

Designing SMART Indicators for Monitoring Provincial Circular Economy Transition and Resilience in Viet Nam¹

Chettiyappan Visvanathan

Venkatachalam Anbumozhi

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This paper develops a SMART (Specific, Measurable, Achievable, Relevant, and Time-bound) indicator framework for assessing provincial circular economy transition and resilience in Viet Nam. Although national strategies identify the circular economy as a strategic pillar of the country's 2045 development vision, implementation largely depends on provincial governments. However, the absence of an operational sub-national monitoring framework has limited systematic performance assessment, policy alignment, and evidence-based decision-making.

First, the paper reviews international circular economy monitoring frameworks and sub-national indicator systems to identify methodological principles relevant to the Vietnamese context. Second, it proposes a structured indicator architecture organised around six pillars: resource efficiency and material flows; waste management and prevention; industrial symbiosis and eco-industrial parks; sustainable consumption and production; circular business models and innovation; and social and economic co-benefits. Third, it develops a consolidated set of indicators specifying definitions, data sources, monitoring frequency, and implementation considerations to support application across provinces with varying institutional capacities.

The proposed framework emphasises outcome-oriented indicators, alignment with national statistical systems, and phased implementation. By linking provincial monitoring with national development, climate, and sustainability objectives, the framework provides a practical foundation for strengthening multilevel circular economy governance and enhancing policy coherence in Viet Nam.

Keywords: Circular economy; Provincial monitoring; Indicator framework; Resource efficiency; Viet Nam; Sub-national governance.

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For inquiries, please contact: publications@eria.org

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1. Introduction

1.1. Context of Circular Economy in ASEAN

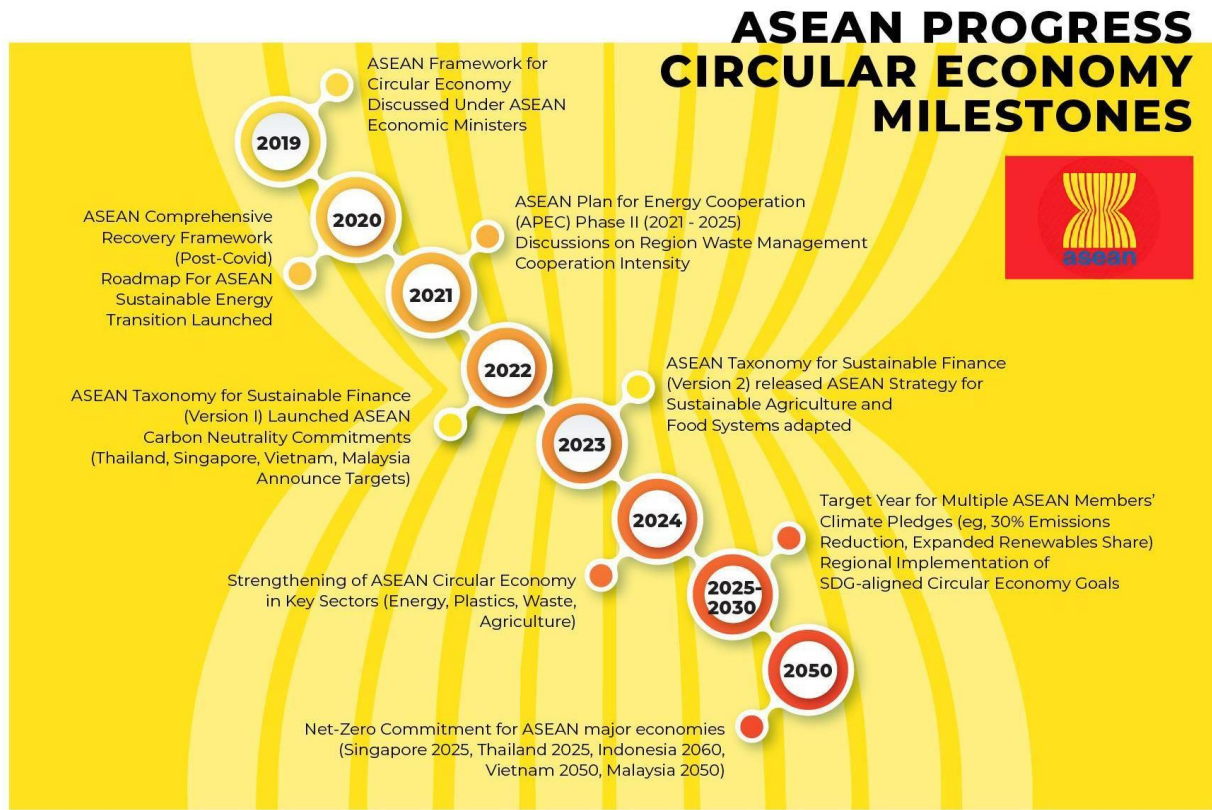
The Association of Southeast Asian Nations (ASEAN) is a regional intergovernmental body comprising ten member states: Malaysia, Singapore, Thailand, Viet Nam, Indonesia, the Philippines, Lao PDR, Cambodia, and Brunei Darussalam. Its primary objectives include promoting economic growth, advancing social progress, supporting sovereignty and autonomy of member states, safeguarding cultural identity while addressing environmental challenges (Association of Southeast Asian Nations [ASEAN], 2021). The region highlights its unique opportunities and challenges. It reflects a diverse socio-economic landscape, ranging from low- to middle-income economies. While countries such as Malaysia and Singapore have witnessed rapid modernisation and robust growth, many others continue to face structural social issues, including unemployment, inequality, and environmental degradation. Despite this, the region's recent modernisation in agriculture, growth in industrial sectors, digital innovation and green technologies showcase its potential for integrated renewable energy transition, circular economy growth and integration with global targets. The region is ambitious in aligning with the United Nations Sustainable Development Goals (SDGs) (ASEAN, 2021; Herrador and Van, 2024; Javed et al., 2024).

To attain the SDGs by 2050, the ASEAN countries are enabling environmentally sustainable visions and plans for resource consumption. From the beginning of this century, various governments and business entities strategised to distance themselves from linear model of resource consumption and production. One crucial juncture was the Ha Noi 3R Declaration of 2013 in Asia, which was jointly organised by the Vietnamese Ministry of Natural Resources and Environment (MONRE), Japan's Ministry of the Environment (MoE), and the United Nations Centre for Regional Development (UNCRD) (Mohan et al., 2024). This event underscored the region's reliance on reduce-reuse-recycle (3R) principles for waste governance with a 10-year roadmap. The ASEAN region co-ordinated with East Asian countries in terms of embedding 3R within the national agendas. Furthermore, the pursuit of SDGs, climate action, and recent socio-economic development necessitated detailed embedding of circular economy principles within the region. Figure 1 gives a detailed timeline of the ASEAN CE progress. It details the region's progress on CE milestones, outlining key initiatives, strategies, and commitments from 2019 through 2050, including sustainable finance, carbon neutrality, and net-zero targets for major ASEAN economies.

The term 'Circular Economy' (CE) has many definitions. The commonly used is 'a regenerative system in which resource input and waste, emission, and energy leakage are minimised by slowing, closing, and narrowing material and energy loops. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling' (Geissdoerfer et al., 2017). Japan has played a pioneering role in advancing 3R principles and circular economy (CE) guidelines by co-ordinating efforts across government and industry, establishing initiatives such as the Japan Partnership for Circular Economy (J4CE). In the recent years, policies in the CE space serve as frameworks

for strategies and decision-making, and system actors stress the importance of coherence across them in the ASEAN region. The key concepts in conceptualising pathways for circulating material resources expanded from 3R to the 9R framework. The 9R hierarchy includes Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, and Recycle/Recover (Geissdoerfer et al., 2017; Losa, 2025). In addition, Waste governance frameworks increasingly draw on principles such as ‘polluter pays’, ‘pay-as-you-throw’ (PAYT), and EPR (Losa, 2025). These mechanisms discourage transboundary waste movements while promoting localised treatment. Recent attempts have been made to treat and manage waste streams such as batteries, accumulators, construction and demolition debris, and emissions from semiconductor and critical raw mineral production (International Solid Waste Association [ISWA], 2023).

Figure 1. Integration of CE within the ASEAN Policy Frameworks and Future Vision of CE



Source: Authors.

The EU has a strong CE engagement across the member states. The European Green Deal is a 'new growth strategy that aims to transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy where there are no net emissions of greenhouse gases in 2050 and where the economic growth is decoupled from resource use' (European Commission, 2019a). Through the Action for the Circular Economy (European Commission, 2020a), suitable circular interventions are pushed for resource-intensive sectors such as electronics and ICT, batteries and vehicles, packaging, plastics, textiles, construction and buildings, food, water, and nutrients. Comparisons with the EU highlight ASEAN's distinct institutional pathway (Sundram, 2023). The European Green Deal, for example, envisions a carbon-neutral economy by 2050, coupled with CE interventions across key sectors such as plastics, construction, textiles, food and automobiles (Losa, 2025). Figure 2 brings about this comparison between the EU and ASEAN context.

Figure 2. EU and ASEAN as a Regional Economic Bloc for Circular Economy

 ASEAN Countries		EU Countries 
Emerging Niches, Fragmented Policy, Sector-specific, Less-regional	01 Policy Framework + Enforcement	Highly Coherent, Harmonized Circular, Economy Action Plan, Green deal, Measurable Targets, Open Data Platform
Systematic Enforcement Mechanisms	02 Promise of EU	ASEAN ADVANTAGES: +Flexibility adapt CR Model +Pilot New Context- driven CE Models
Regional Policy, Alignment Incomplete, Infrastructure Integration	03 Regional coordination	Seamless, Intra-regional Trade, Shared Data Systems, Mutual Recognition of Standards
Dependent on International Finance and Development aid	04 Investment in Innovation+ Infrastructure	National Recovery Plans, Infrastructure Integration (Sorting, Recycling and Digital Monitoring)
Funding through Donors, NGOs, Multi National Corporation Local CE Clusters exist but not interlinked	05 Business + SME Engagement	Strong Incentives, Funding Mechanisms. Strong Public Procurement Policy These processes support circular innovation + supply chain integration
Priority for Plastics, Electronics, Agriculture, Textiles, Cross - sector integration limited	06 Sectoral Coverage Integration	Sectoral Coverage across Plastics, Electronics, Metals, Chemicals, Construction, Agriculture, Cohesive Policy and Regulation
Recycling Rates Low, High Informal Sector Involvement, Gaps in Data Infrastructure	07 Waste management Recycling	High Recycling Rates Integrated MSW, Strict Landfill, Reduction Targets
Early Pilot, EPR, Limited Mandatory Enforcement	08 EPR Mechanism	Well-Established, Electronic Battery, EPR Schemes with Development in Packaging

Source: Authors.

ASEAN adopted the Framework for Circular Economy for the ASEAN Economic Community (AEC), which sets common principles and levers (standards, innovation, financing, trade, MSMEs) (ASEAN, 2021). The Framework for Circular Economy for the AEC, endorsed at the 20th AEC Council Meeting in 2021, provides strategic guidance to advance resource

efficiency, competitiveness, and sustainable and inclusive growth across ASEAN member states. It positions circular economy principles within the broader AEC sustainability agenda, recognising the need to decouple economic growth from resource depletion and waste generation. The Framework promotes co-ordinated action across priority sectors, supports innovation and sustainable finance mechanisms, and encourages cross-sectoral integration under the post-2025 sustainability vision. While it establishes a common regional direction, implementation remains largely nationally driven, reflecting ASEAN's consensus-based governance model (Economic Research Institute for ASEAN and East Asia [ERIA], 2025).

It also rolled out a Regional Action Plan for Combatting Marine Debris with co-ordinated measures on product design, waste systems, and financing (ASEAN Secretariat, 2021). While ASEAN's institutional setting is less centralised, its regional and national CE visions reflect growing aligning with global sustainability transitions. Unlike the EU, ASEAN operates through 'soft institutionalism', granting broader autonomy to member states while maintaining a relatively weak Secretariat (Sundram, 2023). This limits the enforcement of CE policies and often attracts criticism for slow progress. However, ASEAN's emphasis on sovereignty and non-interference, rooted in its colonial past, explains its preference for advisory rather than binding mechanisms (Sundram, 2023).

ASEAN's regional importance within East Asia is rising, as both advanced and emerging economies confront global waste and resource challenges (Mohan et al., 2024). Fundamentally, ASEAN's CE strategies aim to reduce dependency on virgin materials, mitigate environmental impacts, and secure resilient supply chains for critical resources (Bengtsson, Schröder, and Siegner, 2021). Additional drivers include digitalisation, the rise of AI, and the post-COVID green recovery pathways. Across member states, there is broad agreement that CE principles are essential for decoupling growth from resource use (Mohan et al., 2024). Singapore, Malaysia, and Thailand, for example, have developed comprehensive CE frameworks. Thailand's 'Bio-Circular-Green' (BCG) model prioritises sectors such as agriculture, food, biomaterials, bioenergy, and tourism, while Malaysia has established a Circular Bioeconomy (CBE) to co-ordinate CE implementation (Mohan et al., 2024). Yet coherence between stakeholders remains vital; without aligned visions and strategies, stakeholder conflicts can stall innovations (Mohan et al., 2024; Losa, 2025).

For example, a definitive example of the plastic sector can differentiate the established EU framework with the evolving ASEAN CE framework. Plastic waste management in ASEAN is shaped by a mix of national roadmaps, regulatory reforms, and regional initiatives. While approaches differ across countries, common features include: (i) bans and phase-outs of single-use plastics; (ii) extended producer responsibility (EPR) frameworks under development or implementation; (iii) investment in waste collection and recycling; and (iv) regional co-operation to address marine debris. However, policy implementation often struggles with fragmented institutional responsibilities, inadequate enforcement, and limited financing (Organisation for Economic Co-operation and Development [OECD], 2025; World Bank, 2022a). By contrast, the European Union's Circular Plastics Strategy integrates EPR into a broader Circular Economy Action Plan, with binding targets for recycled content

in products and regionally harmonised design-for-recyclability standards (European Commission, 2020a). The EU also operates a unified monitoring and reporting framework under Eurostat, which enhances data transparency and accountability. While ASEAN's regional frameworks are an important starting point, the absence of binding regional targets and harmonised reporting systems highlights a key divergence from the EU model. Figure 2 gives a comprehensive comparison of EU and ASEAN approaches to the CE highlighting in policy frameworks, waste management, innovation and business engagement, while showing ASEAN's flexibility and EU's structured enforcement. As mentioned in Figure 2, the data systems for ensuring the transition to CE needs are currently being developed, synchronised across sectors and countries in ASEAN while they are matured in EU context.

This study extends the contributions of Tleuken et al. (2022), Djalante et al. (2020), and Herrador and Van (2024), who explored circular economy (CE) strategies in ASEAN. It addresses a critical gap in the literature: the lack of analysis of cross-sectoral CE discussions and their integration into regional CE discourse.

1.2. Purpose and Scope of the Paper

Following the identification of research and policy gaps, the overall objective of the report is to enhance the transition to the circular economy at the provincial level in Viet Nam. The specific objectives include:

- To design a specific set of measurable, achievable, relevant and time-bound (SMART) indicators to assess the readiness, evaluate, and monitor the progress of circular economy implementation at the provincial level.
- Suggest a clear methodology for the selection, definition, and calculation of SMART Circular Economy indicators, including considerations for data sources, collection methods, and frequency of monitoring as applicable to provinces in Viet Nam.
- To develop guidelines for the circular economy at a provincial level.

2. Literature Review and International Good Practices

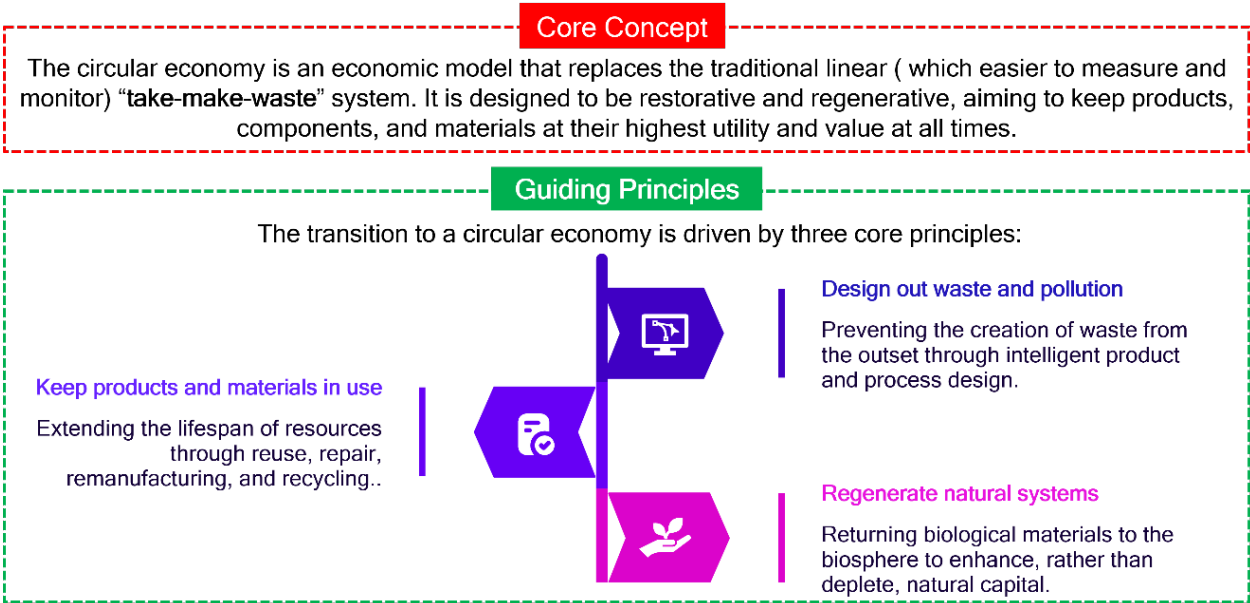
2.1. Global Circular Economy Frameworks

The concept of the circular economy (CE) has evolved from earlier approaches rooted in waste management and industrial ecology into a comprehensive framework for the systemic transformation of production and consumption systems. Contemporary CE frameworks move beyond a narrow focus on recycling and instead emphasise value retention, resource productivity, and the decoupling of economic growth from virgin material extraction. This evolution reflects growing recognition that circularity is not only an environmental objective, but also a strategic pathway for economic resilience, competitiveness, and long-term sustainability. At the global level, the most influential and

widely cited frameworks have been developed by the Ellen MacArthur Foundation (EMF), the United Nations Environment Programme (UNEP), and the World Bank. While these frameworks share a common conceptual foundation, they differ in institutional orientation, policy emphasis, and implementation pathways, offering complementary perspectives for the design of sub-national monitoring systems.

The Ellen MacArthur Foundation conceptualises the circular economy as a regenerative system by design, structured around three core principles: (i) designing out waste and pollution, (ii) keeping products and materials in use at their highest value for as long as possible, and (iii) regenerating natural systems as shown in Figure 3. This framework places strong emphasis on upstream interventions, including eco-design, circular business models such as product-as-a-service, and innovation across value chains (Ellen MacArthur Foundation, 2015). EMF’s approach has been particularly influential in shaping private-sector engagement and in shifting the focus of circularity from end-of-pipe waste treatment to systemic redesign of products, services, and business models.

Figure 3. Guiding Principles of Circular Economy



Source: Authors.

UNEP approaches the circular economy from a sustainability and development perspective, framing CE as a key instrument for achieving the Sustainable Development Goals (SDGs), climate mitigation objectives, and long-term resource security. UNEP emphasises policy coherence, institutional capacity, and multilateral co-operation, particularly in developing and emerging economies. In contrast to EMF’s business-driven orientation, UNEP places greater emphasis on environmental safeguards, social inclusion, and equity considerations, recognising that circular transitions must be just and inclusive to be sustainable (UNEP, 2019). This perspective implies that CE monitoring systems should capture not only material efficiency, but also governance readiness and social outcomes.

The World Bank integrates circular economy principles into its broader agenda on sustainable development, poverty reduction, and economic resilience. Its analytical work links CE to competitiveness, job creation, and improved resource productivity, particularly in low- and middle-income countries. The World Bank underscores the importance of governance reform, investment frameworks, and robust data systems to support CE implementation in sectors such as waste management, plastics, construction materials, and critical resources (World Bank, 2022b). This framing reinforces the role of monitoring systems as tools for guiding public investment and policy prioritisation.

At the regional level, ASEAN has translated these global principles into a policy-relevant framework through the 'Framework for Circular Economy for the ASEAN Economic Community'. Conceptually, the framework operates at two levels. First, its basic functions focus on promoting resource efficiency, sustainable consumption and production, resilient supply chains, and waste minimisation within ASEAN's economic integration agenda. Second, its enabling mechanisms include standards harmonisation, innovation and technology development, sustainable finance, trade facilitation, MSME support, and capacity building. Rather than imposing binding regional targets, the framework reflects ASEAN's soft institutionalism by prioritising co-ordination, voluntary alignment, and nationally driven implementation (ASEAN, 2021). The framework is further reinforced by the ASEAN Economic Community (AEC) Strategic Plan 2026–2030, which mainstreams green growth, sustainable finance, and circularity across regional economic co-operation objectives (ASEAN, 2025).

Taken together, global and regional frameworks converge in recognising CE as a systemic transition rather than a collection of isolated recycling activities. They diverge, however, in emphasis: EMF prioritises innovation and business transformation, UNEP foregrounds environmental integrity and social outcomes, the World Bank focuses on development finance and institutional reform, while ASEAN emphasises flexibility, inclusiveness, and regional diversity. For Viet Nam, these complementary perspectives indicate the need for an integrated CE approach in which national strategies are operationalised at the provincial level through coherent, measurable, and context-sensitive indicators.

2.2. International Indicator Systems

Monitoring progress towards a circular economy requires robust, transparent, and harmonised indicator systems. International experience demonstrates that indicators play a critical role not only in tracking performance but also in informing policy design, enabling comparison across jurisdictions, and ensuring accountability in implementation. Well-designed indicator systems provide an empirical basis for evaluating whether circular economy strategies are delivering tangible environmental, economic, and social outcomes. International practice shows that CE indicator systems work best when they combine:

- i) core physical flow metrics (materials, waste, energy, water),
- ii) enabling governance and infrastructure metrics (rules, procurement, facilities), and

iii) economic and employment metrics (value added, investment, jobs).

2.2.1. Indicator Architecture

A key lesson from global indicator practice is that provinces need a tiered measurement structure. The OECD inventory explicitly highlights that CE measurement is conducted at different scales (micro/meso/macro) and compiles macro-level indicators to support policy monitoring across cities and regions. As illustrated in **Figure 4**, circular economy indicators can be classified into three measurement scopes based on their modelling depth and use of life cycle thinking (LCT) (Moraga et al., 2019):

- **Scope 0 – Physical properties (no LCT):**

Indicators measure observable material and product flows within technological cycles without applying life cycle thinking (e.g. recycling rate, waste generation). These indicators rely on readily available data and are suitable for initial provincial implementation.

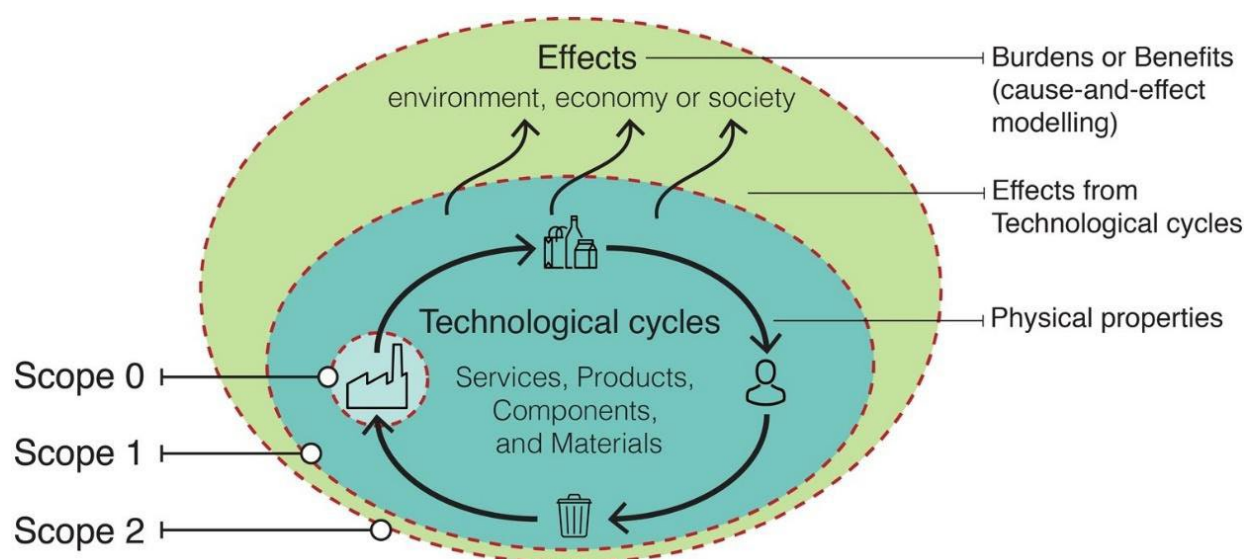
- **Scope 1 – Technological cycles with LCT:**

Indicators measure physical properties of products, components, materials, or energy while incorporating partial or full life cycle thinking (e.g. reusability, recyclability, recoverability). These indicators provide a more accurate representation of circular performance.

- **Scope 2 – Impact-oriented indicators (cause–effect modelling):**

Indicators assess environmental, economic, and social effects generated by technological cycles using cause-and-effect modelling (e.g. emissions reduction, economic benefits). These indicators require advanced data and analytical capacity and are typically applied in later implementation stages.

Figure 4. Classification for the Three Measurement Scopes from CE Indicators.



Source: Moraga et al., 2019.

This classification supports a phased approach to provincial circular economy monitoring, allowing gradual progression from basic flow indicators toward impact-based assessment as institutional and data capacity improves. Several established international models provide relevant reference points for the development of provincial-level CE indicators in Viet Nam, notably the European Union Circular Economy Monitoring Framework, China's circular economy indicator system, and Japan's 3R-based indicator framework. Despite differences in institutional context, these systems reveal common principles regarding indicator scope (what is measured and at which level), indicator structure (how indicators are organised and categorised), and governance (how indicators are reported, monitored, and institutionally managed).

2.2.2. Priorities of International Models

The European Union Circular Economy Monitoring Framework represents one of the most comprehensive and institutionalised CE indicator systems to date. It is structured around four thematic areas: (i) production and consumption, (ii) waste management, (iii) secondary raw materials, and (iv) competitiveness and innovation. Indicators such as material consumption per capita, recycling rates, circular material use rate, and green investment levels are reported through Eurostat, ensuring data harmonisation and comparability across member states (European Commission, 2018). This framework is directly linked to binding policy instruments, including the Circular Economy Action Plan and the European Green Deal, making it a powerful tool for policy enforcement and evaluation (European Commission, 2019b; European Commission, 2020b).

China's circular economy indicator system reflects a different institutional and developmental context. Anchored in the Circular Economy Promotion Law (2008)², China's indicators are organised across micro (enterprise), meso (industrial park), and macro (city and provincial) levels. The system emphasises resource productivity, energy efficiency, waste utilisation, and pollution reduction. While this multi-level structure allows for local experimentation and sectoral targeting, empirical studies identify persistent challenges related to data consistency, regional comparability, and the limited integration of social and innovation indicators (Geng et al., 2012; Saidani et al., 2019).

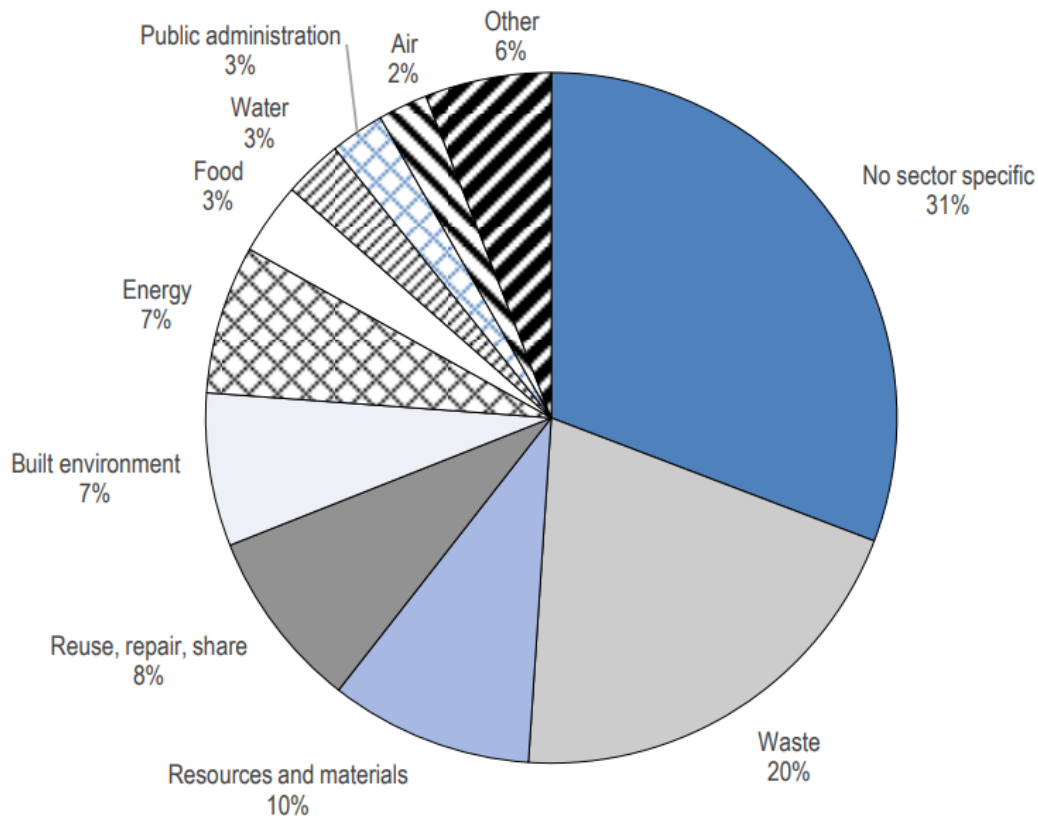
Japan's 3R framework (Reduce, Reuse, Recycle) represents one of the earliest and most stable CE-related indicator systems. Japan relies heavily on material flow analysis-based indicators, including resource productivity, cyclical use rate, and final disposal amounts. These indicators are embedded in national legislation such as the Fundamental Law for Establishing a Sound Material-Cycle Society, ensuring long-term policy continuity and strong institutional enforcement (Ministry of the Environment, Japan, 2020). Japan's experience highlights the importance of institutional clarity and sustained political commitment in maintaining effective CE monitoring systems over time.

² Standing Committee of the National People's Congress, China (2008). *Circular Economy Promotion Law of the People's Republic of China*. <https://www.lawinfochina.com/display.aspx?id=7025&ndlib=law>.

2.2.3. Empirical Evidence for a Balanced Provincial Dashboard

Beyond individual country systems, comparative analyses of CE indicators provide important methodological insights. Moraga et al. (2019) classify CE indicators according to what they measure, physical properties, technological cycles, and broader environmental, economic, and social impacts, highlighting the need to distinguish between direct circularity metrics and indirect enabling indicators. Building on this work, the OECD compiled an inventory of 474 circular economy indicators used by cities and regions worldwide, categorising them into five major groups (OECD, 2021): environmental indicators (39%), governance indicators (34%), economic and business indicators (14%), infrastructure and technology indicators (8%), and social and employment indicators (5%). The detailed sector distribution for OECD indicator is demonstrated in Figure 5.

Figure 5. OECD Indicator Category Distribution by Sector.



Source: OECD, 2020.

This empirical distribution demonstrates that effective sub-national CE monitoring systems extend well beyond waste and recycling metrics. While environmental flow indicators form the foundation of measurement, governance capacity, economic transformation, infrastructure readiness, and employment effects are also essential components of a comprehensive circular economy dashboard. For provinces, such balanced indicator systems support evidence-based decision-making across planning, investment, and regulatory functions.

For Viet Nam, comparative studies of CE indicators emphasise that no single model is universally applicable. EU-style comprehensive indicator systems require high-quality data infrastructure and strong institutional co-ordination, while more focused, sector-based systems may be more appropriate in emerging economies (Saidani et al., 2019; Castillo-Díaz et al., 2024). Accordingly, a staged implementation pathway is recommended: initial emphasis on high-confidence indicators related to material flows, waste management, and resource productivity; followed by medium-term integration of indicators on reuse, repair, innovation, and longer-term development of impact-oriented indicators addressing carbon emissions/pollution reduction, employment creation, and socio-economic resilience. This phased approach provides a practical foundation for designing SMART provincial-level circular economy indicators aligned with both national priorities and international best practices.

2.3. Sub-National Level Implementation Models

Sub-national and regional implementation models play a critical role in translating national CE strategies into practical outcomes. International experience demonstrates that provinces, cities, and local governments often function as testing grounds for circular policies, enabling experimentation while responding to local socio-economic conditions. Lessons from ASEAN member states are particularly relevant for Viet Nam given similarities in governance structures and development trajectories.

Within ASEAN, CE implementation varies widely across member states. Advanced implementers such as Singapore have integrated circular principles into urban planning, construction, and waste management through strong regulatory frameworks, dedicated agencies, and public-private partnerships. Thailand's 'Bio-Circular-Green' (BCG) model prioritises sectors such as agriculture, food, biomaterials, bioenergy, and tourism, while Malaysia has established a Circular Bioeconomy (CBE) to co-ordinate CE implementation (Mohan et al., 2024). Indonesia's Waste Bank system exemplifies community-based circular practices, combining waste segregation with social incentives and livelihood generation (Ikawati and Handian, 2017). These models demonstrate pragmatic reliance of ASEAN on pilot projects, voluntary mechanisms, and donor-supported initiatives rather than binding regional mandates.

Across jurisdictions, successful sub-national CE monitoring systems share three defining characteristics:

- 1) **Multi-dimensional structure**, integrating material flows, environmental performance, economic outcomes, and governance readiness.
- 2) **Contextual customisation**, allowing indicators to reflect dominant regional industries and resource endowments.
- 3) **Phased implementation**, enabling gradual expansion from core environmental indicators toward innovation, social, and resilience dimensions.

The following international case studies illustrate different approaches to sub-national circular economy indicator design that are directly relevant to provincial context of Viet Nam.

2.3.1 Case Study: Wielkopolska Region, Poland

Background and context

The Wielkopolska Region in Poland provides a well-documented example of sub-national CE indicator development within a transition economy operating under European Union policy alignment. As part of the EU, Poland is required to comply with the EU Circular Economy Action Plan; however, the design and implementation of CE monitoring systems at the regional level are not centrally standardised. This has allowed regions such as Wielkopolska to develop region-specific indicator frameworks aligned with EU principles while reflecting local economic structures and data availability. Wielkopolska is characterised by a diversified regional economy, including agriculture and agri-food processing, manufacturing, construction, transport, and emerging innovation sectors. These characteristics make the region particularly relevant as a reference case for provinces in Viet Nam that also exhibit heterogeneous economic profiles.

Indicator framework and structure

The primary objective of the Wielkopolska CE indicator framework was to translate high-level EU circular economy objectives into measurable and actionable indicators at the regional level. Rather than focusing exclusively on waste management, the framework was designed to capture circularity across production systems, material flows, infrastructure, governance, and socio-economic outcomes. The regional framework comprises 93 indicators, grouped into six thematic subsystems corresponding to major regional production and service systems (**Table 1**). Indicator selection was informed by a review of EU and national CE policies, regional development strategies, and expert consultation. Emphasis was placed on indicators that could be monitored at the regional level using existing or realistically obtainable data sources (Cader, Koneczna, and Marciniak, 2024).

Table 1. Circular Economy Indicator Subsystems in the Wielkopolska Region, Poland

Subsystem	Measurement Focus	Illustrative Indicator Types
Agri-food system	Biomass use and recovery, food waste reduction	Organic waste recovery rate, nutrient reuse
Construction sector	Material efficiency and waste recovery	Construction and demolition waste recycling
Industrial processing	Resource productivity and eco-innovation	Material productivity, industrial waste intensity

Subsystem	Measurement Focus	Illustrative Indicator Types
Transport and mobility	Energy efficiency and transition	Share of low-emission vehicles
Energy system	Renewable energy and efficiency	Share of renewables in final energy consumption
Socio-innovation	Enabling conditions and outcomes	Green jobs, CE education, public procurement

Source: Adapted from Cader, Koneczna, and Marciniak, 2024.

Key implementation features

Several features of the Wielkopolska framework are particularly relevant for provincial-level CE monitoring:

- **Sector-specific structuring:** Indicators were organised around dominant regional systems rather than generic CE categories, improving policy relevance.
- **Balanced indicator coverage:** The framework integrates material flow indicators with governance, innovation, and socio-economic indicators.
- **Trend-based assessment:** Priority was given to monitoring changes over time rather than establishing rigid thresholds, especially during early implementation stages.
- **Alignment without duplication:** EU-level indicators were adapted to the regional context rather than replicated verbatim.

Key lessons for Viet Nam

The Wielkopolska case demonstrates that effective provincial CE monitoring systems do not require exhaustive indicator lists, but rather strategic selection aligned with local economic structures and administrative capacity. The experience highlights the importance of combining environmental performance indicators with institutional readiness and socio-economic metrics, and of adopting a phased approach that allows gradual expansion of indicator scope as data systems mature. For Viet Nam, this case supports the feasibility of developing provincial-level circular economy indicator frameworks that are consistent with international best practices while remaining adaptable to local development conditions.

2.3.2. Case Study: Sichuan Province, China

Background and context

Sichuan Province represents one of China's most advanced provincial-level applications of integrated low-carbon and circular economy (LCCE) assessment. As a major inland province with a mixed economic structure including heavy industry, energy production,

agriculture, and urban services, Sichuan was selected as a pilot region to evaluate how circular economy strategies could simultaneously support resource efficiency, carbon emissions reduction, and economic development. China's CE governance framework is anchored in the Circular Economy Promotion Law (2008), which mandates implementation across multiple administrative levels. Within this structure, Sichuan developed a provincial evaluation system to measure LCCE performance in a manner compatible with national objectives while reflecting regional characteristics.

Indicator framework and structure

The primary objective of the Sichuan LCCE indicator system was to quantitatively assess the level of circular and low-carbon development at the provincial scale, and to support benchmarking and policy prioritisation across regions. Unlike frameworks focused solely on material recovery, the Sichuan system explicitly integrates carbon performance into circular economy monitoring. The Sichuan framework consists of 30 indicators, organised into six subsystems (Table 2) that jointly capture economic structure, resource efficiency, environmental performance, and enabling conditions (Ye et al., 2022).

Table 2. Low-Carbon Circular Economy Indicator Subsystems in Sichuan Province, China

Subsystem	Measurement Focus	Illustrative Indicator Types
Economic development	Structural efficiency and productivity	GDP per unit of energy/ material use
Resource efficiency	Energy and water intensity	Energy consumption per unit of GDP
Pollution reduction	Emissions and effluent control	Industrial SO ₂ and wastewater discharge
Waste recycling	Material recovery performance	Industrial solid waste utilisation rate
Low-carbon transition	Carbon intensity	CO ₂ emissions per unit of GDP
Social and institutional support	Enabling conditions	Environmental investment intensity

Source: Adapted from Ye et al., 2022.

Key implementation features

Key characteristics of the Sichuan approach include:

- **Integration of circularity and climate objectives**, reflecting the interdependence between material efficiency and emissions reduction.

- **Composite index construction**, enabling comparison of LCCE performance across provinces.
- **Emphasis on trend-based improvement**, rather than absolute threshold compliance.

However, empirical evaluation also highlights limitations, particularly the aggregation of diverse indicators into composite scores, which may obscure sector-specific bottlenecks and local implementation challenges.

Key lessons for Viet Nam

The Sichuan case demonstrates the feasibility of integrating circular economy and climate indicators at the provincial level. For Viet Nam, the case illustrates the potential value of aligning CE monitoring with Net Zero objectives, while also highlighting the need to balance composite indices with sector-specific indicators, such as manufacturing, energy, construction, agriculture, and waste management, to maintain policy relevance at the local level.

2.3.3. Case Study: Dalian Municipality, China

Background and context

Dalian Municipality is one of China's earliest pilot cities for circular economy implementation. As a major coastal and industrial city, Dalian faces significant pressures related to resource consumption, industrial emissions, and waste generation. In response, the municipality developed a city-specific circular economy indicator system to guide industrial transformation and environmental management. Unlike broader provincial frameworks, Dalian's approach reflects the practical realities of urban-scale governance, where indicator selection must align closely with dominant local industries and municipal data systems.

Indicator framework and structure

The objective of Dalian's indicator system was to evaluate circular economy performance at the city level, with particular emphasis on industrial efficiency, waste reduction, and resource recovery. The framework was designed to support targeted policy interventions rather than comprehensive national benchmarking. Dalian adopted a focused indicator set (Table 3), concentrating on key material and pollution flows most relevant to its industrial profile (Zhu et al., 2022).

Table 3. Core Circular Economy Indicator Categories in Dalian Municipality, China

Indicator Category	Measurement Focus	Illustrative Indicators
Resource consumption	Input efficiency	Energy and water consumption intensity
Waste discharge	Pollution pressure	Industrial solid waste generation
Waste treatment	Control and compliance	Wastewater treatment rate
Waste reclamation	Circular recovery	Industrial waste reuse rate

Source: Adapted from Zhu et al., 2022.

Key implementation features

- **Context-specific indicator selection**, aligned with local industrial activities.
- **Strong emphasis on industrial systems**, reflecting the city's economic structure.
- **Limited indicator breadth**, prioritising operational feasibility over systemic coverage.

While effective for targeted management, the framework places less emphasis on social outcomes, innovation, and governance readiness.

Key lessons for Viet Nam

The Dalian case illustrates that indicator relevance is more important than indicator quantity, particularly at the city and provincial levels. For Viet Nam, the case underscores the value of starting with sector-relevant, high-confidence indicators, while progressively expanding coverage to include governance, innovation, and socio-economic dimensions as monitoring capacity improves.

2.3.4. Comparative Synthesis of Sub-National Circular Economy Indicator Systems

International experience demonstrates that sub-national CE indicator systems vary significantly in scope, complexity, and policy intent, reflecting differences in governance structures, development priorities, and data capacity. A comparison of the Wielkopolska Region (Poland), Sichuan Province (China), and Dalian Municipality (China) highlights key design choices relevant for the development of provincial-level CE indicators in Viet Nam.

While all three cases aim to operationalise national or supranational CE strategies at the sub-national level, they differ in emphasis. The Polish case prioritises balanced, system-wide coverage across sectors and enabling conditions; the Sichuan case integrates circularity with climate objectives through composite evaluation; and the Dalian case adopts a targeted, operational approach focused on industrial efficiency and waste management. Together, these cases illustrate a spectrum of indicator architectures,

ranging from comprehensive dashboards to focused performance monitoring tools (Table 4).

Table 4. Comparison of Sub-National Circular Economy Indicator Systems

Dimension	Wielkopolska Region (Poland)	Sichuan Province (China)	Dalian Municipality (China)
Governance scale	Regional (EU sub-national)	Provincial	Municipal
Policy alignment	EU Circular Economy Action Plan	Circular Economy Promotion Law; Low-Carbon Strategy	National CE pilot city programme
Primary objective	Translate EU CE principles into regional monitoring	Integrate circular economy and low-carbon development	Improve industrial efficiency and waste management
Indicator scope	Broad, multi-sectoral	Integrated CE–climate	Focused, sector-specific
Number of indicators	93	30	Small targeted indicator set
Indicator structure	Six thematic subsystems	Six evaluation subsystems	Four core indicator categories
Integration of climate metrics	Limited (implicit)	Explicit and central	Limited
Inclusion of governance indicators	Strong	Moderate	Limited
Inclusion of socio-economic indicators	Moderate (e.g. green jobs, education)	Limited	Minimal
Use of composite indices	No	Yes	No
Data requirements	Medium to high	High	Low to medium
Key strength	Balanced and	Alignment of CE	Practical and feasible

Dimension	Wielkopolska Region (Poland)	Sichuan Province (China)	Dalian Municipality (China)
	policy-relevant dashboard	with carbon reduction	implementation
Key limitation	Data intensity in initial stages	Risk of over-aggregation	Limited systemic coverage

Source: Authors.

2.4. Key Lessons and Gaps for Viet Nam

Synthesis of international indicators frameworks and sub-national implementation experiences reveals several lessons that are directly relevant for the design of provincial-level CE indicators in Viet Nam. At the same time, it highlights structural and institutional gaps that must be addressed to ensure effective monitoring and policy application.

2.4.1 Key Lessons from International Practice

i) Circular economy monitoring must be systemic rather than sector isolated.

Global frameworks and sub-national case studies consistently demonstrate that CE cannot be effectively assessed through waste management indicators alone. Successful systems integrate indicators on resource efficiency, production and consumption patterns, infrastructure readiness, governance capacity, and socio-economic outcomes. Regions such as Wielkopolska illustrate the value of balanced dashboards that reflect the full circular system rather than isolated material flows.

ii) The sub-national (provincial) level is critical for implementation.

International experience confirms that provinces and cities serve as the primary interface between national CE strategies and on-the-ground implementation. Provincial-level monitoring enables alignment of national objectives with local economic structures, resource endowments, and institutional capacity, allowing for differentiated pathways across regions.

iii) Phased indicator development improves feasibility and policy uptake.

Comparative evidence shows that effective CE monitoring systems are typically implemented in stages. Initial focus on high-confidence physical flow indicators (e.g. waste generation, landfill diversion, resource productivity) is followed by progressive integration of life-cycle-based performance indicators and impact-oriented metrics. This phased approach reduces administrative burden while supporting continuous improvement.

iv) Indicator relevance outweighs indicator quantity.

Case studies from both Europe and China demonstrate that a smaller number of well-chosen, policy-relevant indicators is more effective than extensive indicator lists. Targeted indicator sets improve interpretability, reduce reporting fatigue, and enhance decision-making at the sub-national level.

v) Alignment with climate and development objectives strengthens policy relevance.

Integration of CE indicators with climate mitigation, industrial transformation, and employment objectives increases their usefulness for strategic planning. Systems such as Sichuan's LCCE framework illustrate the potential benefits of linking circularity with emissions reduction and economic resilience, provided that excessive aggregation is avoided.

2.4.2. Key Gaps and Challenges for Viet Nam

Despite progress in establishing a national circular economy policy framework, several gaps constrain effective provincial-level CE monitoring in Viet Nam.

i) Fragmented data systems and limited data integration.

Existing data on waste, materials, energy, water, and economic activity are often collected by different agencies using inconsistent definitions and reporting cycles. This fragmentation limits the ability of provinces to construct coherent CE dashboards and to track progress across sectors.

ii) Overemphasis on end-of-pipe indicators.

Current monitoring practices remain heavily weighted toward waste collection and treatment metrics, with limited coverage of upstream indicators related to product design, reuse, repair, and circular business models. This constrains the ability to assess progress toward value retention and waste prevention.

iii) Uneven provincial capacity.

Significant disparities exist amongst provinces in terms of technical expertise, financial resources, and institutional co-ordination. Uniform indicator requirements risk overburdening less-resourced provinces while underutilising the analytical capacity of more advanced regions.

iv) Limited integration of CE indicators into planning and budgeting processes.

In many cases, CE-related indicators are monitored in isolation and are not systematically linked to provincial socio-economic development plans, public investment decisions, or performance evaluation mechanisms.

v) Insufficient coverage of socio-economic and governance dimensions.

Indicators capturing employment, skills development, innovation, stakeholder participation, and institutional readiness remain underdeveloped, despite their importance for ensuring a just and sustainable circular transition.

These lessons and gaps feature the need for a provincial circular economy indicator framework that is selective, phased, and globally informed. For Viet Nam, this implies prioritising a core set of SMART indicators that:

- (i) capture system-level circular performance rather than isolated activities,
- (ii) are adaptable to varying provincial capacities,
- (iii) align with national development and climate objectives and
- (iv) can evolve over time toward more comprehensive impact-oriented assessment.

The proposed indicator framework in subsequent chapters builds on these principles, translating international best practices into a practical monitoring tool to support provincial circular economy resilience in Viet Nam.

3. Viet Nam's National Context and Policy Framework

Viet Nam's transition toward a circular economy (CE) is shaped by an increasingly co-ordinated policy landscape connecting environmental protection, waste management reform, sustainable production and consumption, and climate commitments. This landscape provides both national direction and an emerging basis for defining indicators and monitoring approaches relevant at national and provincial levels. Viet Nam's shift toward a circular economy is being driven by four key developments (Institute of Strategy and Policy on Agriculture and Environment [ISPAE], forthcoming):

- i) **Cleaner production practices** – Companies are increasingly adopting low-emission processes, improving energy efficiency, and switching to renewable materials;
- ii) **International market demands** – Trade partners, especially the EU and free trade agreements, are requiring exports to meet environmental standards and producer responsibility requirements;
- iii) **New business models** – Digital platforms, resource sharing, product longevity programmes, and material recovery systems are emerging as viable economic approaches; and
- iv) **Local leadership** – Regional authorities and industries are actively testing and implementing circular economy solutions.

Viet Nam comprises 34 provincial-level administrative units: 28 provinces and 6 centrally governed cities. The national government plans to implement circular economy initiatives at the provincial level, supported by clearly defined indicators and monitoring systems to track progress and measure outcomes.

3.1. National Circular Economy Strategy (2021–2030): Status and Strategic Implications

The National Strategy on Circular Economy Development to 2030, with a Vision to 2050 (Manh and Pham, 2023) represents a significant shift in development thinking. Rather than treating waste and resource efficiency as isolated environmental issues, the strategy frames circular economy as a structural transformation affecting production systems, consumption patterns, and investment priorities across the economy. At present, the strategy functions primarily as a strategic umbrella. Its value lies in setting national

direction and legitimising CE as a cross-cutting priority, while detailed operational rules are developed through sectoral strategies, decrees, and provincial plans.

For national government, the key implication is the need to move from strategic endorsement to operational clarity. This includes translating CE principles into sector guidance, clarifying mandates amongst ministries, and embedding CE objectives within national planning, public investment, and budgetary processes.

The 2030 horizon is particularly important. It coincides with other major national strategies, including green growth, waste management, and climate commitments, creating both opportunities for coherence and risks of overlapping or fragmented implementation if co-ordination is weak. (Prime Minister of Viet Nam, 2022).

3.2. Policy Integration through Waste Management and Sustainable Production and Consumption

The National Waste Management Strategy to 2030 (Ministry of Natural Resources and Environment [MONRE], 2020) is currently the most operational CE-related instrument in Viet Nam. It addresses immediate pressures arising from rapid urbanisation, industrialisation, and rising consumption levels. From a CE perspective, the waste strategy is important not only for environmental protection, but also because it establishes administrative systems for data collection, reporting, and service delivery. These systems can be progressively reoriented from disposal-focused approaches toward prevention, reuse, recycling, and resource recovery.

In parallel, the Sustainable Production and Consumption Strategy (Ministry of Industry and Trade [MOIT], 2021) address upstream drivers of material use and waste generation. This strategy is critical for shifting industrial practices, promoting cleaner production, and influencing market demand through labelling, standards, and procurement. The current situation suggests that integration between these two strategies remains a work in progress. Stronger co-ordination could help ensure that upstream efficiency gains translate into measurable downstream waste reduction, reinforcing the overall CE narrative.

3.3. Provincial Implementation: Emerging Practice and Uneven Capacity

Circular economy implementation is highly dependent on provincial action, as provinces and cities manage waste services, industrial zones, and local investment approvals. Leading localities such as Ho Chi Minh City, Ha Noi, and Da Nang illustrate how national strategies are being interpreted and localised. These early movers typically have stronger institutional capacity, access to finance, and higher exposure to international co-operation and private-sector engagement. As a result, they are well-positioned to pilot CE initiatives, data systems, and public-private partnerships.

In contrast, many provinces face constraints related to staffing, technical expertise, and financial resources. This uneven capacity landscape is a defining feature of the current

situation and has direct implications for how national government should design CE guidance and monitoring requirements. A differentiated approach, providing common national direction while allowing flexibility in implementation sequencing, can help ensure that CE policies remain realistic and inclusive across provinces.

3.4. Data Availability, Statistical Infrastructure, and Institutional Readiness

A credible transition to a circular economy (CE) is fundamentally dependent on the quality, granularity, and timeliness of data. In Viet Nam, the current statistical infrastructure is transitioning from traditional environmental monitoring toward a more integrated resource-management approach. This section provides an expanded assessment of the data landscape, identifying core assets, structural challenges, and the institutional readiness required to support the 2030 Strategy.

3.4.1. Core Statistical Assets and Administrative Data Streams

The primary anchor for CE monitoring is the Environmental Statistics Yearbook (Viet Nam General Statistics Office [GSO], 2021). This product provides a standardised national baseline for key variables such as municipal solid waste (MSW) generation, collection rates, and basic treatment methods. Complementing this are administrative data streams managed by the Ministry of Natural Resources and Environment (MONRE) and the Ministry of Industry and Trade (MOIT), which track industrial waste, hazardous waste, and energy consumption patterns.

However, CE requires moving beyond 'end-of-pipe' waste data. Current assets are strongest in downstream monitoring (waste disposal) but remain nascent in upstream monitoring (material intensity, product design, and secondary material utilisation). Institutional readiness is currently high for reporting 'what we throw away,' but lower for reporting 'how efficiently we use what we take.'

3.4.2. Structural Challenges in CE Data Integration

Several structural barriers currently limit the effectiveness of Viet Nam's CE monitoring framework:

- **Inconsistent Definitions and Classifications:** There is a lack of harmonised definitions for 'recycling,' 'recovery,' and 'reuse' across different provinces and ministries. For instance, waste treated through incineration with energy recovery may be classified differently in different jurisdictions, leading to data aggregation errors at the national level.
- **The 'Informal Sector' Blind Spot:** A significant portion of Viet Nam's circular activity – particularly plastic and paper recycling – occurs within the informal sector and craft villages. These flows are largely uncaptured in official statistics, meaning national recycling rates are likely under-reported, while environmental leakage from informal processing remains difficult to quantify.

- **Fragmented Data Ownership:** Data relevant to CE is siloed. Customs data (scrap imports), industrial production data (MOIT), and waste management data (MONRE/DONRE) are not currently integrated into a single interoperable platform. This fragmentation prevents a 'Material Flow Analysis' (MFA) approach, which is the international gold standard for CE monitoring.
- **Lag in Reporting Cycles:** The time gap between data collection and the publication of the Statistical Yearbook can hinder real-time policy adjustment. For rapidly evolving sectors like e-commerce packaging or renewable energy components (solar panels), current reporting cycles are often too slow to capture emerging waste streams.

3.4.3. Digital Transformation and Monitoring Infrastructure

The National Strategy emphasises digital transformation as an enabler for CE. Current initiatives to build national geographical space data infrastructure and digital government platforms offer a pathway to modernise CE monitoring. Potential high-impact digital interventions include:

- **Digital Waste Manifests:** Transitioning from paper-based to digital tracking for industrial and hazardous waste to improve data accuracy and enforcement. **EPR Reporting Platforms:** Developing digital portals for producers and importers to report on their Extended Producer Responsibility (EPR) obligations, creating a new and highly granular dataset on packaging and product lifecycles.
- **Provincial Dashboards:** Standardising the 'DONRE-to-MONRE' reporting pipeline through cloud-based templates to reduce manual entry errors and speed up aggregation.

3.4.4. Institutional Readiness and Capacity Building

Institutional readiness varies significantly between central ministries and provincial departments. While GSO and MONRE have strong technical foundations, provincial DONREs often lack the specialised staff required to verify complex CE data (e.g. industrial symbiosis metrics or life-cycle assessments). Strengthening the statistical infrastructure, therefore, requires a dual focus on technical systems and human capital development at the sub-national level.

Data availability is not only a technical issue but also an institutional one. While national and provincial agencies collect large volumes of administrative data, challenges remain in data standardisation, verification, and timely reporting. For CE, particular challenges include limited data on material flows within production systems, informal-sector activities (especially in recycling), and product-level life-cycle information. These gaps affect the ability to measure true circularity beyond basic waste indicators.

In the current situation, a pragmatic approach is to prioritise data improvements that have immediate policy relevance, such as standardising waste treatment categories and

strengthening reporting from major urban centres and industrial zones. Over time, more sophisticated indicators can be phased in as systems mature.

3.5. Alignment with Climate Policy, SDGs, and Regional Experience

Viet Nam's circular economy (CE) agenda aligns strongly with the Sustainable Development Goals (SDGs) and increasingly with regional policy directions. This alignment is strategically important for national government for three reasons:

- i) it provides an internationally comparable results framework for tracking progress.
- ii) it strengthens policy coherence across climate, green growth, waste management, and industrial modernisation agendas; and
- iii) it can improve access to international finance and technical co-operation by demonstrating contribution to shared global and regional priorities. (Viet Nam Circular Economy, n.d).

Regionally, Viet Nam's CE direction is consistent with broader trends in Southeast Asia, where governments are increasingly prioritising resource efficiency, plastic pollution reduction, and green growth. While commitments vary across ASEAN member states, common regional features include:

- i) emphasis on improving waste governance and infrastructure;
- ii) movement toward producer responsibility and packaging controls;
- iii) promotion of sustainable production in manufacturing and industrial zones; and
- iv) increasing interest in harmonised standards and metrics that enable comparability across markets.

For Viet Nam, this regional context matters because CE competitiveness is increasingly shaped by supply-chain requirements, trade-related standards, and buyer expectations – especially for export-oriented manufacturing sectors. A practical implication for national government is to ensure that Viet Nam's CE policy instruments remain compatible with emerging regional practices in three areas: (1) metrics and reporting (consistent definitions and progressively stronger material-efficiency indicators); (2) product and packaging measures that support enterprises – particularly SMEs – in meeting market expectations without undue administrative burden; and (3) governance of cross-border material flows (including scrap and secondary materials) to prevent environmental leakage while enabling legitimate recycling and manufacturing inputs.

Overall, positioning CE implementation as a contribution to SDG delivery and regional alignment strengthens the strategic rationale for action, supports policy coherence across ministries, and improves the case for phased investment in both infrastructure and data systems. Viet Nam's circular economy agenda is closely linked with its climate commitments under the Nationally Determined Contribution (NDC) (The Socialist Republic of Viet Nam, 2020) and broader green growth objectives. CE measures that reduce waste,

improve energy efficiency, and substitute secondary materials for virgin resources can deliver measurable climate co-benefits. The Green Growth Strategy (Decision No. 1658/QĐ-TTg) provides explicit quantitative targets that can serve as reference points for CE-related progress, including reductions in greenhouse gas emissions intensity and improvements in waste treatment performance.

At the regional level, Viet Nam can draw on lessons from sub-national CE implementation across Southeast Asia, as documented by UNEP and ERIA (2021). These experiences highlight the importance of clear governance arrangements, phased implementation, and strong local ownership of CE initiatives. Taken together, these alignments strengthen the strategic case for CE, positioning it not as a standalone environmental agenda but as a core component of Viet Nam's sustainable development pathway.

Text Box 1. Summary of the Current Situation

In summary, Viet Nam's current circular economy policy landscape is characterised by strong strategic intent, an increasingly supportive enabling conditions for implementation, and early sub-national implementation in leading cities. At the same time, gaps remain in operational clarity, indicator integration, and data systems.

Addressing these gaps does not require a wholesale redesign of existing systems. Rather, it requires focused efforts to integrate policies, standardise indicators, and support provinces through phased and realistic implementation pathways.

4. Conceptual Framework for Sub-National Circular Economy Indicators

4.1. Characterisation of Circular Economy at the Sub-National Level

Circular economy implementation at the sub-national level differs fundamentally from national-level strategy formulation. While national governments define principal policy objectives, regulatory frameworks, and long-term targets, provinces are the primary units where circular economy (CE) principles are translated into operational actions through planning, infrastructure development, service provision, and local economic governance (OECD, 2020; ERIA, 2024).

At the provincial level, circular economy is best understood as a territorial system of material flows, production and consumption activities, infrastructure, and governance arrangements operating within defined administrative boundaries. Provinces play a vital role in managing municipal solid waste and wastewater services, approving and regulating industrial zones and clusters, guiding land-use and urban development, and mobilising public and private investment. As such, the effectiveness of national circular economy strategies ultimately depends on provincial capacity, co-ordination, and monitoring

performance.

From an analytical perspective, the sub-national scale represents an intermediate level between enterprises and the national economy. It is sufficiently large to capture significant material and energy flows, industrial symbiosis opportunities, and infrastructure systems, while remaining sufficiently granular to reflect local economic structures, resource endowments, and development priorities (OECD, 2020; Cader, Koneczna, and Marciniak 2024). This makes the provincial level particularly suitable for circular economy monitoring and performance assessment.

Circular economy at the sub-national level can be characterised by the following key features:

- **Systemic nature:** Provincial circular economy performance emerges from interactions amongst resource extraction, production, consumption, waste management, and environmental systems, rather than from isolated sectoral interventions (Ellen MacArthur Foundation, 2015).
- **Context specificity:** Circular economy pathways differ across provinces depending on dominant economic activities (e.g. industrial manufacturing, agriculture, tourism), urban–rural composition, and availability of infrastructure and services (ERIA, 2024).
- **Governance dependence:** Effective circular transitions require co-ordination across multiple provincial departments, including environment, planning and investment, industry and trade, construction, and agriculture, as well as engagement with enterprises and communities (OECD, 2020).
- **Phased progression:** Provinces typically move from basic waste management and pollution control toward more advanced circular practices such as material efficiency, reuse and repair, industrial symbiosis, and circular business models as institutional and data capacity improves (Moraga et al., 2019).

In practical terms, sub-national circular economy monitoring should not attempt to measure abstract or economy-wide circularity. Instead, it should focus on tracking progress, readiness, and direction of change across key systems that provinces can influence through policy instruments, investments, and service delivery. This requires indicator frameworks that are aligned with provincial mandates, sensitive to data availability, and capable of supporting decision-making rather than solely reporting compliance (OECD, 2021).

4.2. Key Dimensions and Pillars of the Sub-National Circular Economy

Building on the characterisation of circular economy at the sub-national level, this section defines the core dimensions and analytical pillars used to structure provincial circular economy indicators in this report. The purpose of defining these pillars is to translate broad circular economy principles into measurable, policy-relevant domains that align with provincial mandates, data availability, and implementation responsibilities. The identification of these pillars responds to a central challenge highlighted in the literature:

while circular economy is inherently systemic, monitoring frameworks must remain sufficiently structured and selective to be operational at the level of public administration (Moraga et al., 2019; Saidani et al., 2019).

International experience demonstrates that circular economy monitoring frameworks are most effective when they are organised around a limited number of coherent pillars that reflect the main leverage points of public policy, rather than around long, unstructured lists of indicators (OECD, 2020; European Commission, 2018). At the provincial level, such pillars must capture both material performance and enabling conditions, while remaining adaptable to differences in economic structure and institutional capacity across regions.

Accordingly, this report adopts six interrelated pillars to guide the design of provincial circular economy indicators in Viet Nam:

1. Resource Efficiency and Material Flows
2. Waste Management and Prevention
3. Industrial Symbiosis and Eco-Industrial Parks
4. Sustainable Consumption and Production
5. Circular Business Models and Innovation
6. Social and Economic Co-Benefits

These pillars collectively reflect the full circular system from resource inputs and production processes to consumption, waste management, innovation, and socio-economic outcomes while allowing indicators to be assigned clearly to specific policy domains. Each pillar is described below in terms of its conceptual relevance, policy significance at the provincial level, and implications for indicator design.

4.2.1. Resource Efficiency and Material Flows

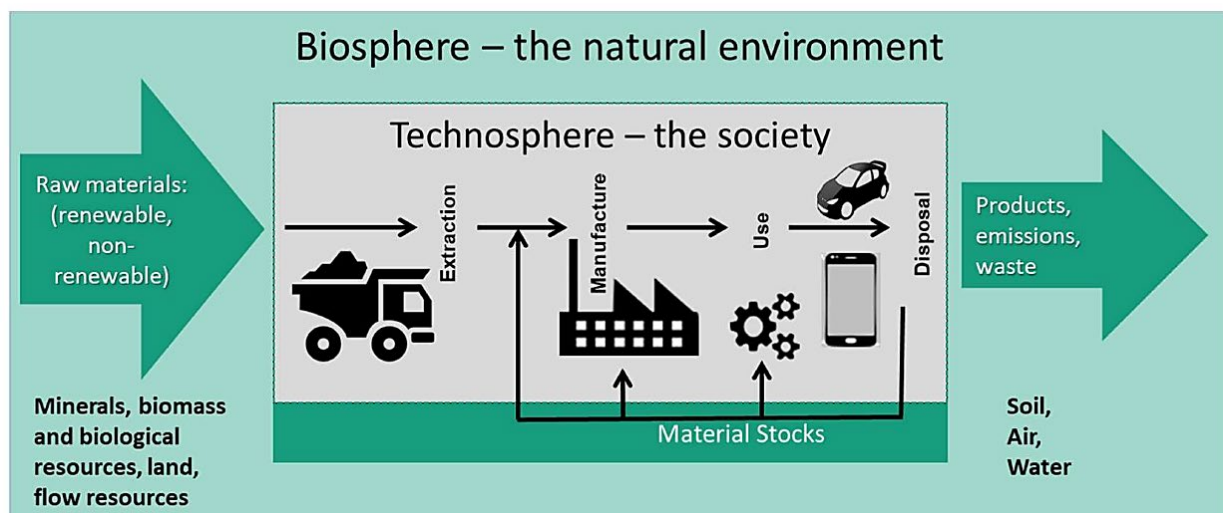
Resource efficiency and material flows constitute the foundational pillar of the circular economy at the sub-national level. This pillar addresses how effectively a province uses natural resources and materials to generate economic value, and how material inputs and outputs are managed within territorial boundaries. In the circular economy literature, improvements in resource efficiency are consistently identified as a prerequisite for decoupling economic growth from environmental pressure and primary resource extraction (Ellen MacArthur Foundation, 2015). At the provincial level, material flows include raw material extraction, imports and exports of materials and products, energy and water consumption, and the generation of residuals in the form of waste and emissions. Monitoring these flows provides insight into the scale, intensity, and efficiency of economic activity, as well as the structural dependence of provinces on resource-intensive production patterns (OECD, 2020).

While comprehensive economy-wide material flow analysis (MFA) is typically conducted at the national level, a growing body of literature demonstrates that simplified, proxy-based,

or sector-specific material flow indicators can be effectively applied at sub-national scales to support planning and policy evaluation (Geng et al., 2012; Cader, Koneczna, and Marciniak, 2024). Such indicators are particularly relevant for provinces in emerging economies, where statistical systems are often not yet equipped to support full MFA accounting. From a governance perspective, provincial authorities influence resource efficiency through land-use planning, industrial zoning, infrastructure investment, energy management, water allocation, and the promotion of cleaner production practices.

In terms of indicator typology, resource efficiency and material flow indicators are primarily positioned within Scope 0 and Scope 1 measurement categories, focusing on physical properties of materials and technological cycles, with partial integration of life cycle thinking where data permit (Moraga et al., 2019). These indicators are generally amongst the most feasible to implement at the provincial level, as they draw on existing statistical yearbooks, sectoral reports, and administrative data, while providing a robust baseline for more advanced circular performance assessment in later phases. Accordingly, this pillar serves as the quantitative and analytical basis for the other aspects of the provincial circular economy, including waste prevention, industrial symbiosis, and the development of circular business models (Figure 6).

Figure 6. Natural Resources and Material Flows



Source: Schebek and Lützkendorf, 2022.

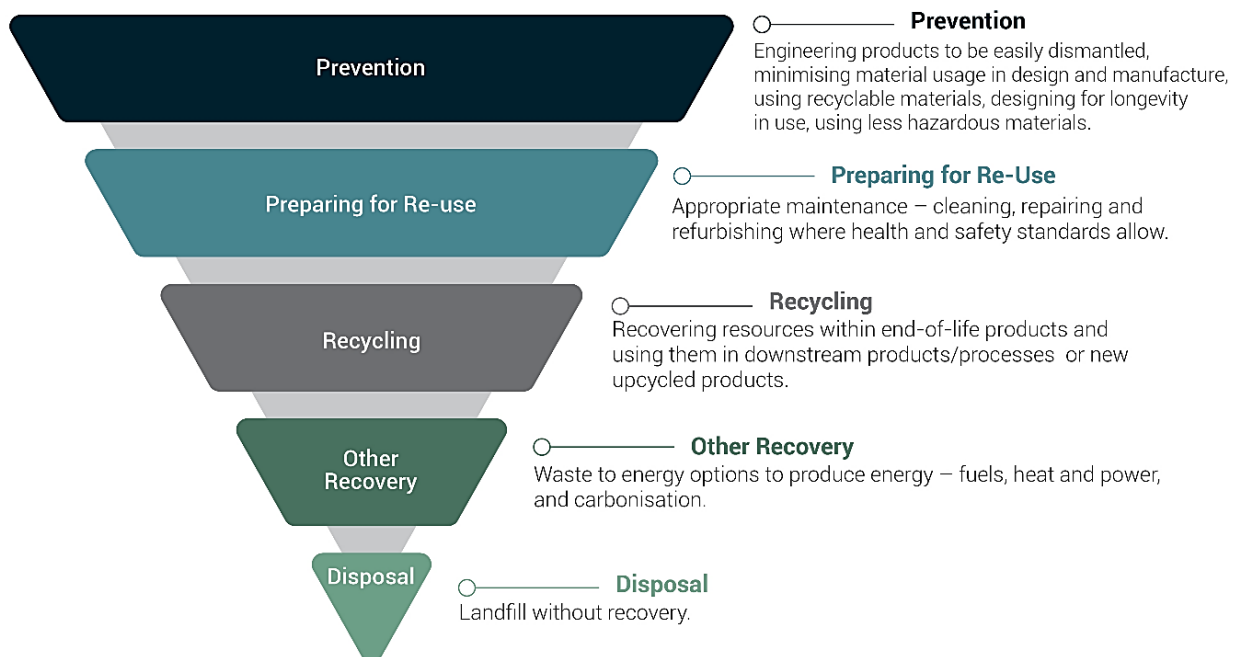
4.2.2. Waste Management and Prevention

Waste management and prevention constitute a core but transitional pillar of the circular economy at the sub-national level. In many developing and emerging economies, including Viet Nam, waste management has historically been the primary entry point for circular economy implementation. However, international experience increasingly emphasises that effective circular economy strategies must move beyond end-of-pipe waste treatment toward prevention, separation, and value retention across the material life cycle (European Commission, 2018; UNEP, 2021). At the provincial level, waste management systems encompass municipal solid waste, industrial waste, construction and demolition waste,

hazardous waste, and wastewater. Provinces are typically responsible for waste collection services, treatment infrastructure, landfill management, and enforcement of waste-related regulations. As a result, waste-related indicators remain amongst the most feasible and policy-relevant metrics for sub-national circular economy monitoring, particularly in the preliminary stages of implementation (Kaza et al., 2018).

In terms of indicator typology, waste management and prevention indicators span Scope 0 to Scope 2 measurement categories, ranging from physical quantities of waste generated and treated to indicators capturing environmental and economic effects of diversion and recovery. However, for provincial monitoring systems, emphasis is typically placed on Scope 0 and Scope 1 indicators, which are more directly measurable using administrative and statistical data, with gradual integration of impact-based indicators as data systems mature (Moraga et al., 2019). Importantly, waste management indicators should not be interpreted in isolation. Their relevance and effectiveness depend on integration with upstream pillars such as resource efficiency, sustainable consumption, and industrial symbiosis. Within a provincial circular economy framework, waste management and prevention thus function not as an endpoint, but as a bridge between linear material flows and circular value creation (Figure 7).

Figure 7. Waste Hierarchy and Circular Economy Priorities.



Source: Australian Bedding Stewardship Council, 2022.

4.2.3. Industrial Symbiosis and Eco-Industrial Parks

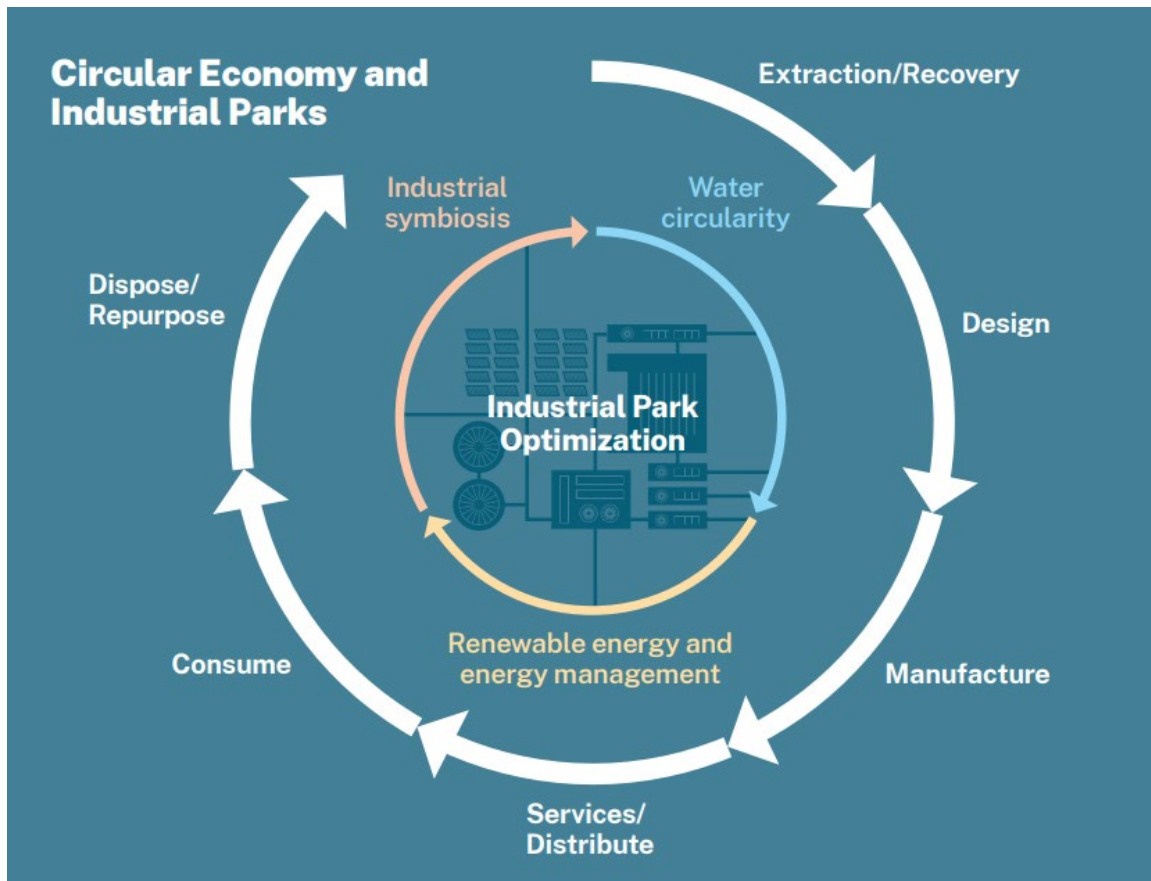
Industrial symbiosis and eco-industrial parks represent a core meso-level mechanism for advancing circular economy implementation at the sub-national level. This pillar focuses on the optimisation of material, energy, water, and by-product flows between firms and

within industrial zones, enabling reductions in resource consumption, waste generation, and environmental impacts while enhancing economic efficiency and competitiveness (Chertow, 2000).

Industrial symbiosis is commonly defined as the process by which traditionally separate industries engage in the physical exchange of materials, energy, water, or by-products, creating mutually beneficial relationships that improve overall system performance (Chertow, 2007). In the context of circular economy monitoring, industrial symbiosis is particularly relevant at the provincial level, where industrial parks, export processing zones, and industrial clusters are planned, regulated, and supported by local authorities. Eco-industrial parks (EIPs) extend the concept of industrial symbiosis by integrating environmental management, resource efficiency, and shared infrastructure into the design and operation of industrial zones. International frameworks developed by the World Bank, UNIDO, and GIZ emphasise that EIPs combine technical, environmental, economic, and social performance criteria, including energy and water efficiency, waste recovery, emissions reduction, and improved working conditions (United Nations Industrial Development Organization [UNIDO], World Bank, and GIZ, 2021).

In terms of indicator typology, industrial symbiosis indicators generally fall within Scope 1 and Scope 2 measurement categories, as they capture both physical exchanges within technological cycles and the resulting environmental or economic effects. However, at the provincial level, emphasis is often placed on structural and participation-based indicators in the initial stages of implementation, reflecting data availability and the need to track system readiness before full performance impacts can be quantified (Moraga et al., 2019). Within the broader provincial circular economy framework, industrial symbiosis and eco-industrial parks function as a linking pillar between resource efficiency, waste management, and circular business model development. By supporting material circulation at scale, they provide a practical pathway for provinces to move beyond isolated recycling activities toward integrated circular production systems. **Figure 8** presents the CE principles applied in industrial parks.

Figure 8. Circular Economy Principles Applied in Industrial Parks.



Source: World Bank, 2021a.

4.2.4. Sustainable Consumption and Production

Sustainable consumption and production (SCP) constitute a critical linking pillar within the sub-national circular economy framework by connecting upstream production systems with downstream consumption patterns. While circular economy discussions often emphasise material recovery and industrial processes, international evidence demonstrates that long-term circular outcomes cannot be achieved without addressing how goods and services are produced, procured, distributed, and consumed (UNEP, 2015; OECD, 2019a). At the provincial level, SCP is particularly relevant because sub-national authorities influence both production and consumption through regulatory instruments, public procurement, market facilitation, infrastructure provision, and awareness programmes. Provinces manage industrial permitting, cleaner production promotion, commercial activity, public service delivery, and, in many cases, tourism and urban consumption systems. As a result, SCP indicators provide an essential lens for assessing whether circular economy principles are being mainstreamed into everyday economic activity, rather than remaining confined to waste management systems.

In terms of indicator typology, sustainable consumption and production indicators typically fall within Scope 1 measurement categories, capturing technological and organisational practices with partial life cycle thinking, and Scope 2 categories where impacts such as emissions reduction or resource savings can be estimated. However, at the provincial level,

emphasis is generally placed on practice- and adoption-based indicators, which are more feasible to monitor using administrative data and sectoral reports (Moraga et al., 2019). Within the overall provincial circular economy framework, SCP functions as a demand-side driver that complements resource efficiency, waste prevention, and industrial symbiosis (Figure 9). By shaping market demand and production practices, SCP indicators help ensure that circular economy transitions are economically viable, socially acceptable, and scalable across provinces with diverse development profiles.

Figure 9. Key Elements of Sustainable Consumption and Production.



Source: UNEP, 2017.

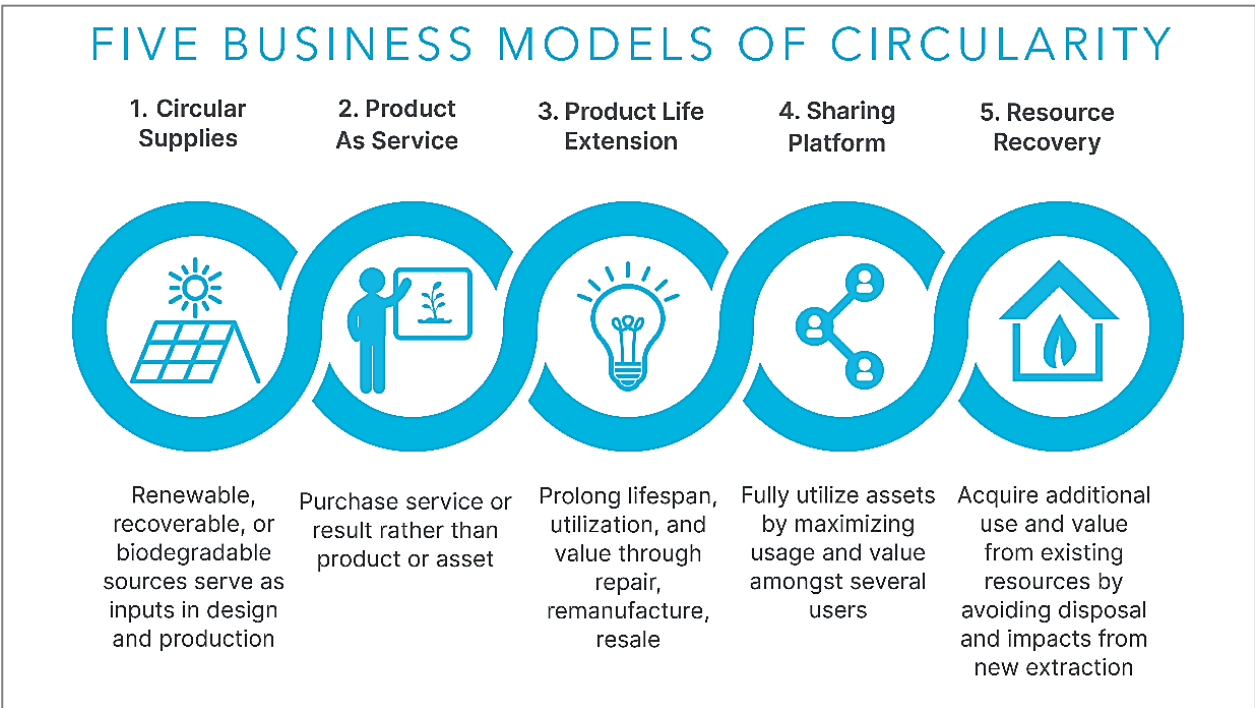
4.2.5. Circular Business Models and Innovations

Circular business models and innovation constitute a forward-looking pillar of the sub-national circular economy framework, reflecting the transition from incremental efficiency improvements toward structural changes in how value is created, delivered, and captured. While resource efficiency, waste management, and industrial symbiosis focus primarily on optimising existing systems, circular business models introduce new organisational and market configurations that enable long-term circularity (OECD, 2020). At the provincial level, innovation does not necessarily imply high-technology or research-intensive activities alone. Instead, circular innovation often takes the form of new service models, repair and reuse enterprises, sharing platforms, local recycling solutions, and product-life-extension practices that are adapted to local economic conditions. Provinces play a critical enabling role by shaping the business environment through licensing, infrastructure provision, investment promotion, access to finance, and targeted support programmes for

small and medium-sized enterprises (SMEs).

In terms of indicator typology, circular business model and innovation indicators generally fall within Scope 1 and Scope 2 measurement categories. They align with Scope 1 because they measure organisational practices within technological and economic systems and may incorporate life cycle thinking. They align with Scope 2 when they assess the broader economic or environmental effects generated by these business models, such as emissions reduction, job creation, or value-added growth. At early stages of implementation, provinces often prioritise readiness and enabling-environment indicators, gradually shifting toward performance-oriented indicators as circular markets mature and data availability improves (Moraga et al., 2019). Within the overall framework, this circular business model and innovation pillar serves as a bridge between technical circular measures and broader socio-economic outcomes. By fostering circular entrepreneurship and innovation, provinces can stimulate job creation, attract investment, and enhance economic resilience, while simultaneously reducing material and environmental pressures. Therefore, the implementation of circular business models and innovation is critical to guaranteeing that provincial circular economy strategies achieve both environmental effectiveness and long-term economic viability at scale. Five business models specified by (Circular Innovation Council, n.d.) are illustrated in Figure 10.

Figure 10. Different Business Models of Circularity.



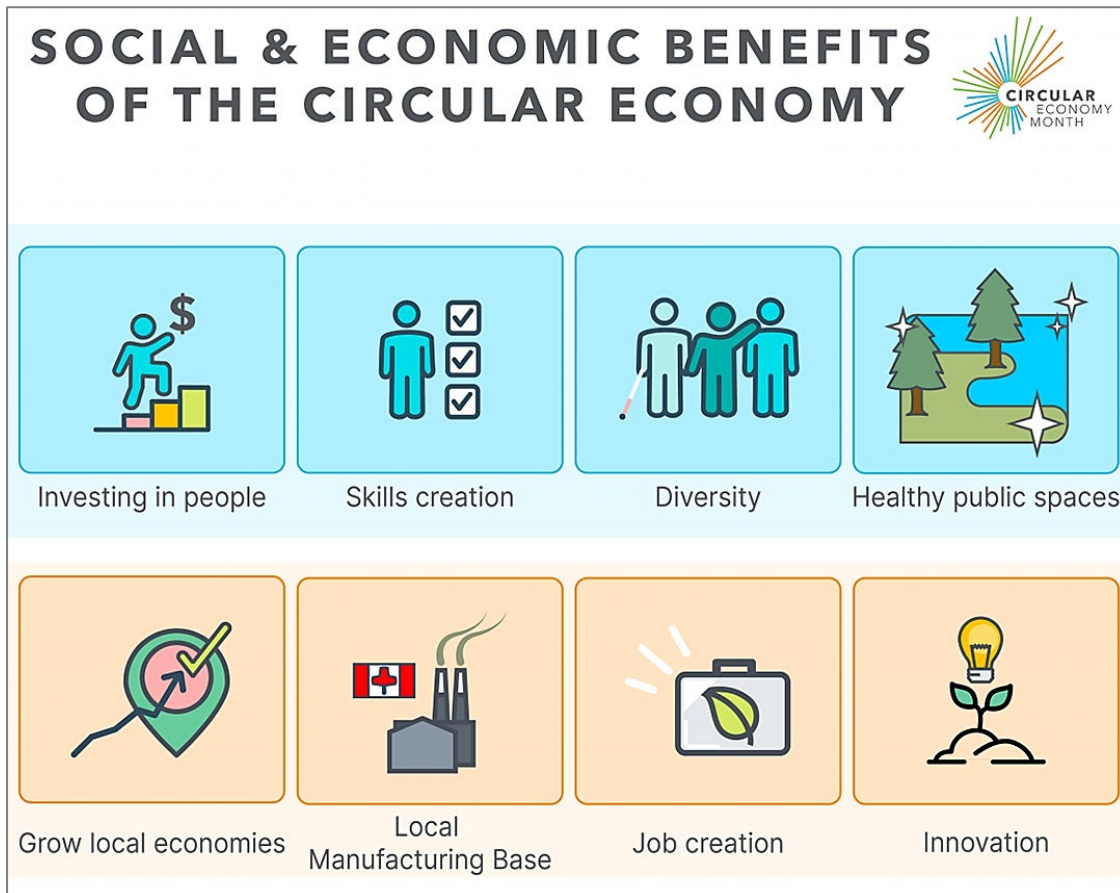
Source: Circular Innovation Council, n.d.

4.2.6. Social and Economic Co-Benefits

Social and economic co-benefits form a cross-cutting pillar of the sub-national circular economy framework, reflecting the growing recognition that circular economy transitions must deliver tangible development outcomes alongside environmental improvements. International experience demonstrates that circular economy policies are more likely to be sustained when they contribute to employment creation, income generation, economic resilience, and social inclusion, rather than being perceived solely as environmental interventions (OECD, 2020; World Bank, 2022c). At the provincial level, circular economy initiatives intersect directly with local labour markets, small and medium-sized enterprises (SMEs), informal economic activities, and community livelihoods. Waste management, repair and reuse services, recycling, and circular manufacturing are amongst the sectors with significant potential to generate employment, particularly for low and semi-skilled workers. As a result, sub-national circular economy monitoring frameworks increasingly incorporate indicators that capture job creation, enterprise participation, and local economic value, alongside environmental performance (UNEP, 2017; ILO, 2021).

Within the indicator typology adopted in this report, social and economic co-benefit indicators predominantly fall within Scope 2 measurement categories, as they capture effects and outcomes resulting from circular economy interventions across interrelated dimensions. At the provincial level, emphasis is placed on feasible, policy-relevant metrics that can be derived from statistical yearbooks, labour surveys, administrative records, and investment data, rather than complex modelling exercises. By explicitly incorporating social and economic co-benefits into the circular economy framework, provinces can ensure that circular transitions are aligned with inclusive growth, poverty reduction, and local development priorities (Figure 11). This pillar therefore provides a critical bridge between technical circular economy measures and the stakeholder-focused governance arrangements discussed in the following section.

Figure 11. Social and Economic Benefits of Circular Economy.



Source: City of St. John's, 2023.

4.3. Governance and Stakeholder Framework for Provincial Circular Economy Implementation

Effective implementation of circular economy at the sub-national level depends not only on technical indicators and policy design, but also on the active participation and co-ordination of multiple stakeholder groups. Provinces operate at the intersection of national policy direction, enterprise-level action, and community engagement, making stakeholder alignment a critical determinant of circular economy performance. International experience consistently highlights that circular economy initiatives fail or underperform when responsibilities are fragmented, incentives are misaligned, and key actors, particularly businesses and communities, are insufficiently engaged (OECD, 2020; UNEP, 2017).

4.3.1. Stakeholder Mapping and Roles

A clear stakeholder mapping framework therefore supports:

- role clarification,
- accountability in indicator reporting, and
- effective governance arrangements for implementation and monitoring.

At the provincial level in Viet Nam, stakeholders involved in circular economy implementation can be broadly grouped into three main categories: government institutions, industry and the private sector, and communities and civil society. Provincial government agencies act as policy enablers and co-ordinators, responsible for translating national circular economy objectives into provincial plans, regulations, and programmes. Line departments supervise sector-specific implementation, including environmental management, industrial development, construction, agriculture, and public services.

Industry and private sector actors are the primary implementers of circular practices. This group includes manufacturing enterprises, industrial park developers and operators, waste service providers, construction companies, and circular service businesses engaged in repair, reuse, and recycling. Their participation determines the practical effectiveness of circular economy policies. Communities, households, informal workers, and civil society organisations influence circular outcomes through consumption behaviour, waste segregation practices, and participation in local initiatives. In many provinces, informal actors play a critical role in waste collection and recycling systems, making their inclusion essential for socially inclusive circular transitions. Each group plays a distinct but complementary role across the circular economy pillars identified in Table 5.

Table 5. Stakeholder Mapping for Provincial Circular Economy Implementation

Stakeholder Group	Key Actors	Primary Roles in Circular Economy	Relevant CE Pillars
Provincial Government	● Provincial People's Committee ● Departments responsible for environment, planning and investment, industry and trade, construction, agriculture	● Policy translation and co-ordination ● Integration into provincial plans ● Infrastructure development ● Regulation and enforcement ● Data collection and reporting	● All pillars
Industrial Park Authorities	● Industrial Park management boards ● Zone developers	● Implementation of eco-industrial park principles ● Co-ordination of shared services ● Facilitation of industrial symbiosis	● Resource efficiency ● Industrial symbiosis ● Waste management

Stakeholder Group	Key Actors	Primary Roles in Circular Economy	Relevant CE Pillars
Private Enterprises	• Manufacturing firms • Waste service providers • Construction companies • Circular service providers	• Adoption of circular production and business models • Waste reduction and recovery • Investment in circular technologies	• Resource efficiency • Sustainable consumption and production • Business models and innovation
Financial Institutions	• Commercial banks • Green finance programmes • Investment funds	• Provision of capital for circular projects • Green credit and investment	• Business models and innovation • Social and economic co-benefits
Communities and Households	• Urban and rural residents • Consumer groups	• Sustainable consumption behaviour • Waste segregation at source • Participation in local circular initiatives	• Waste prevention • Sustainable consumption and production • Social and economic co-benefits
Informal Sector	• Waste pickers • Small-scale recyclers • Repair workers	• Collection, sorting, reuse, and recycling of materials • Livelihood generation	• Waste management • Social and economic co-benefits
Civil Society and Academia	• NGOs • Research institutions • Training providers	• Awareness raising • Capacity building • Technical support • Monitoring and evaluation	• Governance • Business models and innovation • Social and economic co-benefits

Source: Authors based on inputs from ERIA-ISPAE.

4.3.2 Institutional Co-ordination and Leadership

Strong institutional co-ordination is a prerequisite for effective provincial circular economy

governance. Provincial People's Committees provide overall leadership by setting priorities, assigning responsibilities, and ensuring alignment across departments. International practice suggests that designating a lead co-ordinating body or focal agency significantly improves coherence and accountability in circular economy implementation (OECD, 2020).

Under this arrangement, line departments retain responsibility for sector-specific actions, while co-ordination mechanisms such as inter-departmental working groups or steering committees facilitate information sharing, joint planning, and resolution of cross-sectoral issues. Technical and advisory support from research institutions and development partners can further strengthen institutional capacity, particularly during preliminary stages of implementation.

4.3.3. Integration into Planning, Budgeting, and Investment Processes

Governance effectiveness depends not only on co-ordination structures but also on the extent to which circular economy objectives are embedded in provincial planning and budgeting processes. International experience shows that circular economy strategies are most impactful when integrated into socio-economic development plans, sectoral strategies, and public investment programmes, rather than treated as stand-alone environmental initiatives (European Commission, 2020a; OECD, 2019a).

At the provincial level, governance frameworks should support:

- incorporation of circular economy priorities into five-year and annual socio-economic development plans;
- alignment of circular economy indicators with investment appraisal and project selection criteria;
- use of monitoring results to inform budget allocation and infrastructure investment decisions.

This integration ensures that circular economy implementation contributes directly to provincial development objectives, including economic growth, employment creation, and environmental protection.

4.3.4. Monitoring, Reporting, and Feedback Mechanisms

Indicator-based monitoring is a central element of provincial circular economy governance. However, monitoring systems are effective only when embedded within clear reporting and feedback mechanisms. Provinces must therefore establish procedures for data collection, validation, reporting, and review, ensuring that indicator results are communicated to decision-makers in a timely and usable manner.

International frameworks emphasise that sub-national monitoring systems should be practical, transparent, and action-oriented, supporting policy adjustment rather than serving purely descriptive purposes (Moraga et al., 2019; OECD, 2020). Regular reporting cycles such as annual or biennial reviews allow provinces to track progress, identify

implementation gaps, and recalibrate policies or investments as needed.

4.3.5. Stakeholder Engagement and Capacity Building

Effective governance structures must also facilitate continuous stakeholder engagement and capacity building. Engagement with enterprises, industrial park operators, financial institutions, communities, and civil society organisations enhances data quality, supports behavioural change, and improves the legitimacy of circular economy initiatives.

Capacity building is particularly important at the provincial and municipal levels, where technical expertise and experience with circular economy concepts may be limited. International experience indicates that targeted training, technical guidance, and peer-learning platforms significantly improve sub-national implementation outcomes (UNEP, 2017; World Bank, 2022c). Governance arrangements should therefore include mechanisms for:

- training officials and practitioners on circular economy principles and indicators;
- supporting enterprises and communities in adopting circular practices;
- facilitating knowledge exchange and dissemination of best practices across provinces.

4.3.6 Implications for Indicator Design and Implementation

The governance and stakeholder framework outlined above directly informs the design of the proposed SMART circular economy indicators presented in Chapter 6. Indicators must be:

- clearly linked to institutional mandates and stakeholder responsibilities;
- aligned with planning, budgeting, and reporting cycles;
- supported by feasible data collection and reporting arrangements;
- capable of informing policy and investment decisions.

By embedding indicators within a coherent governance framework, provinces can move from passive reporting toward active, evidence-based management of circular economy transitions.

5. Proposed Smart Circular Economy Indicators

This chapter presents a structured set of SMART (Specific, Measurable, Achievable, Relevant, and Time-bound) circular economy indicators designed to support monitoring, evaluation, and policy decision-making at the sub-national (provincial) level. Building on the conceptual framework introduced in Chapter 4, the proposed indicators translate circular economy principles into operational metrics that can be systematically tracked using available data sources.

The indicator framework is organised around six interrelated pillars that reflect internationally recognised circular economy dimensions while remaining aligned with provincial mandates, planning instruments, and investment responsibilities. For each pillar, the chapter first outlines the policy rationale and analytical scope, followed by proposed indicators, including their definitions, calculation methods, data sources, monitoring frequency, benchmarks, and limitations.

5.1. Pillar A: Resource Efficiency and Material Flows

Resource efficiency lies at the core of the circular economy, as it reflects the extent to which economic growth can be achieved while reducing reliance on primary material extraction and consumption. Improving resource efficiency is central to decoupling economic development from environmental degradation and is widely recognised as a key pathway toward sustainable development, green growth, and climate mitigation objectives (OECD, 2021; UNEP, 2017). Indicators under this pillar therefore serve several critical policy functions:

- tracking progress toward national green growth, circular economy, and climate objectives;
- identifying resource-intensive sectors and spatial hotspots requiring intervention; and
- supporting the integration of circular economy considerations into provincial socio-economic development plans and investment decisions.

International monitoring frameworks consistently emphasise that resource efficiency should be assessed using a combination of complementary indicators rather than a single metric. A set of five indicators is proposed under this pillar to balance analytical completeness with data availability and institutional feasibility at the provincial level. These dimensions are applied in international frameworks developed by the OECD, the International Resource Panel, and Japan's Ministry of the Environment to assess structural economic change and resource decoupling trends (International Resource Panel, 2019; Ministry of the Environment, Japan, 2020; OECD, 2021).

Indicator A.1 Material Productivity

Definition and rationale

Material productivity measures the economic value generated per unit of material input and is one of the most widely used indicators of resource efficiency in circular economy monitoring. It reflects how effectively materials are transformed into economic output and is commonly applied to assess relative decoupling between economic growth and material consumption (Eurostat, 2025; OECD, 2021).

Calculation formula³

$$\text{Material Productivity} = \frac{\text{Gross Regional Product (GRP)}}{\text{Domestic Material Consumption (DMC)}}$$

Indicator A.2 Resource Extraction Rate

Definition and rationale

The resource extraction rate measures the intensity of primary material extraction relative to population size or economic output. It serves as an indicator of pressure on natural capital and highlights the sustainability implications of prevailing production and consumption patterns, particularly in resource-intensive provinces (International Resource Panel, 2019; UNEP, 2017).

Calculation formula⁴

$$\text{Resource Extraction Rate} = \frac{\text{Total Extracted Materials}}{\text{Population or GRP}}$$

Indicator A.3 Recycled Content Usage

Definition and rationale

Recycled content usage measures the proportion of secondary materials used as inputs in production processes and directly reflects progress toward closing material loops. Increasing recycled content is a central objective of circular economy strategies, as it reduces demand for virgin raw materials and supports secondary material markets (European Commission, 2020b; OECD, 2021).

Calculation formula⁵

$$\text{Recycled Content (\%)} = \frac{\text{Secondary Materials Used}}{\text{Total Material Input}} \times 100$$

³ This formula is adapted from the OECD and Eurostat definition of resource productivity, which is calculated as GDP divided by Domestic Material Consumption (DMC). The substitution of GDP with Gross Regional Product (GRP) follows established practice in sub-national and regional material flow analysis and is consistent with applications in OECD regional studies. Domestic Material Consumption follows the official United Nations methodology under SDG Indicator 8.4.2 (Eurostat, 2025; OECD, 2021; UNEP, 2025).

⁴ This indicator is derived from material extraction intensity metrics used by the UNEP International Resource Panel and the World Bank, which normalise extracted material quantities by population (per capita extraction) or economic output (extraction intensity per GRP). Both normalisation approaches are internationally accepted, with per capita values reflecting environmental pressure and per-GRP values reflecting economic material intensity (International Resource Panel, 2019).

⁵ This formula follows internationally accepted definitions of recycled content used in EU circular economy policy, OECD circular material uses indicators, and ISO 14021 standards on environmental claims. At the sub-national level, this simplified ratio is recommended where full circular material use rate calculations are constrained by limited trade and import–export data (European Commission, 2020; OECD, 2021).

Indicator A.4 Resource Consumption Intensity (Energy and/or Water)

Definition and rationale

Resource consumption intensity measures the amount of energy and/or water consumed per unit of economic output or per capita, reflecting the efficiency with which key resources are used to support economic activities. Within a circular economy framework, reducing resource consumption intensity is critical for decoupling economic growth from environmental pressure and for improving system-wide efficiency in production and service delivery. Energy and water intensity indicators are widely used in international sustainability and circular economy monitoring frameworks, as they provide a clear link between resource use, climate mitigation, and economic structure (International Energy Agency [IEA], 2022; OECD, 2019a; UNEP, 2017).

Calculation formula⁶

$$\text{Resource Consumption Intensity} = \frac{\text{Total Energy or Water Consumption}}{\text{Gross Regional Product (GRP) or Population}}$$

Indicator A.5 Material or Land-Use Pressure Indicator

Definition and rationale

Material or land-use pressure indicators capture the spatial and environmental implications of material-intensive production and consumption systems, particularly in rapidly urbanising and industrialising provinces. These indicators reflect pressures associated with construction materials, land take, and infrastructure expansion, which are often closely linked to linear economic models. Within a circular economy framework, monitoring material and land-use pressure supports the identification of unsustainable development patterns and highlights opportunities for material efficiency, reuse, and compact urban development (European Environment Agency [EEA], 2020; International Resource Panel, 2019).

Calculation formula⁷

⁶ This indicator follows internationally applied definitions of energy and water intensity used by the OECD, the International Energy Agency, and UNEP, which normalise total resource consumption by economic output or population. The use of GRP instead of GDP is consistent with sub-national and regional monitoring practices and allows comparison across provinces with different economic structures (IEA, 2022; OECD, 2019; UNEP, 2017).

⁷ This indicator is derived from international practices used by the International Resource Panel and the European Environment Agency, which apply per capita or area-based measures to assess material demand and land-use pressure associated with economic development and urban expansion. Adaptation at the provincial level is recommended to reflect locally relevant material streams and land-use dynamics (EEA, 2020; International Resource Panel, 2019).

$$\text{Material or Land – use Pressure} = \frac{\text{Construction Material Consumption or Land Take}}{\text{Population or Land Area}}$$

(The specific variable used may depend on data availability, such as construction material use per capita or annual land take per square kilometre.)

Table 6 presents the proposed set of resource efficiency and material flow indicators under Pillar A, designed to capture key dimensions of material use, resource pressure, and circularity at the provincial level. The selected indicators collectively address material productivity, primary resource extraction, use of secondary materials, intensity of energy and water consumption, and spatial or land-use pressures associated with economic development. Together, they provide a balanced and operational framework for monitoring progress toward circular economy objectives while remaining aligned with data availability and institutional capacities at the sub-national level. The table summarises the main data sources, monitoring frequency, target benchmarks, and key limitations for each indicator, thereby supporting transparent implementation and consistent interpretation across provinces.

Table 6. Resource Efficiency and Material Flow Indicators

Indicator		Data Sources and Collection Methods	Monitoring Frequency	Target Benchmarks	Limitations and Considerations
A.1	Material Productivity	- Provincial GRP statistics - Economy-wide material flow accounts Industrial and sectoral surveys compiled by national or provincial statistical offices.	Annual	- National circular economy and green growth targets - Comparison with OECD average material productivity values	- Requires consistent material flow accounting. - Informal economic activities and small-scale production may be under-represented, potentially leading to underestimation of material consumption.
A.2	Resource Extraction Rate	- Mining and quarrying statistics - Construction material production data - Administrative records from provincial natural resource and environment departments.	Annual to biennial	- National sustainability and resource efficiency targets - Sector-specific extraction intensity benchmarks where available.	- Data gaps may exist for artisanal, small-scale, and informal extraction activities. - Indicator does not distinguish between renewable and non-renewable resources unless disaggregated.
A.3	Recycled Content Usage	- Industrial reporting systems - Sectoral surveys - Recycling industry data - Extended producer responsibility (EPR) reporting where applicable.	Annual	- National recycled content standards - Sector-specific targets for priority material streams such as plastics, construction materials, or packaging.	- Verification of recycled content can be challenging in complex supply chains, particularly where intermediate products are imported. - Consistent definitions of secondary materials are required for comparability.

Indicator		Data Sources and Collection Methods	Monitoring Frequency	Target Benchmarks	Limitations and Considerations
A.4	Resource Consumption Intensity (Energy and/or Water)	- Provincial energy balance statistics - Electricity and water utility records - Administrative data from energy, water, and environment authorities - Industrial and sectoral surveys.	Annual	- National energy efficiency and water efficiency targets - Sector-specific benchmarks - Relevant international reference values.	- Structural economic differences between provinces may influence intensity values. - Data quality may vary, particularly for industrial and commercial water use.
A.5	Material or Land-Use Pressure Indicator	- Construction and infrastructure statistics - Land-use and spatial planning data - Remote sensing and GIS datasets - Administrative records from provincial planning and construction authorities.	Annual to biennial	- National land-use efficiency and construction material efficiency targets - Relevant urban development benchmarks.	- Definitions of land take and material consumption may vary across jurisdictions. - Data availability may be limited in provinces without systematic land-use or construction material monitoring.

Source: Compiled from OECD (2021); Eurostat (2025); UNEP (2017); International Resource Panel (2019); European Commission (2020b); and IEA (2022).

5.2. Pillar B: Waste Management and Prevention

Waste management is often the most visible entry point for circular economy implementation at the sub-national level. However, a growing body of literature cautions that waste-centric monitoring frameworks risk reinforcing linear thinking if they focus solely on quantities collected or treated, rather than on upstream waste prevention, source separation, and material recovery outcomes (OECD, 2020; Wilson et al., 2012). Within a circular economy framework, waste management indicators must therefore be carefully designed to reflect not only system performance but also underlying structural changes in production and consumption patterns (OECD, 2025a).

From a circular economy perspective, waste management and prevention at the provincial level can be conceptualised along three interrelated dimensions (OECD, 2019b):

- Waste generation and prevention, capturing trends in per capita waste generation and sector-specific waste intensity as indicators of consumption behaviour and production efficiency;
- Collection and source separation performance, reflecting the extent to which waste streams are segregated at source and collected in a manner that enables high-quality recycling and material recovery;
- Treatment and diversion outcomes, measuring the share of waste diverted from landfill through recycling, composting, anaerobic digestion, or energy recovery.

International monitoring frameworks increasingly prioritise landfill diversion rates, recycling rates by material stream, and source separation coverage as key indicators of circular progress, rather than absolute volumes of waste treated or disposed (EEA, 2018; OECD, 2021; OECD, 2025a). These indicators are particularly relevant at the provincial level, where decisions regarding waste infrastructure investment, service coverage, and operational performance are typically made. At the same time, waste prevention indicators play a critical complementary role, although they are often more challenging to operationalise.

Direct measurement of avoided waste remains difficult; as a result, international practice relies on proxy indicators such as trends in waste generation per capita, uptake of reusable or refillable products, and implementation of extended producer responsibility (EPR) schemes to assess prevention efforts (Kaza et al., 2018; UNEP, 2017). Based on these considerations, a set of five indicators is proposed under this pillar to balance analytical completeness with data availability and institutional feasibility at the provincial level.

Indicator B.1 Municipal Solid Waste Generation per Capita

Definition and rationale

Municipal solid waste (MSW) generation per capita measures the average quantity of waste generated by residents over a given period and is widely used as a proxy indicator for consumption patterns and waste prevention performance. Within a circular economy

framework, stabilisation or reduction in per capita waste generation is interpreted as progress toward waste prevention, improved product use efficiency, and more sustainable consumption behaviours. International experience consistently applies this indicator to assess upstream prevention efforts where direct measurement of avoided waste is not feasible (Kaza et al., 2018; OECD, 2019a; UNEP, 2025).

Calculation formula⁸

$$MSW \text{ Generation per Capita} = \frac{\text{Total Municipal Solid Waste Generated}}{\text{Population}}$$

Indicator B.2 Source Separation Coverage Rate

Definition and rationale

Source separation coverage rate measures the proportion of the population or service area covered by formal waste segregation systems at source. High coverage is a prerequisite for effective recycling and organic waste treatment, as mixed waste collection significantly reduces recovery efficiency and material quality (Sukholthaman and Sharp, 2016). International waste management literature consistently identifies source separation as a foundational enabling condition for circular waste management systems (Wilson et al., 2012; EEA, 2018; UN-Habitat, 2021).

Calculation formula⁹

$$\begin{aligned} \text{Source Separation Coverage (\%)} \\ = \frac{\text{Population Covered by Source Separation Services}}{\text{Total Population}} \times 100 \end{aligned}$$

Indicator B.3 Recycling Rate by Material Stream

Definition and rationale

Recycling rate by material stream measures the proportion of specific waste streams such as plastics, paper, metals, glass, or organic waste that are recycled rather than disposed. Disaggregating recycling performance by material type provides more actionable insights than aggregate recycling rates and supports targeted interventions for priority materials. International circular economy frameworks increasingly emphasise material-specific recycling indicators to improve policy effectiveness and resource recovery outcomes (OECD, 2025b; UNEP,

⁸ This indicator follows definitions used in global waste monitoring frameworks developed by the World Bank, OECD, and UNEP, where municipal solid waste generation per capita is applied as a standard proxy for waste prevention and consumption intensity (Kaza et al., 2018; OECD, 2019a).

⁹ This indicator is derived from integrated sustainable waste management frameworks and EU municipal waste monitoring practices, which emphasise source separation coverage as a key structural indicator for circular waste systems (EEA, 2018; Wilson et al., 2012).

2017; European Commission, 2020b).

Calculation formula¹⁰

$$\text{Recycling Rate (\%)} = \frac{\text{Recycled Waste by Material}}{\text{Total Waste Generated for that Material}} \times 100$$

Indicator B.4 Landfill Diversion Rate

Definition and rationale

Landfill diversion rate measures the share of total waste diverted from landfill through recycling, composting, anaerobic digestion, or energy recovery. It is widely applied as a headline indicator of progress away from linear disposal-based waste management systems toward circular material recovery pathways. International experience consistently uses landfill diversion as a core outcome indicator reflecting structural change in waste management systems (EEA, 2025; OECD, 2019a).

Calculation formula¹¹

$$\text{Landfill Diversion Rate (\%)} = \frac{\text{Waste Diverted from Landfill}}{\text{Total Waste Generated}} \times 100$$

Indicator B.5 Waste Prevention and Extended Producer Responsibility (EPR) Implementation

Definition and rationale

This indicator captures the presence, scope, and coverage of waste prevention and extended producer responsibility (EPR) measures at the provincial level, such as EPR schemes for packaging, electronics, batteries, or tyres; restrictions on single-use products; and incentives for reuse and refill systems. These measures represent upstream structural change and are widely recognised as essential for long-term waste prevention within circular economy strategies (OECD, 2024a; OECD, 2024b).

Calculation formula¹²

Qualitative Index

= *Score based on presence, coverage, and enforcement of prevention and EPR measures*

¹⁰ This indicator follows OECD, UNEP, and EU recommendations to measure recycling performance by material stream rather than aggregate waste flows, enabling more targeted circular economy policy responses (European Commission, 2020; OECD, 2025b).

¹¹ This indicator follows EU and OECD circular economy monitoring frameworks, which prioritise landfill diversion as a key indicator reflecting reduced dependence on final disposal (EEA, 2025; OECD, 2019a).

¹² International practice increasingly applies qualitative or composite indicators to capture waste prevention and EPR implementation, recognising that upstream policy impacts are not immediately reflected in waste quantity data (OECD, 2024a; OECD, 2024b).

Table 7 presents the proposed set of waste management and prevention indicators under Pillar B, designed to capture both system performance and structural change in provincial waste management systems from a circular economy perspective. The selected indicators address key dimensions of waste generation and prevention, source separation and collection performance, material-specific recycling outcomes, diversion of waste from landfill, and the upstream responsibility of producers through extended producer responsibility (EPR) schemes. Together, they provide an operational and policy-relevant framework for monitoring progress toward circular waste management objectives while remaining aligned with data availability and institutional capacities at the sub-national level. The table summarises the main data sources, monitoring frequency, target benchmarks, and key limitations associated with each indicator, thereby supporting transparent implementation and consistent interpretation across provinces.

Table 7. Waste Management and Prevention Indicators

Indicator		Data Sources and Collection Methods	Monitoring Frequency	Target Benchmarks	Limitations and Considerations
B.1	Municipal Solid Waste Generation per Capita	• Municipal waste collection records • Local government administrative data • Population statistics from national or provincial statistical offices.	Annual	• National waste reduction targets • Comparison with national or regional average MSW generation levels.	• Does not directly measure avoided waste. • Results may be influenced by population dynamics, tourism, or changes in reporting practices.
B.2	Source Separation Coverage Rate	• Municipal service coverage records • Waste management authority reports • Household service and infrastructure surveys.	Annual	• National waste segregation policies • Targets for household source separation coverage.	• Coverage does not necessarily reflect actual household compliance or quality of separation. • Contamination rates are not captured.
B.3	Recycling Rate by Material Stream	• Recycling facility records • Municipal waste composition studies • Extended producer responsibility (EPR) system reporting • Industry association data.	Annual	• National recycling targets • Material-specific recycling targets for priority waste streams.	• Data quality depends on reliable waste composition studies and reporting by recycling operators. • Informal recycling activities may be under-represented.
B.4	Landfill Diversion Rate	• Landfill and disposal facility records • Municipal waste flow reports • Treatment facility data.	Annual	• National landfill reduction or landfill diversion targets.	• Does not distinguish between high-value recycling and lower-value recovery options such as energy recovery. • Should be interpreted alongside recycling quality indicators.
B.5	Extended Producer	• National and provincial EPR registries	Annual to biennial	• Alignment with national EPR	• Coverage does not directly reflect effectiveness or enforcement of

Indicator		Data Sources and Collection Methods	Monitoring Frequency	Target Benchmarks	Limitations and Considerations
	Responsibility (EPR) Coverage Rate	- Regulatory and policy reviews - Reports from EPR authorities and producer responsibility organisations.		regulations Targets for coverage of priority product categories.	EPR schemes. Informal producers or non-compliant actors may not be fully captured.

Source: Compiled from OECD (2019a); OECD (2024a); OECD (2024b); EEA (2018); EEA (2025); UNEP (2017); Kaza et al. (2018); and UN-Habitat (2021).

5.3. Pillar C: Industrial Symbiosis and Eco-Industrial Parks

From a sub-national governance perspective, provinces play a critical enabling role in the development of industrial symbiosis and eco-industrial parks (EIPs) through land-use planning, infrastructure provision, environmental permitting, and co-ordination amongst park developers, enterprises, and service providers. As a result, indicators under this pillar are particularly well aligned with provincial mandates and investment decisions, making them a strategic component of sub-national circular economy monitoring systems (OECD, 2020; UNIDO, World Bank, and GIZ, 2021; World Bank, 2025a).

International experience demonstrates that successful industrial symbiosis initiatives typically evolve incrementally. Initial stages often focus on improving resource efficiency within individual firms, followed by the introduction of shared services and utilities, and eventually by more complex exchanges of materials, energy, and by-products across enterprises. Indicator frameworks must therefore be capable of capturing both readiness (institutional arrangements, participation, and infrastructure) and performance (actual resource and material exchanges), rather than focusing exclusively on mature exchange outcomes (ERIA, 2020; OECD, 2020; Henriques et al., 2021).

At the provincial level, industrial symbiosis and EIP indicators generally address four interrelated analytical dimensions: participation and coverage, resource and utility efficiency, material exchange and by-product utilisation, and governance and co-ordination mechanisms (Fraccascia, Giannoccaro, and Albino, 2021; Henriques et al., 2021). Based on these dimensions, a set of five indicators is proposed to balance analytical completeness with data availability and implementation feasibility.

Indicator C.1 Eco-Industrial Park (EIP) Coverage Rate

Definition and rationale

EIP coverage rate measures the proportion of industrial parks within a province that have formally adopted eco-industrial park principles or are participating in recognised EIP or industrial symbiosis programmes. This indicator reflects the breadth of adoption of circular economy practices in industrial areas and provides a high-level measure of policy uptake and institutional readiness (UNIDO, World Bank, and GIZ, 2021; van Beers et al., 2020).

Calculation formula¹³

$$\text{EIP Coverage Rate (\%)} = \frac{\text{Number of EIPs or Participating Industrial Parks}}{\text{Total Number of Industrial Parks}} \times 100$$

¹³ This indicator follows international EIP monitoring practices developed by UNIDO, World Bank Group, and GIZ which emphasise park-level participation as a key readiness indicator for industrial symbiosis implementation (UNIDO, World Bank, and GIZ, 2021; van Beers et al., 2020).

Indicator C.2 Industrial Symbiosis Participation Rate

Definition and rationale

Industrial symbiosis participation rate measures the proportion of enterprises within industrial parks that actively engage in symbiotic activities, such as shared utilities, by-product exchanges, or joint waste and resource management initiatives. This indicator reflects the level of enterprise engagement and collaboration, which is critical for the success of industrial symbiosis systems (OECD, 2020; UNIDO, World Bank, and GIZ, 2021; Lippi et al., 2025).

Calculation formula¹⁴

$$\text{Participation Rate (\%)} = \frac{\text{Enterprises Participating in Symbiosis}}{\text{Total Enterprises in Industrial Parks}} \times 100$$

Indicator C.3 Shared Utility and Resource Efficiency Rate

Definition and rationale

This indicator measures the extent to which shared infrastructure such as energy systems, water supply, wastewater treatment, or waste management facilities is utilised within industrial parks. Shared utilities are a foundational component of eco-industrial development, enabling efficiency gains, cost reduction, and lower environmental impacts (Chertow, 2000; UNIDO, World Bank, and GIZ, 2021; Ramin et al., 2024; World Bank, 2025a).

Calculation formula¹⁵

$$\text{Shared Utility Coverage (\%)} = \frac{\text{Industrial Parks with Shared Utilities}}{\text{Total Industrial Parks}} \times 100$$

Indicator C.4 By-Product and Material Exchange Rate

Definition and rationale

By-product and material exchange rate measures the proportion of industrial by-products or waste materials that are reused as inputs by other enterprises within or across industrial parks. This indicator directly reflects the core principle of industrial symbiosis, closing material loops and reducing waste generation (OECD, 2020; Chertow, 2007; ERIA, 2020).

Calculation formula¹⁶

¹⁴ Participation-based indicators are widely used in OECD and UNIDO assessments to capture the extent of enterprise engagement beyond formal policy adoption (OECD, 2020; UNIDO, World Bank, and GIZ, 2021; Lippi et al., 2025).

¹⁵ UNIDO identifies shared utility systems as a core performance area for EIP monitoring, particularly in early and intermediate stages of development (UNIDO, World Bank, and GIZ, 2021).

¹⁶ Material exchange indicators are widely recognised in industrial symbiosis literature and OECD circular

$$\text{Material Exchange Rate (\%)} = \frac{\text{By-products Reused or Exchanged}}{\text{Total By-products Generated}} \times 100$$

Indicator C.5 Industrial Symbiosis Project Implementation Rate

Definition and rationale

This indicator measures the proportion of planned or identified industrial symbiosis projects that have been implemented within industrial parks or industrial zones. It reflects the transition from planning and facilitation to tangible circular economy outcomes and provides a practical measure of implementation effectiveness at the provincial level (Neves et al., 2019; Castellet-Viciano et al., 2022; UNIDO, World Bank, and GIZ, 2021).

Calculation formula¹⁷

$$\text{Implementation Rate (\%)} = \frac{\text{Number of Implemented Symbiosis Projects}}{\text{Number of Planned or Identified Projects}} \times 100$$

Table 8 presents the illustrative set of indicators for industrial symbiosis and eco-industrial park development under Pillar C, designed to capture both institutional readiness and performance outcomes at the provincial level. The selected indicators address the coverage of eco-industrial parks, enterprise participation in symbiotic activities, implementation of shared utilities and resource-efficient infrastructure, the extent of by-product and material exchanges, and the rate of implementation of identified industrial symbiosis projects. Together, these indicators provide a balanced and operational framework for monitoring the progressive development of industrial symbiosis, reflecting its typically incremental evolution from policy adoption and co-ordination toward tangible circular economy outcomes. The table summarises the key data sources, monitoring frequency, target benchmarks, and limitations associated with each indicator, supporting transparent implementation and consistent interpretation across provinces.

economy monitoring frameworks as key outcome indicators of symbiotic performance (Chertow, 2007; OECD, 2020; ERIA, 2020).

¹⁷ OECD and UNIDO assessments of industrial symbiosis emphasise tracking implemented exchanges and projects as a key indicator of programme effectiveness, particularly at sub-national and park levels (Neves et al., 2019; Castellet-Viciano et al., 2022; UNIDO, World Bank, and GIZ, 2021).

Table 8. Industrial Symbiosis and Eco-Industrial Parks Indicators

Indicator		Data Sources and Collection Methods	Monitoring Frequency	Target Benchmarks	Limitations and Considerations
C.1	Eco-Industrial Park (EIP) Coverage Rate	- Provincial industrial park registries EIP programme records - Administrative data from industry and investment promotion agencies.	Annual to biennial	- National EIP development targets - International EIP programme benchmarks.	- Formal designation does not necessarily reflect depth or effectiveness of symbiotic practices. - Outcome-based indicators are required for performance assessment.
C.2	Industrial Symbiosis Participation Rate	- Industrial park management records - Enterprise surveys - Programme participation reports.	Annual to biennial	National circular economy or industrial symbiosis participation targets.	- Participation does not indicate scale or environmental significance of exchanges. - Confidentiality concerns may limit enterprise-level reporting.
C.3	Shared Utility and Resource Efficiency Coverage	- Industrial park infrastructure records - Utility service providers - Park management authorities.	Annual	- National EIP guidelines - International eco-industrial park performance benchmarks.	- Does not directly measure efficiency improvements or emission reductions. - Additional technical assessments may be required.
C.4	By-Product and Material Exchange Rate	- Enterprise material flow reporting Industrial waste records - Industrial park management data.	Annual	- National circular economy targets - Sector-specific material recovery benchmarks.	- Accurate measurement depends on enterprise-level reporting and clear definitions of by-products. - Data availability may be constrained by confidentiality concerns.

Indicator		Data Sources and Collection Methods	Monitoring Frequency	Target Benchmarks	Limitations and Considerations
C.5	Industrial Symbiosis Project Implementation Rate	- Industrial park development plans - Programme monitoring reports - Park management records - Enterprise surveys.	Annual to biennial	- National industrial symbiosis or EIP programme targets - Project implementation milestones.	- Definitions of 'planned' versus 'implemented' projects must be clearly specified. - Project counts do not capture differences in scale or environmental impact.

Source: Compiled from OECD (2020); UNIDO, World Bank, and GIZ (2021); World Bank (2025a); and Chertow (2007).

5.4. Pillar D: Sustainable Consumption and Production

From an analytical perspective, sustainable consumption and production (SCP) within a circular economy framework shifts the focus from managing waste after consumption toward reducing material intensity, extending product lifetimes, and increasing demand for circular and environmentally preferable products (Upadhayay et al., 2024). At the sub-national level, SCP indicators are particularly important because provinces influence both production practices through regulation, permitting, and industrial support, and consumption patterns, notably through public procurement, urban services, and market facilitation (OECD, 2020).

International SCP frameworks commonly distinguish three interrelated domains relevant for sub-national monitoring: sustainable production practices, sustainable consumption patterns, and public sector leadership. Green public procurement (GPP) is widely recognised as one of the most effective SCP instruments available to sub-national governments, as it directly links policy objectives with purchasing decisions and budget allocation. International experience demonstrates that GPP can accelerate the uptake of recycled materials, energy-efficient products, and environmentally preferable services, while also supporting domestic circular industries (OECD, 2015; European Commission, 2016; UNEP, 2022).

Beyond procurement, SCP monitoring increasingly relies on proxy indicators to capture changes in consumption behaviour, such as the availability of reusable or sustainable products and the uptake of environmental certification schemes, recognising that direct measurement of consumer behaviour remains challenging (EEA, 2019). Based on these considerations, five indicators are proposed to capture SCP performance at the provincial level in a manner that is both policy-relevant and operationally feasible.

Indicator D.1 Green Public Procurement (GPP) Share

Definition and rationale

Green public procurement share measures the proportion of public procurement expenditure that meets defined environmental or circular economy criteria. GPP is a key SCP instrument at the sub-national level, as public authorities are major purchasers of goods and services and can use procurement to create stable demand for circular products and services (OECD, 2015; UNEP, 2022; Casier and Bechauf, 2022).

Calculation formula¹⁸

$$GPP\ Share\ (\%) = \frac{Value\ of\ Green\ Public\ Procurement}{Total\ Public\ Procurement\ Expenditure} \times 100$$

¹⁸ This indicator follows OECD and EU guidance on monitoring green public procurement, which recommend expenditure-based measures to assess the scale and impact of GPP implementation (OECD, 2015; European Commission, 2016; Casier and Bechauf, 2022).

Indicator D.2 Adoption of Cleaner Production and Resource-Efficient Practices

Definition and rationale

This indicator measures the proportion of industrial or commercial facilities adopting cleaner production or resource-efficient practices, such as energy efficiency measures, waste minimisation, or eco-design. Cleaner production is a core SCP strategy that reduces environmental impacts at source and supports circular production systems (UNEP, 2017; OECD, 2018).

Calculation formula¹⁹

$$\begin{aligned} & \text{Cleaner Production Adoption Rate (\%)} \\ &= \frac{\text{Facilities Implementing Cleaner Production Measures}}{\text{Total Facilities}} \times 100 \end{aligned}$$

Indicator D.3 Availability of Sustainable and Reusable Products

Definition and rationale

This indicator captures the proportion of retail outlets or service providers offering sustainable, reusable, or environmentally preferable products, such as reusable packaging, refill systems, or certified eco-products. It serves as a proxy for sustainable consumption opportunities at the local level, recognising that consumer behaviour is shaped by availability and accessibility (EEA, 2019; UNEP, 2022).

Calculation formula²⁰

$$\text{Availability Rate (\%)} = \frac{\text{Retail Outlets Offering Sustainable Options}}{\text{Total Retail Outlets Surveyed}} \times 100$$

Indicator D.4 Share of Certified Green Buildings and Services

Definition and rationale

This indicator measures the proportion of buildings or services certified under recognised environmental or sustainability standards. Certification schemes provide a practical proxy for SCP implementation, particularly in construction, tourism, and service sectors where material and energy intensity are significant (European Commission, 2016; EEA, 2019; Global Real Estate Sustainability Benchmark [GRESB], 2024).

¹⁹ UNEP and OECD SCP frameworks emphasise the use of adoption-based indicators to track diffusion of cleaner production practices where detailed performance data are not available (OECD, 2018; UNEP, 2017).

²⁰ International SCP monitoring practices increasingly rely on availability-based proxy indicators to assess sustainable consumption trends at sub-national and city levels (EEA, 2019; UNEP, 2022).

Calculation formula²¹

$$\text{Certification Share (\%)} = \frac{\text{Certified Green Buildings or Services}}{\text{Total Buildings or Services}} \times 100$$

Indicator D.5 Circular Procurement Coverage

Definition and rationale

Circular procurement coverage measures the proportion of public procurement processes or expenditure that incorporate circular economy criteria, such as durability, reparability, reuse, recycled content, take-back schemes, or product-as-a-service models. Within a sustainable consumption and production framework, circular procurement extends beyond conventional green public procurement by explicitly targeting material circularity and value retention across product life cycles (European Investment Bank, 2025). International experience demonstrates that circular procurement can accelerate the diffusion of circular business models, support local circular industries, and reduce lifecycle environmental impacts of public spending (OECD, 2015; European Commission, 2016; UNEP, 2022; European Investment Bank, 2025).

Calculation formula²²

$$\begin{aligned} &\text{Circular Procurement Coverage} \\ &= \frac{\text{Procurement contracts or expenditure with circular criteria}}{\text{Total public procurement contracts or expenditure}} \times 100 \end{aligned}$$

Table 9 presents the proposed set of sustainable consumption and production indicators under Pillar D, designed to capture both demand-side and supply-side dimensions of circular economy implementation at the provincial level. The selected indicators address public sector leadership through green and circular procurement, adoption of cleaner production and resource-efficient practices by enterprises, availability of sustainable and reusable products in local markets, and uptake of environmental certification in buildings and services. Together, these indicators provide a practical and policy-relevant framework for monitoring SCP progress, recognising the significant role of sub-national authorities in shaping production practices, market conditions, and consumption opportunities. The table summarises the key data sources, monitoring frequency, target benchmarks, and limitations associated with each indicator, supporting transparent implementation and consistent interpretation across provinces.

²¹ EU and international SCP frameworks recognise certification uptake as a proxy indicator for sustainable production and consumption in sectors where direct performance measurement is complex (European Commission, 2016; EEA, 2019; GRESB, 2024).

²² This indicator is derived from OECD and EU guidance on sustainable and circular public procurement, which recommend tracking the share of procurement incorporating lifecycle, reuse, and circularity criteria as a practical measure of SCP implementation (OECD, 2015; European Commission, 2016; UNEP, 2022; European Investment Bank, 2025).

Table 9. Sustainable Consumption and Production Indicators

Indicator		Data Sources and Collection Methods	Monitoring Frequency	Target Benchmarks	Limitations and Considerations
D.1	Green Public Procurement (GPP) Share	- Public procurement records - Government financial management systems - Procurement authority reports.	Annual	- National GPP targets - Alignment with national SCP and circular economy strategies.	- Requires consistent definitions of 'green' procurement. - Differences in procurement classification may affect comparability.
D.2	Adoption of Cleaner Production and Resource-Efficient Practices	- Industrial surveys - Environmental permitting records - Cleaner production programme reports.	Annual to biennial	National cleaner production and industrial efficiency targets.	- Adoption does not necessarily reflect the scale of environmental benefits achieved. - Self-reported data may affect reliability.
D.3	Availability of Sustainable and Reusable Products	- Retail and commercial surveys - Business association data - Local market assessments.	Biennial	- Local or national SCP objectives - Sector-specific targets where available.	- Does not directly measure consumer purchasing behaviour. - Survey coverage and methodology influence results.
D.4	Share of Certified Green Buildings and Services	- Certification bodies - Construction and tourism authorities - Administrative registries.	Annual to biennial	National green building or sustainable tourism targets.	- Certification schemes vary in scope and strictness. - Uptake may be influenced by market incentives rather than performance alone.
D.5	Circular Procurement Coverage	- Public procurement databases - Financial management	Annual	National circular or sustainable procurement targets	- Requires standardised definitions of circular procurement criteria. - Differences in reporting practices

Indicator		Data Sources and Collection Methods	Monitoring Frequency	Target Benchmarks	Limitations and Considerations
		systems ● Procurement authority reports ● Contract reviews.		● SCP strategy benchmarks.	may affect cross-provincial comparability.

Source: Compiled from OECD (2015); European Commission (2016); EEA (2019); UNEP (2017); and UNEP (2022).

5.5. Pillar E: Circular Business Models and Innovation

Circular business models and innovation are central to operationalising the circular economy at the sub-national level, as they translate policy objectives into market-based solutions, new services, and value creation opportunities (OECD, 2019c). International literature identifies several circular business model archetypes that are particularly relevant at provincial and city scales. These include product life extension models such as repair, refurbishment, and remanufacturing; sharing and service-based models that reduce demand for new material production; resource recovery and recycling models that transform waste streams into secondary materials; and local circular supply chains that shorten value chains, reduce transport intensity, and strengthen regional economies (Bocken et al., 2016; Laukkanen, Tura, and Kähkönen, 2026).

From a monitoring perspective, circular business models and innovation present specific challenges. Unlike waste quantities or resource consumption, innovation outcomes are heterogeneous, context-dependent, and often qualitative, making them difficult to measure through single output-based indicators. As a result, international practice increasingly relies on proxy, structural, and activity-based indicators such as the number of circular enterprises, pilot projects, technology adoption, and public support mechanisms rather than attempting to directly quantify innovation outputs or economic value creation (OECD, 2020; Díaz Duarte, Puron-Cid, and Rivera Martinez, 2025).

At the provincial level, indicators under this pillar therefore focus on market participation, enabling policy and financial frameworks, technology diffusion, and experimentation through pilot and demonstration initiatives (OECD, 2020). Based on international experience and data feasibility considerations, five indicators are proposed to capture both the scale and maturity of circular business models and innovation ecosystems.

Indicator E.1 Share of Circular Economy Enterprises

Definition and rationale

This indicator measures the proportion of enterprises engaged in circular economy activities, such as repair, reuse, refurbishment, remanufacturing, recycling, and circular services. It reflects the penetration of circular business models within the local economy and provides a structural proxy for market transformation toward circularity (Bocken et al., 2016; OECD, 2019c).

Calculation formula²³

$$\text{Share of Circular Enterprises (\%)} = \frac{\text{Number of Circular Economy Enterprises}}{\text{Total Number of Enterprises}} \times 100$$

Indicator E.2 Adoption of Product Life Extension Services

Definition and rationale

This indicator measures the availability or uptake of services that extend product lifetimes, including repair, refurbishment, and remanufacturing. Product life extension is a core circular business model that retains value in existing products and reduces demand for virgin materials and new production (Circular Innovation Council. (n.d.); OECD, 2019c).

Calculation formula²⁴

$$\begin{aligned} \text{Life Extension Adoption Rate (\%)} \\ = \frac{\text{Enterprises Offering Life Extension Services}}{\text{Total Relevant Enterprises}} \times 100 \end{aligned}$$

Indicator E.3 Circular Business Model Adoption Rate

Definition and rationale

This indicator measures the proportion of enterprises that have adopted circular business models, such as repair and refurbishment services, product-as-a-service models, sharing platforms, remanufacturing, or resource recovery activities. Adoption of circular business models reflects the transition from experimentation to market uptake and provides a more direct signal of circular economy integration into local economic systems than pilot or demonstration activities alone. International experience highlights business model adoption as a critical step in scaling circular innovation and achieving sustained economic and environmental benefits (OECD, 2019c; Groot et al., 2019).

²³ OECD assessments commonly use enterprise-based indicators to capture the scale of circular business activity, recognising limitations in measuring innovation outputs directly (OECD, 2019c; OECD, 2020).

²⁴ International circular economy frameworks identify life extension services as priority business models and recommend adoption-based indicators where performance data are limited (OECD, 2019c).

Calculation formula²⁵

$$\text{Model Adoption Rate (\%)} = \frac{\text{Enterprises Applying Circular Business Models}}{\text{Total Relevant Enterprises}} \times 100$$

Indicator E.4 Technology Adoption in Circular Activities

Definition and rationale

This indicator captures the adoption of technologies supporting circular economy activities, such as recycling technologies, material recovery systems, digital platforms for sharing or traceability, and cleaner production technologies. Technology adoption is a key enabler of circular business models and innovation diffusion (Sánchez-García et al., 2024; InvestCEC, 2025).

Calculation formula²⁶

$$\text{Technology Adoption Rate (\%)} = \frac{\text{Enterprises Using Circular Technologies}}{\text{Total Relevant Enterprises}} \times 100$$

Indicator E.5 Circular Business Survival and Scaling Rate

Definition and rationale

This indicator measures the proportion of circular economy enterprises that remain operational and demonstrate growth over a defined period. Survival and scaling rates provide a more outcome-oriented measure of circular business and innovation success than financial inputs alone, reflecting whether enabling policies, market conditions, and support mechanisms translate into durable and competitive circular enterprises. International innovation and SME literature increasingly emphasises business survival and growth as key indicators of ecosystem effectiveness and innovation maturity (Ellen MacArthur Foundation, 2015; Dreyer et al., 2020).

²⁵ OECD circular economy and innovation frameworks increasingly recommend adoption-based indicators to capture the diffusion and scaling of circular solutions, recognising that pilot project counts alone do not reflect systemic change or market penetration (OECD, 2019c; Groot et al., 2019).

²⁶ International practice increasingly uses technology adoption indicators as proxies for innovation diffusion in contexts where R&D output data are limited (Sánchez-García et al., 2024; InvestCEC, 2025).

Calculation formula²⁷

Survival and Scaling Rate (%)

$$= \frac{\text{Circular enterprises operating and growing after a defined period}}{\text{Total circular enterprises established in the base year}} \times 100$$

Table 10 presents the proposed set of indicators for circular business models and innovation under Pillar E, designed to capture the scale, adoption, and maturity of circular economic activities. While conceptually applicable across governance levels, they are operationalised here for provincial level monitoring. The selected indicators address market participation of circular enterprises, uptake of product life-extension services, diffusion of circular business models and enabling technologies, and the survival and scaling of circular businesses over time. Together, these indicators provide an outcome-oriented and policy-relevant framework for monitoring how circular economy strategies translate into sustained business activity, innovation diffusion, and local economic transformation. The table also summarises key data sources, monitoring frequency - biennially or annually, target benchmarks, and limitations for each indicator, supporting consistent implementation and interpretation across provinces.

²⁷ Innovation and SME frameworks recommend survival and growth indicators as robust proxies for innovation ecosystem performance, recognising that financial inputs or programme counts do not necessarily result in sustainable market outcomes (Ellen MacArthur Foundation, 2015; Dreyer et al., 2020).

Table 10. Circular Business Models and Innovation Indicators

Indicator		Data Sources and Collection Methods	Monitoring Frequency	Target Benchmarks	Limitations and Considerations
E.1	Share of Circular Economy Enterprises	● Business registries ● Sectoral classifications ● Enterprise surveys ● Chambers of commerce and industry associations.	Annual to biennial	● National circular economy strategies ● SME development and innovation targets.	● Requires clear criteria for classifying 'circular' enterprises. ● Informal businesses may not be fully captured.
E.2	Adoption of Product Life Extension Services	● Business and service registries ● Enterprise surveys ● Trade and industry associations	Biennial	● National circular economy and waste prevention targets ● Sector-specific benchmarks.	● Does not capture service quality or scale. ● Data collection may require targeted surveys.
E.3	Circular Business Model Adoption Rate	● Enterprise surveys; business registries ● Programme monitoring reports ● Chambers of commerce and industry associations.	Biennial	● National circular economy strategies ● SME and innovation policy targets.	● Requires consistent definitions of circular business models. ● Self-reported data may affect reliability.
E.4	Technology Adoption in Circular Activities	● Enterprise surveys ● Technology programme records ● Industrial permitting and compliance data.	Biennial	● National innovation, digitalisation, and industrial modernisation targets.	● Adoption does not guarantee effective or optimal use. ● Technology scope must be clearly defined.
E.5	Circular Business Survival and Scaling Rate	● Business registries; tax and employment records ● Enterprise surveys ● SME and innovation agency databases.	Biennial	● National SME development, innovation, and circular economy targets.	● Requires longitudinal data and consistent enterprise definitions. ● External economic factors may influence survival independently of circular economy policies.

Source: Compiled from OECD (2019c); OECD (2020); and Ellen MacArthur Foundation (2015).

5.6. Pillar F: Social and Economic Co-Benefits

From an economic perspective, circular economy implementation can enhance provincial competitiveness and resilience by reducing dependence on imported raw materials, stabilising material supply chains, and stimulating local markets for secondary materials and circular services. International evidence indicates that regions adopting circular practices often retain greater value within local economies, improve productivity, and attract green investment, particularly in resource-intensive and waste-related sectors (OECD, 2020; European Commission, 2020b).

Social co-benefits are especially pronounced in waste-related circular activities, where labour-intensive processes such as collection, sorting, repair, and recycling generate employment opportunities, including for low-skilled and informal workers. Integrating informal actors into formal circular economy systems through improved working conditions, service contracts, and access to social protection has been identified as a key determinant of inclusive and effective circular transitions in developing and emerging economies (Wilson et al., 2012; Van Opstal et al., 2024). At the provincial level, authorities play a critical role in enabling these outcomes through the implementation of regulatory frameworks, driving targeted investment decisions, and local economic development programmes.

Monitoring social and economic co-benefits is inherently more complex than tracking physical material flows. As a result, international practice relies on outcome-oriented and proxy indicators that capture employment, income generation, investment mobilisation, and productivity effects associated with circular economy activities. While such indicators do not fully capture distributional impacts, they provide robust signals of whether circular economy implementation contributes to broader economic and social development objectives (Moraga et al., 2019; Sustainability Directory, 2025). Based on data feasibility and international practice, five quantitative indicators are proposed under this pillar.

Indicator F.1 Employment in Circular Economy Sectors

Definition and rationale

This indicator measures the share of employment in circular economy sectors, such as recycling, repair, reuse, remanufacturing, and circular services. Employment generation is a core economic and social benefit of circular economy implementation, particularly in waste-related and service-oriented activities (OECD, 2019a; Circle Economy, ILO, and World Bank, 2025).

Calculation formula²⁸

$$\text{Circular Employment Share (\%)} = \frac{\text{Employment in Circular Economy Sectors}}{\text{Total Employment}} \times 100$$

Indicator F.2 Value Added from Circular Economy Activities

Definition and rationale

This indicator measures the economic value-added generated by circular economy activities, reflecting their contribution to provincial gross regional product (GRP). Value-added indicators capture productivity and value retention effects associated with circular business models (Ellen MacArthur Foundation, 2023; OECD, 2025c).

Calculation formula²⁹

$$\text{Circular Value Added Share (\%)} = \frac{\text{Value Added from Circular Activities}}{\text{Gross Regional Product (GRP)}} \times 100$$

Indicator F.3 Public and Private Investment in Circular Economy

Definition and rationale

This indicator measures the total volume of public and private investment mobilised for circular economy activities, including infrastructure, enterprises, and innovation. Investment levels provide a proxy for market confidence and long-term commitment to circular transitions (Muñoz H. et al., 2022; OECD, 2024c).

Calculation formula³⁰

$$\text{Circular Investment Intensity} = \frac{\text{Public} + \text{Private Circular Economy Investment}}{\text{Gross Regional Product (GRP)}}$$

Indicator F.4 Productivity of Circular Economy Sectors

Definition and rationale

This indicator measures labour productivity in circular economy sectors, providing insight into economic efficiency and value creation potential. Productivity gains are critical for

²⁸ OECD and EU circular economy monitoring frameworks recommend employment-based indicators to assess labour market impacts and inclusive growth outcomes of circular transitions (OECD, 2019a; Circle Economy, ILO, and World Bank, 2025).

²⁹ International circular economy assessments recommend value-added indicators to complement employment measures and capture economic performance beyond activity counts (Ellen MacArthur Foundation, 2023; OECD, 2025c).

³⁰ OECD and EU monitoring frameworks use investment indicators to assess the enabling environment and financial commitment to circular economy development (Muñoz H. et al., 2022; OECD, 2024c).

sustaining employment growth and competitiveness in circular activities (Eurostat, 2024).

Calculation formula³¹

$$\text{Circular Sector Productivity} = \frac{\text{Value Added from Circular Activities}}{\text{Employment in Circular Economy Sectors}}$$

Indicator F.5 Formalisation Rate of Waste-Related Employment

Definition and rationale

This indicator measures the proportion of waste-related workers operating within formal employment arrangements, reflecting social inclusion and improved working conditions. Formalisation of informal workers is widely recognised as a key social outcome of inclusive circular economy transitions (Wilson et al., 2012; ILO, 2022; Circle Economy, ILO, and World Bank, 2025).

Calculation formula³²

$$\text{Formalisation Rate (\%)} = \frac{\text{Formally Employed Waste Workers}}{\text{Total Waste – Related Workers}} \times 100$$

Table 11 presents the proposed set of social and economic co-benefit indicators under Pillar F, designed to assess how circular economy implementation contributes to broader development outcomes at the provincial level. The selected indicators capture employment generation in circular economy sectors, value added and productivity effects, mobilisation of public and private investment, and the formalisation of waste-related employment. Together, these indicators provide an outcome-oriented framework for monitoring the economic competitiveness, resilience, and social inclusion impacts of circular economy strategies, complementing the physical and operational indicators presented in preceding sections. The table summarises the key data sources, monitoring frequency, target benchmarks, and limitations associated with each indicator, supporting transparent and consistent interpretation across provinces.

³¹ EU productivity analysis frameworks support the use of sector-specific productivity indicators to assess economic performance and competitiveness (Eurostat, 2024).

³² International waste and circular economy literature recommends formalisation indicators to assess social inclusion and labour protection outcomes in waste-related circular systems (Wilson et al., 2012; ILO, 2022; Circle Economy, ILO, and World Bank, 2025).

Table 11. Social and Economic Co-Benefits Indicators

Indicator		Data Sources and Collection Methods	Monitoring Frequency	Target Benchmarks	Limitations and Considerations
F.1	Employment in Circular Economy Sectors	• Labour force surveys • Employment registries • Sectoral statistics from national or provincial statistical offices.	Annual	• National green jobs or circular economy employment targets.	• Requires clear sectoral classification of circular activities. • Informal employment may be under-represented.
F.2	Value Added from Circular Economy Activities	• Regional accounts • Sectoral economic statistics • Enterprise surveys.	Annual to biennial	• National circular economy contribution targets • Regional economic development objectives.	• Disaggregation of circular activities may be challenging in conventional accounting systems.
F.3	Public and Private Investment in Circular Economy	• Public budget and expenditure reports • Investment promotion agency data • Financial sector statistics.	Annual	• National green or circular economy investment targets • Financing strategies.	• Investment attribution to circular activities may require clear classification rules. • Data may be fragmented across institutions.
F.4	Productivity of Circular Economy Sectors	• Regional accounts • Labour statistics • Enterprise surveys.	Annual to biennial	• National productivity growth targets • Sector-specific performance benchmarks.	• Data availability may be limited for SMEs and informal activities.
F.5	Formalisation Rate of Waste-Related Employment	• Labour force surveys • Municipal service contracts • Social security and employment registries.	Annual to biennial	• National labour formalisation and social protection targets.	• Estimation of informal employment remains challenging. • Specialised surveys may be required for accuracy.

Source: Compiled from OECD (2019a); OECD (2024c); OECD (2025c); Eurostat (2024); and Circle Economy, ILO, and World Bank, (2025).

6. Regional Stakeholder Perspectives

6.1. Government Roles and Responsibilities

ASEAN faces common systemic barriers: fragmented policy frameworks, weak enforcement, poor data collection, and over-reliance on landfilling. Although the informal sector contributes significantly to recycling, it remains excluded from formal policy frameworks, reducing traceability and efficiency (Hoang et al., 2020; Tie et al., 2023). The role of government is crucial in these areas, and the roles and initiatives of government actors need to be critically reviewed. Across sectors, institutional fragmentation across ministries further slows progress. Collaboration amongst academia, industry, and policymakers is also essential to expand research and scale pilot projects into national systems. Different sectors show varying circular adaptation pathways.

For instance, ASEAN countries are adopting circular economy practices in construction at different rates, with trends including increased use of RCA (Building and Construction Authority [BCA], 2024), promotion of renewable materials such as bamboo in sustainable construction (Bandyopadhyay, 2024), innovations such as plastic-asphalt roads in Thailand (Dow Thailand, 2018), and exploration of carbon capture and storage (CCS) and renewable energy technologies within the sector (IEA, 2022). At the regional level, harmonised construction and demolition (C&D) waste policies and green public procurement mechanisms have been identified as key instruments to stimulate markets for recycled construction materials (OECD, 2019a; European Commission, 2020a). With co-ordinated action, C&D waste can shift from being an environmental burden to becoming a foundation of ASEAN's circular economy transition.

Furthermore, governance fragmentation across ministries of health, environment, and local governments leads to inconsistent enforcement and overlapping responsibilities (Kühling and Pieper, 2012). For pharmaceuticals, the absence of harmonised regional enforcement and structured take-back schemes contributes to unsafe disposal through landfills, sewage, or open burning, with active pharmaceutical ingredients (APIs) detected in rivers and soils across Asia (Wilkinson et al., 2022; Sapkota and Pariatamby, 2023). Moreover, although the ASEAN Pharmaceutical Regulatory Framework (APRF) has been adopted to strengthen standards and co-operation, it remains focused on regulatory convergence rather than waste or end-of-life management (ASEAN Secretariat, 2023).

Design and product-level challenges persist, as most medical devices and packaging are not designed for reuse, repair, or recycling, creating structural barriers to CE adoption (Hoveling et al., 2024). Specifically, within the pharmaceutical industry, Sapkota and Pariatamby (2025) argue that harmonising pharmaceutical waste legislation across ASEAN would enable co-ordinated regional action by improving both safety and sustainability. At a broader level, the APRF provides an institutional anchor that can be expanded to incorporate eco-design, traceability, and EPR requirements (ASEAN Secretariat, 2023).

Finally, regional alignment through the ASEAN Framework for CE and the CE Stakeholder Platform can lead to harmonising definitions across sectors and waste types, create cross-border markets, and attract foreign investment to scale solutions (ASEAN Secretariat, 2021; Herrador and Van, 2024).

6.2. Business and Industry Engagement

Strong involvement of the private sector is needed, especially in emerging sectors where the sole government intervention may not be sufficient. Often, the challenges need multistakeholder dialogue and negotiation. For instance, the barriers to circularity in ASEAN plastic waste management are multifaceted. Collection coverage remains uneven, with urban centres such as Singapore and Kuala Lumpur approaching universal service while peri-urban and rural areas in Indonesia, Cambodia, and the Philippines remain underserved (World Bank, 2022c).

Second, limited treatment infrastructure outside urban centres restricts access to environmentally sound technologies such as autoclaves and microwaves, with rural areas continuing to rely on open burning or rudimentary incinerators (UNDP, 2023). In such cases, businesses can innovate and create economically sustainable circular economy business models. For instance, across ASEAN within the healthcare waste (HCW) sector, there is a general trend toward private sector ownership and operation of specialised treatment facilities such as high-temperature incinerators and autoclaves.

In Malaysia, healthcare waste is managed by licensed private contractors under Department of Environment (DOE) regulation (e.g. Kualiti Alam). In Thailand and Viet Nam, private operators manage incineration and autoclave facilities under contract with provincial or municipal governments. Even in Singapore, licensed private companies carry out collection and treatment under NEA regulation. This reflects a wider model where governments retain regulatory authority, but treatment infrastructure is largely privatised through concession agreements, PPPs, or licensed contracts.

The construction industry has witnessed similar innovations. SCG and Dow, in collaboration with the Bangkok Metropolitan Administration, have piloted recycled plastic roads where construction aggregates are blended with shredded plastic waste to increase durability and extend road lifespan (Dow Thailand, 2018). In Viet Nam, pilot programmes in Hanoi and Ho Chi Minh City employ RCA in sidewalks and sub-base layers, showing growing momentum for reuse in urban infrastructure (Lockrey et al., 2016; Hoang et al., 2020). Figure 12 illustrates the ASEAN CE Strategies and Pathways, highlighting the complementary roles of business-led and government-led initiatives in driving CE development through collaboration, innovation, regulation, and policy support.

Figure 12. ASEAN Circular Economy (CE) Strategies and Pathways Showing the Interplay between Business-Led and Government-Led Initiatives in Advancing Circular Economy Goals across the Region



Source: Authors.

6.3. Business and Industry Industry-Led Circular Economy Practices in Viet Nam

6.3.1. Industry-Led Extended Producer Responsibility

To illustrate how business-led co-ordination mechanisms can operationalise extended producer responsibility and support national circular economy objectives, Text Box 2 presents the case of Packaging Recycling Organization (PRO) Viet Nam. This example highlights how collective industry action can complement regulatory frameworks by mobilising private finance, strengthening recycling markets, and improving traceability of packaging waste streams.

Text Box 2. Industry-Led Extended Producer Responsibility through PRO Vietnam

Viet Nam has taken a significant step toward business-led circular economy implementation through the establishment of **PRO Vietnam**, an industry-led Producer Responsibility Organisation created to support compliance with the country's Extended Producer Responsibility (EPR) framework under the Law on Environmental Protection (2020)³³. PRO Vietnam brings together major producers and importers of packaging, including companies in the food, beverage, and consumer goods sectors, to collectively fulfil EPR obligations related to packaging waste collection, recycling, and treatment.

Under this model, businesses pool financial resources and co-ordinate with recyclers, waste service providers, and informal collectors to improve material recovery rates and strengthen domestic recycling markets. The approach reduces transaction costs for individual firms while enabling scale in recycling investments and operational efficiency. PRO Vietnam also works closely with the Ministry of Natural Resources and Environment (MONRE) to align industry actions with national EPR targets and reporting requirements.

This case demonstrates how business co-ordination mechanisms can complement government regulation by mobilising private finance, improving traceability of packaging waste flows, and accelerating the transition toward shared responsibility for waste management. It represents a scalable model for other ASEAN countries implementing EPR systems.

Key circular economy features:

- Shared producer responsibility and pooled financing
- Market creation for secondary materials
- Integration with national regulatory frameworks

Source: Vietnam Briefing, 2024; World Bank, 2025b.

6.3.2. Circular Construction Materials and Industrial Symbiosis

The construction sector represents one of the largest material flows in Viet Nam and therefore offers significant opportunities for circular economy interventions led by industry. **Text Box 3** showcases how private sector innovation in construction materials and infrastructure development has enabled material substitution, industrial symbiosis, and the use of recycled inputs in urban development projects.

³³ The Socialist Republic of Vietnam (2020). *Law On Environmental Protection No. 72/2020/QH14*. <https://moitruongachau.com/en/law-on-environmental-protection-no-72-2020-qh14.html>.

Text Box 3. Circular Construction Materials and Industrial Symbiosis in Viet Nam

The construction sector in Viet Nam has emerged as an important arena for business-led circular economy innovation, particularly through material substitution and industrial symbiosis. Large construction material producers such as SCG Viet Nam have incorporated industrial by-products – including fly ash and blast furnace slag – into cement and concrete production, reducing reliance on virgin raw materials and lowering lifecycle emissions.

In parallel, pilot initiatives in Hanoi and Ho Chi Minh City have explored the use of recycled construction and demolition waste (RCA) in sidewalks, road sub-bases, and non-structural applications. These pilots are often implemented through collaboration between private construction firms, municipal authorities, and research institutions, demonstrating how business innovation can support circular procurement and urban infrastructure development.

This case illustrates how private sector leadership in heavy industry can drive material circularity at scale, particularly when supported by enabling regulations and public procurement demand.

Key circular economy features:

- Industrial symbiosis and by-product utilisation
- Recycled aggregates in urban infrastructure
- Alignment with green public procurement

Source: Lockrey et al., 2016; Hoang et al., 2020.

6.3.3. Plastic Recycling and Informal Sector Integration

Private investment in recycling infrastructure plays a critical role in closing material loops and integrating informal collection systems into formal value chains. **Text Box 4** examines a business-led plastic recycling initiative in Viet Nam that demonstrates how market-driven demand for recycled content can support circular supply chains while creating economic linkages with informal waste collectors.

Text Box 4. Closed-Loop Plastic Recycling and Informal Sector Integration

Viet Nam's plastics sector provides a notable example of how private investment can strengthen circular supply chains while engaging informal actors. Duy Tan Recycling has invested in advanced PET recycling facilities capable of producing food-grade recycled resin, enabling bottle-to-bottle recycling within domestic markets.

The company sources post-consumer plastic waste through aggregators and informal collectors, integrating informal collection networks into formal recycling supply chains. This approach improves feedstock quality and traceability while providing income opportunities for informal workers. Recycled outputs are supplied to major consumer goods companies seeking to meet recycled content commitments and EPR obligations.

This case demonstrates how business-led recycling investment can operationalise circular economy principles by closing material loops and strengthening collaboration across the value chain.

Key circular economy features:

- Closed-loop plastic recycling
- Integration of informal collection systems
- Market-driven demand for recycled content

Source: World Bank, 2021b; Viet Nam Circular Economy, 2021.

7. Recommendations and Future Outlook of Application of Smart Indicators

This chapter translates the proposed SMART circular economy indicators into actionable guidance for provincial and national stakeholders in Viet Nam. It outlines practical steps for implementation, alignment with national monitoring systems, institutional strengthening, and future refinement of the indicator framework to support long-term circular economy resilience.

7.1. Guidance for Provincial Implementation

Provincial governments play a pivotal role in operationalising circular economy policies, as they are directly responsible for spatial planning, infrastructure investment, public service delivery, and engagement with local businesses and communities. To ensure effective implementation of the proposed SMART indicators, provinces should adopt a phased and prioritised approach, recognising differences in economic structure, administrative capacity, and data availability.

In the initial phase, provinces are encouraged to focus on core indicators with high policy relevance and data feasibility, particularly those related to material productivity, waste

diversion, green and circular procurement, and employment in circular economy sectors. These indicators align closely with existing provincial mandates on SDG implementation and Climate Goals and can be integrated into socio-economic development plans and annual performance reviews.

Provinces should designate a lead co-ordinating agency, typically the Department of Natural Resources and Environment (DONRE) or a provincial planning authority, to oversee indicator reporting and inter-departmental co-ordination. Clear assignment of responsibilities across departments such as construction, industry, finance, labour, and procurement, is essential to avoid duplication and ensure data consistency. Where data gaps exist, proxy indicators and pilot surveys may be used during early implementation, with gradual refinement over time.

7.2. Integration with National Monitoring Systems

To maximise policy coherence and reduce reporting burdens, provincial circular economy indicators should be embedded within existing national monitoring and statistical systems, rather than developed as stand-alone reporting exercises. Alignment with national frameworks on green growth, sustainable consumptions and production, waste management, and climate action will enable aggregation of provincial data and support evidence-based national policymaking.

National authorities should provide standardised indicator definitions, calculation guidance, and reporting templates, ensuring consistency across provinces while allowing flexibility for local adaptation. Integration with national statistical offices and digital reporting platforms can enhance data quality, transparency, and registry comparability. Where relevant, indicators should be mapped to existing national targets and international commitments, enabling Viet Nam to track progress across governance levels.

Regular feedback loops between national and provincial authorities are recommended to validate data, address implementation challenges, and update indicator methodologies based on emerging policy needs and technical advances. In addition, integration with local-level governance structures is essential for operationalising circular economy indicators. Many CE-related activities such as waste collection, recycling services, industrial symbiosis initiatives, and SME support programmes are implemented at the local level. Therefore, provincial monitoring systems should include data from local authorities and service providers by reflecting grassroots implementation in higher-level reports with manageable requirements.

7.3. Recommendations for National Government

At the national level, government action is essential to create an enabling environment for provincial circular economy implementation. First, the designated national authorities should provide clear policy signals and long-term targets that link circular economy

objectives with economic development, industrial policy, and social inclusion goals. This includes integrating circular economy indicators into national development strategies and sectoral roadmaps.

Second, the national government should strengthen regulatory coherence and institutional co-ordination across ministries responsible for agriculture, resource environment, industry, construction, finance, labour, and procurement. Harmonised regulations and guidance can reduce fragmentation and support provinces in implementing circular practices consistently across sectors.

Third, targeted financial and fiscal instruments such as grants, concessional finance, and incentive, should be aligned with the indicator framework to reward measurable progress at the provincial level. Linking funding allocation for developing and application of indicator to monitor performance can further incentivise implementation and innovation.

7.4 Capacity Building and Training Needs

Effective implementation of SMART circular economy indicators requires sustained investment in human and institutional capacity at both provincial and national levels. Many indicators rely on cross-sectoral data collection, interpretation, and analysis, which may exceed current technical capacity in some provinces.

Capacity-building programmes should therefore focus on:

- training provincial officials in indicator interpretation, data management, and reporting;
- strengthening analytical skills for linking indicator results to policy design and investment decisions; and
- enhancing co-ordination between technical departments and statistical units.

Peer-learning platforms, pilot provinces, and knowledge-sharing networks can play a valuable role in disseminating best practices and lessons learned. Collaboration with academic institutions and research organisations can further support methodological development and evidence-based policymaking.

7.5. Future Research and Indicator Refinement

The proposed indicator framework should be viewed as adaptive and iterative, evolving alongside improvements in data availability, institutional capacity, and circular economy maturity. Future research should focus on refining indicators that are currently based on proxies, particularly in areas such as sustainable consumption behaviour, informal sector integration, and innovation outcomes.

Further work is also needed to explore causal linkages between circular economy indicators and broader development outcomes, including climate resilience, poverty

reduction, and public health. Longitudinal studies and pilot evaluations can help identify which indicators most effectively drive policy change and investment.

As digitalisation advances, future refinements may incorporate real-time data, remote sensing, and digital tracking systems to improve accuracy and reduce reporting burdens. Continuous stakeholder engagement will be essential to ensure that the indicator framework remains relevant, credible, and aligned with Viet Nam's evolving circular economy ambitions.

8. Conclusions

This paper has developed a comprehensive and policy-relevant framework of SMART circular economy indicators to support provincial-level implementation and monitoring of circular economy resilience in Viet Nam. By drawing on international best practices and adapting them to Viet Nam's institutional, economic, and data contexts, the report responds to a critical gap in existing circular economy frameworks, which often remain conceptually strong but operationally weak at the sub-national level.

The proposed indicator framework is structured around six interrelated pillars – resource efficiency and material flows; waste management and prevention; industrial symbiosis and eco-industrial parks; sustainable consumption and production; circular business models and innovation; and social and economic co-benefits. Together, these pillars capture both physical material dynamics and enabling socio-economic conditions, reflecting the multidimensional nature of circular economy transitions. The use of outcome-oriented and proxy indicators ensures that the framework remains implementable even in contexts where data availability and institutional capacity vary across provinces.

A key contribution of this report lies in its emphasis on provincial governance and implementation realities. Provinces in Viet Nam play a decisive role in spatial planning, infrastructure development, public procurement, and engagement with businesses and communities. By aligning indicators with existing provincial mandates and data systems, the framework supports practical decision-making rather than parallel reporting exercises. The inclusion of business-led and public-private circular economy case studies further demonstrate how regulatory frameworks, market incentives, and private innovation can interact to deliver tangible circular outcomes.

The analysis also highlights the importance of institutional co-ordination and capacity building. Fragmentation across sectors and administrative levels remains a significant barrier to circular economy implementation. Addressing this challenge requires not only technical indicator design, but also sustained investment in institutional capacity, data harmonisation, and cross-sectoral collaboration. Integration of provincial indicators into national monitoring systems is therefore essential to ensure coherence, comparability, and policy impact.

Looking ahead, the proposed framework should be regarded as adaptive and evolving. As Viet Nam's circular economy matures, indicators can be refined to capture more complex outcomes, including behavioural change, innovation performance, and distributional impacts. Continued research, pilot testing, and stakeholder engagement will be necessary to ensure that the indicator system remains relevant, credible, and responsive to emerging policy priorities.

In conclusion, this paper provides a robust foundation for strengthening provincial circular economy resilience in Viet Nam. By combining global practices with local realities, it offers a practical pathway for translating circular economy ambitions into measurable action, supporting Viet Nam's broader goals of sustainable development, economic resilience, and social inclusion.

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