing countries operate in the informal economy. They are typically micro-to-small-sized and often do not apply proper circular practices, i.e. they may be harmful to the environment and offer jobs that are not decent with regard to income and occupational health (see section on informal sector, **chapter 1.3**).

CBMs are often perceived as uncertain and risky, with unpredictable financial returns given the lack of track records and the deviation from the standard linear type of businesses. They face several barriers,

including access to investment capital, high costs for development of technologies, limited access to suppliers and buyers, and dependence on government regulations and incentives (see section on macro-economic barriers to the CE, **chapter 2.1**). Implementing a sustainable, environmentally friendly, and climate sensitive CBM requires a combination of conditions that encompass economic, social, environmental, and technological factors:

- a. First and foremost, CBMs must be **economically viable**. Value creation from waste can be more profitable than using costly raw materials for manufacturing, provided there is a reliable supply of recyclable materials, cost-efficient technologies and a sufficient sales market. Revenue can also be generated through leasing, subscription, or rental models instead of one-time product sales.
- b. **Regulatory frameworks** need to enable CBMs to gain an advantage over linear business models through a combination of **taxation** and **incentives**. Establishing robust enabling frameworks is crucial to level the playing field for CBMs (Menzel-Hausherr et al., 2022b, p. 26).
- c. **Market demand**: Customers need to value and demand circular products and services, which requires both awareness and incentives.
- d. **Access to finance**: Business financing mechanisms include green loans and grants, or venture capital.
- e. Access to **technological know-how** and innovations: The wheel does not need to be reinvented. Many low-cost technologies have been developed locally and are now widely used. Open-source platforms provide information on technologies and machinery/ equipment needed. Platforms are useful for exchange and access to information and know-how, but entrepreneurs starting a CBM still need to be far more explorative and innovative than conventional businesses.

Availability of resources (e.g. recyclable materials) can be a critical factor for maintaining the circular flow of materials for production (see section on plastic waste, **chapter 4.4**).

To operate effectively, CBMs require **efficient recycling technologies** that increase material recovery rates and reduce contamination. **Digital solutions** can optimise the tracking of materials, resource usage and ensure supply chain transparency.

CBMs need **strong leadership commitment** that prioritises sustainability goals, invests in circular initiatives, and is capable of operating in collaboration with other actors. This demands high levels of entrepreneurial competences and motivation.

Case studies clearly demonstrate that **collaborative business ecosystems** are key to enabling CBMs to emerge and grow. Green business hubs provide space for businesses to connect, share resources and knowledge, and access infrastructure and development services. They also foster interaction with academia for technology development and transfer. There are various examples of business innovation hubs and business development services across Africa and Asia that address the development of CBMs:

Table 1: Examples of Business Innovation Hubs & Development Services Supporting CBM Models in Africa/Asia

Fashion for Good
Fashion for Good is a global platform and innovation hub that connects companies, startups, and innovators in the fashion industry to collaborate on circular solutions. It enables fashion innovations that reduce waste, emissions, and resource use by offering access to a wide network of brands, retailers, suppliers, innovators, and funders. (Source: Fashion for Good).

Just Transition Innovation Platform (J-TIP)

J-TIP, founded by the African Centre for a Green Economy (AfriCGE), promotes nature-based solutions, which support to manage natural resources sustainably to achieve both environmental and human-wellbeing outcomes. Targeting businesses across various sectors, **J-TIP** invests in small and micro enterprises which play a critical role in the transition to a low carbon economy. The platform provides tailored support, a network of green entrepreneurs in Africa, access to technical experts, and services regarding business development and climate finance opportunities. (Source: [AfriCGE Green Innovation Hub](#)).

Creating Business through Circular Design (CIRCO) Hubs

CIRCO is a Dutch programme that supports companies and designers in transitioning to circular business models and product strategies. Through practical workshops — called "Circular Business Design Tracks" — participants identify circular opportunities, develop new value propositions, and create actionable implementation plans. Since 2015, more than 1,400 companies and over 650 designers have taken part in the programme in the Netherlands. **CIRCO** has established hubs in more than 13 countries including such as Brazil, Sri Lanka and Nigeria (Source: [CIRCO NL](#)).

Circular Bioeconomy Innovation Hub (CBEIHub)

CBEIhub, established in 2025, is a new one-stop shop and platform for training, advisory support, research and collaboration with the aim to promote circular bioeconomy innovations. The hub is positioned as a multi-institutional platform involving 17 stakeholders as co-owners, including international and national research institutions, private sector and social enterprises in the bio-waste sector, management consultancies and NGOs. (Source: [CBEIHub](#)).

Artificial Intelligence (AI) can play a powerful role in enabling and scaling circular business models by optimising resource use, extending product lifecycles, and facilitating reverse logistics and innovation. In the Global South, AI use cases are mostly related to improving recycling processes and material recovery:

Table 2: AI-use Cases Supporting CBMs in the Global South

Recykal (CircularNet)

CircularNet, an open-source machine learning model developed by Google, helps to sort plastic waste by material form and type using AI, thereby diverting recyclable waste from reaching landfills (Source: [CircularNet](#)).

Recykal, a waste management firm in India, has used **CircularNet** to build the fastest-growing waste commerce marketplace in Asia, achieving more than 90% detection accuracy for metals, bottles, tubes, cutlery, PETE, HDPE, and LDPE plastics. The use of **CircularNet** diverts 50,000 metric tonnes of waste from landfill in India every month, provides local governments with critical waste management data, and lowers the costs for recycling processes (Source: [Recykal](#) | [Google Sustainability](#) | [Packaging Europe Narrative](#)).

Gringgo Tech (AI-driven App for Waste Collectors)

Gringgo Tech, an Indonesian startup, applies AI-driven image recognition through a mobile application that assists waste collectors in categorising waste. The app also helps optimise waste collection systems by generating data for better route planning and waste management decision-making (Source: [Gringgo](#) | [Google's AI Impact Challenge](#) | [MIT Solve Submission](#) | [ASEAN-Japan Centre](#)).

While this desk study identified a number of business innovation networks and hubs that either specifically promote green business, including circular business ideas, or broader innovation hubs that also address green business, no specific research results could be found that assess the effectiveness of these hubs with regard to CBM start-up promotion, business acceleration, or scaling up in the context

of the Global South. However, the mapping study “The Circular Economy: Our Journey in Africa So Far” (Footprint Africa, 2021) and research on CE models and CBMs in India (Dhodapkar et al., 2023) and Indonesia (see case study Indonesia in **Part II**) have identified several lessons learned:

- Due to limited resources (capital, essential equipment), the main **value addition** to recyclable materials collected and extracted often takes place outside developing countries. Sometimes this is due to small domestic markets, where investment in costly equipment for further processing or production would not meet capital returns.
- Especially small to medium-sized businesses experience **barriers** for scaling: Machinery is often not suitable for more efficient production, while purchasing modern equipment is expensive and usually must be imported, which is costly and time consuming. Lack of spare parts threatens operations, and local mechanics often lack the necessary skills for maintaining the machinery.
- The **supply of recyclable materials** may not meet quantity requirements or may be inconsistent. For example, Indonesia could have a substantial supply of recyclable materials as a country, but, because of its geographical nature as an archipelago impedes collection of recyclable waste in sufficient quantity in many regions.
- Case studies across Africa and beyond show a “parallel evolution” of technologies, such as using plastic waste for construction materials or black soldier fly farming for production of animal feed. **Availability of technological information** (e.g. open-source designs) is very important to save costs for technology development, enable learning from other businesses, and foster further improvements in locally adaptable technologies.
- **CBM entrepreneurs** need to be explorative, adaptable, and networked as they venture into “new territory” with their business ideas. As mentioned in the previous section: access to networks and information is essential for avoiding that “wheels are reinvented”.
- Recycling businesses can leverage **digital technologies** to integrate informal workers into their business models. Since material recovery for recycling and energy is predominantly carried out by the **informal sector**, AI-based platforms are used to establish waste selection and collection supply chains, enhancing the efficiency of the informal recycling system.

For **more information**, we recommend reading the following key publications:

- **GIZ & ILO** "Green Business Guide" (2022) provides a guideline for establishing green business models, including CBMs (**Source:** [International Training Centre of the ILO & GIZ, 2022](#))
- **Footprints Africa** "The Circular Economy: Our Journey in Africa So Far" features 23 case studies on biowaste for composting and feeding, e-waste, and plastics (**Source:** [Footprints Africa, 2021](#); in collaboration with inter alia **ACEN** and Circle Economy)
- **ACEN** Interactive Map on “African Circular Economy Case Studies” in collaboration with **Footprints Africa** provides an overview of circular businesses and business initiatives in Africa (**Source:** [ACEN, n.d.](#))
- **OECD’s** "The Geography of Green Innovation Hubs in OECD Regions" (2024) examines the role of green innovation hubs, mainly in Europe (**Source:** [Peñalosa & Kleine-Rueschkamp, 2024](#))
- **Exponential Roadmap Initiative** "Circular Action Guide" (2023) analyses how to align business models with CE-oriented value chains (**Source:** [Falk et al., 2023](#)).

4 Elaboration of Selected Circular Economy Sectors

4.1 Delineation of Relevant Sectors for this Study

Broadly speaking, the CE is a comprehensive concept that entails a structural transformation in the way that economic activities are carried out, meaning that **it will have an impact on every area of the economy**. To gain a deeper understanding of what the CE comprises, it is necessary to examine its application across various sectors and respective areas, bearing in mind that these sectors are defined differently depending on perspective (e.g. focus on top-hill or down-hill approaches). For instance, the Africa Climate and Environment Foundation (ACEF) highlights the following four areas as key-sectors in CE:

- Integrated Waste Management
- Regenerative Agriculture and Food Systems
- Sustainable Built Environment
- Circular manufacturing (AfDB, 2023).

In terms of existing structures and capacities for CE in the Global South, this study focuses primarily on sectors situated at the “lower end” of the circularity hierarchy, namely (recycling, recovery, and disposal of materials, which have

- a) high environmental relevance in the context of waste management,
- b) provide potential for job and income generation in both urban and rural settings,
- c) are applicable with lower levels of technology.

Accordingly, this study concentrates on the following three sectors: **plastics, e-waste, and organic waste management**.

- Plastic waste is considered as one of the most pressing challenges in waste management, due to the increasing use of plastics globally and its huge environmental impact.
- E-waste is especially problematic in the context of global trade, where poor recycling and disposal practices cause substantial harm to natural resources such as water and soil.
- Agricultural waste, while generally posing fewer environmental risks (except for waste from large-scale animal husbandry), represents a valuable resource for fertiliser production and biomass energy.

These three sectors are particularly important in the Global South across both rural and urban regions and therefore imply high relevance for development cooperation (DC) strategies. At this point, reference is made to the GIZ commissioned sector studies implemented by FAKT Consult in the areas of skills development for sustainable construction and renewable energies, which also intersect with CE themes.

4.2 Plastic Waste Sector

Global Data on Plastic Waste Streams

Plastic is extensively utilised across various sectors for valid reasons, with an annual production exceeding 450 million tonnes. However, when plastic waste is mishandled—whether not recycled, incinerated, or confined in sealed landfills—it transforms into an environmental hazard. Globally, only 9% of plastics are recycled, while most plastics are poorly managed, resulting in one to two million tonnes of plastic entering our oceans each year, impacting wildlife and ecosystems. Enhancing plastic

waste management globally, particularly in the Global South – from where the majority of ocean plastics originate – is imperative to addressing this issue (Ritchie et al., 2023).

Approximately 74% of marine litter, with 80% originating from land-based sources, consists of plastics, according to an analysis of 1,392 publications. Human activity releases litter onto land, which primarily reaches the marine environment through waterways, runoff or wind. Plastics, being highly durable, take between 20 and 500+ years to break down, persisting in the environment and gradually disintegrating into microplastics. Plastic globally inflicts approximately EUR 13 billion in annual damage to marine ecosystems (Stretz et al., 2023, p. 13).

One root cause for plastic pollution is a lack of awareness among the population. Plastic bags, for instance, are inexpensive, lightweight, and widely available. These single-use plastics are often distributed freely. Widespread beliefs that plastic bags are naturally degradable contribute to uncontrolled dumping, causing substantial environmental hazards including the clogging of drainage systems (contributing to flooding) and harm to domestic animals and wildlife. Increasing urban populations generate more plastic waste without corresponding improvements in waste management systems. Waste pickers focus on high-value plastics (like PET bottles) rather than low-value, lightweight items such as plastic bags.

Enabling Environment for the Circular Economy in the Plastic Waste Sector

As discussed in chapter 2, **primary drivers** for circular economy practices are **regulatory frameworks and enforcement**. This also applies to the plastic waste sector. One example is Rwanda (see case study “Rwanda as a CE Leader in Africa?”, **text box 1**). Rwanda took a decisive step against plastic pollution in 2008 by implementing a nationwide ban on single use plastic bags, making it one of the first countries to take such a comprehensive measure. Economic and policy frameworks are essential for phasing out linear waste management practices and promoting circular solutions.

Text Box 1: Rwanda as a CE Leader in Africa?

Text Box 1: Rwanda as a CE Leader in Africa?

Rwanda took a decisive step against plastic pollution in 2008 by implementing a nationwide ban on single-use plastic bags, making it one of the first countries to adopt such a comprehensive measure. The legislation encompassed the production, importation, sale, and use of these plastics. It was broadened in 2019 with a law prohibiting the utilisation and sale of single-use plastics such as bottles, straws, plates, and forks. The ban was enforced through public awareness campaigns, customs inspections at borders and airports to prevent smuggling, and strict penalties for violations.¹

While Rwanda has continuously utilised the plastic ban to present itself as a leader in the CE and sustainability within Africa, the shift towards plastic-free alternatives has had economic implications, including business closures, job losses, and price increases for various products. The responsibility for innovating sustainable alternatives to plastic largely fell on manufacturers. The negative socio-economic and political effects of the ban help explain why it was initially unsuccessful or took longer to implement in neighbouring countries like Kenya and Uganda.²

The case of Rwanda shows that policies guiding the transition from linear to circular production models need to be accompanied by initiatives that address the initial negative effects on businesses and for workers, many of whom operate in the informal economy without any safety net. Measures could include tax incentives for businesses transitioning from linear to circular practices, development of

¹ Uzayisaba, 2023.

² Ogutu et al., 2023.

financial instruments that provide loans for investment in new production facilities as well grants for developing R&D capacities. In addition, governments should continue raising awareness of the importance of CE among both the population and the business community.

The manufacturing chain of plastics is often highly **fragmented**, meaning that different parts of the process (designing, producing, recycling, and selling) are controlled by separate entities with varying levels of influence. This results in an **uneven distribution of power**, for instance:

- Plastic manufacturers often do not prioritise or advocate for product designs that facilitate easier recycling.
- Producers of recycled plastic typically have limited influence over pricing, which is largely controlled by dominant wholesalers or major corporate buyers.
- Material designers (formulators) may have the technical knowledge to develop recyclable plastics, but they lack decision-making power within companies to determine which materials are ultimately used in products.

Studies conclude that involvement of all stakeholders across the entire plastic value chain in the development or revision of regulatory frameworks is a key condition for making the plastic sector more circular (Menzel-Hausherr et al., 2022a, p. 37).

Technological Trends and Innovations in Plastic Recycling and their Application in the Global South

Various technologies have been developed to enhance plastic recycling processes, including automated processes for sorting plastics using AI. However, high-tech industrial solutions used by modern recycling facilities are often not applicable in contexts with lower levels of industrial development, due to high investment costs, limited access to equipment and spare parts, and a lack of technological know-how for operation and maintenance. It is therefore considered crucial to prioritise processes and technologies that are context-relevant (e.g. urban vs rural), that take into account existing financial resources, human resource development as well as socio-economic issues such as job creation (GIZ & BMUV, 2016, pp. 21–22). For instance, in many countries of the Global South, labour-intensive methods providing basic-level employment opportunities are considered far more socially relevant than automated recycling processes.

In the sector of plastic recycling many low-tech and open-source technological solutions already exist that have been adapted to fit to specific local circumstances. They focus on affordability, simplicity and adaptability to local conditions, such as the need to empower small-scale entrepreneurs and communities to address plastic waste challenges with minimal resources in an environmentally friendly manner. The following **table** provides an overview of open-source technologies that are used by local manufactures in countries such as Ghana, India, Indonesia, and Kenya. These include manually or machine operated appliances that shred plastic into small pieces for easier processing, plastic extrusion machines that melt shredded plastic and form it in new shapes (e.g. filaments for 3D printing), or technologies that enable recycling of thinner plastic materials – usually not suitable for recycling – for production of construction materials.

Table 3: Examples of Technologies Used in Plastic Waste Recycling Processes

Description of Technology	Application	Use Cases
Recycling of hard plastics (including PET bottles) as raw	Collection and shredding of plastic waste into small pieces for easier processing, mostly for sale to processing	Various businesses focus on collection and primary processing (shredding). Since these businesses operate at the lower end of the value chain, business profitability often depends on market leverage held

material for further processing	industries; represents the lowest step in the plastic recycling value chain.	by potential buyers of raw materials for further processing. RecyclePoints (Nigeria): Promotes safe dismantling and material recovery in local recycling hubs (Source: RecyclePoints).
Plastic extrusion	Extruders melt shredded plastic and form it into new shapes, such as filaments for 3D printing, plastic threads for weaving, or construction blocks. Various types of machines widely available, including small-scale applications.	SomeNicePlastic (Ghana): as part of the global Precious Plastic Network transforms plastic waste into everyday items such as coasters or flower pots using extruders and 3D printing. It also provides instructions for building affordable basic extrusion machines (Source: SomeNicePlastic).
Compression moulding	Simple moulds and heat sources (e.g. ovens or solar heaters) are used to melt and shape plastics into new products for producing tiles, bowls, or other small items. Processes can be improved by using renewable energy sources (e.g. biogas, solar energy).	ECO Tile (Kenya): Combines recycled plastic and sand to create roof tiles that resemble natural clay but are twice as light and strong (Source: ECO Tile).
Plastic brick making	Plastic waste is melted and combined with sand or other materials to create durable bricks for construction.	Gjenge Makers (Kenya): Produces paving bricks made from recycled plastic and sand, which are stronger than concrete alternatives (Source: Gjenge Makers). Green Pavers (Kenya): Manufactures roofing tiles, fencing posts, and flooring products from recycled plastic waste and sand, creating jobs for 250 young waste collectors and 50 sorters (Source: Green Pavers).
Pyrolysis for fuel	Small-scale pyrolysis systems convert non-recyclable lightweight plastic waste (e.g. plastic bags) into fuel like diesel or kerosene.	Entrepreneurs in Africa and South Asia have developed low-cost pyrolysis units to generate fuel from non-recyclable plastics. Francis Kantavooro (Ghana): An innovator, who developed a reactor that converts plastic waste into fuel using pyrolysis (300-900 °C, oxygen-free environment). The system reduces plastic waste, provides jobs for about 150 local waste collectors, and generates fuel at half the cost, lowering Ghana's dependence on imported crude oil. Supported by the UNDP Global Environment Fund, the project continues to improve efficiency. If scaled, it could generate thousands of jobs, while also addressing Ghana's growing plastic waste problem (Source: SciDevNet on African Innovator).
Plastic-modified asphalt	Use of non-recyclable plastic as a substitute for bitumen for road construction.	South East Gateway Terminals (Sri-Lanka): A Public Private Partnership launched a road surfacing

concrete (PMAC)		initiative using PMAC (Source: SAGT Road Resurfacing Project).
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The case studies examined revealed various product and technology innovations for substituting plastic packaging with biodegradable materials. Technological innovations include:

- **Mechanical and thermal processing** of agro-waste fibres (such as bagasse, rice or maize husk, or invasive plant species such as water hyacinths) into moulded products using low-energy compression or heat pressing. The material is often coated with biodegradable films for water and oil resistance.
- **Production of starch-based bioplastics** using modified starches (from cassava, corn, or potato), often blended with plasticisers or polylactic acid for strength and flexibility.
- **Research into fungi- and algae-based biopolymers** to create biodegradable foams, films, and packaging materials.

Examples come from a range of countries including Thailand (production of tableware moulded from sugarcane bagasse), Indonesia (production of plastic-free bags from cassava starch that dissolve in water), or Bangladesh (creation of plastic-like sheets from extracted cellulose). These innovations strongly depend on investments in basic scientific research as well as private sector driven product and production process development, highlighting the need for close cooperation with scientific institutions and industry, as well as mechanisms for technology dissemination ([see](#) section on examples of CBMs in plastic substitution, [table 4](#)).

Circular Business Models in the Plastic Sector

CBMs in the plastics sector build on common CE strategies such as cycling, extending, substituting and dematerialising³ material and energy loops within organisational systems. These strategies aim to **reduce resource inputs**, **minimise waste**, and **prevent emissions leakage**, contributing to more sustainable production and consumption (Geissdoerfer et al., 2018, p. 7).

The following [table](#) shows examples of CBMs in the plastic sector across the individual CE categories⁴:

Table 4: Examples of CBMs in the Plastic Sector by CE Category

Typology	Plastic Relevant Business Applications	CBM Examples
(Re)cycling	Sorting, shredding, and moulding of various types of plastics (see section on technological trends, chapter 4.4)	Buotobom Recycling Company (Ghana): Produces plastic granulates from hard plastic waste for further processing into plastic products (see case study “Ghana”, Part II). Mr Green Ltd (Kenya): Recycles various plastics, including soft plastic material (see case study “Mr. Green Africa Ltd. (Kenya)”, text box 2)
(Up)cycling	Use of plastics in combination with other waste (e.g. textile) to produce fashion items	Trashy Bags (Ghana): Produces fashion products from a mix of textile and plastic wastes (see case studies, Part II).

³ Dematerialising means reducing the amount of physical materials needed to deliver a product or service.

⁴ For case study publications, see also Footprints Africa, 2021.

Substituting	Replacing plastic packaging with non-plastic alternatives using various technology innovations	Hya Bioplastics (Kenya/Uganda): A start-up producing biodegradable packaging (replacing plastics) from fibrous materials such as maize husks and water hyacinths (Source: SolarImpulse on Hya Bioplastics Social Media). Urban Plastics (Indonesia): large scale producer of biodegradable bags from cassava starch (Source: Cassava Bags).
Extending	Producing reusable packaging; second-hand sales of plastic-based products	Jibu (Tanzania): A franchise supplying drinking water using 20-litre polycarbonate bottles that can be refilled up to 400 times. Each bottle is sanitised before re-use, ensuring safe drinking water (Source: Maji Jibu Company CE Knowledge Hub).

Practice reviews from Africa and Asia (Footprint Africa, 2021; Dhodapkar et al., 2023) show that CBMs in the plastic sector most commonly focus on plastic recycling (with PET bottles being the most easily collectable and recyclable material). Despite progress in technological innovations, the market for substitution of plastic packaging remains small, especially in lower-income contexts. Besides the general impediments for CBMs listed in **chapter 3.**, CBMs in the plastic sector encounter several specific challenges in their implementation and scalability. The following **table** provides an overview of the challenges identified and how they can be mitigated:

Table 5: Implementation Challenges & Mitigation Strategies for CBMs in the Plastic Sector

Typology	Challenges	Mitigation Strategies
Recycling	Unstable and fragmented supply chains for recyclable plastic materials; inadequate segregation of plastics from other wastes; contamination issues	- IT-based solutions for better management of supply chains from small collectors to aggregators (see case study “India”, Part II) - Training of collectors - Use of digital technology (e.g. smartphone applications) to aid sorting of plastics - Alternative use for soft plastic waste (e.g. for construction materials).
Substituting plastics	Low costs of plastic packaging; premium costs for degradable alternatives	- Regulations banning plastic bags (e.g. Rwanda, Kenya) or increasing prices of plastic products - Customer awareness building - Investment into development of low-cost technologies.
Extending product use	Higher maintenance and operational costs associated with renting equipment and conducting deliveries	AI-based systems for resource efficient delivery systems.

Text Box 2: Mr. Green Africa Ltd. (Kenya)

In Kenya, numerous types of plastic labelled as "recycled" are frequently exported to other countries. Locally recycled plastics often undergo downcycling, resulting in products of lower value. For instance, "bottle-to-bottle recycling" – where old plastic is used to make new equivalent plastic products – is not a common practice. "Closing the loop" in plastic life cycles can save costs of importing new materials, generate local jobs and minimise litter causing environmental degradation.

Mr. Green Africa collects, converts, and sells over 140 metric tonnes of post-consumer plastic monthly, operating 15 trading points in Nairobi.⁵ Approximately half of this plastic comes directly from informal waste pickers, who are integrated into the value chain by applying fair trade principles. Currently around 2,500 waste collectors supply to MGA, representing a consistent supply from Kenya's most marginalised workers. MGA primarily focuses on three types of plastics: HDPE, PP, and PET, which are found in bottle tops, food containers, shampoo and soap bottles, beverage bottles, and food packaging. MGA transforms this post-consumer plastic waste into high-quality (Post Consumer Recyclates (PCR), which is sold as a substitute for imported virgin plastic at competitive rates. In addition, MGA is currently exploring the collection and processing of "flexible" single-use plastic. The business model enables waste collection at the source and incorporates not only informal waste workers into the value chain, but also local manufacturers of equipment and plastic products. Customers include suppliers of packaging to Unilever and other strategic partners. By engaging in three-way offtake agreements with fast-moving consumer goods companies and third-party plastics manufacturers, MGA facilitates the use of high-quality post-consumer recycled content, enabling partners to achieve their sustainable packaging objectives by accessing ethically sourced and locally produced materials.⁶

For **more information**, we recommend reading selected case studies in Part II of this study.

4.3 E-Waste Sector

Key Aspects of the Global E-Waste Sector:

The 2024 "Global E-Waste Monitor" offers the most comprehensive collection of current data on the e-waste sector. The most important aspects are summarised below (Baldé et al., 2024, pp. 10–18):

Global E-Waste in Numbers

When Electrical and Electronic Equipment (EEE) is discarded, it creates a waste stream comprising hazardous and valuable materials, known as e-waste. E-waste is the fastest growing waste category worldwide. In 2022, global e-waste reached 62 million tonnes, representing an 82% increase since 2010. Projections indicate a further 32% growth to 82 million tonnes by 2030. However, only 22.2% of this waste was officially documented as collected and recycled in an environmentally sound manner in 2022.

Composition of Global E-Waste

In 2022, the e-waste produced comprised 31 billion kg of metals, 17 billion kg of plastics, and 14 billion kg of other materials. Notably, metals such as iron, which are abundant in e-waste, demonstrate high recycling rates across various e-waste management channels. However, despite the significant demand, recycling rates for rare earth elements remain at approximately 1% of current demand, largely due to market prices being too low to sustain larger-scale commercial recycling operations.

⁵ Mr. Green Africa, n.d.

⁶ Africa Footprint, 2021, p. 29.

Difference among Countries

The rates of documented formal collection and recycling vary significantly between regions. Countries in the Global North generate and export most e-waste; while developing and emerging economies import the majority. In Europe, where e-waste generation averages 17.6 kg per capita, the recycling rate stands at 42.8%. In contrast, African countries, with the lowest e-waste generation at 2.5 kg per capita, struggle with recycling with rates below 1%. In these countries, the informal sector plays a critical role in e-waste management, though its contributions are often not captured in official statistics and rarely monitored by governmental authorities.

Globally, 81 countries (42% of all nations) have implemented e-waste policies, covering 72% of the global population. Among these, 67 countries have adopted legal frameworks governing e-waste management, including provisions for EPR. However, implementation and enforcement of e-waste policies and regulations remain weak. The stagnation in global e-waste collection and recycling rates may be worsened by the fact that only 46 countries have established collection rate targets, while only 36 have set recycling rate targets.

Global Transboundary E-Waste Flows

Although transparency regarding data on waste shipments is lacking, it is estimated that about 5.1 billion kg of e-waste traversed borders in 2022. Despite international efforts, such as the Basel Convention, which was adopted back in 1989 to curb the illegal trade in e-waste, this trade continues to take place. An estimated 3.3 billion kg made its way from high-income to middle- and low-income countries via unregulated and undocumented transboundary movements, representing 65% of the global e-waste transboundary movement.

A major regulatory challenge in the transboundary movement of e-waste lies in distinguishing between actual waste and used EEE. Exploiting this loophole, illegal shipments occur with the e-waste being falsely declared as used EEE. This situation paves the way for misclassification, misdeclaration, and the mingling of legitimately used EEE with illicit e-waste items. Within the African continent, West Africa bears the brunt of this issue, experiencing a significant impact, with an additional one-third of imported e-waste contributing to the overall e-waste generated.

Informal Work and Gender Aspects

With comprehensive regulations lacking, informal e-waste enterprises have flourished in numerous countries. These informal systems typically entail refurbishing used electronic devices for resale or dismantling and processing them for valuable components, often employing rudimentary tools and techniques. However, the extraction of metals from e-waste involves hazardous processes and chemicals, posing risks to workers, such as improper chemical handling, exposure to toxic fumes, and contact with harmful substances. Evidence indicates that chronic exposure resulting from these practices may disproportionately impact women.

Impact on Human Health

Unmanaged e-waste poses significant environmental and health risks. It contains toxic and persistent substances, such as flame retardants found in appliances and plastics within EEE. Numerous international studies on emissions resulting from the open burning of various materials, including hazardous ones, underscore the health hazards associated with inhaling heavy metals like lead, cadmium, chromium, copper, and brominated flame retardants present in plastic e-waste. A recent study has shed light on the considerable risk of harm faced by approximately 11 million informal entrepreneurs working closely with waste in low- and middle-income countries, as well as the broader communities residing in close proximity to these activities.

Technological Trends and Innovations:

Technological advancements are pivotal in enhancing recycling rates and the overall effectiveness of e-waste management, especially concerning the recycling of crucial raw materials found in EEES. In developing country contexts, technologies used for recycling e-waste are often very rudimentary and harmful to the environment and human health (see section on impact on human health, **this chapter** above), demonstrating the need for developing more efficient and safer technical solutions that are applicable in these contexts.

On a global scale, patent application data serves as a valuable indicator of innovation in the e-waste sector. The proportion of patent applications related to e-waste recycling surged from 148 per million in 2010 to 787 per million in 2022. This growth was primarily propelled by advancements in cable recycling. However, there is currently no evidence of a corresponding increase in the number of patents filed specifically for the recovery of critical raw materials.

Table 6 provides examples of current practices of e-waste recycling in the informal sectors that are often harmful for the environment and occupational health, and examples of improvement:

Table 6: Informal E-Waste Recycling Practices & Opportunities for Environmental and Occupational Health Improvements

Common Processes Used	Examples of Improvement
Manual dismantling of E-waste items: Micro businesses disassemble computers, phones, and other appliances. Components such as circuit boards, wires, and casings are separated for further processing or reuse. Environmental issues include uncontrolled dumping of non-recyclable parts and use of unsafe equipment.	Basic e-waste dismantling processes can be improved by introducing safety equipment (e.g., gloves, masks, goggles) and better handling practices. Example: Chintan Environmental Research and Action Group (India) provides informal waste workers with safety training and equipment to dismantle e-waste more safely (Source: Chintan India).
Handheld separation in the informal sector: Workers manually sort e-waste into categories such as metals, plastics, and glass. Cable stripping machines or handheld tools are used to remove plastic insulation from cables to extract copper or aluminium wires. Recovered materials are sold to local scrap markets or smelters. Similar issues persist, such as unsafe dumping of residual materials and poor working conditions.	Establishing Community E-Waste Collection Centers, where e-waste is sorted, dismantled, and pre-processed using safer, semi-mechanised methods. Example: Enviroserve (Rwanda) operates a state-of-the-art recycling facility using manual and mechanical sorting for safe material recovery. It has helped to create an e-waste ecosystem in partnership with the Government of Rwanda (Source: Enviroserve Rwanda Global Leap Awards).
Open-air burning: Wires and circuit boards are burned in open pits to recover metals like copper and aluminium. Extracted metals are sold in scrap markets. Although widespread in informal settings, this method causes severe environmental and health impacts and is not sustainable.	Use of environmentally friendly hydrometallurgical processing to recover valuable metals without harmful emissions. Example: Attero Recycling (India) uses proprietary hydrometallurgical processes to safely recover up to 99% of precious metals such as lithium, cobalt, and gold from various batteries (e.g. Li-ion) (Source: Attero Recycling Cleantech 100 Case Study Attero Recycling Pioneering CE).

Circular Business Models in the E-Waste Sector

The analysis of CBMs in the E-waste sector follows the same typology as applied in the section on plastic waste. According to the case studies analysed, CBMs can be categorised as follows:

Table 7: Overview of CBMs in the E-Waste Sector: Key Applications & Examples

Typology	E-Waste Relevant Business Applications	Examples of CBMs
Recycling (1)	CBMs using safer methods for metal recovery	City Waste Recycling (CWR) Ltd (Ghana): Recycles various types of waste, including e- waste, which it sources from local industries and waste collectors. CWR claims to be the first formally registered e-waste company in Ghana that applies national and international norms. It also provides training to informal sector workers (Source: City Waste Recycling Ltd SEED on City Waste Recycling).
Recycling (2)	Deposit-refund systems: consumers pay a deposit for electronic products, refunded when devices are returned for recycling	India's E-Waste Management Rules 2016 (India) establish Extended Producer Responsibility (EPR), placing responsibility on producers to ensure that their electronic waste is delivered to authorised recyclers or dismantlers. Mobile phone producers such as Samsung, Apple, and Xiaomi offer free pick-up services and cash rewards in exchange for old products, encouraging customers to return old phones for safe recycling and material recovery (Source: E-Waste Management Rules 2016 Press Information Government of India Samsung Xiaomi, LG, and Dell).
Upcycling	Using e-waste components to produce upcycled products like jewellery or other fashion products	The recovery of gold and silver from e-waste for use in jewellery production is a well-established practice in various countries including South Africa, although there are claims of recycled streams being misused to launder precious metals from problematic sources due to lacking standards and control mechanisms. ⁷ Ashley Heather Studio is one example for upcycling e-waste into high-quality jewellery (Source: twyg)
Extending (1)	Discarded electronics are refurbished for resale to extend their lifecycle and reduce waste	Decarbonisation Divide (Ghana): In Accra, a vibrant informal sector thrives on refurbishing imported electronics. Approximately 2,500 refurbishment businesses operate in the region, providing employment to an estimated 10,000 to 15,000 workers (Source: SciDevNet Future of Upcycling). Digital Pipeline (South Africa) : Provides new and refurbished electrical equipment (computers, laptops, printers, copiers) to educational institutions (Source: Digital Pipeline Africa).
Extending (2)	Leasing of electronic equipment	CSI-Leasing International (locations in Malaysia, Philippines, Taiwan, South America): Enables the leasing of electrical equipment, reselling and recycling it at the end of the lease contract (Source: CSI Leasing Solutions). Equipment-as-a-Service (EASE®) by the African Asset Finance Company (AAFC) (across Africa): Provides organisations with cost-effective access to electronic equipment. The pay-per-use model includes maintenance, operator training and support,

⁷ OECD (2016), Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict Affected and High Risk Areas

		aiming at equipment longevity. Electronic equipment is leased for use in healthcare, ICT, and small to large-scale agriculture enterprises (Source: EASE)
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Text Box 3: Ghana's E-Waste Challenge

With regard to e-waste, Ghana has drawn attention from around the globe thanks to the Old Fadama Scrap Yard, also known as Agbogbloshie. This site was once considered the largest uncontrolled e-waste dump in the world and serves as an example of improper and informal recycling practices.⁸ The site was abolished by state authorities in 2021.

Ghana has been a major importer of used electronic appliances for more than five decades and has developed a flourishing, mostly informal electronics repair industry. A 2011 study estimated that the country imported 215,000 metric tonnes of electronic equipment, of which 70% were second-hand items.⁹ About 15% of these items were non-functional upon arrival, and many of the second-hand items had a short life span.¹⁰ In addition to the traditional repair industry, Ghana has become known for its fast-growing, largely informal e-waste industry. The country is considered the 5th largest importer of e-waste globally. The Institute of Security Studies estimated in 2024 that 150,000 tonnes of e-waste are shipped to Ghana both legally and illegally. In 2023, Ghanaian authorities discovered an illegal shipment of 331 containers of e-waste, smuggled from the Canary Islands.¹¹

In 2016, the government enacted the Hazardous and Electronic Waste Control Act (Act 917) to combat illicit waste management practices in the e-waste sector.¹² To ensure the safe and environmentally responsible treatment of waste, it generally restricts the import, export, and transport of hazardous wastes and e-waste, thereby incorporating the Basel Convention into national law. Additional measures include establishing an E-Waste Management Fund, designating an external service provider, and setting up recycling. The Act also marked the beginning of EPR implementation, thereby establishing a legal framework for more sustainable e-waste management. According to the current status, however, it is unclear to what extent the principle is being applied, as there is a lack of information regarding the functionality and performance of EPR systems.¹³

For **more case studies** on e-waste, see Part II.

For **more information**, we recommend reading the **GIZ** guideline “Alternative Business Models: Towards creating secure and sustainable income opportunities for scrap workers (and their wider service support system) in Old Fadama (Agbogbloshie)”, which identifies alternative business models for the Agbogbloshie case that could help the larger scrap metal recycling workforce in and around Agbogbloshie to improve working conditions and reduce negative environmental impacts ([Source: GIZ, 2019](#)).

4.4 Organic Waste Sector

Unlike the other two sectors discussed above, the agriculture and food sector is still underrepresented in the concept of CE, even though it produces large amounts of organic waste. In the Global South, where agriculture is still a major source of rural livelihood, the potential of organic waste is not yet sufficiently recognised (Hemkhaus et al., 2020, p. 67). The agricultural sector employs 60% of Africa's

⁸ Hemkhaus et al., 2020, p. 6.

⁹ Amoyaw-Osei et al., 2011.

¹⁰ GIZ E-Waste Programme & MESTI-PIU, 2022, p. 4.

¹¹ UNITAR, 2024; African Insider, 2023.

¹² Parliament of Ghana, 2016.

¹³ Baldé et al., 2024, p. 64.

workforce and contributes nearly a quarter of the continent's GDP (AfDB, 2023). In terms of food security and sustainable development, there are various practices related to CE at the farm level, such as organic agriculture, agroforestry, biodynamic agriculture and regenerative agroforestry. However, these will not be further examined in this study. Instead, this chapter focuses mainly on turning agriculture and food waste into organic fertiliser, animal feed and biofuel or other plant-based products (for products substituting plastics, see section on plastic waste, chapter 4.2).

Key Aspects of the Organic Waste Sector and Its Potential for Fertiliser Production

Organic waste, also called biodegradable waste, is organic material that can be broken down into carbon dioxide, methane, or simple organic molecules. Organic waste streams occur in agriculture, households (as part of municipal waste), as well as the food, beverage, and paper industries. This reinforces its cross-sectoral nature, as it is related both to municipal waste management and the agri-food sector.

Global and Regional Food Waste Scenarios

In the global context, food waste is highlighted as a highly important issue, with the United Nations Global Food Waste Index providing key data to highlight its significance. A distinction must be made between the following two concepts: "**Food loss**" usually refers to food that was lost during the harvest, storage, and transportation phases of the production process; "**food waste**" is defined as items fit for human consumption but are discarded, frequently by consumers or at supermarkets (O'Sullivan, 2023). As literature is not always precise, the term "food waste" will be used here to include both definitions.

According to estimates, food waste annually exceeds US\$1 trillion. Utilizing nearly 30% of the world's agricultural land, this amounts to more than one-third of all food produced globally. The environment and human well-being are both severely impacted by the quantity of food wasted. Especially if not treated appropriately, food waste has a big impact on the global footprint due to the high potency of methane. The Food and Agriculture Organisation (FAO) estimates that 8–10% of global greenhouse gases (GHG) are caused by food waste. On the other hand, reducing food waste can make food more accessible to those in need. According to FAO estimates, up to 783 million people were affected by hunger in 2022 – roughly 122 million more than in 2019 – and approximately 30% of the world's population was either moderately or severely food insecure (UNEP, 2024a, p. 2).

According to the Global Food Index, high-income and low-income countries discard similar amounts of food. The global average is 91 kg in lower-middle-income nations and 79 kg in high-income nations. However, it is crucial to recognise the significant variations in where and how food waste occurs across the world. Losses occur earlier in the supply chain more frequently in Lower Middle-Income Countries (LMIC). For instance, the World Resources Institute reports that in Sub-Saharan Africa, 83% of food is lost during production, handling/storage, and processing, while only 5% is wasted by consumers. In comparison, 32% of food is lost in the early stages and 61% is wasted by consumers in North America and Oceania (O'Sullivan, 2023).

Text Box 4: Municipal Solid Waste Composition and Management in Sub-Saharan Africa

In Sub-Saharan Africa, around 57% of municipal solid waste (MSW) is organic, with 13% plastics, 9% paper and cardboard, 4% glass, 4% metals, and 13% other materials. Waste collection services in most African countries are insufficient, with an average MSW collection rate of 55%. Over 90% of urban waste in Africa is disposed of in uncontrolled dumpsites and landfills, often leading to open burning. As data on waste generation and management in rural Africa is scarce, estimates primarily focus on solid waste in urban areas. It is generally believed that waste generation per person is lower in rural areas compared to urban areas.¹⁴

¹⁴ UNEP, 2018, p. 24.

Municipal Solid Waste (MSW) and Its Potential for Circular Approaches

Globally, food waste and green waste account for 44% of municipal solid waste (MSW), with paper and cardboard contributing an additional 17%, bringing the total to 61% (Kaza et al., 2018). The remaining waste includes plastic (17%), other waste types (14%), glass (5%), metal (4%), and rubber, leather, and wood (2% each). The increasing generation of MSW – driven by population growth and rising demand for food – poses significant challenges for waste management but also creates opportunities for sustainable reuse methods aligned with CE principles.

Composting processes, which utilise materials such as food waste, green waste, paper, cardboard, and animal manure, present a synergistic solution by reducing organic waste and replenishing soils with essential minerals for agriculture. Recycling food waste, byproducts, and nutrients can not only reduce the consumption of organic resources, close nutrient cycles, and support sustainability, it also addresses the growing global demand for fertiliser (Pajura, 2024). As various case studies demonstrate, effective links can be created between municipal waste management utilities and recycling of municipal waste as a CBM.

Use of agricultural waste: Compost is a cornerstone of regenerative agriculture, providing a natural, sustainable way to improve soil health, enhance biodiversity, and restore degraded lands. Compost not only adds organic matter to soil, including macro- and micronutrients and beneficial soil organisms, but also improves the health and structure of soil, retains water and, sequesters GHG from the atmosphere (Footprints Africa, 2021, p. 11). By incorporating compost, farmers can create resilient farming systems that benefit both the environment and agricultural productivity. Various low-cost composting methods for organic waste have been developed and are widely applied in rural communities and urban gardening world-wide. These include basic techniques like pit or pile composting and improved methods such as vermicomposting (using earthworms for production of nutrient-rich compost). These simple techniques are used as circular methods at the farm or household level, turning agricultural and food waste into fertiliser for on-site use.

Text Box 5: CE in the Context of Regenerative Agriculture in Africa

The significance of African soils for ensuring food security on the continent cannot be overstated. Unfortunately, 40% of these soils are currently degraded, which negatively impacts food production, contributes to soil erosion, and ultimately accelerates desertification. This is particularly concerning as 83% of people in sub-Saharan Africa depend on the land for their livelihoods. It is projected that by 2050, food production will need to nearly double to adequately feed Africa's growing population.¹⁵

As food demand continues to rise due to rapid population growth in the region, regenerative agriculture is seen as a key approach to ensuring sustainable food production without causing further harm to the environment. One promising investment opportunity is the local production of organic fertilisers, which reduces reliance on synthetic fertilisers (thus lowering costs) and benefits farmers who prefer organic options. Producing organic fertiliser also helps to manage the increasing organic waste while addressing local fertiliser demand.¹⁶

Use of food waste from agro-processing industries: In the agri-food sector and its supply chain, one of the most significant challenges is the generation of byproducts, which are often discarded as waste. This practice not only creates environmental problems but also misses the potential to generate financial value by turning food waste into valuable resources, such as energy (via biogas processing), compost or upcycled, degradable products.

¹⁵ Footprints Africa, 2021, p. 11.

¹⁶ Whyte et al., 2020, pp. 50–51.

According to the United Nations Industrial Development Organisation (UNIDO), there is a significant potential for developing nations for transforming both food and agricultural waste into biomaterials, organic fertilisers, medicines, and bioenergy using emerging technologies (UNIDO, 2021a, p. 11).

Text Box 6: Black Soldier Fly (BSF) Farming for Africa's Growing Meat Demand

Sub-Saharan Africa's meat consumption is predicted to double by 2050, which will tangentially increase the demand for feed supplies.¹⁷ Large-scale animal farming depends heavily on fishmeal and grain-based protein. However, the production of agricultural proteins such as soy necessitates enormous amounts of land and water resources, which has detrimental effects on deforestation and land degradation. Fish meal, another popular source, negatively affects marine ecosystems. BSF farming offers a sophisticated circular solution that has recently gained popularity across Africa as a means of reducing the amount of unrecycled waste. BSF larvae convert organic waste into a high-protein, low-cost, and more sustainable alternative to conventional animal feeds. This innovation not only addresses feed supply needs but also contributes to waste reduction and sustainable agriculture.¹⁸ However, industrial BSF systems may require high amounts of electricity (for drying the larvae). In general, the processing of plastic-contaminated organic waste may contribute to increased micro-plastic pollution of livestock and soils.

Technology Trends for Processing of Organic Waste

Composting technologies have evolved significantly, integrating innovative methods to enhance efficiency, reduce environmental harm, and suit diverse composting needs. One example is the use of various **microbe composting methods** that rely on microorganisms (bacteria, fungi, and other microbes) to break down organic waste into nutrient-rich compost. These processes harness the natural ability of microbes to decompose organic matter efficiently while producing high-quality fertiliser. Microbe composting methods vary in their approach and application but share the core principle of accelerating decomposition through microbial activity. **Smart composting systems** monitor parameters like temperature, moisture, and oxygen levels in real-time, optimising conditions for microbial activity and improving compost quality. Innovations include **composters powered by renewable energy sources**, such as photovoltaic systems. For instance, autonomous rotary composters powered by solar energy have been designed to process household organic waste efficiently, reducing reliance on conventional energy sources. **AI** is also used in automated processing facilities to segregate compostable materials from non-compostable ones. Due to investment costs, these high-tech solutions are mainly used in industrialised countries and emerging economies like India. The **table** below provides an overview of composting technologies from household/community levels to medium- and large-scale facilities in urban waste management.

Table 8: Technology Examples for Organic Waste Composting & Their Levels of Application

Technology	Features of the Process	Application
Aerobic Composting	Relies on specific microbes requiring or preferring oxygen to decompose organic material; method requires turning or aeration	Large-scale composting facilities for urban organic food and green waste
Anaerobic Composting (e.g. Bokashi)	Fermentation of organic waste in sealed, oxygen-free conditions using microbial inoculants like Effective Microorganisms (EM). The process creates methane, which is a	Rural and urban households; Also used for pre-treatment before further composting in commercial settings

¹⁷ Erdaw, 2023.

¹⁸ Footprints Africa, 2021, p. 15.

	harmful greenhouse gas if not contained and used for energy creation	
Bio-Enzyme Composting	Microbes produce enzymes (e.g., cellulase, protease) to break down complex organic compounds	Composting of tough agricultural waste like straw and husks; industrial-scale composting of mixed organic waste
Biogas Plants for Compost Production, Heating and Energy	Animal and green waste is processed by biogas technologies	From household-size small-scale plants to large-scale facilities; Multiple uses: energy production (cooking gas/ electricity for larger facilities) and compost
BSF Bioconversion Processing	Uses larvae of the black soldier fly to decompose organic waste quickly. The larvae consume organic material and transform it into nutrient-rich compost or frass (larval waste)	Commercial application (small to medium-sized businesses) (see case study “Black Soldier Fly (BSF) Farming for Africa’s Growing Meat Demand” , text box 6)
Thermophilic Composting	Decomposition at high temperatures (> 45°C) by heat-resistant microbes	Commercial composting of municipal solid waste or waste from food processing industries and livestock
Vermicomposting	Combines earthworms and microbes to decompose organic matter into nutrient-rich vermicompost	Small-scale organic waste management in households and farms; urban farming

Circular Business Models in Organic Waste

This section elaborates on different types of CBMs in the organic waste sector. Household-based waste composting is not discussed here.

The CBMs can be broadly classified as the following:

- **Community-based urban initiatives** processing municipal organic waste, mainly for urban gardening
- **Small to medium-sized companies** (some of them social enterprises) engaged in organic fertiliser production
- **Medium to large scale municipal** or privately owned solid waste processing enterprises using CE principles.

Table 9: CBM Examples in the Organic Waste Sector

CBM Example	Description
Agricentric Ventures (Ghana)	A social enterprise in Kumasi (Ghana), which processes food waste in markets and from food processors. Manual processing creates jobs for approximately 30 employees. Products include solid and liquid fertiliser. (Source: Field visit, 2024

	See case study “Making Fertiliser from Waste – Examples from Africa”, text box 7).
Community-based Social Enterprise: Slums Going Green and Clean (SGGC) (Kenya)	SGGC is a community-based youth enterprise that organises waste collection in the Kibera slum area of Nairobi, home to an estimated 700,000 inhabitants. The group, active since 2015, organises waste picking, sorting, and processing as a social enterprise. It collects and sorts all types of solid waste including organic waste and runs a composting facility. The organisation has two main goals: improving local waste management and creating employment opportunities for disadvantaged youth (Source: Talk Africa on SGGC Urbanism-Sustainable City Nexus).
Ecodudu (Kenya)	Founded in 2018, Ecodudu uses the Black Soldier Flies (BSF) life cycle to produce high-protein animal feed for fish, poultry, and pig as well as fertiliser from organic farm waste (Source: Ecodudu Insect-based CE See case studies, Part II).
KAZE Green Economy (KAGE) (social enterprise in Burundi)	Kaze Green Economy converts biodegradable waste into two products: biofuel and Makara, a substitute for charcoal. Maize stalks are collected from households and dumps, dried to remove all moisture, partially burned in ovens, crushed into a carbon-rich powder, then combined with other agricultural residues such as rice husks and coffee parchment (Source: World Bank Ideas4Action Kaze Green Economy Wikipedia KAGE Narrative)

Text Box 7: Making Fertiliser from Waste – Examples from Africa

AgriCentric Ventures, which is based in Kumasi/Ghana, collaborates with smallholder and commercial farmers to purchase their farm waste, which is then converted into valuable organic products such as bio-char, bio-fertiliser, dietary supplements for livestock and fish, and biopesticides. These products are sold back to farmers at affordable prices to support sustainable food production practices. Additionally, the company provides soil remediation services and works with government agriculture offices to offer free Livelihood Empowerment Programmes for rural farming communities. It also conducts sensitisation programmes on sustainable food production.¹⁹ Through this work, which is supported by GIZ and other organisations, 600 smallholder and commercial scale farmers were trained and use the new fertiliser products. The use of synthetic chemicals was reduced by 80 % for around 400 farmers; production costs were cut by 30 %, and crop yields increased by 35 %.²⁰ The business was honoured with the SEED Low Carbon Award in 2019 (see full case study, Part II).

A slightly different strategy is used by an Ivory Coast-based company:

Headquartered in Abidjan, Ivory-Coast, **LONO** develops solutions to convert organic waste into valuable agricultural inputs and renewable energy.²¹ The company operates through two complementary models: For farmers and cooperatives wishing to process their own organic waste, **LONO** produces patented prefabricated composters and biodigesters under the Kubeko® brand. These units transform crop residue, manure, and agro-processing by-products into compost, liquid fertiliser, and biogas for cooking. In parallel, LONO works with mid-sized manufacturing facilities to design and build large-scale biodegradation and composting plants, avoiding waste incineration and creating additional marketable products.²² Through these interventions, LONO improves soil fertility, reduces GHG emissions from unmanaged waste and offers rural households renewable energy alternatives to wood and charcoal. The company also provides training to ensure proper use of its systems and long-term adoption of sustainable waste management practices.²³ As

¹⁹ SEED, n.d.(a).

²⁰ SEED, n.d.(b).

²¹ Footprints Africa, 2023.

²² Whyte et al., 2020, p. 18.

²³ Thomas, 2019.

winner of the 2021 Africa Prize for Engineering Innovation, LONO has received recognition for its role in advancing the circular bioeconomy in West Africa.²⁴

For **more information**, we recommend reading the **DBFZ** Report No. 47 “WasteGui – Guideline for organic waste treatment in East Africa” (**Source:** [Wiegel et al., 2022](#)).

²⁴ Royal Academy of Engineering, 2021.

5 Decent Jobs and Skills in the Circular Economy

5.1 The Impact of CE Scenarios on Employment

One of the primary objectives of this study is to assess the impact of the CE on labour markets, and the demand and development of relevant skills in targeted sectors. Projections regarding labour demand in the context of CE are complex, as they must be based on modelling that considers different CE scenarios and the development of global macro-economic conditions (Laubinger et al., 2020). In addition, such modelling must consider the specific economic conditions of individual countries or regions. According to an OECD review of 13 modelling studies, nine focus on industrialised countries – primarily within the EU – while only four adopt a global perspective. This indicates a clear bias in existing data toward industrialised contexts. The ILO report on “Decent work in the circular economy” (ILO et al., 2023) provides a detailed analysis of the current data landscape and identifies the following limitations:

- **Absence of a universal CE definition:** The lack of a universally accepted definition of the CE complicates the measurement and comparison of labour market impacts across different contexts. This lack of standardisation hinders the development of consistent forecasting models.
- **Scarcity of sector-specific employment data in developing countries:** There is a notable gap in comprehensive, sector-specific data on CE-related employment, particularly in developing countries, limiting the ability to generate accurate labour demand forecasts.
- **Prevalence of informal CE-related work:** Many CE-related jobs, especially in waste management and recycling, are part of the informal economy. This informality makes it challenging to collect accurate employment figures or model future labour demand in the informal economy effectively.
- **Regional and sectoral variability:** The impact of CE transitions on employment varies significantly across regions and sectors, influenced by factors such as regulatory environments and economic structures. This variability complicates the creation of generalised labour demand forecasts.

Moreover, most of the reviewed studies linked to sectors covered in this paper do not offer detailed insights into skills demand. As a result, the sections on skills development are primarily informed by expert opinions gathered through qualitative methods rather than quantitative evidence.

Redistribution of Jobs in the Labour Market (Global, Across Industries)

Employment and job creation are frequently cited as significant social benefits of the CE. Various studies suggest that transitioning to a CE model generally has a positive net impact on employment, though estimates vary depending on the methodology or assumptions used. For instance, the ILO report “World employment and social outlook” (ILO, 2018) predicts a global shift to a CE could result in a net gain of **6 million** jobs by 2030. Key drivers for this growth include labour intensive sectors like repair and refurbishment, emergence of localised circular value chains, and the growth of new business models like “Product-as-a-Service” (PaaS). By contrast, the OECD suggests that without adequate comprehensive labour market interventions, CE transition may have **neutral effects, with CE-related job gains potentially offset by losses** in traditional sectors (Laubinger et al., 2020). While CE-related policies may enhance overall employment, the distribution of these benefits is likely to be **uneven across different regions and sectors** (ILO et al, 2023, p. 27). Key constraints include: Automation in recycling and sorting, weak demand for circular skills in emerging economies, and regional disparities in CE investments. Other studies caution that in absence of Just Transition measures, the CE shift could lead to net job losses and exacerbate existing inequalities – especially in regions and sectors dominated by

informal and unprotected labour. Key risks are: increased job precarity, unequal job distribution among social groups and growing discrepancies between rural and urban economies (ILO, 2023b).

CE policies are considered the strongest instrument to facilitate the transition to a CE, with significant implications for labour markets. The OECD identified four key underlying drivers that affect economic sectors and labour markets, all of which apply in CE transitions (Laubinger et al., 2020, p. 17):

- a) **Production modes:** CE regulations, such as disincentives for using certain raw materials, encourage firms to shift towards recycled inputs, thereby altering production processes
- b) **Market demand patterns:** Taxes and incentives influence both consumers and producers to reduce their material footprint and favour resource-efficient goods and services
- c) **Macroeconomic conditions:** Fiscal policies promoting CE can stimulate employment or mitigate job losses. However, economic downturns can limit governments' capacity to implement these interventions
- d) **International trade and competitiveness:** CE policies may affect production structures and pricing differently across regions, influencing trade patterns and competitive positioning on global markets.

The OECD classifies CE-policy-induced changes in labour markets into four broad categories (Laubinger et al., 2020, p. 18):

1. **Job creation** is expected in 'green' sectors that benefit from CE policies, aimed at reducing environmental pressures or improving resource efficiency. The development of new circular business models also contributes to job growth.
2. **Job substitution** occurs when economic activity shifts—either within or across sectors—from resource-intensive practices to more circular ones. Substitution refers to instances where one type of labour is directly replaced by another (e.g., jobs moving from landfilling or waste incineration to recycling).
3. **Job destruction** takes place when employment is lost without direct replacement. This can happen in sectors with high environmental or material footprints, especially where products or practices are banned, discouraged, or phased out without a circular alternative.
4. **Job redefinition** involves changes to existing roles, including shifts in required skillsets, work methods, and job profiles, as part of the broader socio-technological transition toward greater resource efficiency and circularity.

In practice these effects typically co-occur during CE transitions. The overall labour market impact depends on the interplay of these partial effects and the factors that drive them. For example, increased material circularity may create jobs in recycling and reuse sectors but may also partially reduce jobs in other end-of-life activities, such as waste incineration and landfilling. Similarly, the rise of new business models, such as product-service systems or the sharing economy, may generate new employment opportunities while simultaneously displacing conventional jobs and reducing labour demand in traditional sectors.

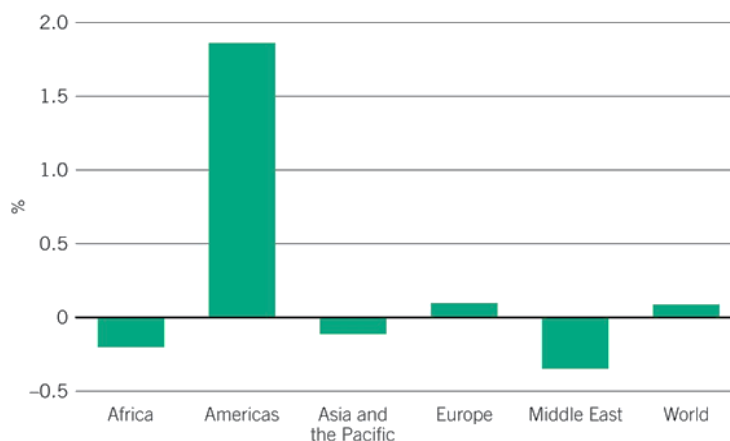
Experience shows that CE-related policy shifts and rapid implementation of new regulations, albeit environmentally necessary, can result in short-term negative impacts on employment and businesses (see case studies "Rwanda as a CE Leader in Africa?", **text box 1**; "Ghana's E-Waste Challenge, **text box 3**). For instance, the livelihoods of informal workers may be seriously threatened if such regulations lead to job losses and are not accompanied by mitigation measures to create more decent or alternative employment opportunities (see section on Just Transition, **chapter 1.3**). Moreover, the transition from

labour-intensive practices to mechanised and automated processing may lead to better quality of jobs but also to a quantitative decline.

Redistribution of Jobs by Regions

The 2018 ILO study predicted that net job gains will occur in the Americas and Europe while net losses were predicted for Asia and the Pacific (approximately five million), Africa (one million) and the Middle East (around 200,000) (see figure 6; ILO, 2018, p. 53). The ILO study does not provide explanations for these discrepancies. None of the studies reviewed provide CE-related labour market projections explicit for the Global South, namely Africa, the Middle East, South and Southeast Asia, or Latin America. The job loss forecast for Asia and the Pacific may reflect the region's strong manufacturing base, particularly in China, where CE policies that extend product lifespans or increase refurbishment could lead to significant employment reductions. For African economies, the reliance on extractive industries means CE transitions could reduce GDP due to lower resource extraction. However, this may be offset by job creation in repair, refurbishment, service industries, and new opportunities in critical mineral extraction linked to the global energy transition.

Figure 6: Employment Forecast by Region (ILO, 2018, p. 51)



Notes: Percentage difference in employment between the circular economy scenario and the IEA 6°C (business-as-usual) scenario by 2030. Appendix 2.1 provides further methodological details on the data and methods used. Vertical scales differ by panel.

Source: ILO calculations based on Exiobase v3.

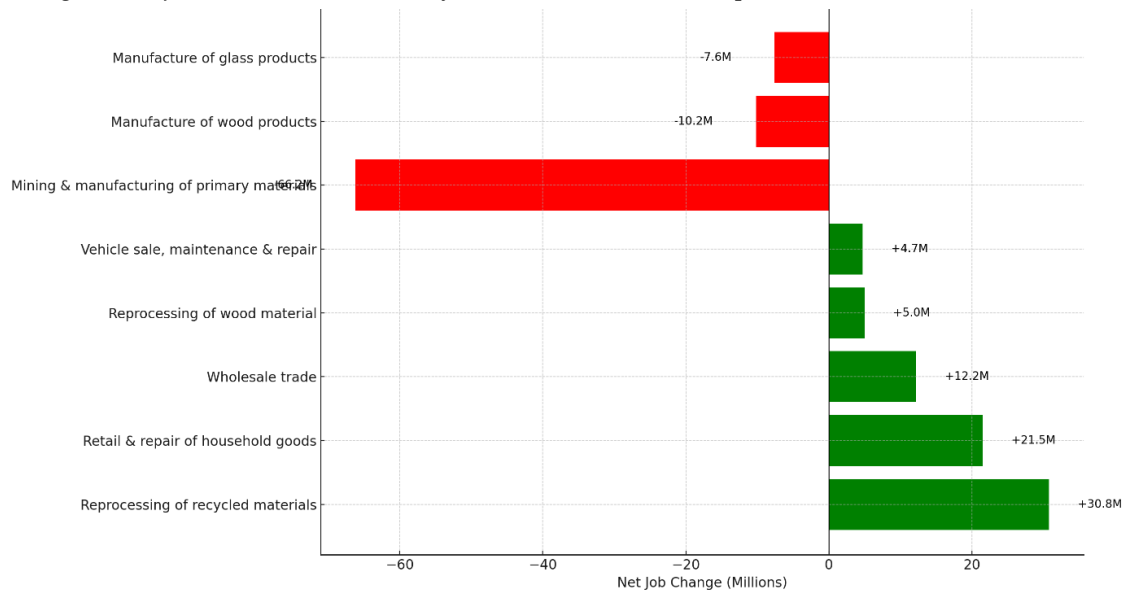
We conclude that the data base is too weak for a valid comparison of CE-related job losses and gains between regions.

Redistribution of Jobs by Sectors

The data on redistribution of jobs by sectors reviewed for this study also has significant limitations: it is either not sufficiently relevant for developing and emerging economies, or it does not clearly distinguish between general aspects of greening of economies and CE-related transformation. Overall, in the case of a positive CE scenario (i.e. favourable CE policies being in place), job creation, substitution and redefinition take place in "green" sectors stimulated by CE policies, which reduce the use of primary materials, while job destruction occurs in sectors with significant environmental and materials footprints (Chateau & Mavroeidi, 2020, p. 16).

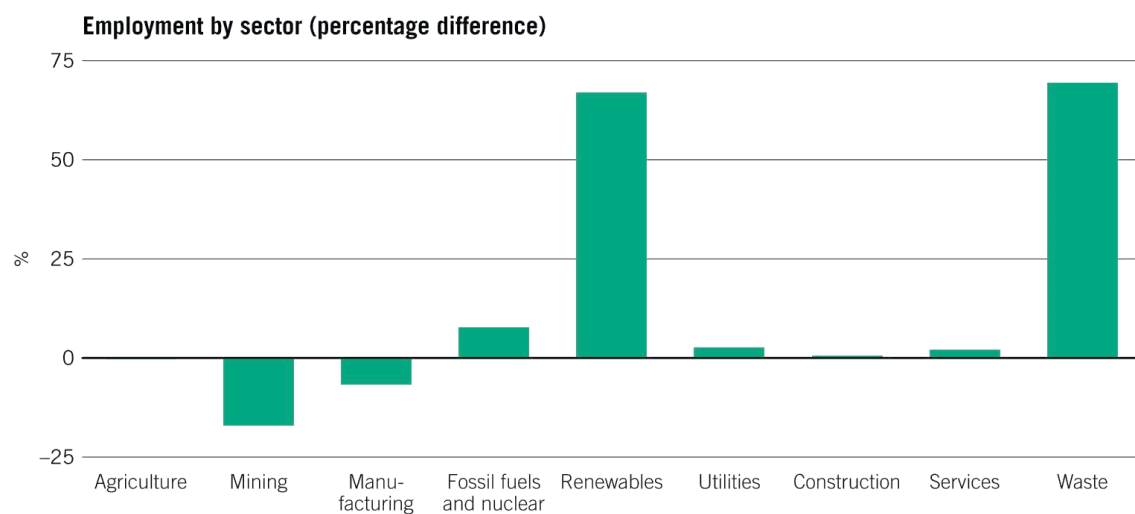
According to the ILO “World Employment and Social Outlook 2018” (2018, pp. 51–52), the sectors with the highest global job demand growth until 2030 are listed in **figure 7**.

Figure 7: Projected Global Job Demand by Sector until 2030 (ILO, 2018, p. 52)



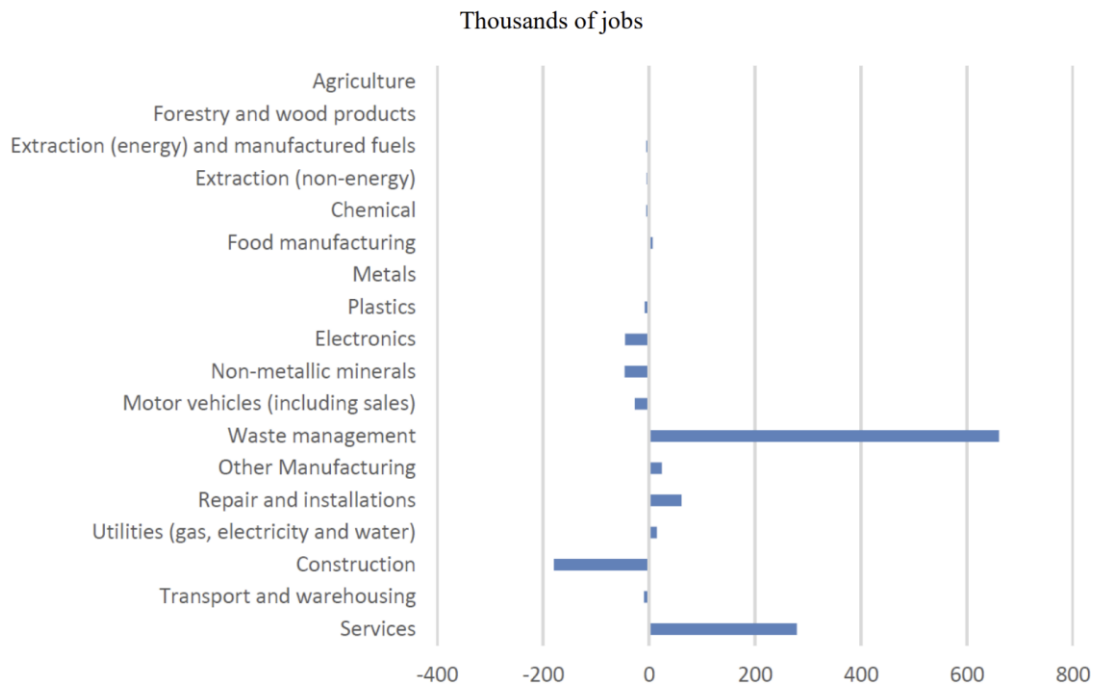
These projections of 2018 show that the circular economy transition will have both winners and losers across sectors. While there is **significant job creation potential** in sectors related to reuse, repair, and secondary material processing (gains of 74.2 million jobs), this is offset by **large-scale job losses** in resource-intensive and linear sectors like mining and primary manufacturing (loss 84 million jobs), with a negative balance of 9.8 million jobs. When including energy sectors in the calculation (on the assumption that industries will increasingly use renewable energy sources) – with gains of 14.7 million in renewable energy and loss of 4.9 million in the coal mining sector – the net balance across sectors would be zero.

Figure 8: Employment Forecast by Sector (ILO, 2018, p. 51)



The OECD Review of 2020 (Laubinger et al, 2020, p. 34) provides the following estimates on CE policy-related job impacts in key sectors for EU countries, as shown in **Figure 9**.

Figure 9: CE Job Impacts in Key Sectors (Laubinger et al, 2020, p. 34)



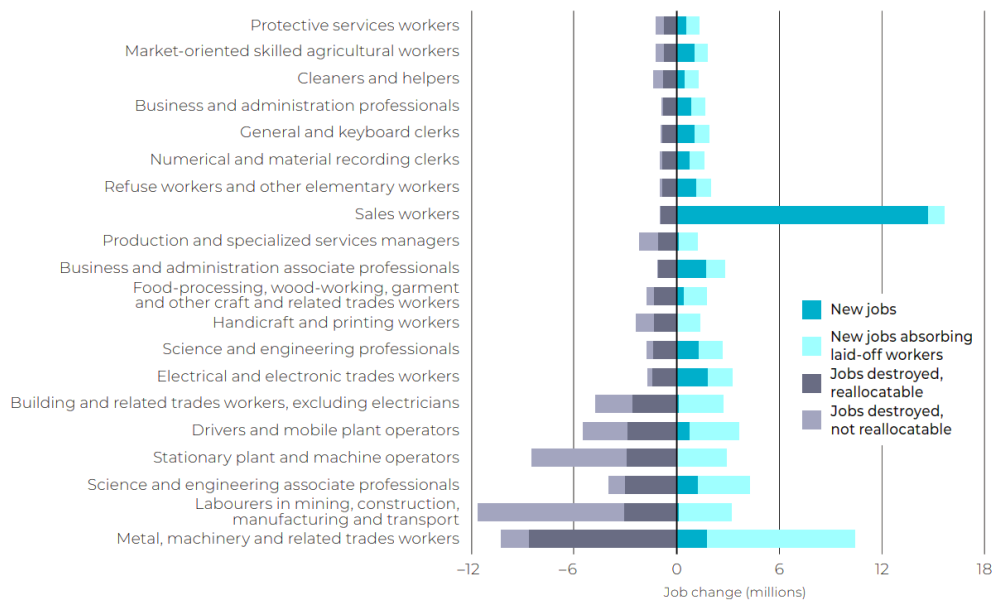
When comparing the ILO Global Outlook (ILO, 2018) with the EU Outlook/OECD Review (Laubinger et al, 2020), the following can be concluded:

- Both data sets suggest the highest gains will be in the waste management sector. Repair and refurbishment services come in second.
- Both sectors are highly relevant for developing countries. In both, the informal sector, i.e. micro and small enterprises with poor environmental records and low job quality, dominates.

Redistribution of Jobs by Occupations

Figure 10 provides an analysis of how the demand for occupations may change as a result of CE transitions. The projection shows that new jobs will be disproportionately created in sales, while job losses that cannot be reallocated will be the highest among labourers in mining, construction, manufacturing and transport, followed by stationary plant and machine operators. The projected job growth in services and sales is expected to lead to a higher proportion of female workers. As noted above, the representativeness of this data for labour markets in low- and lower middle-income countries is questionable, as these countries have a large proportion of informal workers, for whom data projections are difficult to make.

Figure 10: Projection of Occupations Most Susceptible to Job Destruction & Relocation Across Industries in a Global CE Scenario, 2030 (ILO, 2019)

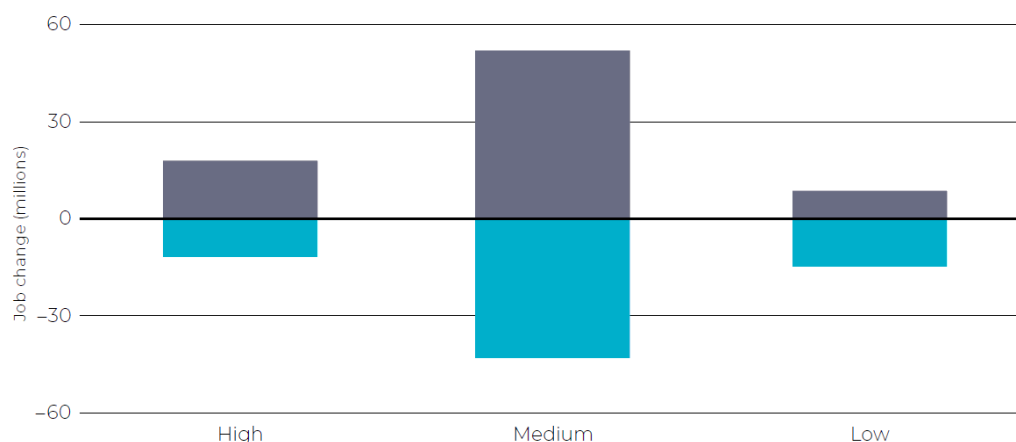


The scenario outlined above assumes that the transition to a CE affects employment across a wide range of economic sectors and occupations. This is due to the interconnected nature of value chains, which extend beyond directly impacted industries. According to ILO (2018), approximately 78 million jobs could be created, while 71 million may be lost because of this transition. Among the workers affected by job losses, a significant portion, about 49 million, are expected to find new opportunities in the same occupations but in different industries within the same country. This indicates strong potential for job reallocation. Of the newly created jobs, approximately 29 million will require a better qualified or reskilled workforce. However, around 22 million job losses will not be matched by vacancies in the same occupations elsewhere, highlighting the need for active labour market measures to ensure a Just Transition.

Change in Demand of Skill Levels as a Result of CE

According to ILO (2018), job gains on the global level will be highest for high-level and medium-level qualifications. For low-level qualifications, losses will outnumber gains.

Figure 11: Jobs Created & Lost in the CE Scenario by 2030 (ILO, 2018, p. 141)



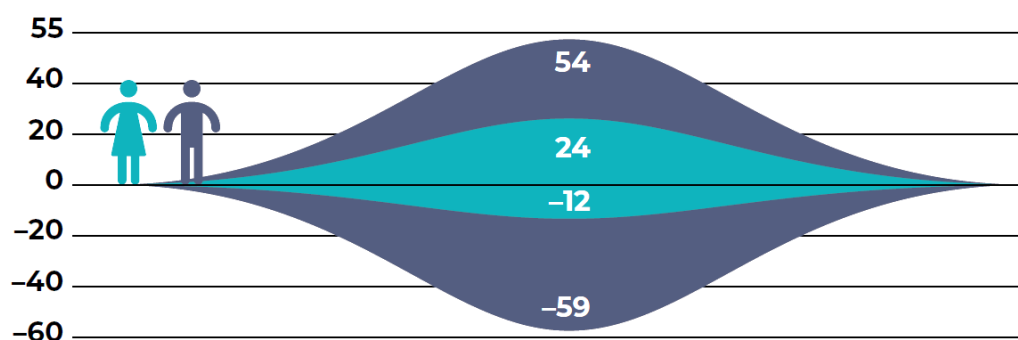
These findings correlate with the findings of sectoral studies on green skills (GIZ & FAKT, 2023). Determining factors include the development of more complex technologies (e.g. for extraction of

recyclable materials), which require higher technological knowledge and occupational competencies for design, operation and maintenance. This also means that more jobs at the lower end will be lost, which, in the context of Just Transition, requires investment in re- and upskilling.

Gender Effects in Labour Markets as a Result of CE

Several studies conclude that transition to CE will increase employment opportunities for women, especially in service-related occupations (e.g. sales), but also in waste management, where the share of female workers is high. Overall, this will improve but not offset gender disparities in the labour market.

Figure 12: Jobs Created & Lost by Gender in the CE Scenario by 2030 (ILO, 2018, p. 142)



5.2 Demand and Supply of Labour Across the Priority Sectors

This section addresses one of the key topics of this study: the demand and supply of skilled labour in the priority sectors chosen (plastic waste, e-waste and organic waste). It first takes a more general view on the demand for labour and skills across the three sectors. In the second part, the study analyses in more detail the jobs and skills needed in the three sectors and the qualifications offered.

The findings in this section derive from four sources: (a) literature review on green skills (ILO 2018; ILO, 2019); (b) the FAKT-implemented studies on selected green skill sectors (GIZ & FAKT, 2023); (c) unpublished labour market studies; as well as (d) interviews with practitioners in the field.

Projections for Labour Demand

At the global level, it is estimated that 6.9 million people are employed in waste collection and recycling industries, while an additional 20 million informal waste workers, predominantly in the Global South, are active in these sectors. For example, informal workers are responsible for collecting approximately 60% of all plastic waste that gets recycled globally. The industry is male dominated, with women representing only 22.7 % of the workforce. Approximately one in seven workers in the sector is between 15 and 24 years old, many of whom have low levels of education (ILOSTAT, 2024).

It is important to note that these figures do not distinguish between the three specific waste management sectors selected for this study. Currently, there are no sector-specific labour market projections available in the literature. Although publications, e.g. by the Ellen MacArthur Foundation, explore opportunities for CE sectors in Africa, they do not provide labour market forecasts.

Consequently, the following analysis is based on a combination of generic sector data (not labour-demand specific), qualitative information drawn from literature, and insights provided by resource persons interviewed for this study.

Across the three sectors, the demand for skills will be determined by the following factors:

- The extent to which **environmental and waste management policies** and regulations are implemented
- **Growth in investments** (public, private and through international cooperation) supporting CE practices
- **Increase in public and community financing** for regulated waste management
- **Technological advancements** and the degree to which they are developed and/or applied in low- and middle-income country contexts
- **The strength of domestic and global markets** for recycled materials and circular products.

The waste management sectors under review are often **severely underfunded**, especially in low- and lower-middle-income countries. As a result, most recycling and material recovery activities operate within the informal sector, characterised by unregulated, low-skilled labour. However, **demand for a more qualified workforce**, particularly at middle and higher skill levels, is expected to grow if a combination of the above factors takes effect. This includes stricter regulation of hazardous waste, greater investment in CE practices, and the expansion of CBMs that require more sophisticated labour inputs.

In such a scenario, skills demand is likely to increase across all qualification levels:

- **Higher-level skills** in material and product engineering, process design, and management
- **Mid-level skills** for equipment manufacturing, maintenance, plant/process operations, logistics and sales
- **Lower-level skills** for basic tasks such as waste sorting and handling—though some of these may become automated over time.

Table 10 provides an overview of qualification levels and skills needed that are relevant across the three sectors discussed in this paper:

Table 10: Cross-Sectoral Overview of Qualification Levels & Skill Requirements in the CE

Qual. Level	Job Categories	Typical Tasks and Skill Levels
High	Specialised engineers/ technologists	Engineering knowledge to develop or improve processing technologies and product designs; Technical management of processing processes, quality control of production
	Senior business management	Management of circular businesses requiring sound business skills
	IT specialists	Expertise to develop and maintain IT applications, including AI-aided models for optimising waste collection and waste separation processes
	Plant supervisors	Responsible for managing the technical processes of a recycling plant; Combination technical and managerial skills
	Service technicians	Specialised technical skills for maintenance of machinery and equipment, requiring a combination of IT, electrical and mechanical skills (mechatronics)

Medium	Sales personnel	Business and admin skills
	Logistic managers	Occupational specialisation on logistics management with adequate IT skills
	Metal fabricators, industrial mechanics, welders, electricians	Metal fabrication skills for production of processing machines (skilled worker level); Electrical installation (skilled worker level)
	Industrial mechanics, electricians	Mechanical, electrical and IT skills for maintenance of machines and equipment (skilled worker level)
	Machine operators (advanced level)	Operation of complex machines that require a more complex set of skills (including digital skills); Relevant vocational certificate and specialised short-term training on the machinery use
	Quality assurance personnel (e.g. lab technicians)	Technicians level (diploma) with specialised further training depending on the technology used
Medium to Low	Machine operators (basic level)	Operation of simple machines, skills may be acquired by short term training; Work safety skills are important
Low	Unskilled labour for waste collection and separation	Skills mostly acquired on the job; Awareness for work safety and hygiene
	Workers in logistics	Packaging work (training on the job or short-term training); Awareness for work safety and hygiene

In quantitative terms, the demand for high-level technical expertise may be lower than for any other worker categories. However, with regard to key qualifications that enable CE transition, engineering expertise is considered crucial in the following fields of specialisation:

- **Material design engineers** with specialised knowledge in resource-efficient and/or recyclable designs
- **Processing technology engineers** with specific knowledge on recycling technologies and processing processes in the selected sectors
- **IT engineers** developing applications for digitalised waste collection and sorting systems.

Typical occupations at the medium (vocational training) level would be:

- **Recycling plant technicians** responsible for installing, operating and maintaining recycling equipment
- **Machine operators** and other skilled workers in the respective waste and waste-recycling value chain
- Personnel in **administration and sales**.

The skills needed for **manufacturing and maintenance** of equipment are often covered by existing occupations within national qualification systems, such as **welders, metal fabricators, and electricians**. However, more sophisticated CE-industries increasingly demand modern technical occupations, such as industrial mechanics and mechatronics technicians.

At the **plant operator level**, qualification requirements vary significantly depending on the technological sophistication of the equipment used. Technologies can range from highly automated, partially mechanised systems – often imported and not locally manufactured – to simpler, manually operated equipment produced locally. Workers must have the technical knowledge and operational skills necessary for the safe and efficient handling of machinery. Depending on the complexity of the work, employers often select candidates based on their level of education and core competencies rather than specific occupational qualifications. Training for these roles is commonly conducted on the job.

A variety of medium- and lower-level jobs are needed to **organise activities such as waste collection, separation, and processing**. These include roles such as supervising waste workers and managing the packaging and sales of recycled products. Again, these are not CE-specific occupations, but roles requiring foundational competencies.

At the **basic level**, workers such as waste collectors, waste separators, and recycling operatives are typically trained directly on the job. Many people in this group have lower levels of formal education and often lack occupational qualifications (see section on Just Transition, **chapter 1.3**). For workers handling hazardous waste or materials posing health and environmental risks, it is critical to ensure basic training in environmental protection and occupational health and safety (ILO, 2018).

Skills Needed to Start and Operate a Circular Business Model

The literature review did not provide any data estimating the number of small and medium-sized enterprises (SMEs) operating in the three CE-sectors selected for this study, nor any information on their labour demand, either at the country or regional levels. Based on the limited scope of documented case studies, it is assumed that the number of SMEs engaged in recycling and material recovery remains relatively small compared to other economic sectors in these countries.

The situation differs in the repair and refurbishment fields, which have a long-standing tradition and employ a large, predominantly informal workforce. However, as noted in the introductory section, these two fields are not covered in this study.

Among CBM entrepreneurs interviewed in Africa, few had received CE-specific training or technical education, as such programmes have barely existed in the past. Very few business owners held related degrees (e.g. environmental engineering), while most came from different technical backgrounds (e.g., agricultural engineering in the case of organic waste management) or from business administration, recruiting technical experts when needed or partnering with other firms for technological expertise. Many entrepreneurs had built their specific technological knowledge through:

- Collaboration with technical experts locally or internationally,
- Partnerships with research institutions (e.g., universities),
- Peer learning,
- Self-learning and trial-and-error experimentation.

Establishing a CBM requires a broad set of core competencies and transversal skills that are typically not taught in formal education (Interviews with CE entrepreneurs in Africa). These include:

- Self-determination and resilience
- High levels of creativity and innovation
- Strong communication and business networking skills
- And crucially, business management competencies.

Workers employed in small-scale waste management and recycling facilities were typically trained on the job, especially where low-tech solutions were applied. However, the skill requirements increase significantly when companies begin to adopt more sophisticated equipment and processing technologies (see section on impact of CE scenarios on employment, **chapter 5.1**).

Demand and Acquisition of Skills in Informal Sector Businesses (primarily in the plastic and e-waste sector)

Informal sector businesses involved in waste management, recycling, and material recovery range from self-employed individuals, working alone or in groups, to family-, clan-, or community-based enterprises that may engage hundreds of informal workers and unpaid family members.

Within the informal sector, the level of technology used is typically rudimentary, with limited attention to occupational health and safety standards. Nevertheless, certain tasks, for instance material extraction processes in the e-waste sector, require relatively sophisticated craft skills. These skills are often acquired through traditional apprenticeship models, where knowledge is gradually passed down through practice and mentoring

For **more information**, we recommend reading the ILO resource guide for Africa “Upgrading Informal Apprenticeship” (Source: [ILO, 2012](#)).

5.3 Demand and Supply of Labour Per Priority Sector

Demand and Supply for Skills in the Plastic Waste Sector

The plastic waste sector is expected to grow significantly in the long term, considering that currently only 9% of plastics produced are being recycled, while this rate is projected to increase to 45% by 2050 due to expected increases in oil prices, stricter regulations, and market changes. This expansion is expected to create jobs not only in the down-hill part of the CE model (waste management and plastics recycling) but also in the up-hill dimension (material designers, production of materials as degradable substitutes for plastics) (Plastics for Change, 2025).

Demand for plastic technologists: As the plastic industry transitions toward CE practices, there is a growing need for specialised technical and technological expertise, particularly in the areas of plastic material design and plastic recycling technologies. Institutions offering specific degree and postgraduate courses in these fields include, for example, Institutes of Polymer Technology in South Africa and Institutes of Technology in India, which provide specialised programmes focused on plastic design and materials innovation.

Demand for plastic waste management professionals: With the rapid increase in plastic waste generation, the demand for plastic waste management professionals in both public and private waste management facilities is growing steadily. Among the countries reviewed in the Global South, India appears to be leading in terms of training supply. Various public and private institutions offer diploma and degree programmes specifically focused on plastic waste management, available through both in-person and online formats. In contrast, similar training opportunities remain limited in many other countries.

Examples of specialised training programmes:

- India’s “Centre for Science and Environment” offers online courses in sustainable plastic waste management (Centre for Science and Environment, n.d.)

- India's "Institute for Skills Development Training" coordinates courses in plastic waste management at different qualification levels (certificate and diploma courses) in authorised training centres across the country (Indian Institute of Skill Development Training, n.d.).

Demand for labour and skills in waste separation and processing: In terms of volume, it is assumed that the majority of jobs are currently created in labour-intensive plastic waste separation and processing activities. However, as the sector transitions towards more mechanised and increasingly digitalised technologies, the quantitative demand for low-skilled labour is expected to decline, while the demand for higher-level skills will grow. The case study "India" (see Part II) illustrates this trend: mobile applications are now being used to assist plastic waste workers in sorting waste according to material properties and quality. This example highlights the emerging need for basic digital competencies among waste pickers and separation workers to adapt to new technologies.

Table 11 provides an overview of qualifications and skills needed for CE in the plastic sector (from high to lower-level qualifications):

Table 11: Job Qualifications & Skills Required for CE Jobs in the Plastics Sector

Job Title and Skill Level	Example of Key Tasks	Examples for Key Skills
Product design engineers (high level)	Design of plastic materials and products with plastic content for recyclability and reuse	CE design principles; materials science; CAD software skills
Plastic material technologist (high to medium level)	Developing and managing sustainable manufacturing practices used in plastic recycling value chain	Technical skills for injection moulding, extrusion, and other relevant plastic recycling technologies
Process engineers	Oversee recycling processes (mechanical and/or chemical)	Materials science; process optimisation; compliance regulations
Sales & marketing agents	Promote recycled products or services (e.g., waste collection platforms)	Digital marketing; eco-branding; customer relations skills
Procurement and supply chain officers (higher to medium level)	Manage the sourcing of recyclables or delivery of end products	Strong skills for negotiation; supplier relations and logistics
Plastic fabrication workers (medium level)	Mould or assemble recycled plastic products	Machine operation; mould handling; finishing skills; work safety
Chemical lab technicians	Analyse recycled plastics' properties for reuse	Polymer testing; spectroscopy; quality assurance skills
Machine operators	Operate shredders, grinders, washers, extruders, agglomerators	Mechanical aptitude; quality control; machine maintenance; work safety
Logistics & transport staff	Waste transport drivers, route planners	Vehicle operation; knowledge of collection schedules; handling and storage

Material Recovery Facility (MRF) workers	Manual sorters, conveyor operators	Speed and accuracy in separating different plastic types; work safety
Waste collectors	Street pickers, door-to-door collectors, community sorting groups	Material identification; collection logistics; basic safety

Demand and Supply of Skills in the E-Waste Sector

The e-waste sector is experiencing rapid growth, with global e-waste generation reaching 62 million tonnes in 2022 and projected to rise to 82 million tonnes by 2030. This surge presents both challenges and opportunities for employment in recycling and refurbishment activities. The ILO notes that recycling, remanufacturing, and repair jobs in this sector are labour-intensive, are found more often in the Global South, and could provide more opportunities for informal workers to transition into better jobs within the CE framework (Baldé et al., 2024).

Unlike the plastics sector, where several formal qualifications have been developed in countries like India and South Africa, the literature and internet research did not reveal similar formally recognised qualifications specifically for the e-waste sector. This is likely due to the dominance of unregulated informal sector activity, where skills are largely informally acquired. Stricter regulations for e-waste handling may enable the growth of formally accredited businesses in the sector that use more sophisticated and less harmful technologies. With this shift, technicians and workers in this sector would require advanced technological and material extraction skills, alongside the ancillary skills needed for maintenance of machinery, marketing and sales, and logistics –elaborated in the sections above. **Table 12** provides an outlook for skills and occupations in the e-waste sector that are expected to increase in demand.

Table 12: Overview Qualifications & Skills in the E-Waste Sector

Job Title and Qualification Level	Key Tasks	Examples for Key Tasks/ Knowledge
Environmental engineer with further qualification or specialisation on e-waste management (higher level)	Inspecting e-waste sites; Technical management of formal e-waste processing plants; Advising/ training for e-waste workers and businesses	Broad knowledge of waste management practices and regulations; Quality & safety management of e-waste handling; Understanding of national/international e-waste policies and practices
E-waste recycling specialist with “add on” qualification for individuals with related vocational trainings or apprenticeship, e.g. in consumer electronics repair (middle level)	Managing an e-waste recycling facility; Overseeing work processes; Ensuring environmental and health standards	Knowledge of environmental/ health hazards and legal aspects of handling e-waste; Ability to clarify e-wastes by toxicity; Good practices in e-waste processing; Quality & safety management; Work organisation and supervision; Occupational Health & Safety; Technical skills in e-waste recycling (cf. E-waste worker)
E-waste worker with skills usually acquired on the job or via short term courses (lower level)	Processing various types of e-waste (cooling appliances; computers, phones, tablets etc.); Dismantling and sorting items; Material recovering	Awareness on harmful and good practices; Practical dismantling and component sorting skills; Safe processing of e-waste; Occupational Health & Safety; Basic knowledge of basic environmental standards

	(e.g. melting) in the e-waste value chain	
Waste pickers	Waste collection and separation	Awareness of hazards posed by e-waste and other hazardous wastes; Sorting e-waste items

The literature review provided several examples of how skills development in the e-waste sector can be improved:

- **Developing capacities for sustainable waste management:** the management of e-waste is integrated as a topic in existing degree programmes for sustainable waste management. Certified further training programmes on e-waste are offered to technical experts of waste management authorities (national to municipal levels) as well as to technical experts and managers of recycling businesses.
- Institution-based **vocational training** for e-waste technicians can be offered as a further qualification module for persons with a related occupation (e.g. repair of consumer electronics) or as a stand-alone qualification.
- As most e-waste workers in the Global South work in the informal sector, where skills are acquired in apprenticeship or on-the-job, **short term non-formal training programmes** are more relevant. These courses aim at creating awareness on environmental and health hazards of existing (“bad”) practices and introducing safer practices and related handling skills. Training aim at all persons engaged in the sector (workers and business owners) as well as ancillary workers (persons selling food at the waste sites, etc.). The training needs to be tailored to both: the specific skills needed as well as the general hazards and organised as part time training close to or on the waste and recycling sites, so as to reach the targeted audience.

The literature review provides several examples of how skills development in the e-waste sector can be enhanced:

Integrating E-Waste Management into Degree Programmes and Further Training on Sustainable Waste Management

E-waste management is included as a topic in existing degree programs focused on sustainable waste management. Certified training programmes on e-waste are offered to technical experts of waste management authorities (national to municipal levels) as well as technical staff and managers of recycling businesses.

Institution-based Vocational Training for E-Waste Technicians

Vocational modules can be developed either as **additional qualifications** for individuals with related occupations (e.g., consumer electronics repair) or as **stand-alone qualifications** for new entrants to the sector.

Short-Term, Non-Formal Training for Informal Workers

As the majority of e-waste workers in the Global South operate informally and acquire skills through apprenticeships or on the job learning, **short-term, non-formal training programmes** are particularly relevant. These programmes raise awareness of environmental, and health hazards associated with current (often unsafe) practices and introduce safer alternatives and more sustainable handling techniques. **Training should target involved** – workers, business owners, and even ancillary workers

(e.g., vendors selling food at waste sites). To be effective, training programmes must be tailored specific technical skills and general hazards, and delivered part-time, close to or directly at waste and recycling sites to ensure accessibility for the target audience.

For **more information**, we recommend reading the **GIZ-comprehensive e-waste training manual**, which was produced in collaboration with **Ghana's Ministry of Environment, Science, Technology, and Innovation (MESTI)**. It covers theory, good vs. best practices, dismantling techniques, and guidelines for managing small-scale dismantling facilities and organising training sessions ([Lenz et al., 2019](#)).

Demand and Supply of Skills in the Organic Waste Sector

The global market size for organic waste is projected to grow from USD 19 billion in 2025 to approximately USD 37.70 billion by 2034 (Organic Waste Management Solution Market Size), though these figures mainly reflect trends in the Global North. If 50% of organic waste generated in low- and middle-income countries were properly treated through composting or biogas production, it is estimated that between 1.6 and 2.75 million jobs could be created by 2030.²⁵

Key enablers for job creation in the organic waste sector include:

- Advancements in composting and waste-to-energy technologies (e.g., anaerobic digestion, small-scale biogas systems), improving operational efficiency and scalability
- Stricter regulations and policies banning or limiting landfill disposal of organic waste, encouraging investment in waste treatment infrastructure
- Growing profitability of CBMs, supported by increasing chemical fertiliser costs and increased demand for organic soil enhancers
- Recognition of organic waste valorisation as a climate mitigation strategy, enabling access to carbon finance and climate-related funding mechanisms
- Expanding urbanisation and agricultural intensification, generating stable markets for compost and biogas products.

As with other sectors, the technical knowledge and skills needed to design, construct, maintain and operate composting technologies largely depend on the level of complexity and application. Household-scale technologies require minimal specialist skills. Community-based training programmes have proven effective in equipping farmers with the knowledge to construct and manage composting facilities as part of circular agricultural practices on the farm level.

More sophisticated composting techniques require a combination of technological and managerial skills. Skills training, to be effective, is usually embedded or complemented by technical and advisory services (**see** section on CBMs, **chapter 3**).

²⁵ This estimation is based on applying employment intensity figures (4–6 jobs per 1,000 metric tons of waste treated) drawn from UNEP's Global Waste Management Outlook 2024 (UNEP, 2024b) and other circular economy studies

Table 13: Overview Qualifications & Skills in the E-Waste Sector (Composting)

Job Title and Qualification Level	Key Tasks	Examples for Key Tasks/ Knowledge
Agricultural or bioengineers managing agro-waste businesses (high level)	Mastering biological composting processes; Managing processing plants; Sales and customer relationship management	Profound knowledge of biological processes in composting; Management skills; Marketing skills
Compost site operators/ composting technicians (middle level)	Operating composting equipment; Ensuring quality assurance	Safe handling of processing machinery; Basic maintenance; Digital skills for operating and programming more sophisticated equipment; Quality control
Bio-lab technicians	Quality assurance	Testing for pathogens; Measuring nutrient content
Sorting centre workers (lower level)	Sorting organic from non-organic waste; Pre-treatment	Machine operation; Safe handling of organic waste; Basic logistics; Occupational health and safety practices

5.4 Features of “Green Skills Development” in the Context of CE

Skills development refers to the process of developing the abilities, competencies, and knowledge that individuals require to carry out specific tasks, improve employability, adapt to evolving labour markets, and support economic and social development. In the context of CE, this includes **technical skills** (e.g., machine operation, composting techniques), **soft skills** (e.g., teamwork, communication), and **entrepreneurial skills** (e.g., starting and managing a circular business).

Green skills in the context of CE refer to the **knowledge, abilities, and mindsets** necessary to design, implement, manage and operate **resource-efficient, regenerative systems** that minimise waste, promote recycling, reuse, and repair, and support sustainable production and consumption models. These include **technical skills** (such as eco-design, materials recovery, remanufacturing, and sustainable supply chain management) as well as **core competencies** (such as systems thinking, innovation, environmental awareness, and cross-sector collaboration) (ILO, 2019).

Green skills development in the CE takes place across various settings, for instance:

- higher technical education and post graduate studies
- formal Technical and Vocational Education and Training (TVET)
- accredited modular or short-term training programmes for up- and reskilling
- non-formal, short-term skills training and mentoring for CBMs
- via workplace learning and community-based education.

All these forms of skills development are essential for building human capacities to support the transition to a CE:

- At the higher technical education level: strengthening **capacities for research and development** of new technologies and product innovations
- At the medium (TVET) level: developing a **skilled workforce** (e.g., operators, maintenance technicians) to enable the transition from low-tech to more resource-efficient and less harmful processing technologies

- Among informal workers and the general public: Promoting generic **green skills** such as good practices in waste management and recycling, and improving work conditions through greater awareness of environmental and occupational health issues
- For specific occupations: fostering **green skills** tailored to particular job roles
- For entrepreneurship: Developing **entrepreneurial capacities** to establish and manage profitable CBMs.

As discussed in the section on Just Transition, skills development is a key intervention for **upskilling and reskilling the labour force directly or indirectly affected by the transition of an economy to CE practices**. This especially applies to informal sector workers in the waste-related sectors discussed in this study. However, reskilling and upskilling programmes are often ineffective in securing employment outcomes if they are not aligned with existing and new job opportunities or are not accompanied by broader employment promotion strategies enabling workers to proceed to alternative livelihood options

For **more information** on skills development and employment promotion for decent jobs, we recommend reading the **GIZ** handbook “Full Productive Employment and Decent Work for all”, module 6: “designing TVET for job creation (**Source: GIZ, 2016; updated version 2022 (in German only) Handbuch Beschäftigungsförderung in der Entwicklungszusammenarbeit.**)

5.5 Aligning TVET & Higher Technical Education with Demand for Skills in the CE

This section explores how TVET and higher education systems are responding to the human resource development needs of a CE in a broader sense, beyond the three sectors addressed in this study.

Tertiary Technical Education for CE Transition

In response to the growing demand for **higher-level qualifications to support the CE transition**, many tertiary education institutions worldwide have introduced new study fields that have a focus on CE topics or have reformed existing study fields by integrating CE as a cross-cutting topic. In the Global North, CE-related academic programmes have a long tradition. For example, the University of Florida is said to have established environmental engineering as a distinct academic discipline as early as 1966. The Swiss Federal Institute of Technology Zurich (ETH Zurich) pioneered environmental engineering education in Europe with a dedicated bachelor's degree in environmental engineering, launched in 1987. Similarly, the Indian Institutes of Technology (IITs) have a long-standing tradition of integrating environmental topics into disciplines such as water and waste management.

Despite substantial growth in environmental science programmes, a lot needs to be done to further develop study fields in the Global South, particularly those relevant to the three sectors covered in this study. This desk research identified examples from India and elsewhere where technical Institutes have developed courses dealing specifically with issues like plastics and e-waste recycling. Nonetheless, the overall landscape still reflects a vast unmet demand for modernised study programmes that address the three CE sectors discussed in this paper comprehensively.

Orienting TVET towards CE

As discussed above, there are four strategic approaches for aligning TVET with CE principles (“greening” TVET):

1. Developing **new CE-relevant occupations**

2. Offering **short-term or modular training** for upskilling/ reskilling for acquisition of CE-relevant skills
3. **Aligning existing occupations** with CE principles
4. **Mainstreaming CE awareness** in vocational education programmes.

According to our analysis the **development of new CE-focused occupations** mainly took place in industrialized countries and emerging economies with a sizable recycling industry, yet there are examples from developing economies such as Ghana and Kenya where new, accredited training programmes, specifically in the three sectors discussed in this paper, have been developed. Examples from a broad range of countries are provided in **text box 8**:

Text Box 8: Examples for development of (new) CE- related occupations

Brazil has an emerging green skills policy mix guided by the Ecological Transformation Plan with references to creation of qualified green jobs. The National Service for Industrial Apprenticeship Training (*Serviço Nacional de Aprendizagem Industrial*), operated by industry, has developed and implements several CE-related VET programmes from basic to high (post-graduate) qualification levels. Examples are certified basic level training programmes for **recyclable material collectors**, **recyclable material sorters** and **machine operators** as well as post-graduate courses in “Circular Economy and Sustainable Production” (sources: [Plano de Transformação Ecológica](#);

Germany has modernised its occupations in the recycling sector in 2024, creating a new occupational profile of the **environmental technologist for circular and waste management**. This accredited dual VET occupation (3 to 3.5 years) qualifies to operate, control, organise and maintain recycling plants and waste management processes. The modernized occupation has a stronger focus on digital skills including operation of fully automated recycling operations and waste management systems or digital management of waste collection fleets and (source: [Bundesagentur für Arbeit](#) (Employment Agency Germany) (in German language)

In **India** the Skills Council for Green Jobs is spearheading the process of identifying the demand for green skills and developing or modernising green occupations. In the context of CE examples are two accredited qualifications, the **assistant operator plastic waste recycling** (NSQF level 3) and **plastic waste segregator** (NSQF level 2). Both qualifications aim to improve the workforce for plastics circularity (source: Skill Council for Green Jobs India, [Green Jobs Handbook Presentation](#)

South Africa developed new qualifications for the e-waste sector including an **e-waste operations controller** (NQF level 4) for supervising e-waste operations (collection, sorting, dismantling, handling of hazardous e-waste) as well as a basic level course aiming to qualify persons for self-employment as **Recycling Material Collectors** (NQF level 1) (source: South African Qualifications Authority, [SAQA](#))

In the **US** community colleges offer a range of new CE-related certificate and diploma courses in field where new market demands emerge, e.g. for assembly and recycling of Lithium-ion batteries. Examples are **Battery Assembly Technician Courses** (source: [Battery Assembly Technician](#)) or **EV battery safety technician and machine operator**, a course designed for safe handling of batteries in recycling facilities (source: US Department of Energy).

We conclude that key factors for developing new CE-related formal occupations are the **demand for certified skills in the labour market**, specifically in waste management and recycling, but also manufacturing, **policies** of a country that address the development of new **green skills** and **regulations** governing labour qualifications in the industry. In the initial stages of CE transition, the demand for labour may be insufficient to justify the creation of entirely new occupational profiles. For example, if waste management is dominated by informal work and the number of public and private waste recyclers is small, introducing a new qualification (e.g. recycling plant technician) may be premature. Moreover, the low social status of waste-related work often deters investment in formal training

pathways. Under such conditions, **short-term or modular training programmes**, either aimed at upgrading the skills of current workers or targeting specific technical competencies, are more likely to be effective.

The most relevant and common strategy for mainstreaming CE concepts and the related occupational competencies within TVET systems is through the **greening of existing TVET qualifications and programmes**. This entails enhancing occupational profiles by integrating CE-related competencies into the curriculum. The aim is to develop attitudes and practical skills aligned with CE within a given job context.

Table 14: Examples for Mainstream Occupations Aligned with CE Principles

Occupational Profile	Examples of CE Alignment	Curriculum Update Suggestions
Business & management professionals	Developing CBMs (e.g., product-as-a-service, sharing platforms); Integrating environmental accounting and circular value propositions	Introduce courses on circular entrepreneurship, impact measurement, and Environmental, Social, and Governance (ESG) Principles
Mechanical engineers	Design for durability, repairability, modularity, and recyclability; Materials selection based on life cycle assessment (LCA) and low carbon footprint	Add modules on eco-design, product life extension, and remanufacturing systems
Construction workers & civil engineers	Use of recycled and renewable materials; Implementing building deconstruction techniques (instead of demolition)	Include circular construction principles, adaptive reuse, and urban mining
Industrial designers	Design for repair, reuse, or disassembly; Minimising materials use and prioritise biodegradable or recycled materials in industrial designs	Include resource efficiency; Introduce design for disassembly and closed-loop designs
Electronic repair technicians	Diagnostics and troubleshooting skills for extended lifecycles; Component-level repair (not just replacement); Safe handling of refurbished, recycled, or 3D-printed parts	Introduce content on e-waste risks and safe handling; Include customer education: advising on repair over replacement
Waste management technicians	Advanced waste separation, materials recovery, and resource management; Digital tracking of materials flows	Strengthen content on recycling processes (e.g., plastics, e-waste, organics) and digital tools for waste management
Sales & retail workers	Promoting product longevity; Communication of environmental and economic benefits of circular products	Develop soft skills for consumer behaviour change (active listening, values-based selling) Add content on sustainable consumption, green marketing, and CE value propositions

Logistics & supply chain professionals	Reverse logistics (managing product returns for reuse, repair, remanufacture); Resource-efficient transportation and supply chain decarbonisation	Include circular supply chain management and end-of-life product handling
Agricultural technicians	Promoting organic farming, regenerative agriculture, and organic waste recycling	Add modules on soil health restoration, biological nutrient cycles, and closed-loop farming systems

Integrating the "greening of TVET occupations" into the regular processes for updating occupational standards and curricula is widely recognised as an effective strategy for embedding sustainability into TVET systems. The European Training Foundation (ETF), through its initiative for "Greening of Vocational Education and Training (GRETA)", advocates for aligning training practices and institutional operations with environmental sustainability principles. This includes the gradual integration of CE-relevant competencies and green skills mainstream TVET offerings (Nielsen, S. M., Fröhlich, K., Lunkeit, A, 2023; GIZ & FAKT, 2023).

Many countries have started to mainstream "**Education for Sustainable Development (ESD)**" into the education system, including vocational education systems. The aim of ESD is to build awareness among the younger generation on climate change, the environment, and sustainable resource management. The concept of CE is often not yet well integrated in ESD.

For **more information**, we recommend reading the **FAKT** study "TVET for Sustainable Construction" (conducted on behalf of GIZ), which provides specific insights on how to green TVET occupation in the construction sector, and how to align construction-related occupations with CE-principles (**Source: [GIZ & FAKT, 2023](#)**).

Relevance of Transversal, Digital and Entrepreneurial Skills for CE oriented TVET:

As widely discussed in the literature, it is of key importance for a modern TVET system to enable its learners to develop cross-occupational, transversal skills that will not only be needed in the shift to a greener CE, but also for the employability of TVET graduates in the labour market in general. According to UNESCO-UNEVOC, transversal skills are "skills that are typically considered as not specifically related to a particular job, task, academic discipline or area of knowledge and that can be used in a wide variety of situations and work settings" (UNESCO-UNEVOC, n.d.(a)).

These include:

- **Critical and innovative thinking**, e.g. needed to explore new business models and product designs
- **Inter-personal skills** (e.g. presentation and communication skills, organisational skills, teamwork, etc.)
- **Intra-personal skills** (e.g. self-discipline, enthusiasm, perseverance, self-motivation, etc.).

The importance of **digital** and **entrepreneurial skills** in skills development for a CE has been highlighted in different sections of this study. It is important that these skills are not taught by theory alone, but in the form of action-oriented learning that is directly related to concrete work tasks in the world of work.

For **more information** on how to integrate green entrepreneurship into vocational skills development, we recommend reading the following key publications/access the following websites:

- **UNESCO-UNEVOC** provides resources for the *digital transformation* of TVET (**Source:** [UNESCO-UNEVOC, n.d.\(b\)](#)) and for the *training* of TVET teachers and trainers in *digital skills* (**Source:** [UNESCO-UNEVOC, n.d.\(c\)](#))
- The **UNESCO-UNEVOC** practical guide “Entrepreneurial Learning for TVET Institutions” (2020) provides a comprehensive guideline on how to integrate entrepreneurial learning in TVET programmes (**Source:** [UNESCO-UNEVOC, 2020](#))
- The **Swiss Academy for Development** training manual “Skills for Green Entrepreneurship” (2017) (based on collaborations and experiences in Egypt) targets young people enrolled in vocational skills training (**Source:** [Swiss Academy for Development, 2017](#))
- The **Jugend & Kulturprojekt e.V.** “Green Entrepreneurship” (2024) manual as part of the NASPLY projects, consisting of five modules covering personal values, SWOT analysis, business model development, financial planning, and business resilience, places emphasis on permaculture and makes references to organic waste businesses. It is based on youth programmes in Europe but contains adaptable concepts for the Global South (**Source:** [Zhakum & Pertsinidi, 2024](#)).

6 Conclusions and Recommendations to Promote Circular Business Approaches and CE-oriented Skills Development and Employment

This section synthesises the key issues raised in the previous sections and puts them into a practical perspective on how development cooperation projects and initiatives can address the promotion of circular business approaches and skills development oriented towards the CE.

One of the key conclusions of this study is the high relevance of **integrated approaches** that target the policy and regulatory level of relevant CE sectors, the development of circular businesses and, not to forget, skills development, which is often overlooked in development interventions promoting the CE.

While fully recognising the high relevance of improving the policy development and regulatory frameworks for a CE, this section, due to the study's focus, does not deal with interventions at that level. For interested readers we refer to the resources mentioned under "recommended reading" in chapter 1 and elsewhere in the paper.

This section mainly deals with business and skills development in the three sectors chosen for this study. The study acknowledges that other sectors are equally relevant for CE transition and green skills, such as the construction sector, agriculture, water management, and various manufacturing sectors. For construction, we refer to the sectoral study "TVET for Sustainable Construction".

Improving Labour Market Projections for CE

As elaborated in the section on the demand and supply of labour per priority sector (see chapter 5.3), the database for assessing labour market demands and making respective projections is flawed by many factors, such as unclear definitions and typologies for the CE and CE sectors, bias in data towards OECD countries, and the challenge of collecting data on informal employment in CE sectors. We recommend supporting country-level or sectoral labour market assessments of CE sectors that use a mix of quantitative and qualitative research methodologies, including the collection of primary data.

Promoting Circular Businesses in the Context of Waste Management, Material Recovery & Recycling

The promotion of CBMs in the sectors discussed in this study is expected to have several impacts: CBMs can be lighthouses, showing policymakers and the public alike that change towards CE practices is possible and can generate positive outcomes. Promoting CBMs will lead to the creation of decent jobs in the CE and will impact other actors in the value chain. Last but not least: CBMs in the context of waste management can provide an alternative to the precarious livelihood of millions of informal waste workers and waste processors, who work in harsh conditions that impact their health and the environment.

We conclude:

- A key intervention area is to support the **creation of conducive CBM ecosystems**, consisting of business development services and platforms that are clearly geared towards the concept of green and circular business.
- Instead of focusing on individual CBMs, we recommend addressing the competitiveness of a respective **value chain** (e.g., plastic, e-waste, organic waste) to make a lasting impact. In the context of waste management, this includes the entire chain – from waste picking and sorting, transport arrangements, and processing technologies to marketing and sales channels to the end user (e.g. in the case of organic waste, farmers using processed food waste as fertiliser).

- In line with Just Transition principles, interventions should address the working conditions of informal sector workers in the respective value chains and promote the (gradual) **transition of informal businesses to more formalised structures** and interest groups (e.g. associations).

Table 15 lists key conclusions and respective recommendations regarding CBM development:

Table 15: Conclusions & Recommendations for Advancing CBM Development

Key Conclusion on Success Stories and Lessons Learned	Recommendations for Projects and Cooperation Initiatives
The existence of a conducive CBM-relevant ecosystem (access to business support structures, exposure to and peer exchange with like-minded CBMs) is key for the establishment and sustainability of CBMs. Entrepreneurial training and mentoring must be tailored to the circular business approach.	• Supporting CBM networks (locally, nationally, regionally) • Supporting access to relevant actors in the CBM value chain • Strengthening CBM-tailored business development services (mentoring, networking, access to finance services)
It requires determined green and social entrepreneurship and endurance to establish and sustain a CBM in economic settings that are often not conducive.	• Business idea contests are one method to identify the most determined entrepreneurs • Access to entrepreneurial training and mentoring is key during the business start-up phase
Access to technological innovations is key for CBM entrepreneurs, who often do not have the resources to invent a technology from scratch	• Promoting access of entrepreneurs to peer networks and research capacities (e.g. universities, knowledge platforms)
Especially CBMs in rural areas (particularly relevant for agrowaste recycling) may find it difficult to link with business networks and innovation hubs.	• Developing outreach structures (digital, physical) that enable rural entrepreneurs to participate through hubs
Access to finance is a key challenge. Start-ups or businesses changing strategy from linear to circular approaches face difficulties convincing financial institutions and other potential supporters (e.g. local self-governments) of the feasibility of their CBM.	• Building specific financial service products for CBMs • Promoting publicity of CBMs through media (local media, social media channels) and CBM fairs
It is key to use technologies and equipment that are well adapted to the local context – preferably locally manufactured and/or maintained.	• Promoting locally adapted or adaptable technologies, suitable for the respective business context
Products made from recycled materials often face disadvantages in the market. Buyers are usually very skeptical of products made from waste.	• Support product promotion activities • Co-finance user trainings (e.g. training of farmers on the use of organic fertiliser made from food and agrowaste)

CE-oriented Skills Development and TVET

The orientation of skills development and TVET towards CE is understood as **part of the broader process of greening TVET**. Yet, the meaning of CE is often unclear or misinterpreted. Apart from higher education study fields, there are very few CE-specialised occupations, especially in countries with few formal circular businesses. Most people working in the three selected sectors acquire their skills on the job.

We conclude that a diversified strategy is needed to develop skills for a CE, with short-term upskilling and reskilling measures being an effective solution to address immediate labour market demands and skills development needs of target groups. The second and most relevant strategy is the “greening” of existing occupations, whereby CE-specific competencies such as resource efficiency, extended product life through repair, refurbishing and recycling are systematically applied in the processes of occupational standards and curriculum modernisation and review.

We also recommend placing more emphasis on key “ancillary” occupations that are needed for a CE. This includes high-level occupations like environmental engineers and other waste management specialists, as well as mid-level occupations like bio-lab or chemical-lab technicians, logistic specialists, and sales personnel. These occupations are suitable for providing women with access to modern and decent jobs, thus addressing gender inequalities in the labour market.

Only in a few instances do we see the need to develop new occupations, provided the labour market is in demand for these specialised profiles (e.g. recycling technologists with specialisation in the three sectors of this study).

Digital skills are of high importance when developing skills for CE. They are relevant for all qualification levels: IT engineers using AI models for improving logistics like waste collection, to recycling plant or machine operators using digitalised technologies, to waste pickers using smartphone apps for sorting and waste collection.

Considering the high percentage of informal work in the respective waste sectors, we recommend to equally consider skills development approaches that target informal workers and apprentices (**see** section on promotion of decent work, **this chapter** below).

Promotion of Decent Work in the Selected CE Sectors

The **case studies** from **Ghana** and **India** show that interventions in the informal economy, particularly in sectors like e-waste, can be complex and conflict sensitive. These sectors often operate in grey zones and are associated with illegal and harmful practices such as the illegal import of waste and dumping of hazardous materials. On the other hand, strict enforcement of new environmental regulations can have immediate negative impacts on thousands of informal workers, often among the poorest members of society. Intervening in such sectors requires systematic and long-term approaches, aiming at improving working conditions as well as prospects for informal businesses to grow out of poverty into more decent circular business models. Development of skills should be a key element of this approach.

This study supports the good practice of **integrated approaches for employment promotion**, addressing a range of issues – from the framework conditions for the development of circular businesses and job creation (or job quality improvement), to skills development, and broader community and infrastructure development. Such integrated approaches are seen as particularly relevant when tackling complex situations, such as those found in the e-waste and plastic waste sectors.

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²⁷ The following sources are part of the "For more information, we recommend reading" section and are not necessarily related to specific sections of the text. However, we recommend them for gaining further insights into the concept of the Circular Economy.

PART II

CASE STUDIES



Part II – Case Studies

Building on the analytical findings presented in Part I, this section complements the study with practical case studies that illustrate how circular economy approaches are being implemented in different country contexts and sectors.

This section presents **two types of case studies**:

- **Country-level cases**, which describe the status of the circular economy (CE) in selected sectors in the respective country context and how CE issues are being addressed at the national level, with a specific focus on lessons learned for the development of circular business models, job creation, and labour conditions in the respective sectors.
- Case studies of **specific circular business models** (CBMs) in the context of selected CE sectors, either listed separately or integrated as text boxes within the country cases.

The country-level cases cover Kenya (see case study 1), Ghana (see case studies 1 and 3), India (see case study 2) and Brazil (see case study 4). The information and data of these cases is solely based on desk research. The case studies on CBMs are based on field visits and interviews (Ghana) as well as on desk research (all other countries).

This case study research was internally financed by FAKT and did not receive any external funding. The publication is intended solely for non-commercial knowledge sharing and aims to contribute practical examples and lessons learned to the global advancement of circular economy practices.

Selected visual materials and graphical illustrations were generated with the support of artificial intelligence (AI).

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List of Abbreviations

AIFIP	Association of Insect Producers and its Products
BNDES	Banco Nacional de Desenvolvimento Econômico e Social
BSF	Black Soldier Fly
CBMs	Circular Business Models
CE	Circular Economy
EEE	Electrical and Electronic Equipment
EPR	Extended Producer Responsibility
FAO	Food and Agriculture Organisation
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
ICT	Information and Communication Technology
ILO	International Labour Organisation
IoT	Internet of Things
LIR	Recycling Incentive Law
MEC	Ministério da Educação
MDIC	Ministério do Desenvolvimento, Indústria, Comércio e Serviços
MMA	Ministério do Meio Ambiente
MTE	Ministério do Trabalho e Emprego
PET	Polyethylene Terephthalate
PNRS	Política Nacional de Resíduos Sólidos
SENAI	Serviço Nacional de Aprendizagem Industrial
TVET	Technical and Vocational Education and Training
UNEP	United Nations Environment Programme

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Case 1

Circular Business Models in Selected Sectors in West and East Africa



1 Circular Business Models in Selected Sectors in West and East Africa (Case 1)

In this case study, we present selected circular business models in West and East Africa and highlight key lessons learned regarding their contribution to resource efficiency, job creation, and inclusive value chains. The following cases are based on visits to enterprises and interviews with the business owners (Ghana), as well as desk research (Kenya).

1.1 “AgriCentric Ventures” – Turning Organic Waste into Fertiliser (Kumasi, Ghana)



AgriCentric Ventures, established in 2019 and based in Kumasi, Ghana, is a social enterprise that produces local fertiliser products from agricultural waste. Waste materials are collected on market days in Kumasi, as well as from commercial farms and food processing companies and are processed into solid and liquid biofertilisers, along with dietary supplements for livestock and aquaculture.



Figure 1: Market waste is separated into solid and liquid components using a press (© Tobias Lange).

The production process combines biochar derived from rice residues (produced on-site through pyrolysis), fresh and finely chopped organic market waste, and a liquid component enriched with microorganisms (see **figure 1** and **2**).

The bacterial cultures used in the liquid fertiliser are enhanced through photosynthesis, and additional organic materials such as pressed fruits, bones, and eggshells are incorporated (see **figure 3** and **4**). The composting process takes approximately two weeks and does not require turning of the material. The method is based on reduced oxygen supply, which represents a non-conventional yet highly efficient composting approach (see **figure 5** and **6**).

The fertiliser products are used seasonally: solid fertilisers are primarily applied during the rainy season, while liquid fertilisers are preferred in the dry season. Overall, the products offer an environmentally friendly and cost-effective alternative to chemical fertilisers and pesticides, contributing to improved soil fertility and helping to promote sustainable agricultural practices.

Processing of waste is largely manual by applying low-tech processing machinery. According to the business owner, the company employs an average of 30 workers, most of them women. As a social enterprise, AgriCentric Ventures reinvests part of its revenue into training programmes for farmers, focusing on sustainable agricultural techniques and the use of biofertilisers for soil rehabilitation.

In addition, the company provides advisory services on soil remediation and collaborates with government agricultural offices to deliver free



Figure 2: Workers chop market waste into small pieces (© Tobias Lange).

livelihood empowerment programmes for rural farming communities. Supported by organisations such as GIZ and others, and according to SEED, these initiatives have trained 600 smallholder and commercial farmers in the use of the new fertiliser products. As a result, among approximately 400 farmers, the use of synthetic chemicals decreased by 80%, production costs were reduced by 30%, and crop yields have increased by 35%. In recognition of its innovative and low carbon approach, the enterprise received the SEED Low Carbon Award in 2019 (SEED, n.d; SEED, 2019).



Figure 3: Components (e.g., eggshells) are stored separately and then further processed (© Tobias Lange).



Figure 4: Liquid fertiliser is enriched through bacterial activity and photosynthesis (© Tobias Lange).



Figure 5: Final processed product (© Tobias Lange).

In interviews with the business owner, the following factors for business sustainability were identified.

Key Factors for Business Sustainability

- **Entrepreneurial capacity:** Founding such an enterprise required strong leadership, innovation, and perseverance to establish a pioneering concept in Ghana's agricultural sector.
- **Institutional cooperation:** Close collaboration with the Ministry of Agriculture and local extension officers has been crucial for farmer outreach and product adoption.
- **Local technology development:** Processing methods and machinery were designed using local expertise, supported by the Kumasi University of Science and Technology.
- **External mentoring:** Business support from SEED and the Innovation Hub Kumasi provided essential guidance, knowledge exchange, and motivation during the start-up phase.
- **Technological independence:** Use of simple, locally manufactured, and repairable equipment ensures low costs, operational resilience, and independence from imported technology.



Figure 4: The mixture turns into solid organic fertiliser (compost) in containers within a few weeks (© Tobias Lange).



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Sources of photographs: Tobias Lange (2024).

1.2 Small-Scale Plastic Recycling Business (Techiman, Ghana)

This case study is based on a field visit and interviews with the business owner.

The small-scale recycling enterprise in Techiman processes plastic waste from products such as jerry cans, buckets, and bottles into reusable plastic granulate. Already collected and pre-sorted plastics – categorised by type and colour – are purchased from local collectors and recyclers (see **figure 7**). The materials are then chopped and washed (see **figure 8**), before being melted down and processed into granulate, which serves as the final product for resale to plastic manufacturers (see **figure 9**).

The business employs around five workers who manually operate the machines and handle the different stages of production. Despite its modest scale, the enterprise represents a typical example of small-scale recycling in Ghana. It operates with simple tools and outdated machines and often under challenging working conditions – including exposure to fumes and heat that may affect workers' health. At the same time, the recycling process and its supply chain are highly employment-intensive, involving numerous people from waste collection and sorting to processing, production, mostly through manual labour, as well as sales.



Figure 5: Plastic waste is collected and separated before being sold to recycling companies (© Tobias Lange).

Key Insights (from the interview with the business owner)

- **Access to finance:** Limited availability of venture capital and the absence of financial advisory support hinder business growth and modernisation.
- **Investment barriers:** Private investors are hesitant to support recycling businesses and technologies that they are not familiar with, even if a clear market gap exist and competition is low.
- **Market dynamics:** Supply chains are unstable, and influential market actors – often foreign-owned industries – determine both input and output prices, placing small-scale recyclers under strong economic pressure.
- **Labour conditions:** The recycling chain is employment-intensive but characterised by informal, low-paid, and physically demanding manual work, often lacking occupational safety and social protection.



Figure 6: The plastic is chopped up and cleaned (© Tobias Lange).

Overall, the recycling business in Techiman illustrates the potential of small-scale circular economy initiatives in Ghana, while also revealing the structural and economic barriers that constrain their long-term sustainability and growth (field visit and interview with business owner, conducted in 2024).



Figure 7: Plastic pieces are melted down and processed into granulate (final product) (© Tobias Lange).



References & Further Reading

Field visit and interview with business owner. (2024). Techiman, conducted September 2024.

Sources of photographs: Tobias Lange (2024).

1.3 “Trashy Bags Africa” – Upcycling of Plastic and Textile Waste for Fashion Products (Accra, Ghana)



This case study draws on field visits and interviews with business owners, as well as desk research (Source: Trashy Bags Africa, 2024.).

Trashy Bags Africa is a social enterprise located in Accra, Ghana, that specialises in the upcycling of plastic and textile waste into fashion and lifestyle products. The company seeks to address the growing problem of plastic pollution while creating sustainable employment opportunities, particularly for women.

In Ghana, drinking water is widely sold in small, single-use plastic sachets. Millions of these sachets are consumed every day, and due to limited waste collection and recycling systems, a large share ends up on streets, in drains, and in waterways, contributing to severe environmental pollution and urban flooding. Trashy Bags Africa responds to this challenge by recovering these sachets and transforming them into valuable consumer products.



Figure 8: Plastic drink bags are collected and processed for upcycling (Source: Plan International Shop, n.d.)

The process is as follows: The enterprise collects discarded drinking sachets and textile remnants from local markets and waste collectors. The materials are manually sorted and washed (see **figure 10**) and then processed together with fabric offcuts to produce items such as handbags, backpacks, and accessories (see **figure 11** and **12**). Around 30 employees currently work in the factory, with women making up the majority of the workforce. The company places strong emphasis on gender equality, skill development, and safe working conditions – setting it apart from many informal recycling operations.

Trashy Bags Africa mainly targets export markets and international customers. Its products are sold primarily to tourists and through global outlets. Within Ghana, however, the market for upcycled fashion remains limited, as clothing made from plastic is still often undervalued. This dependence on export markets creates challenges for business stability and growth, while at the same time demonstrating the broader potential of environmentally responsible entrepreneurship (Boadi et al., 2021; Trashy Bags Africa, 2024; UNEP, 2023; field visit and interview with Trashy Bags Africa management, conducted in 2024).

Key Insights

- **Circular value creation:** The enterprise exemplifies how local waste can be transformed into marketable goods while reducing environmental pollution.
- **Employment and inclusion:** Its structured, small-scale production model creates stable jobs and promotes gender inclusion.

- **Market constraints:** Limited domestic demand and strong reliance on exports highlight both the opportunities and vulnerabilities of sustainable fashion ventures in Ghana



Figure 11: Final product (Source: Linking Maker and Market, n.d.).



Figure 12: Plastic is processed into products together with fabric remnants (© Tobias Lange).



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1.4 Community-based Waste Management and Recycling Initiative (Lagos/Oyo, Nigeria)

This case study is based on internet research.

RecyclePoints is a Nigerian recycling initiative that addresses the country's growing waste management challenges through an incentive-based system. With more than 80,000 metric tonnes of waste generated daily in Nigeria – around 80% of which is recyclable – the organisation combines environmental sustainability with local community empowerment.

The model is based on a simple but effective concept: households collect recyclable materials such as plastic bottles, beverage cans, and paper, and deposit them in exchange for points recorded on so-called GreenCards. These points can then be redeemed for household items through iRecycle stores, creating a direct incentive for waste collection and recycling.

At the core of the system are community-based Collection and Sorting Hubs (CoSoHUBs). These hubs employ local residents, especially women and young people, to sort and process recyclable materials. Each hub manages around 5 metric tonnes of waste per day, with materials sold to local manufacturing and recycling plants.

Operating mainly in Lagos and Oyo States, RecyclePoints currently processes around 25 metric tonnes of recyclable waste per day. They partner with schools, private companies, and the Lagos State Waste Management Authority (LAWMA) to promote waste recycling and sanitation awareness. Recognised nationally and internationally, RecyclePoints has won awards such as the Best Waste & Recycling Innovation Award. The organisation has also presented their model at the national level, including to President Muhammadu Buhari.

Overall, RecyclePoints demonstrates how community-based approaches can transform waste management systems. By turning waste into value, the initiative reduces environmental pollution while creating economic opportunities for local communities in Nigeria (RecyclePoints, n.d.; Solar Impulse Foundation, n.d.; UCLA Institute of the Environment and Sustainability, n.d.).



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1.5 Using Insects for Processing Waste into Animal Feed and Fertiliser (Nairobi, Kenya)

The cases below are based on internet research.

In Kenya, Black Soldier Flies (BSF) farming has gained increasing attention over the past two decades. Several companies are now harnessing the flies' natural capacity to consume and convert organic waste into valuable products, including high-protein animal feed for fish, poultry, and pigs, as well as fertiliser from farm waste.

Two interesting business examples include:

- “Ecodudu”;
- and the “Sanergy Collaborative”

Ecodudu, founded in 2018, uses organic waste streams (such as avocado residues from food processing companies, waste from fruit farms, brewery by-products, and open-air market waste from Nairobi) as an input for the BSF larvae life cycle, which lasts around 45 days. After this period, the larvae are harvested, dried, and turned into nutrient-rich animal feed. The remaining residues are further processed into soil revitalisers and fuel pellets. By 2020, the company had processed around 16,000 tonnes of waste and created approximately 800 direct and indirect jobs. Ecodudu has also benefitted from support by GreenTech Capital, providing venture capital for green investments and business advisory consultancy (Ecodudu, n.d.; Footprints Africa, 2021; Murungi, 2020; Strathmore University, 2024).



Figure 9: Collected organic waste prepared for further processing (Source: Ecodudu, n.d.).



Figure 10: Workers loading sacks of organic material for transport (Source: GoGetta Africa, n.d.).

Sanergy Collaborative, a social impact company based in Nairobi, focuses mainly on sanitation services. Through Regen Organics, one of its branches, the company uses BSF for the processing of human waste, thereby pioneering circular sanitation solutions (Aqua for All, 2023). According to its website, Sanergy has, since 2015, processed an average of 60,000 tons of human waste into BSF fertiliser (Sanergy, n.d.). The company operates what it describes as the largest BSF processing facility in East Africa, employing around 250 staff for waste collection, processing and distribution, and creating approximately 2,000 indirect jobs.

However, the company faced several major challenges in establishing this model. One key barrier was obtaining registration approval from municipal and health authorities – as processing of

human waste involves strict hygiene standards and pathogen risks as well as other regulatory concerns – which took years to achieve. Many jurisdictions require strict testing and certifications for the use of insect-derived proteins or fertilisers with human waste as input. Compliance with regulations and certification requirements for insect-based products is complex and costly. Another challenge was (and still is) access to research and technical knowledge. Processing of human waste by BSF is a highly sensitive process to maintain, as larval mortality can be high in the case of small environmental variations (temperature, humidity) and several trials were required to establish the process effectively (Sanergy, 2021).



Figure 11: Worker collecting liquid waste from a sanitation facility
(Source: Sanergy, n.d.).

With “BSF farming” gaining popularity and momentum, the **Association of Insect Producers and its Products (AIFIP)** was established in Kenya in 2020, initially with 24 members. One of its key initiatives was the creation of an “Emerging Insects Technology Hub”, which serves as a platform for collaborative networking and knowledge exchange. The AIFIP’s stakeholder meetings and other reports point to the following lessons learned from CBMs in the Kenyan BSF industry, which may also apply to other CE sectors (Martinussen, 2024).

Key Lessons Learned:

- **“Access to finance** “is by far the largest challenge faced by BSF farmers” (ibid, p. 18). An association can act as a central actor to build partnerships with investors and donors to fund research and training and advocating for more accessible loan products and public financing, required the association is functional and trusted.
- **Lack of government recognition** and absence of regulations have been a barrier to the commercialization and acceptance of BSF products. For this reason, stronger proactive support from government agencies is a key success factor.
- **Access to research and information:** Information sharing between BSF producers remains limited and is often hindered by mistrust, leaving BSF operators to “learn by themselves”, which stalls innovation and growth. The association can help fill this gap through its “Emerging Insects Technology Hub”, which serves as a platform for collaborative networking and knowledge exchange between its members, companies abroad, and research institutions.
- **Collaboration and shared infrastructure:** The creation of a shared infrastructure (e.g. larvae drying facilities), and the division of value chain activities between several small-scale producers could improve their business feasibility and competitiveness.



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For **more information**, we recommend consulting the report “*Mapping of the Black Soldier Fly value chain in East Africa*”, published by the Food and Agriculture Organisation of the United Nations (FAO), which provides comprehensive insights into the structure, actors and development potential of BSF value chains across the region (Source: FAO, 2023).

In **addition**, the Ellen MacArthur Foundation report “*Insects as part of a circular economy for food*” offers valuable perspectives on the role of insect-based solutions within circular food systems, highlighting their potential to reduce waste and create sustainable resource loops (Source: Ellen MacArthur Foundation, 2022).

Case 2

India's Approach to Tackle Plastic Pollution and Recycling



2 India's Approach to Tackle Plastic Pollution and Recycling (Case 2)

In this case study, we focus on India's approach to addressing plastic pollution and derive key lessons for the development of circular business models, addressing the poor labour conditions in this sector and the use of digital technologies. The case is solely based on desk research with Dhodapkar et al. 2023 as the primary source.

Plastic pollution has long been a major environmental concern in India, prompting various local campaigns aimed at changing individual behaviour: In this regard, the Plastics (Manufacture, Usage and Waste Management) Rules of 2009 marked a significant government response (Dhodapkar et al., 2023, p. 8).

Despite a range of promising initiatives by government, corporations, and communities, the sector continues to face numerous challenges. These include mixed streams of plastic waste, contamination, limited and inadequate segregation, and insufficient investment in technology. While regulations and norms mainly address larger businesses, these represent only a small share of the sector. In practice, most waste management activities in India are carried out by small businesses or informal sector workers, resulting in fragmented material flows which are difficult to monitor. Consequently, working conditions in this sector are often characterised by low-skilled labour, manual sorting practices, unstable incomes, and limited access to social security and healthcare (ibid, p. 7).

Among very optimistic studies, it is estimated that 61% of generated plastic waste in India is recycled, 12% is reutilised, and 27% remains mismanaged (Baynes et al., 2021, p. 29). However, other comparative studies indicate a much lower overall circularity rate of only 8% in 2019. Limited publicly available data therefore remains a key barrier for both innovation and effective policymaking. In addition, the government's ban on single-use plastics in July 2022 addresses only a relatively small fraction of total plastic usage (Dhodapkar et al., 2023, p. 9).

Material recovery (i.e. waste collection and sorting) is predominantly carried out by informal sector workers. Mechanical recycling is the dominant technology, accounting for around 94% of plastic recycling. It is mainly used by small-to-medium-sized local facilities catering to industrial areas. The process typically involves several steps including sorting, segregation, cleaning, shredding, and thermo-mechanical extrusion, resulting in the formation of plastic granules without altering their chemical composition significantly. These granules are then reused in the production of various recycled products or blended with virgin plastics for manufacturing purposes (ibid, p. 63). In most cases, mechanical recyclers rely on locally fabricated machinery. Common recycling technologies include single screw extrusion and pelletisation, blown film extrusion, and the conversion of post-consumer Polyethylene Terephthalate (PET) into washed PET flakes, as well as recycling Expanded Polystyrene. PET recycling rates in India are particularly high, standing at around 90% and thereby surpassing rates for other polymers, which is largely due to the strong market demand (ibid, p. 64).

Studies from India have identified the following **potentials and lessons learned** for CBMs in the plastics sector (ibid, pp. 54–55).

- **Digital integration of informal workers:** Recycling businesses can leverage digital technologies to integrate informal workers into their business models. For instance, platforms

such as *Kabadiwalla Connect*, a social enterprise in India, use Information and Communication Technology (ICT) and Internet of Things (IoT)-based platforms to link informal waste collectors with formal recycling systems: It enables individuals to segregate and sell recyclable materials to local '*kabadiwallas*' (waste aggregators), who then supply larger aggregators and recycling processors. Thus, by establishing a network of '*kabadiwallas*', such platforms improve the efficiency of the informal waste collection and recycling system.

- **Emerging alternative materials:** New alternative packaging materials are gaining traction in India's markets, fostering innovation across industries. Bioplastics, derived from non-fossil sources such as agricultural byproducts, offer alternatives to single-use and packaging plastics. Their environmental impacts vary, with some being biodegradable or compostable. However, certain environmental challenges remain, particularly with compostable alternatives, which can contribute to the microplastics problem since some biomass materials are difficult for microorganisms to break down.
- **Extended Producer Responsibility (EPR) as a driver of innovation:** EPR regulations are driving technological innovation and encourage new business models in India. Initially introduced in 2012 to address e-waste, EPR regulations were extended to cover plastic waste in 2016. At the same time, however, effective implementation of EPR faces challenges due to dispersed waste collection networks dominated by the informal sector. To address this gap, technology platforms are emerging to connect the informal sector with formal EPR collection, facilitating improved implementation. For example, *Saahas Zero Waste*, a Bangalore-based enterprise in Southern India that works in e-waste, plastic- and textile waste, offers waste management services that connect consumers and recyclers for promotion of EPR principles (Saahas Zero Waste, n.d.).
- **Growth of second-hand markets:** The second-hand goods market is experiencing growth in India, driven by the widespread adoption of smartphones and increased internet penetration. This sector is becoming more formalised, with e-commerce platforms facilitating easier trading of pre-owned products alongside well-organised second-hand markets.

Text Box 1: Aviral (Case Example)

Text Box 1: Aviral – Piloting a Circular System for Plastics in Haridwar and Rishikesh for Reducing Plastic Waste in the Ganga River

The rapid increase of plastic waste pollution poses a serious threat to human health, wildlife, and biodiversity in India. It is also clogging rivers and streams, contributing to flooding and landslides. Aviral – an alliance of several NGOs, municipalities, and community-based organisations representing waste workers – aims to reduce plastic waste entering the environment by piloting sustainable waste management solutions in Haridwar and Rishikesh. Supported by German international cooperation (GIZ), the initiative focuses on strengthening municipal capacities, improving waste segregation infrastructure, supporting local innovations, and driving behaviour change through awareness campaigns. The project brings together a wide range of key stakeholders including local authorities, private sector actors, informal waste workers, schools, and civil society organisations. Through its activities, Aviral has successfully identified practical and replicable

approaches that can be scaled up across India. In doing so, the initiative contributes to the development of a circular system for plastics and helps reduce pollution in the Ganga River (Saahas, n.d.).



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Case 3

Lessons Learned in Finding Sustainable Solutions for Ghana's E-Waste Sector



3 Lessons Learned in Finding Sustainable Solutions for Ghana's E-Waste Sector (Case 3)

In this case study, we elaborate on the current situation of informal e-waste recycling and the lessons learned in supporting the transition into an economically responsive and more inclusive e-waste sector. This case study is based on desk research.

As discussed in Part I of this study, Ghana has gained global attention due to the Old Fadama Scrap Yard (Agbogbloshie), once considered the world's largest uncontrolled e-waste dump, which was shut down by authorities in 2021. For more than five decades, the country has imported used electronics, leading to the development of a predominantly informal repair and recycling industry. Ghana is the world's fifth-largest importer of e-waste, receiving approximately 150,000 tonnes annually – both legally and illegally. In response, and to better regulate the e-waste sector, the government passed the Hazardous and Electronic Waste Control Act (Act 917) in 2016, aligning national regulation with the Basel Convention. The Act restricts hazardous waste imports and transport, establishes an E-Waste Management Fund, designates a service provider, and supports the development of recycling infrastructure. In addition, several donor-funded initiatives, particularly the German government-funded project “Environmentally and socially responsible handling of e-waste”, which was implemented by GIZ, and projects of the Pure Earth Centre –are supporting the transition of Ghana's e-waste sector.

As various sources cite, the transformation process has been complex and challenging. When the Agbogbloshie site was demolished, around 8,000 informal workers were displaced literally overnight, as they had no negotiated place for relocation. Leaders had previously rejected government offers as being inappropriate (too small and poorly connected). As one account describes: “On the day of demolition scrap worker lost everything: their goods, their workplace, their routines ... and their dignity” (Akese et al, 2022).

Through training of informal workers and provision of safer working spaces before and after the demolition, some progress was made in introducing safer sorting, dismantling and processing technologies. Yet, recent studies observe persistence of harmful informal sector e-waste recycling practices. After demolition of the scrapyards, many “relocated their operations to the Old Fadama slum, located next to the demolished site or to other urban spaces, where they continue to practice manual e-waste recycling and processing, with all the accompanying health and environmental consequences”. Newly established sites evolved into ‘mini-e-waste hubs’, “resulting in the disintegration of one unwanted site into many undesirable sites in the city”, pushing hazards closer to urban homes and complicating monitoring, outreach and safety (Sarpong et al, 2025, pp. 8–9).

Various lessons can be drawn from this process:

- **Planned relocation based on negotiated agreements with stakeholders** is essential: Relocation processes must include negotiated timelines, compensation, and mediated land-use agreements that enable the creation of secure services sites (electric power, water and security). Otherwise, it will lead to dispersed activities that do not eliminate the hazards but spreading it to wider areas with even greater risks for the population.

- **Strengthening informal sector organisations:** Building strong informal sector associations helps informal workers gain recognition and negotiating power with authorities.
- **Prioritising high-risk processes:** Interventions should focus first on the most hazardous activities (such as burning of wires instead of mechanical stripping) and reinforce control mechanisms accordingly.
- **Building trust and legitimacy:** As pictured in this case study, if informal workers feel criminalised, the readiness of cooperation with authorities declines and voluntary compliance with safer practices may collapse. The legitimacy of actions needs to be built first, through improved public recognition and negotiated agreements.
- **Provide incentives alongside introducing regulations:** Bans can lead to the contrary if not accompanied by incentives, especially if they address livelihoods of people who lack alternative sources of income. Many of the informal businesses lost all their assets during demolition with no compensation afterwards, which limits their motivation to collaborate with authorities and work on more sustainable solutions in future.

While efforts have been made to strengthen formal sector e-waste companies, to create business innovations, and to support the formalisation of informal businesses, the share of formal businesses in the overall employment in Ghana's e-waste sector is still small. While an estimated 500–1,000 people are working in registered e-waste businesses in Ghana, the number of informal workers is estimated to be above 30,000 (Grant et al, 2021).

Text Box 2: GIZ E-Waste Programme (Project Example)

Text Box 2: “Environmentally and Socially Responsible Handling of E-Waste”, German Cooperation Project, implemented by GIZ

Since 2016, the German government supports the transition of Ghana's e-waste sector through a programme implemented by GIZ in cooperation with the Ghanaian Ministry of Environment, Science, Technology and Innovation.

The project operates on three interconnected levels:

- 1 **Macro level interventions - policy development and access to finance:** First, it focuses on establishing a policy framework for sustainable e-waste management. A national recycling fund is a key component of this framework. The fund is financed by an eco-levy imposed on electronic and electrical equipment (EEE) devices at market entry points and is designed to support sustainable recycling along Ghana's e-waste chain.
- 2 **Business development:** Second, the project emphasises the development of economically viable business models. Recycling businesses receive support in designing and implementing innovative and profitable goods and services. Public and private sector decision-makers are encouraged to explore and evaluate technology and business options for e-waste management, including operator models. Through networking and communication efforts, the project fosters a shared understanding of appropriate technical solutions and their economic, social, and environmental impacts.

- 3 **Supporting recognition and transition of informal businesses:** Third, the project provides support to turn unregistered waste disposal and processing sites into environmentally sound recycling centres and integrate the informal sector into the national e-waste management system. It works with associations for the informal recycling industry throughout the country and provides mobile training to workers in waste disposal sites.

Through these approaches, the programme contributes to a more structured, inclusive, and environmentally sound e-waste management system in Ghana (GIZ, 2023).



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For **more information**, we recommend visiting the website of the project “Environmentally and socially responsible handling of e-waste”, which provides a rich collection of useful case studies and guidelines, including an e-waste baseline study, descriptions of circular business models, strategies for formalising scrap businesses, as well as training manuals for the handling of e-waste (Source: GIZ, 2023).

Case 4

Promoting Circular Economy Practices in Brazil



4 Promoting Circular Economy Practices in Brazil (Case 4)

In this case study, we focus on Brazil's approach to advancing the circular economy. This case study is based on desk research.

In recent years, Brazil has made significant progress in developing a policy framework for the circular economy. A key milestone was the introduction of the National Solid Waste Policy (PNRS) in 2010, which established guiding principles for waste management, including reuse, recycling, and shared responsibility across society and industry. More recent legislation, such as the Recycling Incentive Law (LIR) of 2021, has introduced financial mechanisms and incentives to encourage businesses to invest in and develop post-consumer waste recovery systems (e.g. with funds such as ProRecicle and Favorecicle, tax-incentivised green bonds¹, and recycling credit certificates²) (Ministério da Fazenda do Brasil, n.d.; SECOM do Brasil, n.d.). More recently, the National Circular Economy Plan (2025–2034) sets out a comprehensive roadmap with 18 strategic macro-objectives and 71 actions to support the transition from a linear, extractive economic model towards a more circular one (MDIC do Brasil, n.d.).

Despite this progress, significant challenges remain. Brazil generates more than 80 million tons of solid urban waste every year, yet recycling rates are estimated to range between approximately only 2.4 to 8.3% (Orizon Valorização de Resíduos, 2022; Movimento Circular, 2025). This gap results in substantial economic losses, estimated at around R\$14 billion annually (Recycling International, 2024). At the same time, however, studies highlight considerable untapped potential for circular economy development. Estimates of job creation potentials vary widely depending on scope and methodology: while some projections, such as the Brazilian Ministry of Environment (MMA) suggest several million jobs could be created as part of a broader green economic transformation (e.g. indicating the creation of up to 7 million jobs by 2030, the reduction of mineral use by 47% and water consumption by 23% (BNDES, 2024; Ministério da Fazenda do Brasil, 2023 ; Instituto Aya, Systemiq, 2023) more conservative estimates focusing specifically on circular economy activities indicate significantly lower figures (Carbon Free Brasil, 2025; Circle Economy, 2023; CNN Brasil, n.d.).

Alongside job creation, the improvement of working conditions in waste management and recycling is a key concern. A central pillar of Brazil's recycling system is the work of *catadores* — informal waste pickers who collect and sort recyclable materials. They are estimated to account for around 90% of all recycled waste in the country, yet their work is often informal and precarious (IPEA, 2013; World Bank, 2018). Most of these workers are women, and only a small fraction is affiliated with cooperatives (WIEGO, 2021). Many lack access to stable income, social protection, and professional training (ILO, 2025), despite growing demand for skilled labour in the waste management sector. Strengthening their inclusion and improving working conditions is therefore critical for advancing circular economy goals. Given the growing demand for skilled labour in the waste management sector and Brazil's distance from its goal of recycling 50% of plastic packaging by 2040, it is considered essential to develop targeted programmes that support the inclusion and upskilling of *catadores* (Ministério do Meio Ambiente e Mudança do Clima, 2025).

¹ The *Letras de Crédito do Desenvolvimento* (Portuguese) are essentially tax-incentivised bonds dedicated to sustainable projects. They are tax-exempt for individual investors and offer reduced tax rates for corporate investors. These instruments finance projects in infrastructure, innovation, industry, and SMEs that support the ecological transition.

² In 2023, three recycling credit certification instruments were introduced to strengthen reverse logistics.

Text Box 3: Empowering *Catadores* (Case Example)**Text Box 3: Empowering *Catadores* – Advancing Dignified Work in Waste Management and Recycling**

The civil society organisation Recicleiros Institute provides technical support to small and medium-sized municipalities in establishing structured waste collection systems, and offers training programmes for catadores, enabling them to join, create and strengthen their own cooperatives. Backed by private sector partners such as HEINEKEN Group, Nestlé and SIG, Recicleiros also shares their training material and best practices openly to expand access to catadores nationwide.

Similarly, the company Plastiweber, a recycled plastics manufacturer, supports cooperatives by providing training and certification, purchasing collected plastics materials, and connecting them to industrial value chains through its Cooperativa + Circular initiative launched in 2020. According to the company, this programme has already helped more than 220 catadores and six cooperatives, while contributing to the recycling of approximately 600,000kg of plastic.

At the national level, the Brazilian government has re-launched the “Diogo de Sant’Ana Pró-Catadoras e Pró-Catadores para a Reciclagem Popular” programme in 2023. The initiative aims to improve catadores’ working conditions and promote the social and economic inclusion of catadores (Naitzel et al, 2023; see also: Plástico Industrial, n.d.; Plastiweber; n.d.; Recicleiros, n.d.).

Development of Skills in the Circular Economy

A key barrier to advancing the circular economy in Brazil is the mismatch between the skills required by CE industry and the training opportunities currently available (Pereira et al, 2023). To address this gap, Brazil is cooperating with Germany through the project “TVET for Green Economic Development and Employment”. The project cooperates with key institutions – including the Brazilian Ministry of Education (MEC), the Ministry of Labour (MTE), the National Service Provider for Industrial Apprenticeship (SENAI) as well as public and private vocational education and training providers to modernise TVET in sustainable sectors of the economy, including circular economy. CE related subjects have been incorporated in curricula of various occupations such as waste management technicians, textile design, or technicians for logistics. CE topics have also been offered as special (skills upgrading) courses, but not as a stand-alone qualification. The project supports training of vocational teachers on CE topics consisting of modules on CE fundamentals, CE applied to plastic waste, cooperativism and CE in urban waste recycling, new business models and circular value chains; circular product design; and CE in specific sectors (e.g., textile and food/beverage production (GIZ, n.d.; SENAI-SP, 2025). These efforts contribute to building the skills base needed for a more sustainable and inclusive CE in Brazil.

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Case 5

Studying the Employment and Labour Market Situation in Indonesia in the Context of Circular Economy



5 Anticipating Skills for the Circular Economy: Lessons from Indonesia (Case 5)

This case study examines how labour-market analysis and skills anticipation can support the adaptation of education and training to the circular economy (CE). It draws on an Employment and Labour Market Analysis conducted in Indonesia in 2025 by FAKT Consult on behalf of GIZ. Rather than forecasting future circular jobs, the case shows what can be concluded about employment and skills needs at an early stage of the transition.

The Challenge of Anticipating Skills for the Circular Economy

Skills anticipation aims to identify how occupations, work activities, qualifications and competencies may change so that education and training systems can respond. Depending on its purpose and available information, it may combine labour-market statistics, employment projections, sector and value-chain studies, employer surveys, occupational analysis, expert consultations and scenarios.

Applying these approaches to the CE is particularly challenging. First, the **CE is not a clearly delineated economic sector**. Circular practices such as reducing material use, repairing, reusing, refurbishing, remanufacturing and recycling can occur across manufacturing, construction, agriculture, retail and services. They are therefore not easily identified in conventional sector statistics.

Furthermore, **circular practices often change tasks within existing occupations** rather than creating entirely new occupations. Engineers may need to consider repairability and material recovery; procurement specialists may need to apply circular purchasing criteria; technicians may require improved diagnostic and repair skills; and production workers may need to separate or safely process secondary materials. These changes may not appear in occupational classifications or vacancy statistics.

Future skills demand depends on whether the economic transition actually takes place. **Training workers in circular design, repair or material recovery does not by itself create employment**. Demand for these competencies emerges when enterprises invest, regulations are implemented, suitable technologies become available and markets develop for circular products and services. Skills analysis must therefore consider both workforce capacities and the wider conditions for business development.

This is especially relevant in low- and middle-income countries, where repair, reuse, waste collection and recycling are often carried out by informal workers and microenterprises. Their activities, working conditions and skills are rarely captured adequately by administrative data, formal enterprise surveys or training statistics. Part I of this study therefore recommends combining quantitative and qualitative methods, including primary data collection, when assessing CE-related labour markets.

Text Box 4: Employment and Labour Market Analysis (ELMA)

Text Box 4: What is an Employment and Labour Market Analysis?

An Employment and Labour Market Analysis (ELMA) is a methodological framework and toolbox developed for German development cooperation. It examines:

- **labour demand** – including enterprises, economic sectors, investment and business development
- **labour supply** – including the workforce, qualifications and education and training
- **matching** – including recruitment, labour-market information and employment services
- the wider **framework conditions** affecting employment

An ELMA may focus on a country, region, locality or economic sector and may be conducted as a rapid or detailed assessment. It can identify major employment constraints, opportunities and areas for further analysis. It does not usually determine detailed occupational competencies or replace detailed occupational competencies or replace quantitative skills forecasts required for designing specific training programmes.

(Adapted from GIZ (2022), Employment and Labour Market Analysis Guidelines)

Applying the ELMA Approach in Indonesia

Indonesia integrated the CE into its national planning framework through the *National Roadmap and Action Plan Circular Economy Indonesia 2025–2045*. Five sectors were prioritised based on their economic importance and circularity potential: food and beverages, wholesale and retail trade, with a focus on plastic packaging, electrical and electronic equipment, construction and textiles and garments. Together, these sectors accounted for more than 30% of Indonesia's GDP and approximately one-third of employment in 2019.

In line with the ELMA framework described above, the Indonesia analysis examined not only qualifications and training provision but also the economic, institutional and business conditions under which demand for circular practices and skills might emerge. The rapid appraisal combined available economic, employment and education data with expert interviews and five sector-specific focus group discussions. During the focus groups, value-chain diagrams and assessment matrices were used to discuss five circular business models: circular inputs, sharing models, product-use extension, resource recovery and product-as-a-service. The discussions explored their perceived viability, the constraints affecting their implementation and possible implications for businesses, occupations and skills.

Practical Example: Assessing Circular Business Models in the Plastic-Packaging Value Chain

The sector-specific focus group discussions were intended to complement the available statistical and policy information with practical knowledge from enterprises and other stakeholders. Participants examined simplified value chains and assessed the perceived viability of five types of circular business models. They also discussed the economic and institutional conditions required for their application and possible implications for occupations and skills.

The discussion on plastic packaging illustrates how this approach was applied. Indonesia has domestic producers of plastic pellets and packaging as well as recycling enterprises, meaning that some design and production decisions can be influenced within the country. However, the geographical concentration of recycling facilities on Java and, to a lesser extent, Bali creates high transport and collection costs across the archipelago. A large share of collection, sorting and other downstream activities is also informal. In addition, the use of multilayer and composite plastics limits the technical and economic feasibility of recycling.

The focus group assessed the five circular business models as follows:

Table 1: Perceived Viability of Circular Business Models in the Plastic-Packaging Value Chain

Circular business model	Perceived viability	Main business and skills implications
<i>Circular inputs</i>	★	Reducing the material used in plastic sachets was considered technically possible, but multilayer sachets have little recovery value and provide few economic incentives for reverse logistics. Alternative materials and packaging designs require further research and development, material-design competencies and a supportive regulatory framework.
<i>Sharing models</i>	★★	Shared transport and standardised containers could reduce the cost of collecting and returning packaging. Their application would require business-to-business

Circular business model	Perceived viability	Main business and skills implications
		agreements, coordination between companies and competencies in logistics and value-chain management.
<i>Product-use extension</i>	★★★	The reuse of containers, including water gallons and returnable bottles, was considered the most immediately applicable model. More efficient transport and return systems would be required. Relevant competencies include reusable-packaging design, quality control, maintenance, hygiene and reverse logistics.
<i>Resource recovery</i>	★★	Recycling is restricted by the diversity and low market value of plastics, with the exception of relatively clean PET. The discussion identified a need to improve the accessibility of qualifications for waste-bank staff and sorters and to strengthen competencies in material identification, traceability, accounting and financial literacy.
<i>Product-as-a-service and refill models</i>	★★	Bring-your-own-container and refill approaches were already being promoted but required further consumer awareness, communication and suitable retail systems. Hygiene, quality assurance and business-model development were also considered relevant.

Note: The star ratings reflect the perceptions of focus group participants and do not constitute forecasts of market development or employment demand.

Source: Adapted from FAKT Consult for Management, Training and Technologies and Protean Consulting LLP (2025), Employment and Labor Market Analysis in Indonesia with Focus on the Circular Economy, pp. 102–106. Not yet published.

The exercise helped make the relationship between circular business development and skills demand more explicit. For example, the reuse of packaging would not require only workers trained in reverse logistics. It would also depend on enterprises establishing economically viable collection systems, common standards and cooperation arrangements. Similarly, training waste staff in sorting and traceability would have limited impact if low material prices, mixed-material packaging and high transport costs continued to make collection and recycling commercially unattractive.

The matrix therefore provided a structured basis for discussing possible changes in business models, work processes and skills. At the same time, the results represented informed stakeholder assessments rather than verified market demand. The relatively positive rating of a business model indicated that participants considered it more feasible than the alternatives; it did not demonstrate that enterprises would invest in it or recruit workers with the associated competencies.

Key Findings from the Indonesia ELMA

The combination of labour-market data, policy analysis, interviews and sector-specific discussions produced several findings regarding employment and skills development for the CE in Indonesia:

- **Demand for circular skills depends on wider economic change:** Training alone will not create circular employment. Skills demand will emerge only where regulation, investment, technology, infrastructure and markets enable enterprises to adopt circular practices.
- **Most initial needs are likely to concern existing occupations:** Rather than creating many entirely new occupations, the transition is expected to add competencies such as repair, material-efficient design, traceability, reverse logistics, quality assurance and circular procurement to existing technical, operational and managerial roles. Short-term upskilling and reskilling may therefore be more relevant than new qualifications.
- **The viability of circular business models differs by sector and activity:** In plastic packaging, for example, reusable containers were considered more feasible than circular inputs, while

recycling remained constrained by low material values, mixed plastics, informality and high logistics costs.

- **CE concepts are not yet systematically integrated into training:** Indonesia has an extensive TVET network, but CE principles remain largely absent from curricula and competency standards. Many stakeholders also continue to associate the CE mainly with waste management and recycling.
- **Skills and business development need to be addressed together:** Training in reverse logistics, reuse or material recovery will have limited impact without viable collection systems, standards, finance and demand for circular products and secondary materials.

Overall, the ELMA helped identify broad areas in which skills may become more relevant, but it did not provide the occupational detail and training volumes required for training design. More focused sectoral and occupational analysis would thus be needed before developing specific training measures.

Limitations Encountered

The Indonesia process also revealed important limitations of analysing employment and skills requirements in an emerging CE.

Indonesia had general employment projections for established economic sectors for 2025–2029, but these did not separately estimate **employment changes caused by the CE transition**. Policy categories such as green, blue or digital jobs were also not consistently aligned with the industrial and occupational classifications used in Indonesia. This made it difficult to monitor such jobs through existing labour-market statistics. Creating a separate category for “circular jobs” would not necessarily resolve this problem, since circular tasks occur across many sectors and occupations.

The CE roadmap included **scenarios comparing different policy approaches**. One assumed lower consumption; another assumed that businesses would reduce the quantity of waste generated per unit of production and a third combined changes in consumption and production. These scenarios illustrated how GDP and employment outcomes could differ if the underlying assumptions and measures were implemented. They did not predict which outcome was most likely. The model also did not fully capture international trade, wider changes in labour and material productivity or the role of the informal economy. Its results were therefore be interpreted as conditional estimates rather than employment forecasts.

Stakeholder consultation helped fill some information gaps but was not fully representative. Participants in the sector discussions came mainly from larger formal enterprises. Only a few suppliers participated, while informal workers and microenterprises were not represented. The discussions therefore provided more information about established formal businesses than about other actors in circular value chains.

Moreover, participants did not necessarily share a **common understanding of the CE**. The facilitators introduced CE principles, value chains and circular business models before the discussions. This enabled participants to assess a wider range of options but also influenced the issues being discussed. Expressions of interest or positive viability ratings should therefore not be interpreted as evidence that enterprises will invest or that related skills demand will emerge.

Finally, a national rapid appraisal could only partly **reflect Indonesia’s considerable regional differences**. Infrastructure, industrial development, training provision, markets and waste collection vary strongly between Java and more remote areas. Circular activities that appear feasible in a densely populated industrial region may not be viable where transport costs are high and material flows small.

From Labour-Market Analysis to Business and Skills Development

The Indonesia experience shows that skills anticipation should not be treated as a direct route from a labour-market study to curriculum reform. An ELMA can identify sectors, value chains and constraints that may be relevant for employment. Demand for CE-related skills will, however, emerge only where the underlying circular business activities are technically feasible and commercially viable. The analysis should therefore distinguish clearly between:

- current statistical evidence
- business practices already applied
- enterprise investment or recruitment plans
- results of modelled scenarios
- stakeholder perceptions of activities that might become viable

These types of evidence answer different questions and should not be combined into apparently precise statements about future skills demand. The selection of stakeholders is also decisive. Consultation with large formal businesses should be complemented, where relevant, by evidence from SMEs, informal workers, technical personnel, training providers, workers' organisations and regional actors.

For development cooperation programmes, a broad labour-market analysis can be followed by a sequence combining business and skills development:

1. **Select priority sectors, regions and value chains:** Use an ELMA or comparable analysis to assess economic potential, employment structures, informality, policy commitments and broad labour-demand and skills-supply conditions.
2. **Validate the demand for circular business activities:** Examine whether the relevant regulations, enterprise investments, markets, technologies, infrastructure and financing conditions are in place or likely to develop.
3. **Analyse occupations, tasks and working conditions:** Identify which production and service processes may change, which occupations and worker groups will be affected and which competencies will be required.
4. **Develop combined business and skills interventions:** Training may need to be accompanied by business advisory services, finance, technology, standards, market development, shared infrastructure or support for cooperation within the value chain. Part I of this study similarly stresses that skills development should be embedded in broader support for circular businesses and value chains.
5. **Pilot, monitor and adjust:** Test short courses, workplace learning or new training modules alongside business pilots. Monitor whether enterprises adopt the expected practices and whether workers apply the new competencies.

This process may also show that a specialised training intervention would be premature. Where regulation, markets, technologies or enterprise investment remain weak, these constraints may need to be addressed before training can generate employment. At the same time, broader CE principles can gradually be integrated into existing occupations and qualifications as part of the continuous modernisation of TVET.

Overall, the Indonesia case illustrates that no single analytical method can reliably determine the future skills required for the CE. A broad **labour-market analysis can provide strategic orientation, identify evidence gaps and help select areas for further investigation**. Specific training measures require more detailed value-chain, enterprise and occupational evidence, together with credible indications that demand for the underlying circular activities is emerging.



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