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REVIEW PAPER

Mapping 3R and Circular Economy Policy Implementation in Asia and the Pacific

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Abstract

The circular economy is a strategy that can lead to sustainable consumption and production, which is critical for decoupling development from environmental concerns. Even though the Asia–Pacific area has made rapid economic progress in recent years, there are fundamental challenges that have created bottlenecks in the adoption of a circular economy. This study attempted to examine regional policies and initiatives geared toward 3R and a circular economy, especially in the background of the Hanoi 3R Declaration: Sustainable 3R Goals for Asia and the Pacific (2013–2023). The analysis relied on secondary data from existing literature, multilateral agency reports, government websites, and nonprofit organization websites. According to our analysis, whereas East Asia, some Southeast Asian countries, and two Oceanian countries have clear strategic roadmaps for establishing a circular economy, the remaining regions are still in the early phases. The study also revealed that one of the key difficulties confronting the Asia–Pacific area is a lack of concrete policies, particularly those aimed at managing emerging waste. However, various hurdles are posed by institutional, technological, and financial issues. A brief examination of best practices from around the world was undertaken to motivate stakeholders. These effective circular economic processes, notably in agriculture, manufacturing, and infrastructure, can be replicated across the Asia–Pacific region to help it achieve its sustainable development goals faster.

Keywords Circular economy · Waste management · 3R · Sustainable development · Resource efficiency

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Introduction

The growing demand is increasing the stress on the environment and affecting its ability to regenerate. To counter this trend, eco-economic decoupling must be achieved. Eco-economic decoupling means that economic growth must be disentangled from both the proportionate use of resources and environmental impact [1]. Often, economic considerations and convenience in the design process overlook the environmental impact and long-term consequences. Furthermore, consumption and behavioural patterns further aggravate the environmental damage, and if the trend continues, renewable resources may not be renewed in time to meet global demand [2]. Recognizing this, Sustainable Development Goal 12 aims to achieve "responsible consumption and production" [3]. To realize this goal, we must look beyond the conventional consumption pattern known as the "linear economy," which is underscored by the "take-make-dispose" approach [4, 5].

One of the ways to achieve resource efficiency is through a closed loop of resources [6]. In 2005, Japan proposed the concept of the 3Rs (reduce, reuse, and recycle) as a means to achieve a sound material-cycle society [7]. Globally, the 3Rs approach, along with waste management policies, are widely recognized as a means of achieving a material-cycle society [8]. The European Union, on the other hand, had adopted the modified 4R framework, incorporating “recover” as the fourth pillar in its waste management directive [9]. To further improve resource efficiency, the circular economy was proposed. The circular economy has been designed to strengthen not only the closing of loops but also to slow, narrow, and establish regenerative resource loops [10, 11]. These are incorporated into the circular economy by adding six more pillars to the 3R framework, which will be discussed further below.

Circular Economy

Origins of Circular Economy

Walter R. Stahel explains in [12] that "a new relationship with our goods and materials would save resources and energy and create local jobs." The idea of replacing energy with labour was first proposed in [13], when the world was reeling from rising energy prices and unemployment. The Ellen MacArthur Foundation, one of the pioneers in the area, has been advocating the concept since 2010 and has defined the circular economy as "a systems solution framework that tackles global challenges like climate change, biodiversity loss, waste, and pollution. It is based on three principles, driven by design: eliminate waste and pollution, circulate products and materials (at their highest value), and regenerate nature" [14]. There is also a school of thought that attributes the origins of the circular economy to the "cradle to cradle" concept as proposed by [15].

The concept of Circular Economy

The circular economy is often considered an umbrella framework consisting of the 9R’s, within which the 3R’s are incorporated [16]. The Ellen MacArthur Foundation’s visualization of a circular economy as a butterfly model is widely used as a reference to understand the various pillars in the economy through which resource circularity can be attained. This model consisted of technical and biological cycles [14]. The technical cycle is the wing

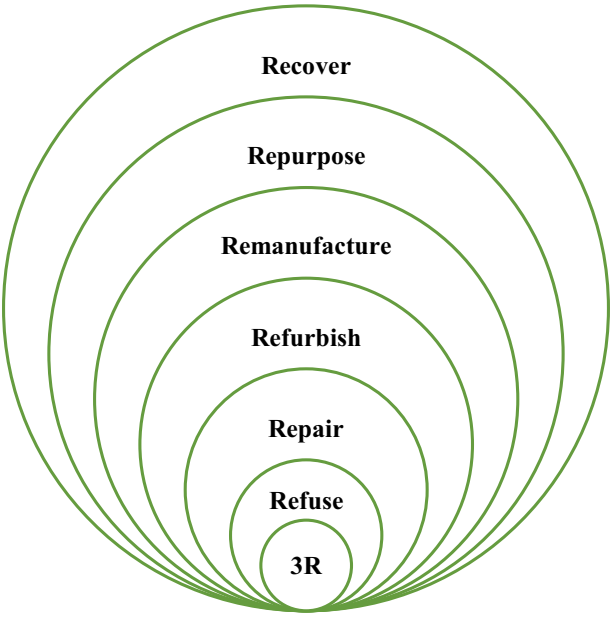
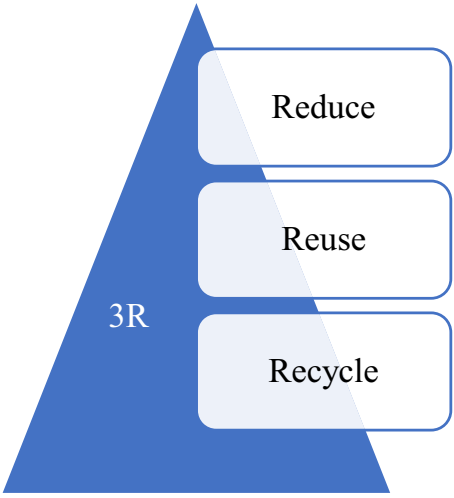


Fig. 1 Circular Economy Framework

that describes the means by which resources are kept in circulation through reuse, repair, refurbishment, remanufacturing, repurposing, and recycling. The biological cycle is the wing that describes how the nutrients from biodegradable materials are returned to nature for regeneration. A circular economy also entails thinking about multiple life cycles and thus refusing the use of certain resources, rethinking the design, and reducing the use of scarce materials at the design stage. The 9R's of circular economy are reproduced below and depicted in Fig. 1 and Fig. 2 [14, 16]:

Fig. 2 3Rs of waste management



i. Reduce: reducing the use of raw materials;
ii. Reuse: product reuse (second-hand, sharing of products);
iii. Recycle: processing and reuse of materials;
iv. Refuse: preventing the use of raw materials;
v. Repair: maintenance and repair;
vi. Refurbish: refurbishing a product;
vii. Remanufacture: creating new products from (parts of) old products;
viii. Repurpose: product reuse for a different purpose; and
ix. Recover energy: incineration of residual flows

There is no standard definition of "circular economy," and the concept is applied differently in different ventures. A quantitative analysis of the 114 definitions that exist was performed in [17], and the authors concluded by defining the circular economy as "an economic system that replaces the 'end-of-life' concept with reducing, alternatively reusing, recycling, and recovering materials in production, distribution, and consumption processes.".

Though promising (as detailed in Sect. 2.1), the adoption of the circular economy differs across the globe. The authors have reported that advanced economies such as Australia, the USA, the Netherlands, France, the UK, Denmark, Germany, Finland, France, Sweden, Norway, China, etc. have actively embraced this framework [18].

Aim of the study

The objectives of the study are as follows:

a) To analyse the existing policies in the Asia–Pacific region and map them to the goals of the Hanoi 3R Declaration.
b) To highlight waste and resource management issues in the Asia–Pacific region.
c) To study the best circular economic practices of other regions of the world.

This paper attempts to bring out the circular economic vision of the Asia–Pacific. We identified and discussed the major impediments to the region's adoption. We also contribute to an understanding of good practices around the world, with the expectation of adoption in the Asia–Pacific and the rest of the world.

The remainder of the paper is organized as follows: Section 2 provides a review of some key literature that helped us understand the knowledge gap. Sect. 3 describes the methodology. Section 4 discusses the results and discussions. Section 4 is subdivided into three subsections related to each objective of our study. Finally, in Sect. 5, the main conclusions are presented.

Literature Review

Benefits of Circular Economy

As stated before, the definition and origin of the system may be debatable, but the benefits that would accrue from it are widely accepted, and many enterprises have championed

it. The authors in [19] surveyed and concluded that a circular economic framework could support SDGs 8 (decent work and economic growth), 12 (responsible consumption and production), and 13 (climate action). The authors in[20] undertook a systematic survey of the literature and highlighted that public policy makers and academia have recognized the circular economy framework to harmonize economic growth, environmental issues, and resource scarcity. A study of the importance of a circular economic framework was also conducted in [21, 22] and [23]. The authors concluded that the circular economy model would be one of the key paths towards attaining sustainable development.

Circular Economy Policy study

China's circular economy policies were reported in [24–26]. The authors in [27], highlighted the case study of Finland. The circular economy paradigm was linked to the Dutch Green Deal in [28]. According to the literature policy studies of Europe as a region were conducted [29–32] and [33]. A comparative study of the policies in China and Europe was brought out in [34]. The authors in [35] reported on the Republic of Korea's circular economy strategy. A comparative study of the two forerunners, Japan and the Republic of Korea, was done by the authors in [36], and the authors have concluded that in Japan there is a collaboration among various stakeholders supplementing the regulations, whereas in the Republic of Korea, the lack of such a platform is a cause for concern, though a strong legislative and policy framework exists. A systemic review of circular economic practices in Australia and other developed countries was conducted by the authors in [18]. A review of circular economy practices in central Asian countries was reported in [37]. The circular economic studies of African Islands were conducted in [38]. The authors in [39] conducted a case study of Kenya's transition to a circular economy.

To the best of the author's knowledge, this is the first research to survey the existing policies of the countries in the Asia–Pacific region. The Asia–Pacific region has acknowledged the importance of the circular economy framework and adopted the Hanoi Declaration to channel their commitment to action.

Ha Noi 3r Declaration-Sustainable 3R Goals for Asia and the pacific for 2013–2023

The Fourth Regional 3R Forum in Asia, jointly organized by the United Nations Centre for Regional Development, the Ministry of Environment, Japan, and the Ministry of Natural Resources and Environment, Viet Nam, was held in Ha Noi, Viet Nam, in March 2013. It acknowledged the effectiveness of 3R and its complementary role in harnessing recyclable resources and deriving economic benefits from waste. The participating governments renewed their commitments to sustainable actions in their development and the Sustainable 3R Goals for Asia and the Pacific for 2013–2023 of the Hanoi 3R Declaration (hereinafter referred to as Hanoi Declaration) was signed as a legally non-binding and voluntary document. This comprehensive declaration underscored the criticality of various aspects of resource efficiency, and 33 goals were set under four categories: (i) 3R Goals in the Urban/Industrial Areas; (ii) 3R Goals in Rural Areas; (iii) 3R Goals for New and Emerging Wastes; and (iv) 3R Goals for cross-cutting issues. The declaration also recognized the unique challenges faced by Small Island Developing States in their path toward the attainment of sustainable development goals. These goals were set to be achieved within a decade from 2013 [40].

Methodology

There is published literature on the application of the circular economic framework to different sectors, such as textiles, construction waste, electronic waste, municipal waste, and so on. However there exists a knowledge gap on the circular economic vision of the Asia–Pacific region. We conducted a systematic search to identify the existing policies in the region with the goal of consolidating the circular economic policies and mapping them to the regional 3R declaration (since 3R is now covered under the umbrella term circular economy). The search for the policies included the publications in the Google Scholar database with the search words circular economy policy, waste management, and resource efficiency. Furthermore, reports published by multilateral agencies, government websites, and non-profit organization websites were also used as references. Subsequently, we undertook a search to identify the regional challenges faced in waste and resource management using a similar database. Finally, we performed research on the best circular economic practices implemented by the various institutions, private as well as public, with the aim of motivating the diffusion of the best practices. The paper was compiled based on the data up until March 2023.

Results and Discussion

This section explains the results of the systematic review in three parts. The first part describes the results of the policy analysis, followed by mapping the major policies to the Hanoi Declaration goals. The second part includes a discussion on the waste and resource management issues and challenges in the region, revealing the major bottlenecks in the implementation of the circular economic framework. Finally, we highlight some of the best circular economic practices around the world.

3R AND CIRCULAR ECONOMY POLICY IMPLEMENTATION IN ASIA AND THE PACIFIC

The challenges and issues of waste management are being viewed as an opportunity, and thus, a massive impetus to the formulation and implementation of 3R and a circular economy can be seen in the Asia–Pacific region. The Hanoi Declaration can be considered one of the factors aiding in this realization, a step towards a resource-efficient and resilient society and transitioning to a green economy. The strategies adopted vary from country to country. The Table 1 summarizes the status of implementation of circular economic framework in the signatories to the Hanoi Declaration. The regions used are as classified by the United Nations [41].

East Asia

Japan is a pioneer and one of the countries that have championed the three Rs (reduce, reuse, and recycle). And thus, the country has foreseen the necessity of a circular economy to tackle future challenges. Japan's Circular Economy Vision 2020 has been designed to adopt circular business models, derive assessments based on the market and society, and realize an early realization of a resilient resource circulation system [42].

Table 1 The circular economic framework existing in the signatories of the Hanoi declaration

Region	Country	Circular Economic Framework	Year
East Asia	Japan	Circular Economy Vision	2020
	Republic of Korea	Framework Act on Resource Circulation	2016
	People's Republic of China	Circular Economy Promotion Law	2008
South East Asia	Singapore	Zero Waste Masterplan	2019
	Thailand	Bio-Circular-Green economy	2021
	Indonesia	Indonesia's Vision 2045	2019
	Cambodia	Circular economy strategy and action plan	2021
	Brunei Darussalam	Wawasan Brunei 2035	2020
	Regional Policy	Framework for Circular Economy for the ASEAN Economic Community	2021
		SEA Circular	2018
Oceania	Australia	National Waste Policy Action Plan 2019	2019
	Regional Policy	Cleaner Pacific 2025 Regional Waste Strategy	2016
South Asia	Comprehensive circular economic framework was not found		

The Japanese Ministry of the Environment, Ministry of Economy, Trade, and Industry, and Japan Business Federation established the Japan Partnership for Circular Economy (J4CE) with an aim to create a common platform for various stakeholders, including public and private agents in the system. According to their reports, the concept of a "circular economy" has progressed from a policy to cross-sectoral best practices that can be replicated elsewhere. The concepts of sustainable steel, the recycling of lithium-ion batteries, bioplastics, the Yokohama food recycling project, etc. are reported as noteworthy practices [43]. The Republic of Korea has also moved well ahead in its march toward becoming a resource-efficient nation. The country passed the Framework Act on Resource Circulation in 2016, with the goal of circulating resources by reducing waste [44]. Also, in Strategy 6 of the Fifth Comprehensive Plan for National Environment (2020–2040), the focus is again on accelerating the transition towards a green, circular economy [45]. The Korean New Deal National Strategy has proposed a "Green New Deal," which aims to promote businesses that can support their march towards green industry [46].

The Circular Economy Promotion Law (2008) is considered one of the first laws in the People's Republic of China to promote the circular economy. The law was subsequently revised in 2018 to tackle future challenges. The 14th Five-Year Plan on Circular Economy (2021–2025) reassures the People's Republic of China's commitment to promoting resource conservation and recycling and attaining resource sufficiency. These goals are assessed by means of target indicators at the provincial, industrial park, and enterprise levels, sometimes referred to as (i) macro, (ii) meso, and (iii) micro indicators, with an additional indicator for the waste industry [47]. The study also reported that these indicators are often the metrics for enforcement. Mongolia has also embarked upon the transition to a circular economy with an amendment to Law on Waste (2017). Moreover, the National Waste Management Improvement Strategy and Action Plan (2017–2030) aims to conserve resources, reduce waste at the source, and engrain 3R principles across sectors. The Sustainable Development Vision 2030 of Mongolia further lays out the significance of adopting a circular economy in meeting the country's ecological balance aspirations [48].

South East Asia

Singapore has adopted a comprehensive approach and formulated a Zero Waste Masterplan. Though the country has an efficient waste collection and disposal system, the scope of sustainable production and consumption goes beyond that. To keep the resources within the closed loop, they have strategized to encourage sustainable production by means of sustainable design, promoting resource efficiency, and promoting industrial symbiosis. Further, the plan aims to extend the lifespan of Semakau landfill by reducing the amount of waste required to be sent to the landfill. Striking the chord of "reduce," the plan aims to control consumption by tackling single-use disposables, sharing the resources, and putting construction and demolition waste back into the buildings. The circular economy approach has specified three priority sectors: food, e-waste, and, plastics. The plan also incorporates the use of technology and innovation to transform the environmental service industry, along with the capacity building. While the plan emphasizes the importance of cross-border collaborations, it also emphasizes increased citizen involvement in order to achieve these goals [49].

Thailand has adopted and is promoting the Bio-Circular-Green economic model, or BCG, based on the priority sectors of the country. The BCG model focuses on promoting four industries: agriculture and food; medical and wellness; bioenergy, biomaterials, and biochemicals; and tourism and the creative economy. BCG is defined as a synthesis of the bioeconomy, the circular economy, and the green economy [50]. In Malaysia, the government has formed a Circular Bio Economy (CBE) Unit to aid the circular economy in bioenergy and biofuels, biochemicals, biomass-based end-products, waste-to-wealth projects, and BioHub and cluster developments [51]. In addition, the country has introduced incentives, among others, to waste management, like the Green Investment Tax Allowance, Green Income Tax Exemption (GITE), and Green Income Tax Exemption solar leasing, with the broader aim of reducing greenhouse gas emissions by 2030. Malaysia has also formulated a "roadmap toward zero single-use plastic" with an aim to attain it by 2030 [52].

UNDP is assisting Indonesia in formulating a circular economic policy roadmap. A study on "The Future is Circular: Concrete Steps for Circular Economic Initiatives in Indonesia" with a focus on the food and beverage, textiles, construction, wholesale and retail trade, and electronics sectors was released in 2022 [53]. The concept of a circular economy has been incorporated into Indonesia's Vision 2045 [54]. According to the studies, there is no specific framework for a circular economy in the Philippines or Myanmar; however, there are signs of steady progress in that direction. In addition, regulations such as the Solid Waste Management Act of 2019, the Philippine Green Jobs Act of 2016, and the National Plan of Action on Marine Litter of 2021, among others, exist in the Philippines to assist agents of the circular economy ([55, 56]). There are active projects underway in Vietnam to develop the circular economy ecosystem [57], and metabolic analysis studies are being conducted in Lao PDR with the assistance of UNDP [58]. Cambodia has prepared a circular economy strategy and action plan with the assistance of UNDP [59]. The Wawasan Brunei 2035, Brunei Darussalam's long-term vision, incorporates strong elements of the circular economy [60]. Timor-Leste, despite being in the early stages of adoption, was able to take a step toward a circular economy for plastics through the Plastic Upcycling Alliance [61].

Cambodia, Indonesia, Malaysia, the Philippines, Thailand, and Viet Nam are part of the SEA Circular, a joint initiative by the UN Environment Programme (UNEP) and the

Coordinating Body on the Seas of East Asia (COBSEA) with an aim to reduce the plastic waste in the region [62]. The ASEAN countries have also framed the Framework for Circular Economy for the ASEAN Economic Community to expedite the adoption of the circular economy in the region [63].

South Asia

Although initiatives such as the Swachh Bharat Mission (Clean India Campaign) and the amendment to the Plastic Waste Management Rules, 2022 incorporate the 3R principles, India lacks a cohesive strategy for a circular economy. The strong essence of a circular economy is ingrained in the Draft National Resource Efficiency Policy, 2019 [64] and NITI (National Institute for Transforming India) Aayog's paper, "Strategy for Secondary Materials Management for Promoting Resource Efficiency (RE) and Circular Economy (CE) in the Electrical and Electronic Equipment Sector" [65]. The report of the Ministry of Housing and Urban Affairs also evaluated and recommended the adoption of a circular economy for municipal solid and liquid waste [66]. Allured by the benefits, industries have already started to adopt circular economic principles in their operations. However, a strong regulatory framework is the need of the hour for one of the most populous countries in the world to drive sustainability at a mega scale and to attain its aspirations and commitments.

Bangladesh formulated the National 3R Strategy for Waste Management in 2010 [67]. The studies have shown that while recycling is adopted, the other pillars are not practiced effectively. The authors in [68] reported that there is a lack of stimulus for its transformation to a circular economy, especially due to policy, technological, and financial challenges. Asian Development Bank Institute studies also point out that the adoption of a circular economy is yet to gather steam in Bangladesh [69]. Bhutan aspires to become a zero-waste society by 2030. To aid this ambition, the country has launched the Waste Management Flagship Program, National Waste Management Strategy, an initiative for composting food waste, and an awareness program called "Zero Waste Hour" [70]. In Nepal too, the circular economy is in its infancy. However, there is a policy direction toward a circular economy, as is evident in the Solid Wastes Management National Policy, 2022, which aims to mobilize solid wastes as resources. The widely acclaimed healthcare waste management system implemented at the Tribhuvan University Teaching Hospital (TUTH) with the support of non-governmental organizations and WHO Nepal has a circular economic fabric [71].

The policymakers in Afghanistan, Pakistan, and Sri Lanka have yet to embrace the circular economy. On the other hand, the Maldives has made numerous strides in their transformation towards a circular economy. A waste-to-wealth approach is rooted in its National Strategic Action Plan. Also, projects like the Maldives Clean Environment Project and the Maldives Enhancing Employability and Resilience of Youth, both financed by the World Bank—PROBLUE, intensify the transformation [72]. In addition to the phasing out of single-use plastic, the government has begun to mull over legislating extended producer responsibility in its waste management strategy [73].

Oceania

Australia's National Waste Policy Action Plan 2019 has incorporated circular economic threads to finetune waste reduction and management, with a special emphasis on plastic, paper, glass, and tyres. The policy also addresses the issue of food waste with an emphasis on improving repairability and reuse, encouraging sustainable design and innovation, and

supporting customer choices across sectors [74]. The country is also providing incentives and grants through the Australian Recycling Investment Fund, the Recycling Modernization Fund, the National Product Stewardship Investment Fund, and the New Investment Engagement Service [75]. Australia has also earmarked a budgetary forecasted expenditure of $83.1 million to guide the transition towards a circular economy for 5 years, with effect from 2022–2023 [76]. New Zealand's long-term vision is to have a circular economy by 2050 with a flourishing bioeconomy. To guide this vision, the country is in the process of formulating a circular economy and bioeconomy strategy with a focus on creating a circular public sector, a bioeconomy framework, realigning the regulatory framework, and creating a conducive business ecosystem, among others, while duly collaborating with the indigenous people [77].

The Cook Islands is adopting the 4R strategy (3Rs + Refuse) by refusing identified products and choosing smarter alternatives. The country's cabinet has also approved a ban on several single-use plastic products. The nation's "National Solid Waste Management Strategy 2013–2016" is being reviewed to attain zero waste by imbibing the principles of a circular economy [78]. Fiji, to fast-track the circular economic transition, has established a Special Economic Zone (SEZ) in Naboro to support recycling and other green technologies [79]. The country is also in the process of adopting a circular economy with the support of the United Nations to sustain marine protected areas while extracting potential business from the reefs [80]. In Samoa, the United Nations Development Programme (UNDP) partnered with CRDC Global to circularize plastic waste management [81]. Tuvalu has incorporated Reduce, Reuse, Recycle, and Return in its Integrated Waste Policy and Action Plan 2017–2026 [82]. The metabolic analysis published by UNDP and the Government of Vanuatu reported that consumption in Vanuatu is 59 percent circular. This is attributed to the reliance on secondary or renewable resources [83]. Also, there are positive trends toward the transition to a circular economy in other Pacific Island nations. The Secretariat of the Pacific Regional Environment Programme (SPREP) is engaging with the member nations and supporting their ambitions towards a circular economy by integrating it with the Cleaner Pacific 2025 Regional Waste Strategy [84].

An effort was made to map some of the policy frameworks and visions existing in the signatories of the Hanoi declaration (based on the above discussions) to understand the areas where direct policy intervention is lacking. The study, based on secondary data described in the methodology section, is summarised in Table 2 and individual goal wise summary is provided in the supplementary document. The study is not comprehensive and included only a few policies based on the data available on government websites and reports from multilateral organizations (secondary data) and is only indicative in nature.

WASTE AND RESOURCE MANAGEMENT ISSUES AND CHALLENGES IN ASIA–PACIFIC

It is reported that by 2025, urban cities in Asia might generate 1.8 billion tonnes of waste [85]. According to the World Bank report, while East Asia and the Pacific region were estimated to produce the most waste in 2020, it is anticipated that South Asia and Sub-Saharan Africa will be the leading generators by 2050 [86]. As per OECD's first *Global Plastics Outlook: Economic Drivers, Environmental Impacts and Policy Options* plastic waste increased from 156 Mt in 2000 to 353 Mt in 2019. It was also found that 22% of the plastic waste was mismanaged (not disposed of properly), and led to leakage into the environment [87].

Table 2 Mapping of 3R and circular economy policies of the Asia–Pacific countries to the Hanoi declaration

Hanoi declaration major goal	Some of the policies in the signatories
3R goals in urban/industrial areas	• Japan: Waste management and public cleansing law • Republic of Korea: Volume based waste disposal fees, Wastes Control Act • Singapore: Zero waste masterplan • Australia: National Waste Policy 2018 • New Zealand: Auckland Waste Management and Minimisation Plan • India: Swachh Bharat Mission
3R goals in rural areas	• India: SAMPADA- Scheme for Argo-marine processing and Development of Argo-processing Clusters • Thailand Bio-Circular-Green Economic Model (BCG) • New Zealand: First emissions reduction plan 2022
3R goals for new and emerging wastes	• People's Republic of China: Plastic Import Ban • Maldives: Plastics Export–Import Act Japan: Act on the Promotion of Sorted Collection and Recycling of Containers and Packaging, Act on Promotion of Recycling of Small Waste Electrical and Electronic Equipment • Singapore: Resource Sustainability Act (RSA)
3R goals for cross-cutting issues	• The Philippine Green Jobs Act of 2016 • Singapore: Food Bank Singapore or Food from the Heart • India: Swachh Bharat eLearning platform • Japan Partnership for Circular Economy

The World Bank studies have identified "ambiguity around organizational structure and responsibility, and coordination both within the same level of government and amongst national, regional, and local governments" as one of the major challenges in waste management [88]. Further, the report highlights that, while in most of the higher-income countries, there exist laws and regulations that act as enablers, the management becomes unsustainable due to institutional and infrastructural issues. In the case of middle- and lower-income countries, challenges stem from financial and technological issues, in addition to institutional issues. Thus, the waste management issues can be categorised into four as shown in Fig. 3.

Policy Issues

A policy targeted at tackling these issues is the framework within which all the agents act to efficiently attain the set goals. It is also estimated that 86 percent of countries have an official national law or set of guidelines that govern solid waste management. In many countries, these laws have outlived their purpose due to rapid development and migration. With increased waste generation and community opposition based on the NIMBY (not-in-my-backyard) movements, existing landfills are limited in their ability to meet demand. As a result, the effectiveness of existing policies and strategies must be reassessed, particularly in developing countries where urbanization is accelerating.

The report indicates that, as of 2019, only 78 countries have established a law, policy, or regulation for e-waste management, with only 19 countries in Asia and Africa having legally binding legislation on e-waste together [89]. Though multilateral treaties such as the Basel Convention exist to regulate hazardous waste dumping, regulatory exemptions

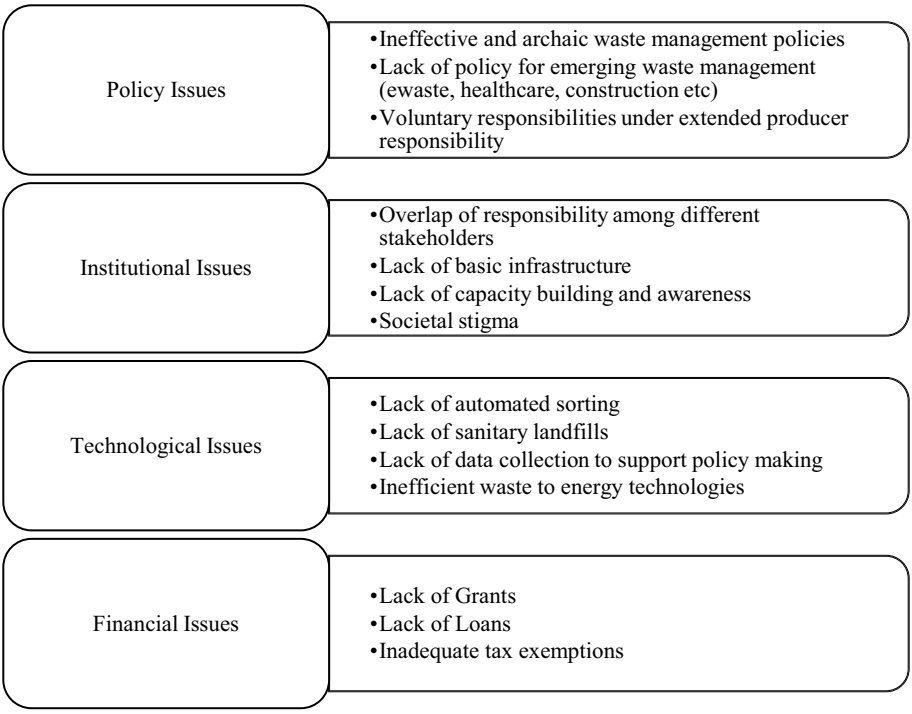


Fig. 3 Categorisation of Waste management issues in Asia Pacific

exist for the purpose of reusing equipment. Studies also suggest that there is a transboundary movement of e-waste for informal disposal in developing countries. The study in [90] highlighted two prominent gaps that ail the existing regulation: (a) a lack of adequate attention to the recovered materials and substances, and (b) control to reduce the reliance on toxic metals used in the manufacture of new products. The studies suggest similar issues exist for plastics waste, healthcare waste, construction waste, food waste, etc.

As per the OECD definition, "Extended Producer Responsibility (EPR) is a policy approach under which producers are given a significant responsibility – financial and/or physical – for the treatment or disposal of post-consumer products. Assigning such responsibility could in principle provide incentives to prevent wastes at the source, promote product design for the environment and support the achievement of public recycling and materials management goals." The authors in [91] have also reported that all EPR is not enforced by legislation and, in certain cases, is on a voluntary basis, rendering the policy inadequate.

Institutional issues

An effective institutional structure is the cornerstone of the effective delivery of the policy framework and should guide, empower, influence, incentivize, and resource policy and strategic planning, regulatory enforcement, monitoring and data reporting, financing, and communications [90]. The studies in [90, 91] suggest ambiguity or overlap in the responsibility of different institutions is a major detriment to policy implementation. In addition

to this, it is also established that a lack of basic infrastructure such as bins, timely waste collection, etc., and an unawareness of appropriate waste handling processes are also major challenges. The societal stigma towards waste workers, especially in non-developed countries, restricts volunteering. A strengthened institutional mechanism by means of a mix of capacity building, encouragement, and enforcement can bring about behavioural change. The relationship between the different institutions, such as different tiers of the government or the industry-government interaction, was found to generate conflicts of interest instead of collaborative working, often leading to innovation and implementation paralysis [91].

Technological gap and issues

The adoption of technology varies according to the income of the country. Although recent trends in low-income countries indicate the adoption of recycling and sanitary landfills, open dumping and burning are still prevalent. Landfills continue to be the common final disposal method in middle-income countries, though waste-to-energy incineration schemes are being adopted at smaller scales. In the case of higher-income countries, sanitary landfills and incinerators are more prominent, along with a focus on the recovery and reintegration of materials through recycling and other methods [88]. Automated sorting of waste is yet to be diffused into lower-income economies. Data forms the basis for arriving at policy. The integration of information and communication technologies that aid centralized data management also follows the same trend as waste disposal.

Financing issues

Financing through instruments like taxation or deposit systems can put an additional burden on consumers in middle- and lower-income countries. While tax exemptions can be effective, regulatory enactments are yet to be put in place. Hence, these countries rely on grants from the government and other agencies. The trend in OECD countries, as summarized in their review, indicates that governments have played a key role in many OECD countries by providing grants, loans, and tax exemptions that support investments [92]. According to the World Bank, effective waste management can cost about 20%–50% of municipal budgets [93]. The figures suggest the criticality of the government prioritizing waste management.

Best Practices and Cases – from Global Perspective

The some of the good circular economic practices from around the world is summarised in Fig. 4.

The circular economy in fashion has gained traction in recent years, with remanufactured fashion becoming a show-stopper. Some of the approaches in the Swedish circular fashion economy are garment take-back programs, clothing swaps, clothing libraries, and repair services, apart from conventional second-hand shopping [94]. Some of the strategies adopted by the Dutch fashion industry are the fashion positive program (cradle-to-cradle design), post-consumer textile sorting, offering textile products as a service, including leasing garments, establishing a fashion library, and establishing an industry standard for using textiles that are no longer re-wearable [95]. Reuse of clothing projects is also extensively found in Europe, such as through the online platform Thrift + in the United Kingdom, clothing rental stores such as Vaatepuu in Finland, Lindström offering workwear as a service, and so on [92].

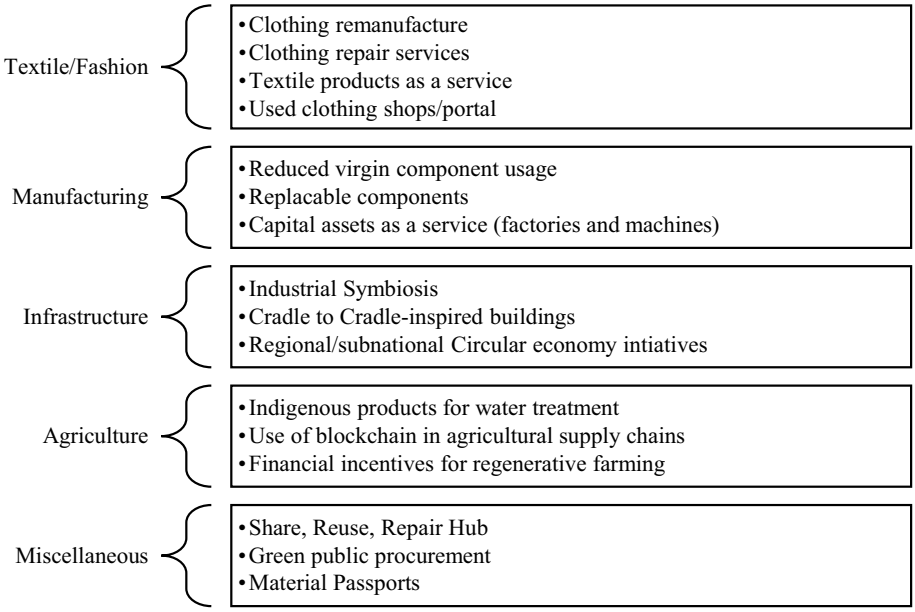


Fig. 4 Best circular economic practices from around the world

The industry's resilience to finite resources can be enhanced by narrowing and even slowing the resource loops. This can be attained by reducing the dependency on virgin materials [96]. Dartford Composites, a manufacturer of fiberglass products in the United Kingdom, successfully reduced its reliance on virgin acetone by recycling the acetone used on site. It is expected that with the reduced reliance on virgin acetone, the expenditure can be brought down by £9,500 in 2022 [97]. Reusability by replacing the light source has been the sustainability success slogan of Valtavalo, one of the leading energy-efficient lighting companies in Finland. By replacing the light source, the life of the lighting unit can be greatly extended. The huge capital investments required for a factory can be an impediment to an idea becoming reality. In Finland, Combi Works introduced the idea of offering factory production as a service, thereby reducing resource requirements. The company does not own the requisite machinery or the factory. Instead, it capitalizes on the underused capacity of its clientele. With this approach, in addition to the savings in the investment cost, one can further save on transportation costs, time, and the environmental footprint of the transportation by producing in a factory close to the target customer [92].

Material passports are digital documents that provide details of the characteristics of materials and components in products and systems that not only aid consumers in use but enable appropriate recovery and reuse [98]. The authors in [99] highlight that material passports can significantly contribute to transforming the construction sector supply chain into a circular model, as the information enables the integration of various stakeholders into the supply chain. Tarkett, a company based in France, has introduced a Material Health Statement, highlighting the health hazards and risks of raw materials, thereby creating customer awareness, and improving disposal. Moreover, the data provided in the statement is verified by an independent auditor, thereby ensuring authenticity [100].

Subnational administrations are major stakeholders in attaining a circular economy. With their efforts, a circular economy can be incorporated into regional development and

thus focus on regional sectors that may miss national priorities. The Netherlands framed a circular economic strategy in 2016 and aims to become a zero-waste economy by 2050. Backed by the policy, a metabolic analysis was conducted for the northern areas of the country, where there is a strong agricultural presence. Based on the study, the city council of Groningen implemented the circular economy in three priority sectors: public procurement, waste, and knowledge [101]. As per the OECD report, the city has further identified sectors of interest for diffusing the circular economy, which includes water, energy, food and beverage, sanitation, biomass, construction and demolition, the creative industry, waste, and mobility. The efforts of the city reflect the role of subnational administrations in the transformation towards a circular economy. The city of Venlo in the Netherlands initiated and built one of the first Cradle to Cradle-inspired buildings, their city hall [102].

One of the most efficient ways to implement a circular economy is by establishing industrial symbiosis. Derived from the biological symbiotic relationship, the definition can be traced to [103], wherein authors define industrial symbiosis as an ecosystem that "engages traditionally separate entities in a collective approach to competitive advantage involving the physical exchange of materials, energy, water, and by-products" Kalundborg Industrial Park in Denmark is considered one of the leading industrial symbioses. The system is a partnership between fourteen public and private enterprises that leverage the principle of converting waste from one into a resource for another [103]. The efforts of Emirate Global Aluminium in the UAE have put a mark on the circular economic practices in the metal sector. One of the by-products of their aluminium factory, spent pot lining (SPL), was stored, and not disposed of. The company conducted extensive research and identified that the product could be used as raw material for the cement industry, and it started feeding it to UAE cement plants [104].

Using advanced digital technologies to diffuse classical concepts is one way of achieving a circular economy. "Share, Reuse, Repair Hub," an online platform started in the York Region of Canada, enables the sharing, reusing, and repairing of products from a range of categories, such as textiles, furniture electronics, household appliances, and even recreational equipment, among individuals as well as businesses. It also features a live map indicating the nearest location of an event or a store that undertakes swapping, second-hand sales, or acts as a drop-off center. A directory of repair services such as tailoring, bike mechanics, electronic repair centers, and the like is also provided to aid consumers [105].

A government leading from the front can instill a lot of confidence in the transformation to a circular economy. Green public procurement or circular public procurement is often considered a tool to encourage industries toward this transformation. EU has defined green public procurement as "a process whereby public authorities seek to procure goods, services, and works with a reduced environmental impact throughout their life cycle when compared to goods, services, and works with the same primary function that would otherwise be procured [106]. The authors in [107] highlighted that green public procurement in Denmark relies predominantly on eco-label products. Elsewhere, the city of Toronto in Canada has issued a "Circular Economy Procurement Implementation Plan and Framework", wherein public procurement is evaluated against a set of metrics grouped into environmental (percentage of recycled content, greenhouse emissions, etc.), social (number of green jobs created, etc.), and economic (waste reduction, etc.) parameters. Such a shift in procurement not only acts as a catalyst for industries to shift to a circular economy but can also instill confidence in other stakeholders [108]. San Francisco passed legislation in 2018 requiring all carpets used in city departments to be cradle-to-grave silver certified or higher, as well as chemical component restrictions. Similar regulations apply to adhesives and tiles used for carpets [109].

With the rising electronic waste in our system, circular economic approaches in the sector are gaining attention. An extended producer responsibility scheme is one of the policy tools adopted to tackle this issue. However, the concept of reuse, one of the major pillars of the circular economy approach, can also be an effective approach [110]. The city of Belo Horizonte in Brazil has established a computer reconditioning center. This government-established remanufacturing facility aids in the reduction of electronic waste by restoring after-use electronic equipment, typically information technology equipment. The initiative created jobs for locals and used refurbished IT equipment for digital inclusion activities [111]. Kenya too has identified the perils of electronic waste, which is regarded as one of the fastest-growing waste streams, and the Waste Electrical and Electronic Equipment Centre has established a network of stakeholders to scientifically process the e-waste [112].

In Africa, a government-led coalition, the African Circular Economy Alliance, was formed in 2016. The alliance, which started as a partnership between three countries (Rwanda, Nigeria, and South Africa), has grown to eight (Ghana, Côte d'Ivoire, Benin, Burkina Faso, and Sudan), and many countries have expressed their interest in joining the alliance to accelerate their transition towards a circular economy. Moreover, Algeria, Tunisia, Egypt, Nigeria, Rwanda, Gabon, Kenya, and Madagascar have incorporated the circular economy into their national development plans [113]. A compilation of the best practices in Africa was done by Footprints Africa. Access to clean drinking water is one of the pillars of the Sustainable Development Goals. Vepox Filter, a company based in Uganda, is using the seeds of indigenous Moringa trees to treat water [112]. OKO Forests is assisting the farmers in Ghana to adopt a regenerative agricultural practice leveraging blockchain technology. In addition, the Brazilian city of Sao Paulo has incentivized regenerative farming practices by purchasing produce from certified farmers at a 30% premium over market prices [111].

Conclusions

The Hanoi 3R Declaration: Sustainable 3R Goals for Asia and the Pacific (2013–2023) was one of the first efforts to create a regional platform to stimulate resource efficiency. The transformation of the 3Rs of waste management into a circular economy framework (9Rs) is a promising approach to fulfilling the sustainable development commitments of the Asia–Pacific region. This paper aimed to analyze the circular economic vision of the region, including the subsumed 3Rs policies, to understand the progress of resource and waste management in the region. This study was conducted using secondary data obtained from numerous sources. The study indicated that there are strong drivers for adopting circular economic practices, and the trend in the Asia–Pacific region also indicates strong intentions. Though countries like Japan, the Republic of Korea, the People's Republic of China, Singapore, Australia, and New Zealand are frontrunners, there is immense potential for further adoption. The other countries in the region also have strong visions that need to be translated into practice. While most countries have implemented waste management, plastic waste management, and extended producer responsibilities, a strong circular economic roadmap to fully capitalize on good management is still in its early stages. National policies are often not backed by stakeholder engagement and institutional frameworks with clear delegation of authorities, which results in only patchy implementation. The study also brought out the successful circular economic practices in the rest of the world. These successes can be adopted in the Asia–Pacific region to fast-track their circular economic efforts.

The Asia–Pacific region is expected to grow at a rapid pace in the coming years. This study aimed to reflect upon the policies existing in the region to guide and motivate the policymakers of other aspiring countries. Moreover, the regional forums can effectively formulate goals that focus on regional concerns. With the Hanoi Declaration's deadline approaching, the need to have cross-sectoral circular goals for the region is imminent.

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Declarations

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