

# MEKONG CONNECT



**CIRCULAR ECONOMY IN THE MEKONG REGION**

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# EDITORIAL FOREWORD

Welcome to the June 2023 Issue of the Mekong Connect Magazine, a joint publication between the Asian Vision Institute (AVI) and the Konrad Adenauer Stiftung (KAS) Cambodia Office. The magazine publishes two Issues per year, which are funded by the KAS Cambodia Office, to provide access to readers wishing to gain a better understanding of a wide range of issues in the Mekong region, including climate change, trade and economy, food security, poverty, sustainable development, COVID-19, peace and security, foreign policy, and international cooperation. The magazine's digital version is free for download on AVI and KAS Cambodia websites.

This June 2023 Issue comprises seven analytical articles focusing on the “circular economy in the Mekong region” theme to provide insights into the specific processes, challenges, policies, and progress toward sustainable development and circular economy.

The first article provides perspectives on the significance of the ASEAN Green Deal for the Southeast Asian region. It is followed by three articles which examine the contexts, challenges, policies, actions, and progress of the circular economy in Cambodia. The fifth article provides an overview of the circular economy in Thailand.

The remaining articles examine specific aspects of the circular economy in Cambodia. One of them focuses on Agri-SME in the circular economy. The other focuses on using Blockchain technology in waste management in Phnom Penh City.

We hope these insights will be useful for policymakers, researchers, development partners, and general readers to gain perspectives about the circular economy in the Mekong region. In addition to the insights, the authors have provided some practical policy recommendations, which encourage more robust debates and further studies to be conducted to provide more enriched analysis.

We want to acknowledge the intellectual contributions and appreciate the authors' efforts. Our special thanks also go to KAS Cambodia's team, especially Dr Daniel Schmücking, Ms Nuon Monika, and Ms Melanie Gerster. We also thank AVI President Dr Chheang Vannarith and the AVI Secretariate team for their support and assistance.

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## Circular Economy in the Mekong Region

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# ASEAN Green Deal: A Game Changer

*Chheang Vannarith*



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The ASEAN Green Deal has emerged as a transformative initiative in Southeast Asia to address the region's economic, social, and environmental challenges. The importance of green development has grown significantly in recent years due to climate change and the impetus created by the COVID-19 pandemic, accelerating the need for green development and digital transformation.

Proposed in 2022 by Cambodia as the rotating Chair of ASEAN, the ASEAN Green Deal seeks to promote resilient, inclusive, and sustainable development in Southeast Asia. Its key elements include green energy, infrastructure, and logistics to support the global transition towards a zero-carbon, affordable, and resilient energy system. Additionally, it focuses on green production and consumption by leveraging new technologies to reshape value chains, improving efficiency, reducing costs, and minimising environmental impact. Moreover, the deal aims to establish a green finance platform to mobilise public and private investments to transform the energy and infrastructure sectors.

The ASEAN Green Deal aims to facilitate the region's transformation towards a green future characterised by sustainability, effective resource utilisation, resilience, and enhanced economic competitiveness by addressing infrastructure, energy, manufacturing, consumption, and agriculture issues. While the detailed concept and action plan for the ASEAN Green Deal is yet to be developed, its overarching objectives involve reducing greenhouse gas emissions, enhancing energy security and efficiency, and promoting sustainable agriculture and circular economy practices.

Despite ASEAN and its member states' commitment to climate action, the region's emissions have been among the fastest-growing globally. Rapid population growth, urbanisation, industrialisation, and rising income levels and development activities have contributed to a significant increase in emissions. While region-wide initiatives focusing on renewable energy and energy efficiency have been on the rise, transitioning to clean energy sources is crucial to mitigate the impacts of these trends. Failure to do so may lead to a predicted doubling of energy-related emissions in ASEAN by 2040.

The ASEAN Green Deal holds the potential to positively impact the region by promoting sustainable economic growth, reducing greenhouse gas emissions, and contributing to global climate change mitigation efforts. It can enhance energy and food security by promoting renewable energy and sustainable agriculture and fostering a circular economy that reduces waste while encouraging sustainable consumption and production patterns.

Several key regional policy frameworks support developing and implementing the ASEAN Green Deal, including the ASEAN Framework on Circular Economy adopted in 2021 to scale up and accelerate the shift towards a low-carbon or carbon-neutral economy. In the same year, ASEAN Taxonomy for Sustainable Finance was introduced with a focus on climate change and a road map towards activities promoting sustainable development. An updated version of the ASEAN Taxonomy was adopted in 2023 to promote harmonisation between national, regional, and international taxonomies to make green investment easier in ASEAN. The focus sectors include agriculture, forestry and fishing, electricity, gas, steam and air conditioning, manufacturing, transportation and storage, water supply, sewerage and waste management, construction, and real estate.

Notably, implementing the ASEAN Green Deal comes with challenges. It requires the cooperation of all ASEAN Member States. However, some countries may hesitate to adopt sustainable policies that could impact their economic growth or face local political resistance. Additionally, transitioning to a more sustainable economy, especially in energy transition and decarbonisation, can be costly, especially for less developed economies. In this connection, national and local governments play crucial roles in implementing the Green Deal, requiring them to develop policies aligning with its objectives while building a political support base.

The ASEAN Member States have pledged and set measures to reduce Greenhouse gas emissions in their respective Nationally Determined Contribution (NDC). Brunei Darussalam aims to reduce emissions by 20% relative to business-as-usual (BAU) by 2030. Cambodia sets an emissions reduction target of 41.7% by 2030. Indonesia sets emissions target of 31.89% unconditionally and 43.2% conditionally by 2030. Lao PDR pledges unconditional emissions reduction by 60% compared to a BAU scenario. Malaysia aims to reduce economy-wide carbon intensity (against GDP) by 45% (unconditional) in 2030 compared to 2005. Myanmar pledges to reduce emissions of 244.52 million tonnes of CO<sub>2</sub>e unconditionally and a total of 414.75 million tonnes of CO<sub>2</sub>e conditionally by 2030. The Philippines is committed to an emissions reduction of 75%, of which 2.71% is unconditional, and 72.29% is conditional, from 2020 to 2030. Singapore sets an emissions reduction target of around 60 million tonnes of CO<sub>2</sub>e in 2030. Thailand sets an emissions reduction by 30% from the projected BAU level by 2030. Vietnam sets an emissions reduction target of 15.8% unconditionally and 43.5% conditionally, compared to BAU by 2030.

Promoting green development through national policies offers several benefits. Governments can create policies and regulations that incentivise sustainable practices and discourage unsustainable ones, utilising tools like taxes, subsidies, and regulations. This approach can foster green industries, generate green jobs, and stimulate economic growth. However, challenges include a lack of political will, institutional capacity, and policies' potential rigidity or inflexibility. Governments must prioritise environmental sustainability, invest in green technologies and industries, engage stakeholders, and ensure fairness and equity in policy implementation.

International support is crucial for the success of the ASEAN Green Deal. ASEAN and its member states require financial and technical assistance from dialogue partners to develop and implement the initiative. Collaborative efforts between ASEAN and the European Union on green economy and climate change exemplify the potential for cooperation. At the national level, establishing cross-ministerial governance bodies can build political consensus and formulate comprehensive transition strategies. ASEAN Member States have identified establishing a regional climate fund, carbon market, energy infrastructure and power grid as key opportunities to accelerate the shift towards a low-carbon economy.

Overall, the ASEAN Green Deal is a game changer. It presents an opportunity for Southeast Asia to expedite its transition to a low-carbon economy, leveraging the benefits of regional cooperation. Strategic interventions encompass developing green energy systems, green infrastructure and logistics, green finance, green innovation, and the transition to a circular economy. By embracing this comprehensive approach, ASEAN can foster sustainable growth, resource efficiency, and a resilient economy while contributing to global climate goals.



# Toward Circular Economy in Cambodia: Policies, Challenges, and Progress

*Khann Ly Hour and Sim Vireak*

## Introduction

Until recently, the global economy has heavily relied on the linear production model, where resources are extracted, processed, and turned into products that are eventually discarded as waste. This model has resulted in the damage of natural resources, environmental degradation, and socio-economic imbalance. In response to these challenges, more countries are initiating and implementing national development and strategic plans aligned with the recommendations of the 2030 Agenda of the United Nations, called Sustainable Development Goals.

Considering this, a new concept of development model, known as the Circular Economy or CE, has gained attention. The Circular Economy aims to reduce waste and pollution by keeping resources in use to obtain the optimum value from them and later recovering and regenerating outputs at the end of their production life cycle (Ellen MacArthur Foundation 2019). Hence, CE is widely recognised as one of the most effective mechanisms to sustainably reform our socio-economic pattern by generating more economic opportunities whilst wisely allocating our finite natural resources and protecting the ecological environment through sustainable and resilient development.

Cambodia has been developing and implementing more policies regarding the transition from Linear Economy to the Circular Economy concept, aligning with its existing governmental vision toward Resilient Green Economy, especially in the post-Covid-19 recovery. After adopting the national CE policy, the Royal Government of Cambodia has been diligently working with multidisciplinary stakeholders from the private sector, international organisations, research and innovation institutes, and development partners to accelerate the progress of the 18 Cambodia Sustainable Development Goals (CSDGs). This article aims to provide an overview of the policies, challenges, and progress towards achieving CE in Cambodia.

## Toward Circular Economy

Cambodia is a developing country that experienced rapid economic growth over the last decade, with an average annual growth rate of 7.6% between 2010 and 2019 (World Bank 2021). However, this growth has been accompanied by environmental degradation, resource depletion, and social inequality. As the population grows and consumption patterns change, the amount of waste generated also increases, exacerbating the existing problems in some urban areas or secondary cities. This fast-growing population has also greatly driven more use of energy and materials with a surge in waste generation, and it is putting additional critical pressure on Cambodia's limited natural resources and bio-ecological environment.

However, Cambodia is in a favourable condition in creating a significant long-term transition and progress towards accomplishing sustainable development through the Circular Economy approach while generating robust economic growth and increasing its young demographic consumer base. To fully reach the Circular Economy, it requires time as it diversely encompasses the entire dimensions of the national economy.

The Royal Government of Cambodia recognises the importance of adopting sustainable practices to address the challenges. In this regard, the National Environment Strategy and Action Plan (NESAP) 2016–2023 was developed to guide the country towards sustainable development. The NESAP identifies the Circular Economy as a key approach for achieving sustainable production and consumption patterns in Cambodia (National Council for Sustainable Development 2019).

In 2019, the Ministry of Environment (MoE) introduced the policy of National Circular Economy Strategy and Action Plan as a result of the proactive collaboration between multi-stakeholders such as the National Council for Sustainable Development under MoE and a team of policy experts of UNDP and SIDA (Ministry of Environment 2021). This Circular Economy, Strategy and Action Plan concretely addresses crucial actions and improves roadmap developments to empower the citizens to socially transform from a linear to a circular system, preliminarily concentrating on resource utilisation, energy consumption, waste management, and socio-economic value.

The Cambodia Climate Change Strategic Plan (CCCSP) is another policy that promotes CE practices. The CCCSP aims to build resilience to climate change while promoting sustainable development. The policy prioritises sustainable land use, including rehabilitating degraded land, promoting agroforestry, and sustainable forest management. Additionally, the plan promotes renewable energy, including solar, wind, and hydropower, to reduce greenhouse gas emissions (Ministry of Environment 2021).

Another initiative is the promotion of sustainable tourism, which has become a major sector of the Cambodian economy. The Ministry of Tourism has developed policies and guidelines for sustainable tourism practices that promote waste reduction and eco-friendly activities. The initiatives include beach clean-ups, waste management training for tourism businesses, and eco-tourism projects development showcasing Cambodia's natural beauty and cultural heritage (Ministry of Tourism 2020).

## Challenges in Implementing Circular Economy

Despite the potential benefits of CE principles for Cambodia's development, several challenges must be addressed. One major challenge is the lack of infrastructure and facilities for waste management and recycling. The country has few recycling facilities, and waste disposal sites are often poorly managed, leading to pollution and health hazards. The government has started to address this issue by investing in waste management infrastructure, such as landfill sites and recycling centres. However, more must be done to ensure that waste is effectively managed and recycled.

Another challenge is that businesses and consumers lack knowledge, consciousness, and apprehension of CE principles. Therefore, there is a need for education and outreach programmes to increase awareness about the importance of sustainable consumption and production patterns and promote behavioural change towards more sustainable practices.

Moreover, implementing CE practices requires significant investment in new technologies, equipment, and infrastructure. This may be challenging for small and medium-sized enterprises (SMEs) that may not have the resources or expertise to adopt CE practices.



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Cambodia's economic growth heavily depends on extractive industries, which pose environmental challenges and may not align with the CE principles. For example, mining contributes to deforestation, soil degradation, and water pollution. Therefore, a shift towards a CE would require significant changes in the structure of the economy and the way it operates.

## **CE in Key Sectors and Milestone Progress**

A CE approach can be applied to not only waste management and resource utilisation but also to many dimensions of an economy. For instance, CE can be effectively applied for resilient food systems, smart city management, green transportation, eco-friendly construction, renewable manufacturing, and sustainable business model. According to UNDP Cambodia director Nick Beresford, "comprehensive adoption of circular economy business models can drastically diminish the utilisation of natural resources and energy, as well as the dumping waste, greenhouse gas emission, and environmental pollution" (Khmer Time 2018). The benefits of promoting a CE are widely broader beyond just only environmental sustainability. Enhancing the efficiency in material use and energy consumption is also a method of minimising the cost of production and increasing a firm's competitiveness.

### ***Sustainable Agriculture and Food System***

The agricultural sector plays an important role in promoting Cambodia's economic activities. Although more labour has been gradually shifting to industrial and service sectors, the agricultural sector still reportedly accounts for approximately 39% of Cambodia's total employment (World Bank, National Accounts Data, 2021). Nonetheless, this sector is also recognised as being at high risk due to its vulnerability to climate change and global warming, and the cost of agricultural inputs is also rising due to the energy crisis caused by the Russia-Ukraine War and some global geopolitical issues. Therefore, introducing CE into the agricultural development sector has been highly recommended to enhance the efficient use of resource inputs in agricultural production through the main 3Rs (Reduce, Reuse, and Recycle) principle of CE.

Reducing the external inputs in agricultural production is a crucial approach to dramatically decrease the cost of farming production by reutilising more renewable or local resources on farms. For instance, farmers can shift from chemical fertiliser to alternative inputs such as using green manure, animal dunks, organic amendment, crop residues or compost etc. The CE model proposes sustainable agriculture practices that promote environmental conservation and social inclusion. Several businesses in Cambodia have adopted these practices to promote sustainable agriculture. For example, the social enterprise Tonle Sap Fisheries produces organic fish fed using locally sourced ingredients to promote sustainable aquaculture.

### **Industry and Manufacturing**

The garment sector in Cambodia significantly consumes vast amounts of production inputs such as chemicals, energy, water, and materials for fabricating, packaging, and transporting textiles. Relying on fuelwood as the primary energy source for mechanising steam boilers, the energy supply has an enormous impact on the degradation of the forest ecosystem. The products from this sector include gas emission to air from primarily wood-based energy, waste created from material losses along the process, approximately 10–30% of inputs, and numerous effluents from colouring and washing the fabric (Reverse Resources 2016).

The construction sector also demands gigantic energy inputs, especially for manufacturing brick and cement, which currently depends on fuelwood and coal, respectively. Raw materials (such as timber, aggregates, and water) are used as inputs for producing construction materials, packaging, and delivering them.

Introducing the CE model into these sectors is crucial not only for the businesses but also for the long-term sustainability of Cambodia.

### **Waste Management**

Waste management is a critical component of the Circular Economy. Waste management is a significant challenge in Cambodia due to inadequate infrastructure and limited financial resources. The informal sector, including waste pickers and scavengers, collects and sorts most of the waste generated in the country. However, this system is inefficient and often results in environmental pollution. The CE model proposes a more efficient and sustainable approach to waste management. The model involves reducing waste generation, reusing and repurposing waste, and recycling. Several businesses in Cambodia have adopted this model to manage their waste effectively. For example, the social enterprise, Dorsu, produces clothing from recycled fabric scraps, thus reducing textile waste and promoting sustainable fashion.



Cambodia can potentially adopt a CE approach in its e-waste management practices. One way to achieve this is by promoting the repair and refurbishment of electronic devices. Repair and refurbishment workshops can be established to provide technical skills training to local communities, thus creating job opportunities and providing affordable services for device owners. Moreover, the government can establish policies that encourage manufacturers to produce eco-friendly products that are easily repairable and recyclable. Introducing tax incentives and subsidies for companies that adopt sustainable practices can also encourage businesses to invest in CE approaches.

Another way to promote CE practices in Cambodia is through community-based e-waste recycling programmes. These programmes can involve the collection of e-waste from households, schools, and businesses for the proper disposal or recycling of them. Implementing such programmes requires public awareness campaigns to educate the public on e-waste management practices and the benefits of a Circular Economy.

## **Renewable Energy**

Cambodia is heavily reliant on fossil fuels to meet its energy needs. However, the country has significant potential for renewable energy, including solar, wind, and hydropower. The CE model emphasises using renewable energy sources to reduce greenhouse gas emissions and promote sustainable development. Several businesses in Cambodia have adopted renewable energy solutions to meet their energy needs sustainably. For example, the hotel chain Song Saa has installed a solar panel system to generate electricity for its operations, thus reducing its reliance on fossil fuels.

## **Conclusion**

The CE model offers a promising solution to Cambodia's environmental challenges while creating new economic opportunities. Adopting the CE principles can help reduce waste, conserve resources, and promote sustainable development. However, implementing these principles requires collaboration between the government, businesses, and communities. The government needs to create policies encouraging CE practices, and businesses need to develop innovative business models prioritising sustainability. Furthermore, community engagement is crucial for raising awareness about the importance of the CE and promoting positive behavioural change. By working together diligently, Cambodia can create a more sustainable and prosperous future for its citizens and the region.

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# Cambodia's Circular Economy: Challenges and Progress

*Keo Piseth and Aditya Gupta*

Emanating from the debate on the Limits to Growth in the 1960s, Circular Economy (CE) developed as a model for reducing inputs in industrial production. It has expanded to multiple realms and sectors, from resources and waste to continued sustainable economic growth (Man 2022). With an increase in the scope of CE and its underlining assumptions and design principles, a consensus on its definition is yet to be reached. Man views "CE as the systemic alternative to the traditional model of a Linear Economy" (R. D. Man 2022). The European Parliament refers to CE as a production and consumption model involving sharing, leasing, reusing, repairing, refurbishing, and recycling existing materials and products for as long as possible (Circular Economy: definition, importance and benefits 2023). In other words, CE could be defined as resource resilience directed towards satisfying unlimited human needs.

The need for sustained actions globally to reduce, reuse and recycle has been well acknowledged, and efforts are being made to ensure that human excesses and wastage do not lead to a resource-deficient and damaged environment. The transition towards the circular economy is a shared responsibility across levels of government and stakeholders (OECD 2022). Comprehensive and coherent regulations will ensure circularity in the economy. These regulations aim to introduce punitive measures for wastage on the one hand and, on the other hand, incentives in the form of tax breaks or rebates for organisations willing to promote and invest in environment-friendly, resource-efficient practices.

In Cambodia, CE is taking shape at a policy level due to the need and the momentum generated to shift towards a green economy, low-carbon deployment, and sustainable development. The National Council for Sustainable Development (NCSO) was established in 2015, as the nation was on the cusp of major economic reforms for green development. The Department of Green Economy of the NCSO is tasked with promoting green growth, focusing mainly on Sustainable Consumption and Production, Sustainable Cities, Green Building, and Sustainable Energy.

The Circular Economy Strategy and Action Plan, developed in collaboration with the United Nations Development Programme (UNDP) and the Swedish International Development Cooperation Agency (SIDA), provides a roadmap for Cambodia's transition towards a circular economy. It emphasises the overarching goal for Cambodia to become "a prosperous economy, a thriving and inclusive society, and a healthy environment [through] more efficient and sustainable use of energy and material resources while maximising resource value and creating new economic opportunities" (UNDP, DGE and MoE 2021). The plan outlines five main strategic objectives, including:

1. Increase the efficient use of raw materials and promote sustainable design, production, remanufacturing, and distribution.
2. Promote sustainable consumption and effective reuse and repair.
3. Enhance waste collection and recycling.
4. Ensure effective management of residual waste.
5. Enhance cross-cutting stakeholder engagement, awareness, and capacity building.

Besides, various policies and strategies are in place to promote CE. These include:

1. Cambodia's Roadmap for Sustainable Consumption and Production (SCP) 2022– 2035;
2. Long-Term Strategy for Carbon Neutrality by 2050;
3. Updated Nationally Determined Contribution by 2030;
4. National Strategic Plan on Green Growth 2013–2030;
5. Rectangular Strategy IV; and
6. National Strategic Development Plan



Source: Shutterstock

Additionally, the recently amended 2021 Law of Investment of the Kingdom of Cambodia, specifically Article 24 of Chapter 6, highlights the investment incentives for environmental management and protection, climate change, biodiversity conservation, and the circular economy. It further extends these incentives to green energy and technology, contributing to climate change adaptation and mitigation. Qualified Investment Projects in these categories could get tax breaks for 3–9 years, depending on the sector and investment activities.

Measures have also been proposed in various forums, such as incorporating green technologies, enabling green procurement and eco-labelling, reducing the use of single-use plastics and a shift from polyethylene terephthalate (PET bottles) to water dispensers. Controlling plastic waste should be one of the key considerations, given that approximately 213,356 metric tonnes of plastic waste are generated in Phnom Penh alone. The committee on plastic management is considering the proposal for banning single-use plastics, a major source of pollution in the country (M. M. Khmer Times 2023).

Transitioning to a circular economy also warrants a change in the societal psyche. Minister of Environment, His Excellency Say Samal, has also emphasised the importance of collective harmony and responsible resource utilisation. Community involvement can play an instrumental role in realising these objectives. The initiative of the Phnom Krom villagers is laudatory, where they weave woven silk fibre found in lotus stems into high-end fabrics and Khmer krama [scarves]. They could fetch up to US\$300 per square meter (The Phnom Penh Post 2023). Another initiative is painting palm tree trunks to create beautiful art pieces (The Phnom Penh Post 2023).

Similarly, in February this year, a plastic clean-up drive called One Step No Plastic was successfully conducted in Battambang province. More than 1000 people participated in the drive. These included people from the tourism community, the provincial environment department, Battambang Town Hall officials, and students (The Phnom Penh Post 2023).

Furthermore, private sector enterprises in Cambodia have acknowledged the importance of CE and have successfully undertaken measures to ensure that the goal of a resource-resilient economy is realised sooner than later. Some of these notable initiatives include:

1. Circular Fashion Partnership Cambodia, a component of the Global Circular Fashion Forum which aims to help the textile manufacturing nations to expedite and expand the recycling of post-industrial textile waste (Ndure 2023).
2. A US\$6 million biomass facility (the largest in Cambodia) for providing fully renewable thermal energy for brewery operations, cutting 60 per cent of carbon emissions and creating extra jobs for millers and farmers (Khmer Times 2022).
3. Recyclable packaging, water stewardship, and community well-being programmes (Khmer Times 2023).
4. Glass bottle return programmes (Cambodia Investment Review 2023).

## Policy Recommendations

Despite steadfast efforts, Cambodia has a long road to traverse to ensure a smooth transition towards CE. Some key recommendations are given below.

First, CE is an evolving concept for Cambodia and the world. It is by trial & error that the nation must learn and adapt to it. Strengthened Public-Private Partnership is critical in advancing the goal of circularity and developing ecologically sustainable solutions. Initiatives aimed at Bio-Geo mineralisation, biochemical remediation of industrial waste & effluents, management of solid waste, and resourceful recycling of valuable metals such as Li-ion batteries could contribute to the goal of a circular economy, thereby reducing carbon footprints.

Second, human resource development for the implementers to understand the importance of circularity is a key driver for bringing a paradigm shift from linearity.

Third, a robust green financing and governance framework encourages organisations to report their CE actions and incentivises them to act. At the same time, punitive measures like fines for greenwashing and wastage should be introduced.

Fourth, continued research and development in the field to allow better technologies and practices to see the light of day and their seamless transfer across borders.

Finally, strengthening public awareness and multi-stakeholder collaboration for driving a positive behavioural change in favour of circularity from linearity.

Given Cambodia's first-mover advantage on many of these fronts, it could be the catalyst in the ASEAN region for realising the goal of resource resilience and greenification.

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# Cambodia’s Path to Green and Circular Economy

Ly Slesman

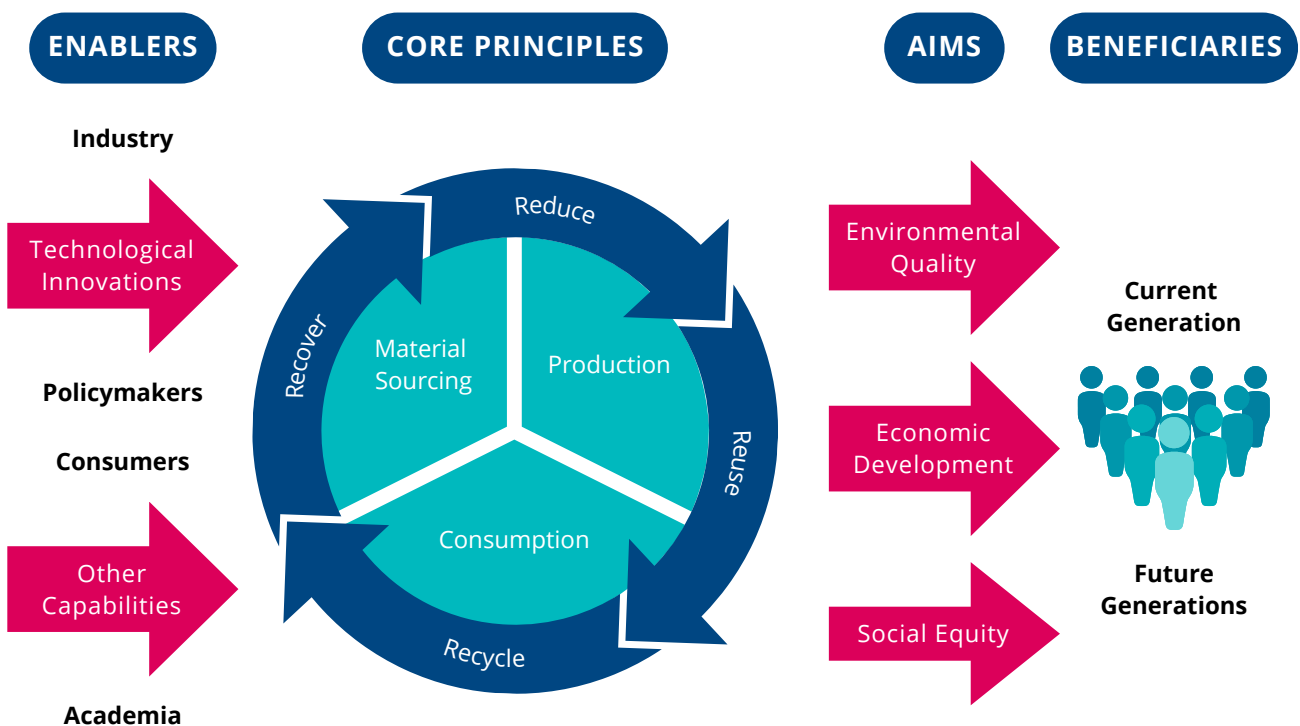
## Introduction to Circular Economy

The frequent and increasingly disastrous environmental problems such as pollution, drought, ozone and natural resource depletion, deforestation, loss of biodiversity, global warming, and climate change have made environmental preservation an integral part of development strategies across developed and developing countries, including Cambodia, in their continuous quest for sustainable economic development. Such strategies require sustainable use of scarce natural resources. To do this, the recent concept of Circular Economy (CE) essentially advocates the sustainable pathway or a new economic framework and process of production and consumption that reduce the use (extraction and mining) of new raw materials while increasing the reuse and recycling of the existing stock of materials in the circularity of a take-make-use-reuse involving the 4Rs dimensions of reduce, reuse, recycle, and recover.

Nevertheless, there are various definitions and usages of the concept of CE among scholars and practitioners, as evidenced in a recent review of the published scholarship on CE by Kirchherr et al. (2023), who found more than 200 CE definitions. They propose a conceptual consolidation of CE that bridges the theory-praxis gap by incorporating (i) CE core principles, (ii) CE aims, and (iii) CE enablers in the following comprehensive definition:

The CE is a regenerative economic system which necessitates a paradigm shift to replace the ‘end of life’ concept with reducing, alternatively reusing, recycling, and recovering materials throughout the supply chain to promote value maintenance and sustainable development, creating environmental quality, economic development, and social equity, to the benefit of current and future generations. It is enabled by an alliance of stakeholders (industry, consumers, policymakers, academia) and their technological innovations and capabilities.

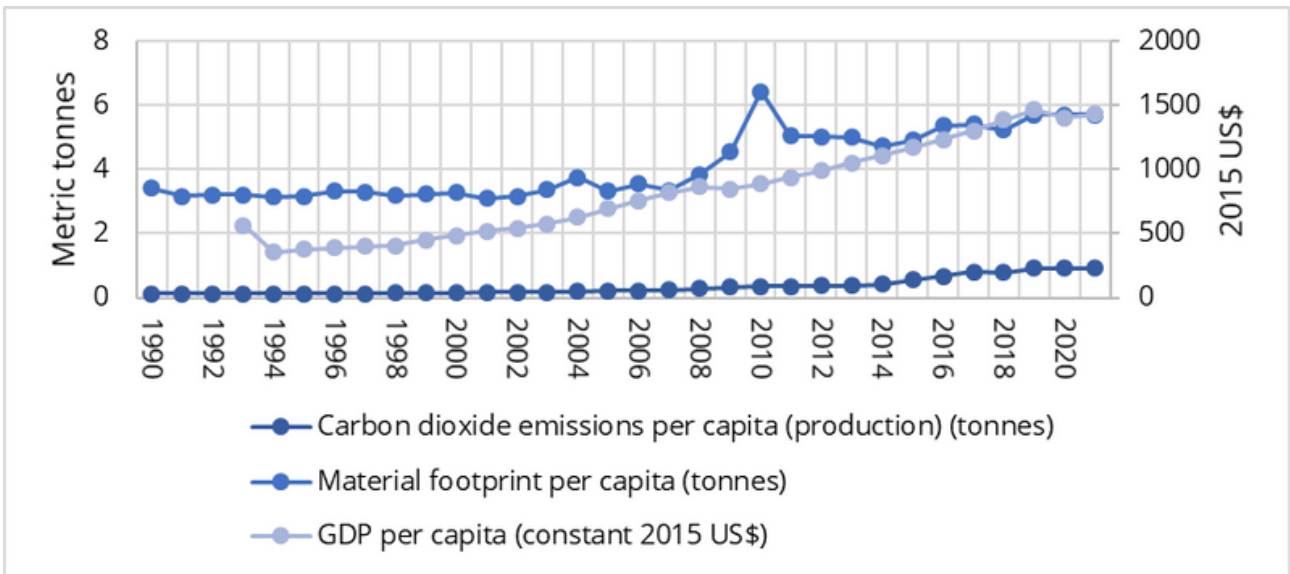
Figure 1. Consolidated CE definition



Source: Kirchherr et al. 2023. (Recreated)

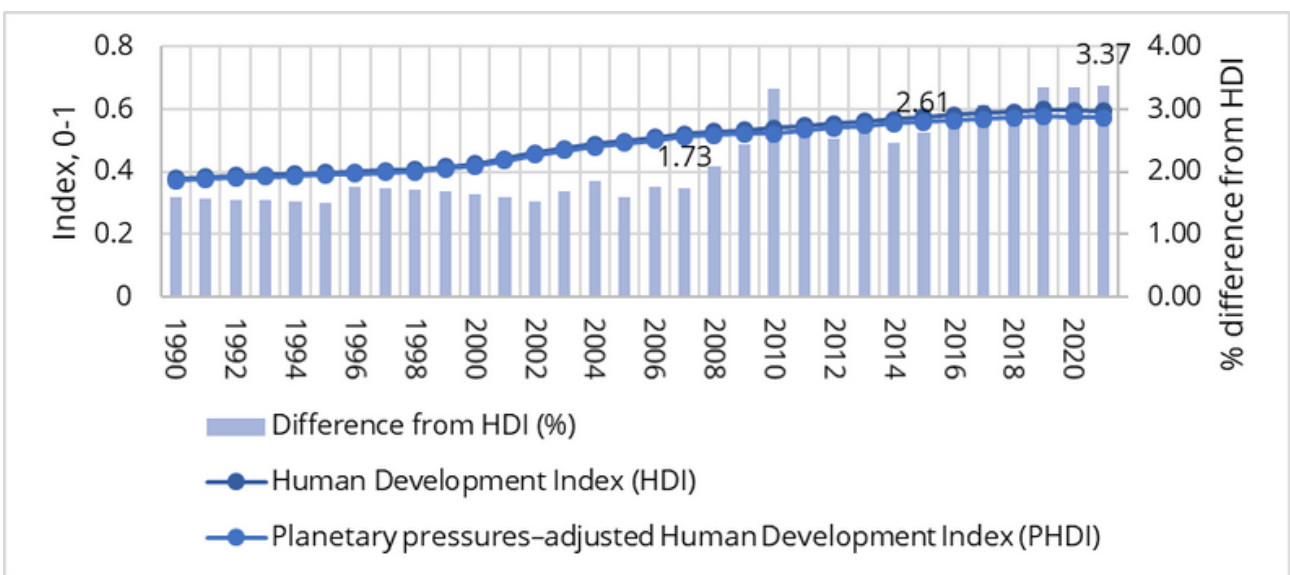
The core principles of CE revolve around “the limits of resource use and waste” (Skene 2022), for example, seeking to recycle the waste to close the loop to prolong life and continuously create value for the stock of material inputs in the economy. This would allow the economy to transit from the linear economic ‘take-make-use-waste’ (take-make-use-disposal) model to a CE’s ‘take-make-use-reuse/recycle/repair’ model. Furthermore, the main purpose of CE is to deliver economic and environmental benefits while reducing societal impact (Robinson 2022) and promoting sustainable development that not only “meets the needs of the present generation without compromising the needs of future generations” (WCED 1987, 4) but also “allows future generations to access the same amount of natural resource and the same economic and social capital as the current generation.” (Skene 2022, 24). Such a transition to CE would involve all stakeholders and the advancement of technology and innovation.

Figure 2. Cambodia's economic activities (World Bank 2023), carbon and material footprints



Source: UNDP 2022.

Figure 3. Cambodia's HDI and PHDI

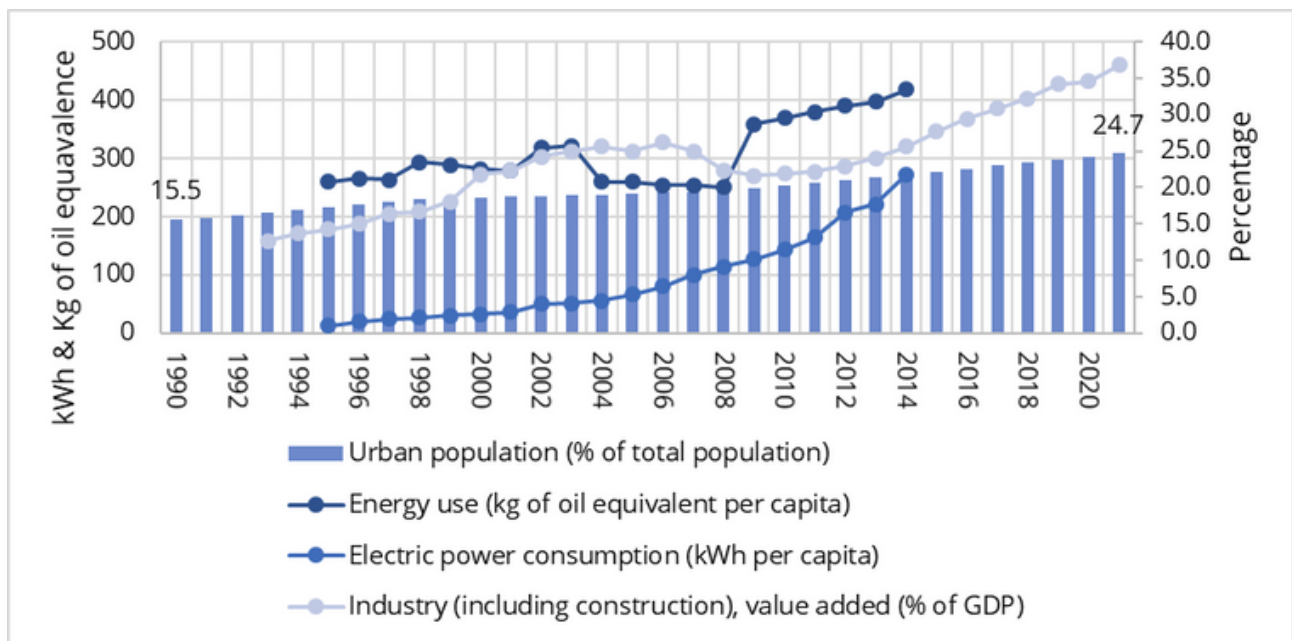


Source: UNDP 2022.

## Cambodia’s Development Path and the Road to Green and Circular Economy

Cambodia’s economy has been growing since 1993, and it graduated into a lower-middle-income country in 2015. Annual GDP per capita (in 2015 US\$) (GDPPC) grew at an average of more than 5 per cent during 1995–2021 (Figure 2). This strong growth in GDPPC was also accompanied by an upward trend in carbon and material footprints, captured by carbon dioxide emission per capita (CO2PC) and material footprint per capita (MFPC), respectively, over the same period. CO2PC is produced through human activities from coal, oil, and gas for combustion and industrial processes, gas flaring, and cement manufacturing. MFPC is the sum of the material footprint for biomass, fossil fuels, metal ores, and nonmetal ores. The upward trend is also observed in Cambodia’s Human Development Index (HDI) and its Planetary pressures-adjusted HDI (PHDI)—adjusting HDI for pressure from CO2PC and MFPC to capture the planetary pressure that discounts HDI (Figure 3). Without planetary pressure, PHDI would equal HDI. It is not the case here; the percentage differences between PHDI and HDI (reflecting Cambodia’s economic development pressure on the environment) increased from 1.7% in 2007 to 2.6% in 2015 and 3.4% in 2021.

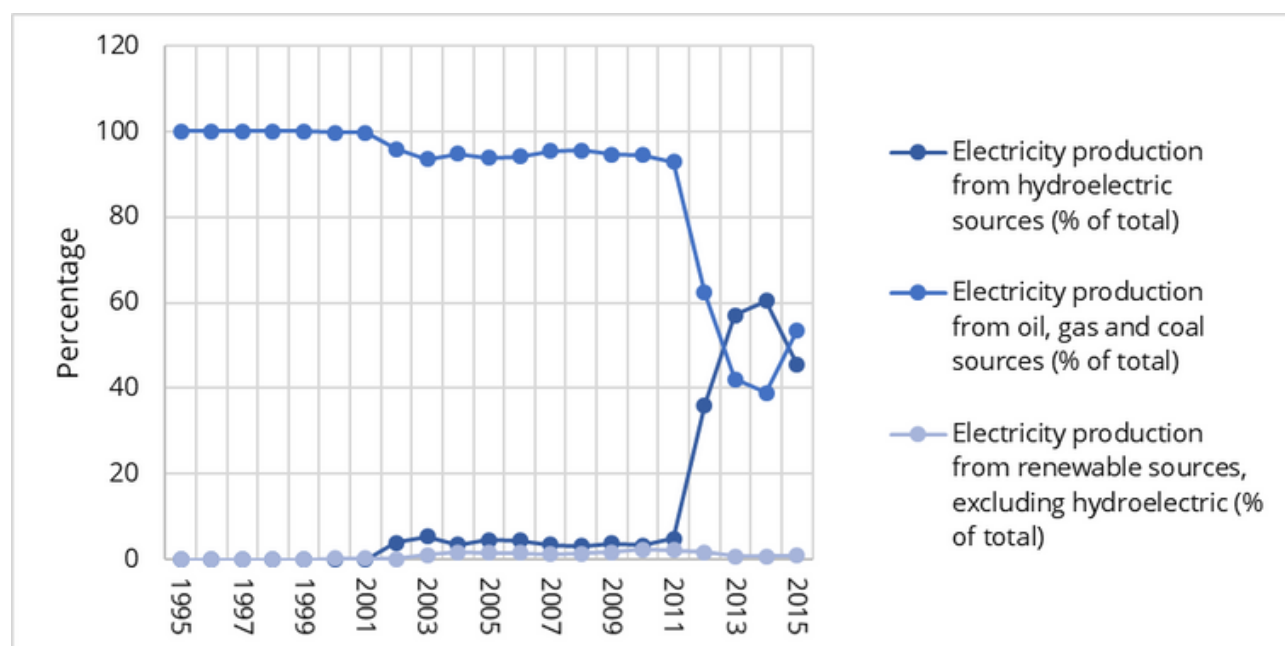
Figure 4. Cambodia’s energy consumption, industry, and urban population



Source: World Bank 2023.

Furthermore, such strong growth coupled with the rapid increase in urban population (growing at an average of 3 per cent p.a. during 1995–2021), industrial growth, and expansion of cities means that Cambodia would consume more materials and energy, hence increasing waste and pollution (Figure 2 and 4). The Royal Government of Cambodia is aware of the environmental burden and seeks to address this in its National Strategic Plan on Green Growth (2013–2030) (NSPGG) to become greener over the long term by adopting the green economic principles of sustainable use of raw materials and natural resources; green technology such as the use of Rs techniques; environmental quality (no pollution to water, land, air, forestry, biodiversity, and ecosystem); low waste emission; renewable energy and energy efficiency; green micro and macro finance; low carbon emission; and green taxes. Since 2011, Cambodia has made significant improvements in producing electricity using less non-renewable sources (oil, gas, and coal) but more renewable sources (hydroelectric and other renewable sources) (Figure 5). Another example of improvement is that, in June this year, it launched new ministerial regulation to accelerate rooftop solar power to further increase electricity from renewable sources to contribute to the goal of carbon neutrality by 2030 (UNDP 2023).

Figure 5. Cambodia's electricity production



Source: World Bank 2023.

In line with NSPGG, in 2021, the National Council for Sustainable Development and the Ministry of Environment (with technical support from UNDP, Sweden, and Japan) further developed the National Circular Economy Strategy and Action Plan (CESAP) to provide a roadmap for a transition to CE. Fundamentally, CESAP rests on the following five Strategic Objectives (CESAP-SO).

1. CESAP-SO1: increase efficient use of raw materials and promote sustainable design, production, remanufacturing, and distribution.
2. CESAP-SO2: promote sustainable consumption and effective reuse and repair.
3. CESAP-SO3: enhance waste collection and recycling.
4. CESAP-SO4: ensure effective management of residual waste.
5. CESAP-SO5: enhance crosscutting stakeholder engagement, awareness, and capacity building.

These CESAP-SOs reflect Kirchherr et al.'s (2023) consolidated CE definition that involves all enablers (CESAP-SO5) to enable the adoption and implementation of CE core principles (CESAP-SO1–4) for a sustainable future. To achieve each of these CESAP-SOs, various policy actions were also laid out. Nevertheless, a key element of CESAP is to ensure the loop is closed over the long term by recycling the stock of material resources while enhancing efficient waste management. This article looks specifically at the increasing problem of waste in Phnom Penh.

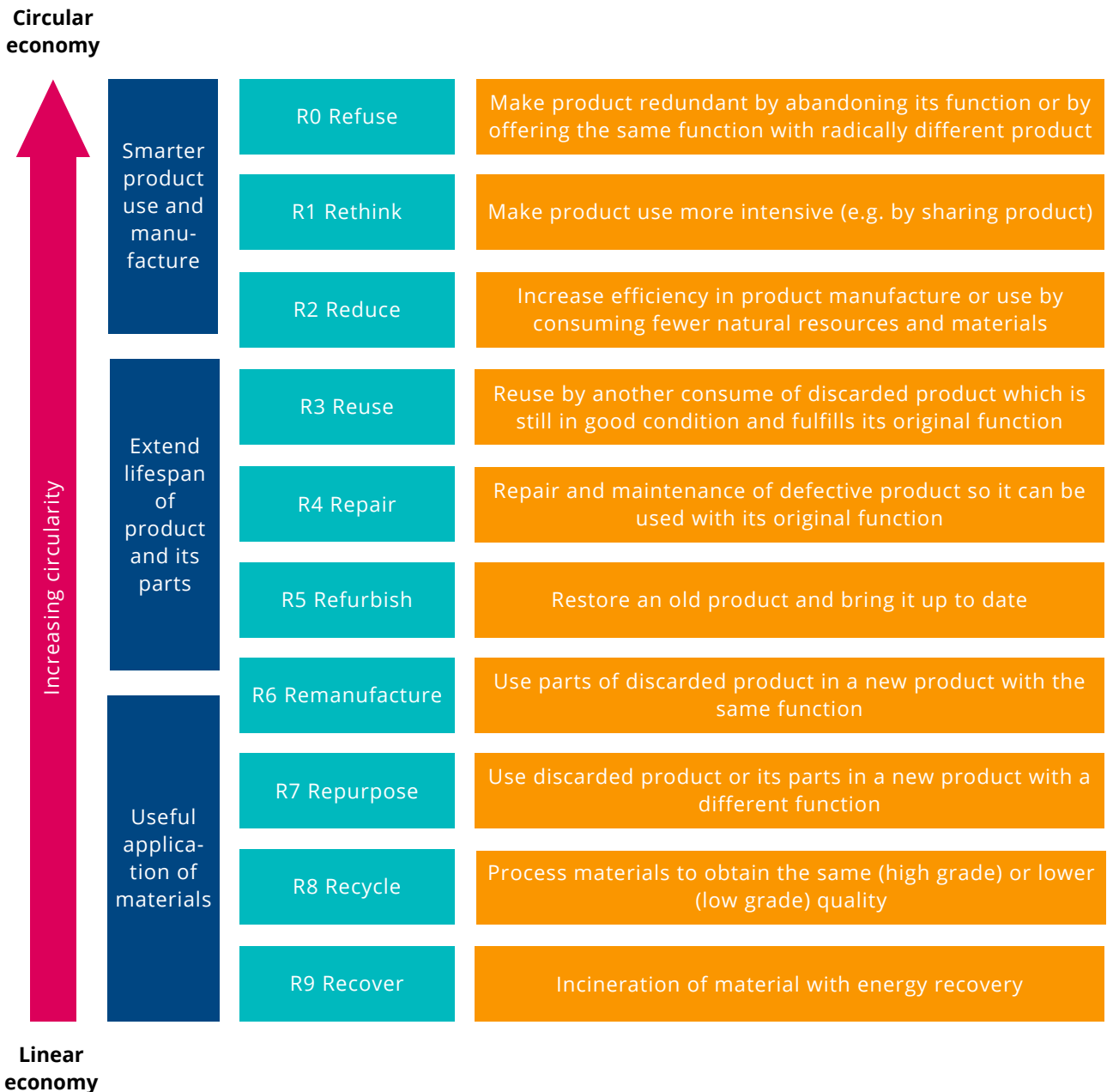
Waste management is an integral part of CE principles and a major problem facing many cities, especially in the developing world, as uncontrolled waste disposal causes pollution, greenhouse gas emission, and ozone depletion. Cambodia's capital city, Phnom Penh, faces serious environmental and administrative challenges in properly managing municipal solid waste (MSW) (Seng et al. 2011). PPCA et al. (2018) estimate that around 70% of the one million tonnes of Municipal Solid Waste (MSW) produced annually is deposited in the landfill in Dangkor district. Its discharge and collection are done in hazardous ways, with an accumulation of uncontrolled waste in the city and environmentally unsound waste treatment and disposal. This is partly due to limited coverage in waste collection and limited actions to undertake the 3Rs (reduce, reuse, and recycle).

Furthermore, more than half of MSW is sourced from households (55.3%), followed by hotels/guesthouses (16.7%), and restaurants (13.8%) (PPCA et al. 2018). Food waste is the largest at 51.9%, plastic (20.9%), paper (9.9%), and other waste account for the rest. In comparison, industrial waste comprises predominantly textile (60%), sludge (15%), leather (10%), plastic (5%), paper (5%), and others (5%). This reflects the large share of textile manufacturing in the industrial sector.



Therefore, one of the challenges to CE transition starts with developing efficient waste management and promoting the 3Rs. Indeed, the recent Phnom Penh Waste Management Strategy and Action Plan (2018–2035) (PPWMSAP) (alongside similar national policy frameworks) to establish a sound waste management system that minimises waste and resource use focuses on five targeted areas: improving waste collection, promoting recycling, improving the management of final disposal site, managing special waste, and stakeholder engagement (via feedback, education, and 3Rs practices) (PPCA et al. 2018). They will lead to a comprehensive 9Rs framework (Figure 6) that promotes a gradual shift from a linear to a circular economy.

Figure 6. The 9R framework on the CE



Source: Kirchherr and Piscicelli 2019. (Recreated)



Source: Shutterstock

## Conclusion and Implications

CE can enhance productivity and economic growth, create employment, and save the environment. Thus, shifting from a linear to a CE model is an ideal solution to achieve long-term sustainable development in Cambodia. The challenges are that this would involve all stakeholders, investment in green technology and innovation, and implementation of core CE principles on the supply side (producers), demand side (consumers), and society. One of the earlier steps is to have an efficient and comprehensive waste management system and is followed by increasing adoption of the comprehensive 9R framework.

Cambodia has received large inflows of development aid and FDI since 1993, which can be leveraged to attract more targeted aid and green FDI to promote CE through policy initiatives and incentives (laid in NSPGG, CESAP, and PPWMSAP), particularly in areas of waste management and recycling, and textile industry and agriculture where most Cambodians are employed. Furthermore, in relative terms, Cambodia has the second lowest environmental pressure in the Mekong subregion (UNDP 2022), which presents another advantage for a more gradual shift to CE.

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# Circular Economy in the Mekong Region: The Case of Thailand

*Ly Monypachpor and Chheng Kimlong*

## Introduction

The concept of circular economy has emerged in response to the problem of waste and low efficiency in using raw materials. A circular economy is a production and consumption model involving sharing, leasing, reusing, repairing, updating, and recycling existing materials and products as much as possible to create added value. This concept has spread to the Mekong region, including Thailand.

For Thailand, the circular economy is the main strategy for its economic growth. It can help solve the problem of scarcity of natural resources because this new concept is different from the traditional linear economy model that extracts natural resources for production, consumption, and disposal. In contrast, a circular or 'rotation' economy conserves natural resources and consumes them in the most possible efficient manner. The Thai government aspires to push the country out of the middle-income status by 2037. However, the economy is still developing and needs to balance its growth with its environment (Acharya 2021). As the demand for green consumption increases, Thailand is trying to shift its business and operation model to a circular economy. Many companies are also trying to innovate waste into production.

## Transition Toward Circular Economy

Any effort to enhance economic growth needs to consider the environment. Thailand is one of Southeast Asia's top ten countries that produce ocean debris globally (Guzmen 2022). The Thai government has pursued a two-pronged approach toward a circular economy while guaranteeing investors about environmental sustainability. Based on this approach, the government uses the provision of Thailand's Bio-Green Circular economic model, known as BCG and the country's Roadmap on Plastic Waste Management 2018–2030.

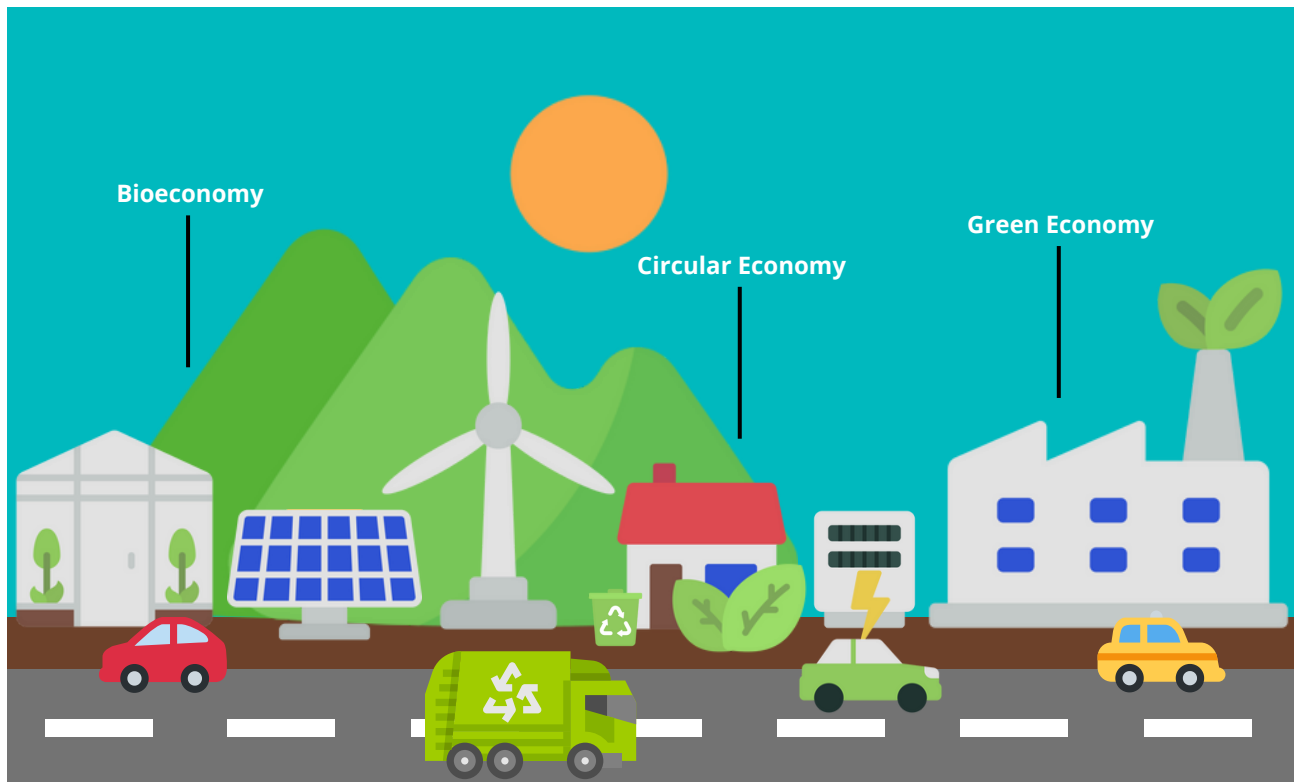


Source: Shutterstock



BCG was introduced during the 29th APEC Meeting in Bangkok. It aims to further promote the goal of sustainable development and environmental protection and conserve resources by reducing their use, processing or recycling, and a green economy to create a balance between socio-economic progress and environmental sustainability based on the conceptual framework of conservation, restoration, and management of the most efficient use of biological resources. Thailand is well known as a country with strong agriculture, rich natural resources, biological resources, and physical geographical resources. According to the Royal Thai Embassy in Washington D.C., the BCG model has been applied to four main industries: medical and wellness, biomaterial and biochemical, agriculture and food, tourism, and creative economy.

Figure 1: Thailand's bio-green circular economy



Source: Thailand Business News. (Recreated)

## Medical Sector and Wellness

The strategy includes the overall support of the country's health care policy in promoting vaccines and clear drugs; capacity building in technology and human resources in research and development; production technology for vaccines and medical devices; clinical research; and registration of pharmaceutical products and medical devices. It also includes establishing a facilitative platform to make it easier for stakeholders and researchers to use genetic data and clinical research.

## Agriculture

The agriculture sector in Thailand has been threatened by negative impacts such as water shortage, limited land resources, and climate change. Thai farmers face severe drought, low rice prices, low income, and rising debt. The agriculture sector has played a significant role in the Thai economy, with a 10% contribution to its GDP. In response to the issues, the government has introduced smart farming technology, which reduces inefficient farming and animal husbandry methods, such as saving irrigation water in production, using chemical fertilisers that do not harm the environment and human health, or reducing the number of farmers and production costs (Netherland Embassy in Bangkok 2020).

## Plastic Waste Management

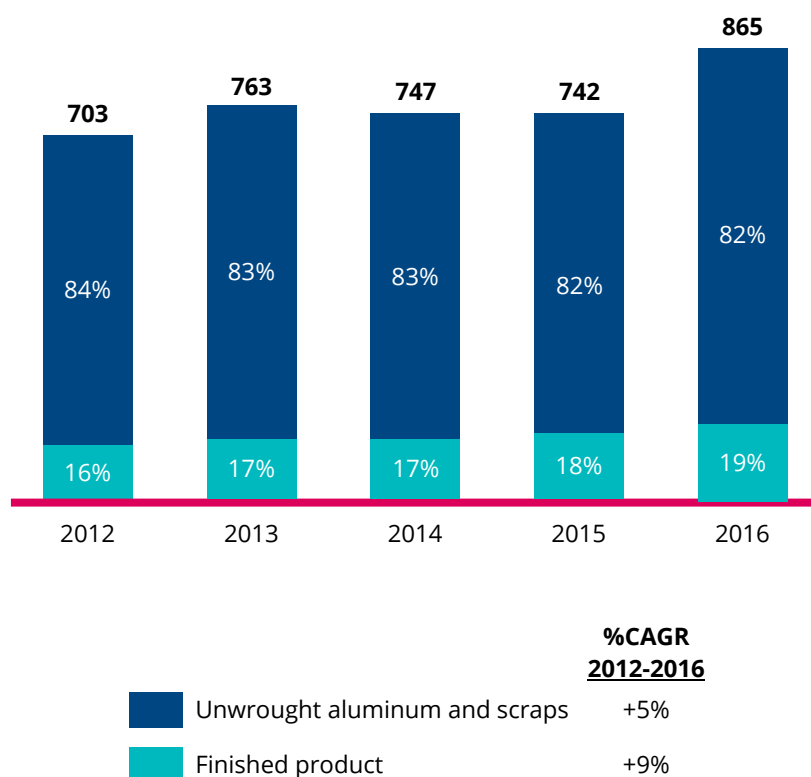
About 20% of the daily plastic waste is in packages such as cakes, snacks, and coffee bags. This type of waste makes processing very difficult. If we do not think about how to process it properly, it can easily end up in the sea. Introduced by the CIRAC team that has competed in the EPPIC competition, their research and technology can turn snack packaging into aluminium and diesel. An important part of this technology is the design of thermal reactors (UNDP 2020). The reactor is not expensive and can use materials already available in Thailand. The raw material used for recycling is coffee bags imported in large quantities from the factory.

The new point of the project is not only the collection and recycling of plastics and other products such as aluminium and diesel. It also adds value and creates huge benefits over conventional plastics processing. This is a potential solution for plastic processing for the Thai market, importing a lot of aluminium with such innovations. At the same time, it will be a driving force for increased plastic collection, thus reducing the dumping of plastic in landfills and the sea. Although the project is in the testing phase, it brings positive results with the ability to handle 1,000 tons of snack packages turning to 200 kg/day of aluminium, which contributes to reducing plastic waste, boosting productivity, and implementing a circular economy in Thailand and the region.

Besides the innovation, the Thai government has laid out a new strategic plan that, from 2024, Thailand will reduce the import of plastic waste to 50% of Thailand's current production capacity. And from the end of 2024, Thailand will stop importing plastic waste to address the environmental problem caused by this type of waste (Waldeck 2022).

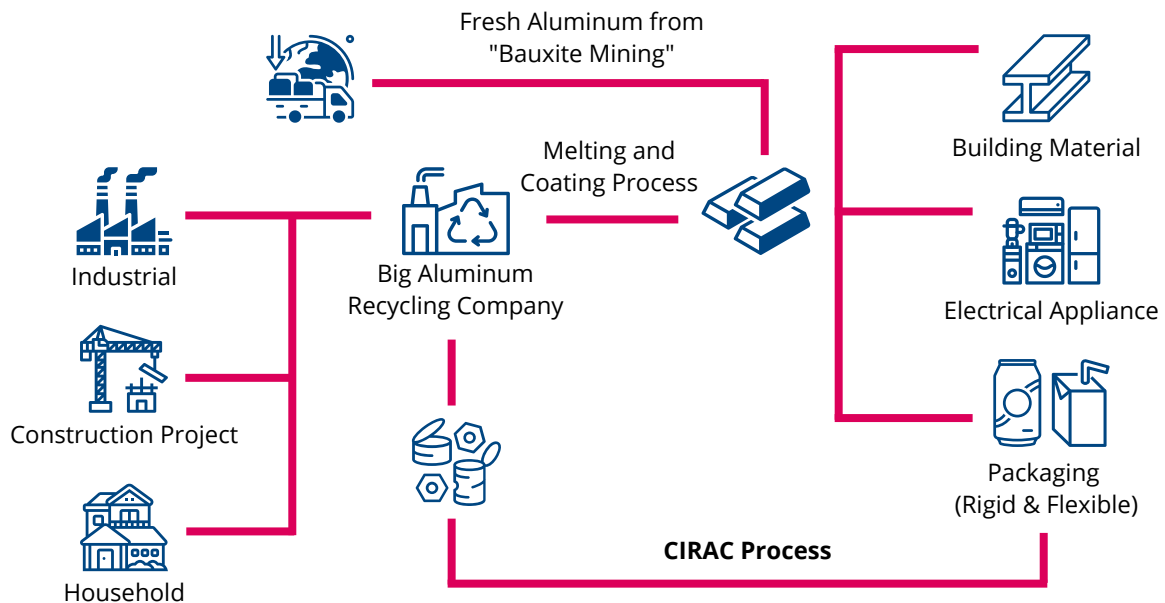
Figure 2: Thailand's imported aluminum by product type

Unit: Million tonnes



Source: EIC analysis based on data from MOC and International Trade Centre (Recreated)

Figure 3: CIRAC AI Product



Source: UNDP (Recreated)

## Renewable Energy

Due to projected economic growth and other data, energy consumption is projected to increase. The more energy increases, the more it affects the environment. Renewable energy has been introduced for communities and villages to address the issue. It comes from using agricultural waste for biomass and biogas and from constructing houses with solar panels. Renewable energy can help with climate change mitigation. It enhances energy access and energy security. Moreover, it promotes trade and socio-economic development (job creation, livelihood improvement, and rural development).

## Challenges

Although Thailand has made progress in clean and renewable energy, the industrial and household demands for energy consumption and natural resources may pose a greater challenge for the country. On the way to a strong circular economy, Thailand might face policy framework changes and industries. However, despite the large expenditure, we cannot expect a quick turnout. Moreover, interest conflict, lack of leadership or cooperation can slow the transaction toward the circular economy as this project required the involvement of many sectors, such as stakeholders and other agencies. This action can lead to more foreign companies competing in the country (European Environment Agency, 2016).

## Conclusion

The economic concept of recycling, reusing, and reducing, known as the circular economy, has been embraced in Thailand's economic development and the need to balance economic growth with environmental sustainability. The circular economy promotes less use of non-renewable energy and less pressure on the environment than the old linear economic model that has caused losses to biodiversity, forest, and mineral resources.

Thailand and other countries in the Mekong region have a greater role to play in embracing a strong and resilient circular economy that can help balance economic growth and the environment (International River 2018). For example, Cambodia is a fast-growing country that increased renewable energy generation from a 10-megawatt pilot project in 2017 to 372 megawatts by the end of 2021 and is expected to increase electricity production from solar energy (Chaker 2021). The number of solar panels added to the state grid will increase to 1,815 megawatts by 2030.

The momentum of adopting a circular economy around the world is due to several social, economic, and environmental factors, such as promoting economic development, increasing energy security, improving access to energy and reducing volatility, and climate change (Pradeep 2023). Despite the challenges, Thailand and Mekong countries are embracing the circular economy to benefit their citizens' present and future generations.

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# Cambodia's Agri-SME in Circular Economy

*Pheap Chakriya*

## Introduction

Small and medium enterprises (SMEs) play an important role in job creation and economic development in developing countries, particularly in reducing poverty in rural areas (World Bank 2023). In the Greater Mekong Subregion (GMS), SMEs account for nearly 98% of enterprises and employ roughly 70% of the national workforce (Mekong Institute 2017).

GMS countries have strengthened their SMEs in diverse sectors and supported them with financial or general support to meet the requirements for integration into the global value chain (GVC). SME also plays important roles along the Southern Corridor Economy, a market hub for GMS countries, and there are initiatives that aim to address SMEs' challenges in integrating into the GVC.

Besides, the 2030 Agenda for Sustainable Development of the United Nations, which encourages the formalisation and growth of SMEs, has brought more attention to SME development. Over the past decade, the world market for agricultural products has expanded quickly, and so have the exports of processed goods from around the world. They reflect the rising demand for safe and nourishing food due to global population growth and innovative technological advancement and efficiency in the farm-to-fork agri-food production chain.

In this context, agro-processing SMEs can contribute significantly to creating a more inclusive and sustainable food system and sustainable agriculture for rural development and food security by increasing farmers' competence through training, networking, and access to essential information. All in all, the sale of inputs, food production, collection and distribution, and processing and retailing of food products are the primary business activities of agri-SMEs.



Source: Shutterstock

## Current Context of Cambodia's Agri-SMEs

The dramatic growth in global food production over the last few decades has come at a tremendous environmental cost. Based on (FAO 2021), the agri-food supply chain contributes approximately 16.5 billion metric tonnes of GHG emissions, a combination of contributions from farming, land usage, and the supply chain process. The ENVForum (2022) stated in its annual conference report that the transition to a circular economy is centred on net-zero emission goals; hence, circular agri-food SMEs have a high potential for fostering system change. SMEs demonstrate their impact by developing low-carbon food alternatives, implementing more efficient agricultural practices, and preventing food waste.

Cambodia, a member of the Greater Mekong Subregion, has an average annual economic growth rate of 7.7% between 1998–2019 (WB 2023), and agriculture has been a key driver of this economic growth. Agriculture dominates 22% of Cambodia's GDP and employs about 3 million people. With the agriculture's considerable potential, Cambodia is in a good position to become an agro-processor and agri-food supplier in Asia. The Cambodian government defined enterprise in four types, micro, small, medium, and large, according to the number of employees and turnover of assets. SMEs are divided into three major sectors: agriculture, industry, and service (KhmerSME 2021).

However, Cambodia's agro-processing industry produces primarily for the domestic market and resides near production zones. It has many areas to improve, including expertise, technical skill, technology, marketing, and financial access. They have become the centre of attention for the Cambodian government to develop and improve Cambodia's manufacturing sector and enterprise.

## Policies and Initiatives for Promoting SMEs

Cambodian SMEs have participated in various national policies and strategic plans for development and growth. The SME Sub-Committee was formed in 2004, followed by the SME Development Framework in 2005 to coordinate and guide SMEs, as well as other policy and strategic plans such as the Rectangular Strategy for Growth, which aims to remove barriers to SME registration and promote SMEs. Other important policy and strategic plans include the National Strategic Plan on Green Growth, the National Strategic Development Plan 2014–2018 by MISTI, the Industrial Development Policy (IDP) 2015–2025 by MISTI, the Agricultural Sector Strategies Development 2014–2018 by MAFF, the Master Plan for Agriculture Sector Development 2030 by MAFF, the Agriculture Strategic Development Plan 2019–2023 by MAFF, the Circular Economy and Action Plan released in 2021, the Roadmap for Food Systems for Sustainable Development 2030 released in 2021, and the Roadmap for Sustainable Consumption and Production 2022–2025 (forthcoming).

There are also various initiatives such as KhmerSME (2020), a web-based portal and one-stop site for Cambodian business owners seeking information on starting, growing, and consolidating a business in Cambodia. Additionally, the Agriculture and Rural Development Bank, a state-owned commercial bank established in 1998, and the SME Bank Plc established in 2020 play critical roles in strengthening funding. Besides, SMEs along the Southern Corridor Economy bring more benefits for clustered SME groups to access the GMS countries' markets. These are the primary benefits of SME development in reaching the global market. There is also guidance for SME activities toward a green and circular economy.

To formally invite SMEs into the development process, the government encourages SMEs to formally register with the MISTI by granting benefits. Proper registered SMEs will obtain benefits such as access to financial services, technical support, and market and business consulting to help them increase their production, businesses, and services. However, because many businesses have not been properly registered, the exact number of SMEs registered with the relevant ministries has been limited. As a result, SMEs that are not legally registered miss out on the chance to gain incentives and opportunities for growth.

## Agri-SME in Circular Economy: Challenges and Recommendations

In the context of the circular economy, it is a transformation of the linear economy model, in which the concept of "take-make-waste" is replaced with "take-make-reuse", intended to eventually decouple growth from the consumption of finite resources. A circular economy purposefully protects the environment while maintaining a continuous economy.

It denotes offering remedies to environmental and climate change challenges while benefiting businesses. It promotes reduced consumption and resource reuse or recycling, which contradicts traditional business models that emphasise linear progress in business operations. Therefore, the life cycle of products is extended.

When the linear concept transforms to a circular one in agriculture design, the action will be related to all steps of the food system, from growing, harvesting, packing, processing, transporting, marketing, consuming, and disposing of food. These will need to be designed to promote sustainable development. They will improve the efficiency of the supply chain process and increase waste management performance. As a result, waste can return to a new value by applying the most economically feasible measures to increase remanufactured commodities.

Food waste management solutions are frequently related to both processing technologies, as they end the conversion of extra food into feed, fertiliser, or energy and the requirement for collaboration among all value chain actors. Meanwhile, there are multiple drivers and barriers to implementing the circular economy in the supply chain, including policy, economy, finance, environmental protection, health, society, product development, and innovative solutions (Amina M et al. 2021). Even though the implementation will benefit the environment and economy, it would become an expensive system if the transition process does not have a proper design.

Cambodia's agri-SME sector is underdeveloped, and several areas need improvement. The challenges for SMEs are not fully resolved yet, including low-quality production, transport and logistics infrastructure, energy supply cost (GBN 2020), access to finance, technical skills and knowledge, and competitiveness (Sambath 2021). The circular model in agribusiness is new and thus a new challenge for SMEs to overcome. Policy, strategic, and development plans, as well as initiatives or programmes need to be designed to involve SMEs in the future green or circular economy concept. These questions should also be answered: whether those SMEs have heard about the circular economy? Are they well aware of the existence of a circular economy? Some businesses that have successfully overcome problems and are aware of the circular economy model may comprehend their position in transitioning to a more circular environment and the several stages that must be managed to ensure a systematic and organised transition to the circular economy. What about those who have not been aware of it? How do we get them involved in the process? What compatible business model is suitable for their businesses?

While transitioning from a linear to a circular model might substantially decrease the negative pressure on the environment, the transition is not simple. It takes place at several levels of awareness, commitment, and behaviour. It needs system-wide innovation, such as a shift in value creation logic and the development of new circular economy-compatible models. Cambodian rural farmers have been practising circular agriculture without realising it. Many SMEs may not have been involved in the practices or might be unaware of the circularity of their business strategy. Therefore, awareness of the circular economy should be widely spread or even initiated in the assessment to get certificates, particularly mainstream regenerative agriculture food waste and materials. Assessment can be a way to understand their level of awareness and needs for improvement. Besides addressing the current challenges, promoting the development of research and innovation in agri-food SMEs should count as critical support.

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# Sustainable Cambodia: Better Food Waste Management with Blockchain Technology

*Soth Sereyboth and Kuok Fidero*

From farm to fork, reducing food waste offers multiple opportunities to achieve the Sustainable Development Goals of zero hunger, responsible consumption and production, and climate action. Almost one billion tons of food are wasted annually and account for approximately 8 to 10% of the world's carbon emissions. Besides, food waste management and environmental remediation cost about US\$936 billion of direct loss and US\$12 trillion worth of health, economic, and environmental impacts (Zhongming et al. 2021). Throughout the food supply chain, food loss could happen during the first three stages: production, handling and storage, and processing, while food waste could be generated at distribution, market, and consumption. This untapped food resource could feed millions of people needing food and perhaps contribute to eradicating hunger.

Our study in 2015 on solid waste generation and composition, as published in The Asia Foundation scoping study report on solid waste management in Kep province, found that food waste from households in Phnom Penh was about 51.9%, followed by plastic at 20.9%, and paper at 9.9%. During this study, 384 waste samples from households and 185 waste samples from non-households were randomly collected for eight consecutive days. The remaining types of waste were grass and wood, metal, textile, ceramic and stone, and other burnable and unburnable waste, which were about 18.3% (Meas, Kuok, and Promentilla 2022).

Furthermore, our forecast on municipal waste composition from household and non-household generation sources found that the percentage of food waste in Phnom Penh accounts for the majority of waste discharge and will gradually decrease to about 46% in 2030 as plastic, paper, glass, and others materials will be increasingly used as wrapping and packing materials and with the public awareness on responsible food consumption. This organic waste as raw material could be composted and used as organic fertiliser, reinforcing the implementation of the Circular Economy (Ibid).



Source: Shutterstock

The rapid population growth and the skyrocketed rate of urbanisation make waste management a challenging issue amid the increasing demand for public well-being and clean and smart cities. As a forward-looking model for smart cities, greater attention must be given to waste management to prevent any adverse impact on the built environment, for example, infiltration of landfill leachate into the groundwater and other water sources. A higher requirement for smart cities means a more complex management system. Any fragmentation in providing access to waste service, feedback, transaction, and data exchange in real-time could hinder implementing an integrated waste management system. In such a case, applying new technologies such as blockchain could be a promising solution.

## Blockchain Usage in Developed Countries

Blockchain technology, known as a distributed ledger technology recording any digital data unchangeable and transparent based on a decentralised network and cryptographic hashing, has been widely used in the management of industrial waste, medical waste, and plastic waste (Taylor, Steenmans, and Steenmans 2020). Another blockchain-based collaborative platform, BlockWaste, has been implemented in Estonia, Germany, Greece, the Netherlands, and Spain to reintroduce waste into the value chain and promote intelligent circular cities. As a result, by deploying blockchain technology, the Netherlands made a remarkable achievement in increasing the waste-to-energy recovery rate from 50% to 93% in 2016 (BlockWaste Consortium 2021). Moreover, adopting blockchain technology, Pay-as-You-Throw, in waste collection is economically viable in cutting one-third of the annual collection cost (Emmanouil et al. 2022). This proof of concept works with the notification from citizens to waste collectors and recycling centres, during which the production of composting and recycling materials could be estimated and communicated with farmers on the same digital platform.

## How Blockchain Technology Works?

The blockchain platform could connect all waste management authorities and stakeholders: citizens, waste collectors, organic fertiliser producers, and farmers. Using IoT sensors and the decentralised network, real-time data could be generated, and waste management activities could be tracked. For example, garbage trucks could be tracked, and the journey could be viewed by citizens using smart contracts. At the same time, any individual could provide feedback on waste collection service and payment. This transparent feedback loop will reinforce the service performance and provide reliable data for organic fertiliser producers and the authorities. Such a platform could also be utilised to incentivise the reduce, reuse and recycle practices (3Rs), during which digital vouchers or currency could be given to citizens who recycle the waste. Moreover, using a blockchain-based app, citizens, organic fertiliser producers, and farmers could benefit from this Circular Economy market. Figure 1 illustrates the interoperability of blockchain technology as a platform for food waste management.

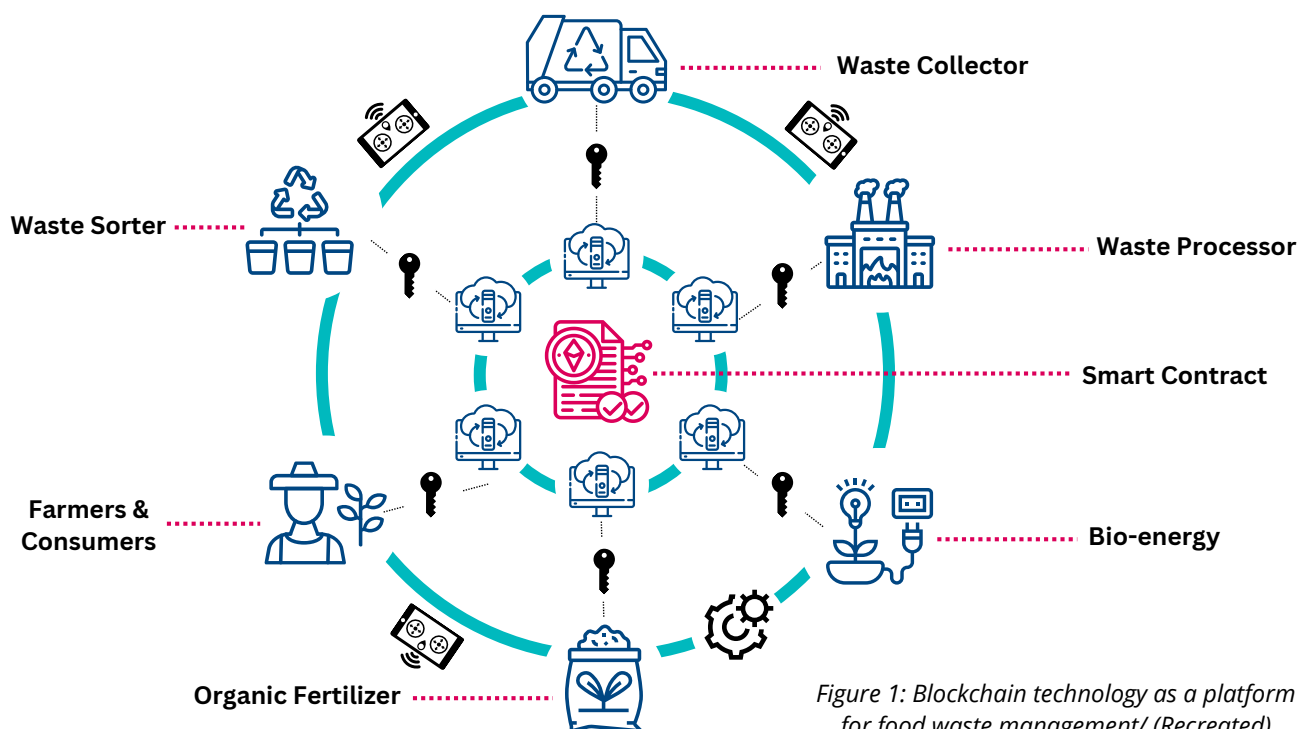


Figure 1: Blockchain technology as a platform for food waste management/ (Recreated)

## Barriers and Immediate Policy Initiatives

The potential of blockchain technology in food waste management, from tracing and tracking waste trucks to securing transparent transactions and services, efficient waste resources management, penalties for non-compliance, and chatbot-assisted and reliable waste management and operation, is widely acknowledged. However, adopting such technology is still in its early stage, especially for Cambodia, where the fundamental infrastructure is yet to be realised. Our recent study indicated potential barriers to adopting blockchain technology in Cambodia, including the lack of a reliable supply of energy, network infrastructure, trustful cybersecurity, data privacy, initial capital investment, market acceptance, government policy and legal framework, and public awareness.

With our novel T-Spherical Neutrosophic Fuzzy DEMATEL method for decision-making, the systematic analysis of the problematic causal map to provide an informative visualisation of all barriers' interrelationships is conducted. Such illustration of complex barriers offers insight into the immediate policy initiatives. In the order of importance, the adoption of blockchain technology in food waste management highly depends on the following policy recommendations:

- Capital investment in blockchain physical infrastructure, such as high-performance computing facilities and data centres, is extremely necessary, and the opportunity for a new law on investment should be well explored.
- Implementation of the legal framework of data privacy to increase public trust in blockchain technology should be strengthened to support the governance of this technology ecosystem.
- Policy support for market acceptance of blockchain technology as a new promising platform, essentially for the innovation and growth of business-to-customer (B2C) with the dynamics of brand marketing, personalisation, and trust.
- Public awareness programmes should be organised to increase public understanding and develop trustful cybersecurity to protect the digital ecosystem.

These policy recommendations rely on the key influential and prominent barrier, i.e., sustainable energy supply under the recently launched Cambodia Power Development Masterplan 2022–2040 and the National Energy Efficiency Policy. The application of blockchain technology could improve food waste management as proved by findings in various studies on SmartNoshWaste, using Blockchain, Machine Learning, Cloud Computing, and QR Code to reduce food waste in DecentralizedWeb 3.0 Enabled Smart Cities and blockwasteproject.eu project in Europe. It is the right time for Cambodia to start applying blockchain technology in waste chain management.

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