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Advancing to a Circular Plastic Economy: A Systematic Review of Policy Instruments

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Abstract: *The transition to a (CE) in plastic waste management is increasingly recognised as a pivotal pathway to achieving long-term environmental sustainability. Policy instruments are critical in facilitating this transition, yet their effectiveness varies significantly across regions due to contextual differences in governance, infrastructure, and economic incentives. This study undertakes a systematic literature review to critically assess the global application of policy instruments that support CE practices in plastic waste management, with a particular emphasis on the Malaysian context. Using the ROSES methodology, this study analyses academic literature and policy documents to categorize instruments into five types: regulatory, economic, informational-based, collaborative, and investment. The analysis identifies key policy gaps, fragmentation, and a lack of sector-specific strategies within Malaysia's current CE policy framework. Drawing on international best practices, this study proposes an integrated, multi-instrument policy model tailored to Malaysia's institutional and economic landscape. The findings offer strategic policy insights and a conceptual foundation to guide more effective CE implementation in developing economies, thereby contributing to ongoing academic and policy discourse on sustainable plastic value chain governance.*

Keywords: *Circular Economy, Policy Instruments, Plastic Waste Management, Systematic Review, Malaysia, Sustainability*

1) INTRODUCTION

The rapid increase of unsustainable plastic production and consumption has led to a critical surge in plastic waste, posing significant risks to ecosystems, public health, and the achievement of the Sustainable Development Goals (SDGs). With annual plastic production exceeding 400 million tonnes, it is estimated that approximately 22% of global plastic waste is mismanaged, often ending up in open dumping or uncontrolled burning, especially in developing economies [50]. This crisis is rooted in the prevailing linear economic model characterised by the "take–make–dispose" paradigm, which promotes unsustainable resource extraction and short product lifespans, ultimately exacerbating environmental degradation and resource depletion.

In response, the Circular Economy (CE) has gained increasing attention as a systemic and regenerative approach that redefines production and consumption patterns [43]. Rather than relying on end-of-life waste management, the CE model aims to retain the value of materials within the economy for as long as possible through reuse, recycling, product redesign, and sustainable substitution [10]. Within the plastics sector, CE approaches target interventions across the entire value chain, from reducing dependency on virgin polymers and promoting material circularity to fostering design innovation and scaling up post-consumer recovery systems [13]. However, the successful operationalisation of such strategies is closely tied to the development and enforcement of coherent and context-sensitive policy instruments.

Policy instruments serve as crucial levers through which governments influence stakeholder behaviour and drive systemic transformation. They play vital role in stimulating innovation, aligning market behaviour with sustainability goals, and mitigating negative externalities across the plastic lifecycle. Globally, several countries have demonstrated notable progress in adopting such instruments to promote circularity in plastics. The European Union's Circular Economy Action Plan, China's Circular

Economy Promotion Law, Germany's Packaging Act (VerpackG), Japan's Strategy for Plastics Resource Circulation, and the Netherlands' Circular Economy Programme exemplify comprehensive policy mixes. These typically combine regulatory instruments (e.g., bans, standards), economic tools (e.g., taxes, subsidies, extended producer responsibility (EPR)), informational-based instruments (e.g., eco-labels, public awareness campaigns), collaborative instruments (e.g., voluntary agreements, multi-stakeholder platforms) and investment tools (e.g., funding for Research and Development (R&D) and infrastructure). The effectiveness of these instruments, however, varies significantly depending on national governance capacities, socio-economic conditions, and industrial maturity.

In contrast, Malaysia, as a rapidly urbanising middle-income country, continues to face significant challenges in advancing a circular plastics economy. Despite recent efforts such as the Roadmap Towards Zero Single-Use Plastics (2018–2030), the Twelfth Malaysia Plan, and the recently introduced Circular Economy Blueprint for Solid Waste (2025–2035), the national policy landscape remains fragmented, with limited regulatory enforcement, weak economic levers, inadequate recycling infrastructure, limited financial incentives for innovation, and low public awareness. Such barriers hinder the country's transition towards a circular plastics economy. Hence, a critical need for comprehensive evaluation of existing instruments and a context-sensitive framework to guide Malaysia's transition.

Although prior studies have explored CE frameworks and plastic governance, few have systematically synthesised global policy instruments and benchmarked them against Malaysia's context. Moreover, existing literature tends to focus on individual policy tools without addressing how integrated policy mixes function across different governance environments. To address these gaps, this study conducts a systematic literature review guided by the ROSES (RepOrting standards for Systematic Evidence Syntheses) methodology to categorise and evaluate CE policy instruments globally, and to develop strategic recommendations tailored to Malaysia's institutional realities. The review synthesises both academic and policy literature to identify and classify CE-related policy instruments into five primary categories: (i) regulatory instruments (e.g., bans, standards, EPR), (ii) economic instruments (e.g., taxes, subsidies), (iii) informational-based instruments (e.g., labelling, education), (iv) collaborative instruments (e.g., digital platform), and (v) investment instruments (e.g., innovation grants). In doing so, this paper contributes to both academic and policy discourse by providing a structured taxonomy of CE-related policy instruments for plastics, benchmarking Malaysia's policy landscape against international best practices, and offering a conceptual basis for an integrated policy model. By aligning CE principles with evidence-based governance mechanisms, the study supports the development of more coherent, enforceable, and inclusive CE policies in emerging economies.

2) METHODOLOGY

2.1 Review Protocol - Reporting Standards for Systematic Evidence Syntheses (ROSES)

This study employed a systematic literature review (SLR) guided by the Reporting Standards for Systematic Evidence Syntheses (ROSES) protocol, as developed by [16], which is specifically designed for environmental management and policy-related reviews. ROSES was selected due to its structured approach to evidence synthesis in complex and interdisciplinary fields such as CE and plastic governance. Compared to other review protocols, ROSES provides enhanced relevance for sustainability and conservation-focused studies, ensuring methodological rigour, transparency, and reproducibility.

In line with the ROSES framework, the review process began with the formulation of a clear and focused research question, which informed the development of a systematic and reproducible search strategy. This strategy employed predefined keywords and Boolean operators to identify relevant literature across selected academic databases. The screening process was conducted in two stages: initial title and abstract screening, followed by full-text assessment based on clearly defined inclusion and exclusion criteria. Subsequently, a critical appraisal was conducted to evaluate the methodological

quality and relevance of each included study. The final stage involved systematic data extraction and thematic synthesis to categorise the types, functions, and effectiveness of policy instruments supporting CE in plastic waste management. By applying the ROSES framework, this review ensures a transparent, methodologically rigorous, and policy-relevant synthesis of existing literature, thereby strengthening both its academic contribution and practical utility.

2.2 Formulation of Research Question

The formulation of the primary research question in this study was guided by insights from relevant literature and structured using the revised PICo mnemonic framework, which stands for Population (P), Phenomenon of Interest (I), and Context (Co), as proposed by [26]. This framework is particularly well-suited for guiding qualitative systematic reviews and for structuring evidence-based inquiry in environmental and policy-oriented research. In this study, the "Population" refers to countries across various stage of CE implementation. The "Phenomenon of Interest" concerns the policy instruments used in plastic waste management. The "Context" pertains to the broader strategic transition toward a CE, with particular attention to Malaysia's policy environment. Based on these elements, the primary research question underpinning this review is as follows: "What types of policy instruments have been implemented globally to support the transition to a CE in plastic waste management, and how do these instruments compare in terms of their design, objectives, and applicability to the Malaysian context?" This question provides a focused analytical lens for systematically investigating the diversity, functionality, and contextual adaptability of CE policy instruments in addressing plastic-related environmental challenges.

2.3 Systematic Searching Strategy

A multi-phase search strategy was designed to ensure a comprehensive and replicable selection of relevant literature. The search process was operationalised in four key stages: identification, practical screening, eligibility assessment, and quality appraisal. Each stage was guided by predefined inclusion and exclusion criteria, carefully aligned with the research question, objectives and scope.

2.3.1 Identification

The identification phase involved designing a comprehensive and replicable search strategy to capture relevant peer-reviewed and grey literature concerning CE policy instruments in plastic waste management. A combination of controlled vocabulary, free-text keywords, and Boolean operators (AND, OR) was used to optimise search specificity and sensitivity. Key search terms included: "circular economy", "circular plastic economy", "policy instruments", "policy mixes", "waste management", "regulatory instruments", "economic instruments", "market-based instruments", "informational-based instruments", "collaborative instruments", and "investment instruments". Searches were conducted across two major academic databases, including Scopus and Web of Science (WoS). These databases were selected for their extensive coverage of interdisciplinary research across environmental, social and political sciences [31]. The search was restricted to literature published between 2010 and 2025, reflecting a period of intensified global policy interest in CE practices. All retrieved records were exported into Mendeley reference management software to facilitate efficient data handling, duplicate removal, and subsequent screening procedures. The initial search yielded 3,042 records from Scopus and 144 records from WoS, as summarised in Table 1.

Table 1: Advanced Search String

Online Database	Advanced Search String
Scopus	("Circular Economy" OR "Circular Plastic Economy") AND ("Waste" OR "Waste Management") AND ("Policy Instruments" OR "Policy Mixes" OR "Regulatory Instruments" OR "Economic Instruments" OR "Market-Based Instruments" OR "Informational-based Instruments" OR "Collaborative Instruments" OR "Investment Instruments")

Web of Science (WoS)	("Circular Economy" OR "Circular Plastic Economy") AND ("Policy Instruments" OR "Policy Mixes" OR "Regulatory Instruments" OR "Economic Instruments" OR "Market-Based Instruments" OR "Informational-based Instruments" OR "Collaborative Instruments" OR "Investment Instruments")

2.3.2 Practical Screening

Following the identification phase, a practical screening process was undertaken to eliminate studies that did not satisfy the predefined inclusion criteria. A total of 3,186 records retrieved from the Scopus and Web of Science (WoS) databases were subjected to an initial screening based on metadata, including title, abstract, publication type, language, subject area, and availability of full text. The inclusion and exclusion criteria applied in this stage are summarised in Table 2.

To ensure methodological consistency and relevance, only records that fulfilled the following criteria were retained: (i) published in the form of a journal article, review, conference proceeding, book chapter, or book; (ii) published between 2010 and 2025, reflecting the contemporary evolution of CE policies; (iii) written in English; (iv) categorised under the subject areas of environmental sciences or social sciences; and (v) available in full-text format. Studies failing to meet any of these requirements were excluded from further analysis.

As emphasised by [36], the objective of this phase is to refine the dataset into a more focused and manageable corpus that aligns closely with the research aims and methodological standards of evidence-based review. Following the application of these screening criteria, 2,338 records were retained for the next stage of eligibility assessment, comprising 2,201 from Scopus and 137 from WoS, as presented in Table 2.

Table 2: Inclusion and Exclusion Criteria

Selection Criteria	Inclusion	Exclusion
Document Type	• **Article** • **Review** • **Conference paper** • **Book chapter** • **Book**	Others: Early access, Editorial Material, Meeting
Year of Publication	• **January 2010 to January 2025**	Prior to January 2010
Language	• **English**	Non-English
Subject Area	• **Environmental Science** • **Social Science**	Other than environmental science and social science

2.3.3 Eligibility

Articles that passed the practical screening stage were subjected to a detailed eligibility assessment through full-text review. The purpose of this stage was to determine the substantive relevance of each study to the research objectives, particularly regarding the role of policy instruments in advancing CE principles within plastic waste management. To be deemed eligible, studies were required to meet the following criteria: (i) provide a focused discussion on one or more categories of policy instruments, namely regulatory, economic, informational-based, collaborative, or investment instruments; (ii) examine the implementation, outcomes, or effectiveness of these instruments in practice; and (iii) be situated within a global or developing economy context, with particular emphasis on relevance to Malaysia. Studies that were purely conceptual, lacked empirical support, or did not explicitly explore the relationship between CE and policy instruments were excluded. Upon completion of this eligibility assessment, a total of 21 studies met the inclusion criteria and were selected for subsequent quality appraisal, as illustrated in Figure 1.

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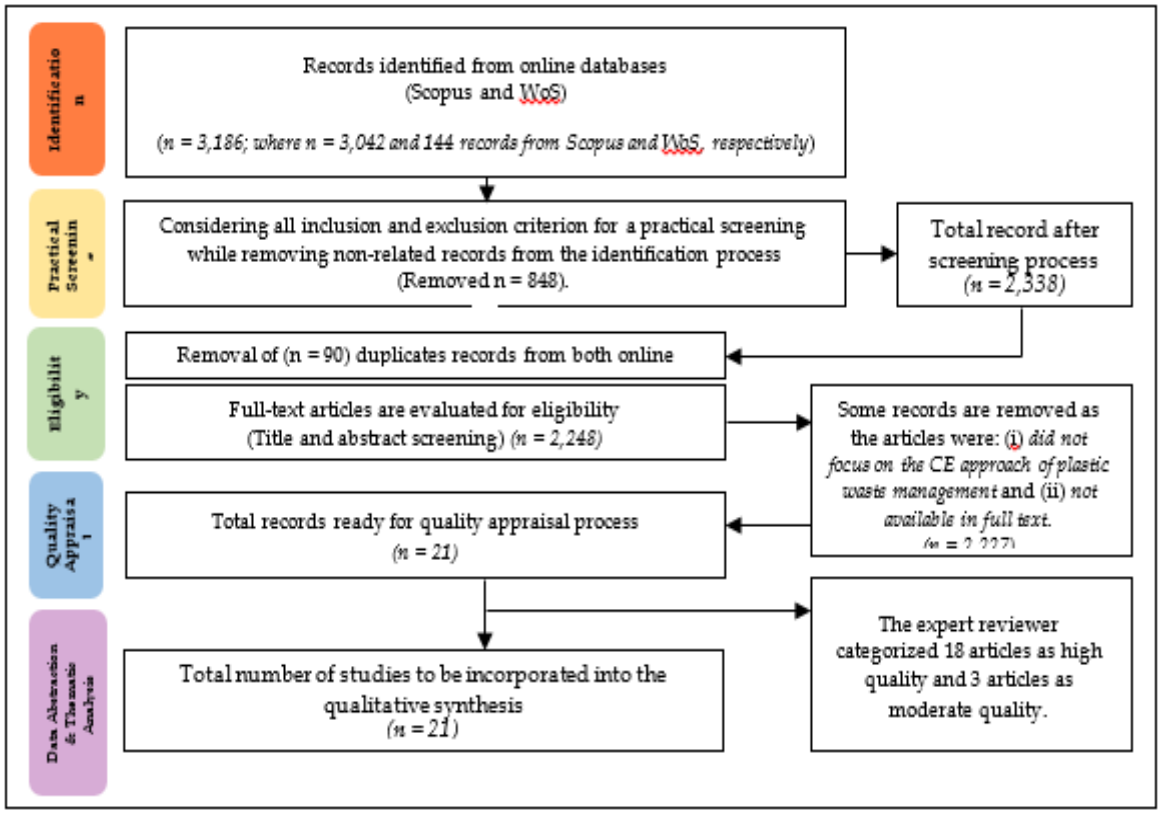

Figure 1: Flow diagram the structure searching

2.4 Quality Appraisal

The quality appraisal phase involved the evaluation of the remaining studies by two subject-matter experts to ensure the reliability and relevance of the selected literature. Studies were assessed based on their methodological rigour and the clarity of their findings and categorised into three quality levels: high, moderate, and low, following the approach proposed by [41]. Inclusion in the final review required consensus between both reviewers regarding the quality ranking. As a result, 18 articles were deemed to be of high quality and 3 were assessed as moderate quality. These 21 studies were considered suitable for inclusion in the subsequent synthesis phase.

2.5 Data Abstraction and Thematic Analysis

This study employed an integrative review approach, which facilitates the synthesis of diverse forms of evidence across various research paradigms, including qualitative, quantitative, and mixed-methods studies [31]. The integrative review enables the aggregation and interpretation of findings from heterogeneous sources, thus allowing for the development of novel insights and theoretical constructs relevant to CE policy instruments.

As emphasised by [6], integrative reviews are particularly valuable for generating a comprehensive understanding of complex policy issues, such as the governance of plastic waste, by drawing upon a wide range of informational inputs. Accordingly, the selected studies were analysed using primary research techniques appropriate for synthesising qualitative and mixed-method evidence, in line with the methodological recommendations of [51].

Thematic analysis was employed as the principal technique for identifying and interpreting patterns within the data. In accordance with the definition by [4], a theme represents a salient and recurring concept that captures meaningful trends related to the research objectives. Through an in-depth examination of study abstracts, findings, and discussion sections, key themes and sub-themes were identified and categorised. Ultimately, 21 studies were included in the data abstraction and thematic coding process.

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3) RESULTS AND DISCUSSION

3.1 Overview and Background of the Selected Studies

The final set of 21 studies included in this review met the final criteria for inclusion and were analysed in this systematic review. The thematic analysis yielded five principal themes, each representing a category of policy instruments pertinent to CE implementation in plastic waste management. These themes and their corresponding sub-themes are: (i) regulatory instruments (4 sub-themes); (ii) economic instruments (8 sub-themes); (iii) informational-based instruments (6 sub-themes); (iv) collaborative instruments (2 sub-themes); and (v) investment instruments (3 sub-themes) as shown in Table 3.

The reviewed literature covered policy implementations from 52 countries across multiple regions, reflecting the global scope and diversity of CE policy adoption. Specifically, the selected studies referenced 29 European countries (including Austria, Belgium, Croatia, France, Germany, Italy, and others), 14 Asian countries (including China, Japan, Malaysia, Indonesia, Thailand, Singapore and others), 6 African countries (including Kenya, Nigeria, and South Africa), as well as Australia, Canada, the United Kingdom, and the United States. This distribution is visually summarised in Figure 2. The studies span a publication period from 2010 to 2025, capturing the evolution of CE policies over a critical phase of global environmental governance and policy development.

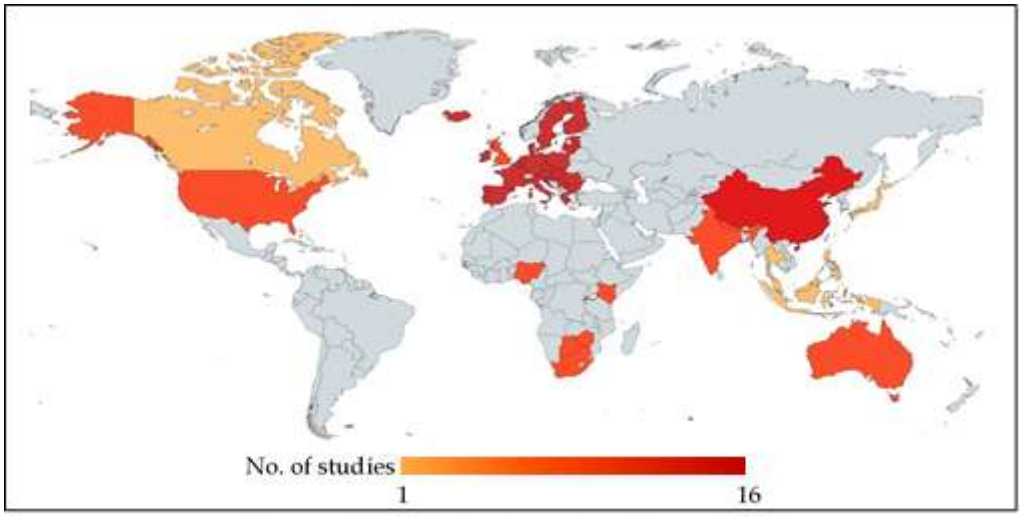

Figure 2: Distribution by regions from selected

3.2 Thematic Analysis (Themes and Sub-themes)

Following a thematic analysis of 21 selected articles, five main themes: (i) regulatory instruments; (ii) economic instruments; (iii) informational-based instruments; (iv) collaborative instruments; and (v) investment instruments and 23 sub-themes were discussed further in this section (see Table 3).

Table 3: Themes and Sub-themes

No.	Published Articles	Themes	Regulatory				Economic								Informational based						Collaborative		Investment		
		Sub-themes	MRC	B&R	EPR	MEDR	T	S	I	P	GPP	DRS	PAYT	R&DF	DPFKS	PAC	E	EL	WID	PEF	PPP	CSC	R&DP	RI	SET
1.	Milios (2018)		/			/	/		/		/							/						/	
2.	Zhu et al., (2018)							/	/							/	/								
3.	Domenech et al., (2019)		/	/	/	/	/	/	/					/									/	/	
4.	Ma et al. (2023)						/	/		/						/	/		/	/	/		/	/	/

5.	Bigano et al. (2016)	/			/	/		/		/							/				/	/	/	
6.	Eckert et al. (2024)		/			/	/			/	/			/			/	/						
7.	Kurniawan et al. (2023)		/	/		/			/				/			/	/							/
8.	Del Rio et al. (2025)																					/		
9.	Darko et al. (2023)		/			/	/																	/
10.	Kiessling et al. (2023)		/	/	/										/		/							
11.	Ono et al. (2023)		/	/												/				/				/
12.	Olatayo et al. (2023)		/			/	/									/				/				/
13.	Fedrigo-Fazio et al. (2016)					/	/								/									
14.	Montevecchi (2016)					/	/					/			/	/								/
15.	Milbreta et al. (2025)		/	/		/													/					
16.	Omondi & Asari (2023)		/	/	/												/	/						
17.	Subekti (2023)		/	/	/			/						/								/	/	/
18.	Herrador & Van (2024)	/		/				/		/				/						/	/		/	/
19.	Najahi et al. (2025)	/	/	/	/	/									/									
20.	Sedtha et al. (2022)		/				/	/	/						/							/	/	/
21.	Turunen & Mateo (2023)	13/	/	/	/13	/				/														
Total studies		6			8		9	7	3	5	1	1	2	3	7	6	6	3	2	4	2	6	7	9

Regulatory instruments		**Economic Instruments**		**Informational-based Instruments**		**Collaborative Instruments**		**Investment Instruments**	
MRC	Mandatory Recycling Content	T	Tax	DPSKF	Digital Platforms for Knowledge Sharing	PPP	Public and Private Platform	R&DP	Research & Development Platform
B&R	Bans and Restriction	S	Subsidies	PAC	Public Awareness campaigns	CSC	Cross-sector Collaboration	RI	Research Innovation
EPR	Extended Producer Responsibility	I	Incentives	E	Education			SET	Smart Enabling Technologies
MEDR	Mandatory eco-design requirements	P	Penalties	EL	Eco-labelling				
		GPP	Green Public Procurement	WID	Waste Information Disclosure				
		DRS	Deposit Retur	PEF	Product Environmental				

			n Scheme		Footprint				
		PAYT	Pay-as-you-throw						
		R&DF	Research & Development Funding						

3.2.1 Regulatory Instruments

Regulatory instrument, often mandated through legislative and administrative frameworks, encompass standards, permitting regimes, recycling obligations and final disposal regulations. These instruments are inherently prescriptive and are instrumental in driving systemic behavioural changes across the plastic value chain from design and production to end-of-life disposal. Drawing from the thematic analysis, four primary sub-themes emerged as critical enablers for fostering circularity: mandatory recycled content (MRC), bans and restrictions (B&S), extended producer responsibility (EPR), and mandatory eco-design requirements (MEDR). Among the 21 selected studies that addressed regulatory interventions, 13 examined bans and restrictions on problematic plastic items, 10 explored the implementation of EPR schemes, 8 analysed eco-design mandates, and 6 discussed MRC policies. These findings underscore the diversity of regulatory pathways through which governments globally are navigating transitions toward a more circular plastic economy.

3.2.1.1 Mandatory Recycling Content (MRC)

Mandatory Recycled Content (MRC) has been extensively examined by scholars as a critical regulatory policy instrument for promoting plastic circularity within the broader CE framework [3, 8, 17, 29, 33, 48]. These studies underscore MRC as a market-pull mechanism that legally requires producers to incorporate a minimum percentage of recycled plastic in new products or packaging. By generating stable demand for secondary materials (recyclates), MRC policies help to strengthen the economic viability of recycling systems and support the transition towards closed-loop material cycles. Several world-leading countries have taken the lead in adopting and institutionalising MRC measures. For instance, the EU's Single-Use Plastics Directive (Directive (EU) 2019/904) mandates that all polyethylene terephthalate (PET) beverage bottles contain at least 25% recycled plastic by 2025 and 30% by 2030. In the US, California's AB 793 similarly require plastic beverage containers to include 15% recycled content by 2022, rising to 25% by 2025 and 50% by 2030. Likewise, the United Kingdom has implemented a Plastic Packaging Tax, introduced in 2022, which applies to plastic packaging that contains less than 30% recycled content. In Asia, Indonesia's National Roadmap & Action Plan CE Indonesia (2025-2045) also outlined to contain 50% of recycled content by 2045 in HDPE, LDPE, PET, and PP plastic packaging. Collectively, these international examples reflect a growing global consensus on the efficacy of MRC as a regulatory lever for advancing plastic circularity.

3.2.1.2 Bans and Restrictions (B&R)

Bans and restrictions are among the most direct regulatory used to eliminate the consumption of plastic items deemed unnecessary, unrecyclable, or environmentally harmful [7, 8, 9, 22, 25, 28, 33, 37, 39, 44, 48]. These measures primarily target single-use plastics (SUPs) items, including bags, straws, cutlery, microbeads, and polystyrene containers that are either unnecessary, non-recyclable, or environmentally harmful. Globally, several world-leading countries have emerged at the forefront of implementing B&R approaches. The European Union's Single-Use Plastics Directive (Directive (EU) 2019/904) stands as a benchmark policy, not only bans specific SUPs but also requires Member States to implement consumption reduction measures for other items. In North America, Canada has adopted a national

ban on several harmful SUPs, including checkout bags, cutlery, and food service ware, under its "Zero Plastic Waste" agenda [12]. Similarly, U.S. states such as California and New York have enacted sub-national bans and restrictions on plastic bags and other SUPs, often supported by supplementary levies or penalties. In the Asia-Pacific region, countries like India and Indonesia have introduced ambitious national regulations banning multiple categories of SUPs. India, for instance, implemented a comprehensive national ban in 2022 covering 19 types of SUP items. Indonesia has introduced localised bans in cities such as Jakarta and Bali, with plans to scale up through its national roadmap on waste reduction [1]. While the scope and enforcement mechanisms vary, these interventions reflect a growing global alignment with CE goals through regulatory action.

3.2.1.3 Extended Producer Responsibility (EPR)

Extended Producer Responsibility (EPR) is one of the most extensively analysed regulatory policy instruments in the context of plastic waste management and CE implementation [3, 8, 17, 22, 25, 28, 29, 33, 38, 39, 46, 48]. EPR policies mandate that producers bear financial and/or operational responsibility for the post-consumer phase of their products. The core objective is to incentivise product redesign, enhance collection and recycling systems, and internalise the environmental costs of plastic packaging and products. Successful examples of mandatory EPR include Germany's Packaging Ordinance, enforced through the Dual System, and South Korea's Resource Circulation Act, both of which require producers to finance and manage collection and recycling systems through accredited producer responsibility organisations (PROs) [24]. Japan also implements EPR under its Containers and Packaging Recycling Law, requiring manufacturers and importers to bear the cost of recycling packaging waste. Additionally, South Africa recently made EPR mandatory across multiple sectors through its EPR Regulations (2021), requiring producers to establish and fund PROs to manage waste streams, including plastic packaging [53]. These developments demonstrate a paradigmatic shift towards producer accountability within global plastic governance frameworks.

3.2.1.4 Mandatory Eco-Design Requirements (MEDR)

Mandatory Eco-Design Requirements (MEDR) have been widely examined by scholars as a strategic regulatory instrument for integrating circularity into product development and plastic packaging systems [3, 8, 22, 29, 33, 38, 46, 48]. MEDR aim to ensure that products are designed with considerations for durability, repairability, recyclability, and minimal environmental impact throughout their lifecycle. This policy tool helps shift upstream production practices towards more sustainable outcomes, thereby addressing waste generation at its source. The EU's Ecodesign Directive (2009/125/EC) and the more recent Sustainable Products Initiative (SPI) have led to binding requirements on various products, including electronic devices and packaging. For plastics, this may involve design features such as monomaterial packaging, detachable components, and clearer labelling for sorting. France further strengthens EU efforts through its Anti-Waste Law for a Circular Economy (AGEC Law), which imposes eco-design obligations on producers, including requirements to improve recyclability and to incorporate recycled content in plastic packaging [11]. These examples demonstrate how leading nations are leveraging MEDR to institutionalise sustainability at the product design stage. By embedding circularity into the earliest phase of the product lifecycle, MEDR play a pivotal role in reducing material throughput, enhancing recyclability, and ultimately supporting the transition towards a more circular plastics economy.

3.2.2 Economic Instruments

Economic instruments serve as crucial levers in facilitating the transition towards a CE, particularly in the context of plastic waste management. Unlike regulatory tools, which compel compliance through legal mandates, economic instruments influence stakeholder behaviour by adjusting the financial incentives or disincentives associated with environmentally consequential decisions. By internalising externalities through assigning costs to environmentally harmful actions or rewards to sustainable practices, these instruments generate market-based signals that encourage producers, consumers, and waste managers to adopt more circular behaviours. From the thematic analysis, seven sub-themes of

economic instruments were identified as salient in global CE policy discourse concerning plastics: (i) taxes (13 studies), (ii) subsidies (9 studies), (iii) incentives (7 studies), (iv) penalties (3 studies), (v) green public procurement (5 studies), (vi) deposit-return schemes (1 study), (vii) pay-as-you-throw (1 studies), and (viii) research & development funding (2 studies). These instruments are often designed to complement regulatory frameworks, reinforce EPR systems, and stimulate innovation and infrastructure development through the plastics value chain.

3.2.2.1 Taxes (T)

Environmental taxation have been widely recognised as a market-based regulatory instrument to discourage the use of virgin plastic, reduce plastic waste generation, and stimulate the adoption of more sustainable alternatives [3, 5, 8, 9, 14, 27, 28, 29, 32, 33, 37, 48]. By internalising the environmental externalities associated with plastic production and consumption, taxation serves as a price signal to both producers and consumers, thereby encouraging eco-friendly choices and promoting CE transitions. Among the leading global examples is the UK, which introduced the Plastic Packaging Tax (PPT) in April 2022. This tax applies to plastic packaging manufactured in or imported into the United Kingdom that does not contain at least 30% recycled plastic, at a rate of £200 per tonne. Denmark and Ireland also have implement a plastic bag tax and successfully has influenced other countries to adopt similar policies. In Denmark, a plastic bag tax introduced as early as 1994 has significantly reduced consumption and served as a model for similar policies across the EU. Similarly, Ireland implemented a plastic bag levy in 2002, which led to an immediate 90% reduction in plastic bag usage [19]. Outside Europe, South Africa introduced a plastic bag levy in 2004 to fund recycling initiatives and raise public awareness. Collectively, these taxation strategies function as market-corrective tools that both penalise unsustainable practices and cultivate the economic viability of circular alternatives.

3.2.2.2 Subsidies (S)

Subsidies are an essential regulatory policy instrument widely acknowledged for their role in incentivising sustainable production and consumption behaviours, as well as in reducing the financial barriers to CE practices [5, 8, 9, 14, 27, 32, 37, 44, 56]. By lowering the cost of adopting circular technologies, improving recyclability, or enhancing end-of-life treatment options, subsidies promote innovation and industry transformation across the plastic value chain. Several world-leading countries have adopted targeted subsidies to accelerate circularity in plastics. Germany, for instance, has implemented financial incentives and grants through its Circular Economy Act to support innovation in material recovery, plastic recycling technologies, and secondary raw material markets. In the EU, the EU Horizon Europe and LIFE Programme provide competitive subsidies for CE initiatives, including those targeting plastic waste reduction, eco-innovation, and industrial symbiosis. South Korea has also provided substantial government subsidies through its Resource Circulation Policy Framework, aimed at supporting eco-design practices, the development of biodegradable alternatives, and the establishment of closed-loop plastic waste systems. Additionally, Japan, under its Plastic Resource Circulation Strategy (2019), allocates government subsidies to support eco-friendly product design, innovation in sorting and recycling technologies, and capacity-building for municipalities and industries transitioning toward circular plastic systems [49]. These country-level experiences underscore the importance of well-structured subsidies in de-risking investments, fostering circular innovation, and supporting structural shifts in the plastic economy.

3.2.2.3 Incentives (I)

Incentives are market-based economic instruments used to promote the uptake of circular practices along the plastic value chain. These instruments aim to influence producer and consumer behaviour by providing financial or operational advantages for adopting environmentally responsible actions, such as using recycled materials, improving product design, or investing in reuse systems. Several scholars [3, 8, 16, 17, 29, 44, 46, 56] have recognised incentives as key policy tools that complement regulatory efforts. For instance, the EU has implemented eco-modulation under its EPR schemes, offering fee reductions to producers who use recyclable or reusable packaging. France applies a bonus-malus system that

rewards or penalises producers based on the environmental performance of their products. In Asia, Singapore's 3R Fund provides cost-sharing incentives to companies that implement operational waste reduction and recycling projects [34]. Indonesia, through its National Action Plan on Marine Debris, includes fiscal incentives to support private sector engagement in plastic recovery and reuse. Canada, under its CleanBC Plastics Action Plan, also offers funding to scale up the use of recycled plastics in commercial applications [2]. Unlike R&D funding, which supports the development of novel solutions, these incentives focus on accelerating the adoption and implementation of existing circular practices to shift markets and behaviours toward more sustainable outcomes.

3.2.2.4 Penalties (P)

Penalties serve as enforcement mechanisms to deter non-compliance with plastic-related CE policies. These instruments typically involve monetary fines, legal sanctions, or operational restrictions imposed on producers, retailers, or consumers who violate rules related to plastic use, disposal, or recycling. [25], [27], and [44] have highlighted penalties as essential tools for upholding the effectiveness of bans, EPR obligations, and eco-design requirements. For instance, the EU imposes monetary penalties on member states that fail to meet recycling and waste reduction targets under directives such as the Waste Framework Directive and the Single-Use Plastics Directive. India enforces penalties on manufacturers and brand owners that do not comply with EPR registration and recycling targets, as outlined in its Plastic Waste Management Rules (2016, amended 2022). Kenya, recognised for one of the world's strictest plastic bag bans, imposes fines of up to $40,000 or imprisonment for offenders involved in the production, importation, or use of banned plastic bags. These economic disincentives play a crucial role in shaping industry behaviour and ensuring accountability across the plastic value chain.

3.2.2.5 Green Public Procurement (GPP)

Green Public Procurement (GPP) is an economic instrument in which public sector purchasing power is strategically used to stimulate markets for sustainable and circular products, including those with recycled plastic content. By setting environmental criteria in tendering processes, governments can create demand for low-impact products, thus encouraging industries to shift towards circular practices. [3], [9], [17], and [29] have identified GPP as an effective policy tool for driving systemic change across the plastic value chain. The EU has been a pioneer in this area, promoting GPP through the EU Green Procurement Guidelines, which encourage the procurement of products with high recyclability or recycled content. Japan implements GPP under its Green Purchasing Law, mandating public institutions to prioritise environmentally friendly products, including recycled plastic items. South Korea has also institutionalised GPP through the Act on the Promotion of Purchase of Green Products, requiring government bodies to report their green procurement performance. In Canada, GPP is integrated into federal procurement strategies to support circular and low-carbon product choices. These examples demonstrate how GPP can leverage public expenditure to create a pull effect for circular plastic solutions in the marketplace.

3.2.2.6 Deposit-Return Scheme (DRS)

Deposit Return Schemes (DRS) operate as economic instruments that incentivise plastic recovery by placing a refundable deposit on beverage containers. [9] identifies DRS as a pivotal mechanism for improving post-consumer collection rates and enabling closed-loop recycling. Countries such as Germany and Norway exemplify best practices, achieving return rates exceeding 90%, attributed to long-established infrastructure and public compliance. Lithuania's introduction of DRS in 2016 resulted in a dramatic increase in return rates, from 34% to over 90% within two years [35]. While these successes highlight the potential of DRS to support CE goals, their implementation is not without challenges. High upfront investment, governance capacity, and stakeholder coordination remain critical barriers, particularly in low- and middle-income economies. Thus, while DRS demonstrates strong potential, its effectiveness is context-dependent and requires integration with broader regulatory measures such as EPR and eco-design mandates.

3.2.2.7 Pay-As-You-Throw (PAYT)

PAYT as an emerging economic instrument aligned with the "polluter pays" principle, encouraging behavioural shifts among households and businesses towards more sustainable consumption and waste segregation practices [22]. This approach internalises the environmental cost of waste generation and stimulates upstream waste prevention efforts. Several countries have successfully institutionalised PAYT schemes within their broader CE agendas. South Korea, for instance, employs a volume-based waste fee system that requires residents to purchase designated garbage bags, thereby creating a direct financial incentive to reduce waste and increase recycling [30]. The system has contributed to a significant decrease in municipal solid waste and an increase in resource recovery. Similarly, Germany has implemented PAYT at the municipal level, with differentiated tariffs for residual, bio, and recyclable waste, effectively enhancing source separation and recycling rates. In the Netherlands, municipalities charge waste fees based on the number of times waste containers are emptied, which has led to improved recycling performance and lower per capita waste generation. In the United States, cities like San Francisco and Portland have also adopted PAYT systems as part of their zero-waste strategies. The effectiveness of PAYT lies in its capacity to directly engage consumers in waste reduction efforts, although its success depends on complementary infrastructure, public awareness, and enforcement mechanisms.

3.2.2.8 Research & Development Funding (R&DF)

Research and Development funding (R&DF) is recognised as a crucial economic policy instrument in advancing innovation, enhancing recycling technologies, and supporting the development of sustainable materials within the plastic value chain. [8] emphasise that targeted R&D investment fosters systemic transformation towards a CE by closing knowledge gaps, improving material recovery efficiency, and accelerating market readiness of eco-innovations. Globally, leading countries have strategically embedded R&D funding into their CE roadmaps. The EU, through its Horizon Europe framework and previously under Horizon 2020, has allocated substantial resources to projects addressing plastic waste valorisation, chemical recycling, and eco-design innovations. For instance, the "PlastiCircle" project exemplifies EU's investment in optimising the entire plastic packaging waste cycle through R&D-led interventions. In Japan, the Ministry of Environment has financed R&D programmes focused on biodegradable plastics and advanced sorting technologies as part of the country's Plastic Resource Circulation Strategy [15]. The United States, via the Department of Energy and the National Science Foundation, has committed to funding R&D in plastic upcycling technologies, including efforts under its "BOTTLE" (Bio-Optimized Technologies to keep Thermoplastics out of Landfills and the Environment) consortium [50]. Similarly, South Korea and Germany have supported research initiatives through national innovation funds and public-private partnerships targeting material substitution, plastic circularity, and recycling innovation. These initiatives are critical to creating a dynamic innovation ecosystem, enhancing recyclability, and fostering new markets for circular products and services.

3.2.3 Informational-based Instruments

Information-based instruments are critical enablers of behavioural change, informed decision-making, and the broader adoption of CE practices throughout the plastics value chain. These instruments operate through transparency, communication, and knowledge dissemination to influence the behaviours of consumers, producers, and policymakers in alignment with CE principles. Unlike regulatory or economic tools that exert direct pressure on the market, information-based instruments exert indirect influence by reshaping preferences, building capacities, and fostering trust in circular products and systems. Six prominent sub-themes emerged from the literature as particularly relevant in facilitating circular transitions within the plastics sector: (i) Digital Platforms For Knowledge Sharing, (ii) Public Awareness Campaigns, (iii) Education, (iv) Eco-Labelling, (v) Waste Information Disclosure, and (vi) Product Environmental Footprints. Collectively, these mechanisms serve as systemic enablers, equipping stakeholders with the necessary tools and knowledge to engage meaningfully with circular practices.

3.2.3.1 Digital Platforms For Knowledge Sharing (DPFKS)

As noted by [9], [17], and [46], digital platforms are key informational policy instrument that supports transparency, education, and cross-sectoral learning in the transition towards a plastic CE. These platforms often serve as hubs for data exchange, guidelines, regulatory updates, case studies, and CE indicators. Notable examples include the EU's Circular Economy Monitoring Framework Portal, which aggregates data on CE progress and Japan's Plastic Smart platform, which promotes best practices and knowledge on marine litter prevention. Besides, Vietnam also launch a national CE hub as an online portal aimed at coordinating data exchange and policy alignment, underpinned by Article 139 of the Law on Environmental Protection (2020). These initiatives demonstrate how DPFKS can bridge institutional and informational gaps, empower decision-makers, and catalyse systems thinking by making CE knowledge publicly accessible and actionable. Thus, they play a complementary but essential role alongside regulatory and economic instruments in enabling the systemic shift to circularity.

3.2.3.2 Public Awareness Campaigns (PAC)

Public awareness campaigns are vital in transforming societal attitudes and behaviours concerning plastic consumption and disposal. In the EU, such campaigns are often integrated within broader CE policy frameworks to encourage source separation, waste minimisation, and sustainable consumption. Studies by [14], [22], [27], [32], [33] and [56] illustrate the strategic use of media outreach, community engagement, and targeted messaging to advance public participation in CE practices. For instance, China's "National Waste Sorting Publicity Week" as supported by the Ministry of Ecology and Environment, has significantly increased public participation in municipal waste separation through televised messages, mobile applications, and school-based education [54]. In Singapore, the government's "Say YES to Waste Less" campaign leverages social media influencers, retail partnerships, and interactive public displays to normalise reuse and reduction behaviours [55]. These examples demonstrate that PACs, when strategically designed and consistently deployed, are not only effective in increasing environmental literacy but also instrumental in achieving broader CE policy goals.

3.2.3.3 Education (E)

Education represents a cornerstone of long-term behavioural change and systemic transformation towards circularity, particularly in plastic waste management. As identified by scholars such as [25], [27], [32], [37], [39], and [56], embedding CE and plastic-related topics into formal education systems is critical for instilling values of resource conservation, responsible consumption, and innovation in waste management. Globally, several countries have institutionalised environmental and CE education through curricula reform and policy alignment. For instance, Finland integrates CE principles into its national education strategy from primary to tertiary levels, reinforcing environmental literacy alongside STEM competencies. In China, environmental education has been incorporated into compulsory schooling since 2003, and more recently expanded to include plastic pollution awareness through nationwide textbook updates and youth engagement programmes. Additionally, jurisdictions such as Hong Kong and Indonesia have employed education-focused strategies to enhance plastic waste segregation and promote circular consumption habits. Overall, education is not only instrumental in promoting awareness but also in embedding a culture of sustainability across society.

3.2.3.4 Eco-Labelling (EL)

Eco-labelling functions as an essential informational tool that promotes sustainable consumption and production by guiding consumer choices and incentivising manufacturers to enhance product sustainability. Several world-leading economies have institutionalised robust eco-labelling schemes [3, 9, 22, 29, 38]. For instance, the EU's Ecolabel covers a wide range of product groups and sets stringent criteria for environmental performance, contributing to market differentiation and transparency. Germany's Blue Angel is one of the oldest eco-labels globally, recognised for promoting products that are particularly resource-efficient and low in emissions. In South Korea, the Korea Eco-Label programme has been pivotal in promoting circularity, particularly for electronic and plastic-intensive products, by encouraging eco-design and recyclability [24]. Japan's Eco Mark similarly informs

consumers about products with minimal environmental impacts throughout their lifecycle [21]. These initiatives demonstrate how eco-labelling schemes can bridge information gaps, shape consumer preferences, and influence upstream production decisions, ultimately advancing CE practices in the plastic value chain.

3.2.3.5 Waste Information Disclosure (WID)

Waste information disclosure enhances CE governance by promoting transparency, accountability, and data-driven decision-making. In the EU, disclosure mechanisms are embedded within environmental regulations, requiring municipal and industrial actors to report plastic waste flows and treatment outcomes [9]. These practices inform policy formulation while enabling civil society to monitor environmental performance. Similarly, African nations are beginning to institutionalise such frameworks to improve public oversight and corporate responsibility [38]. In China, the 2021 "Measures on the Management of Environmental Information Disclosure for Enterprises" mandates large firms to publicly report environmental data, including waste-related metrics [27]. Local authorities determine reporting obligations and publish the information. Such initiatives address information asymmetries and build trust, thereby supporting informed stakeholder engagement in plastic governance.

3.2.3.6 Product Environmental Footprint (PEF)

The Product Environmental Footprint (PEF) is a methodological tool designed for assessing and communicating the environmental impacts of products throughout their entire life cycle. As recognised by [27] and [28], PEF encouraging producers to evaluate and reduce the ecological burdens of their products, thereby facilitating more sustainable design and production practices. Globally, the EU has pioneered the development and implementation of PEF through its PEF pilot phase (2013–2018), aimed at standardising life cycle assessment (LCA) methods across product categories to improve comparability, credibility, and consumer trust. The EU Circular Economy Action Plan further integrates PEF into its sustainable product policies, particularly in sectors with high plastic use. France has also embraced PEF principles through its Environmental Labelling Law, mandating LCA-based product disclosures in certain industries. Similarly, Sweden and Italy are actively promoting PEF-aligned approaches in their national eco-innovation strategies. By quantifying resource use, emissions, and end-of-life impacts, PEF enables data-driven decision-making across the plastic value chain, advancing transparency, eco-innovation, and market competitiveness in alignment with CE goals.

3.2.4 Collaborative Instruments

Collaborative instruments have become increasingly central to advancing CE objectives, particularly by facilitating inclusive governance and collective problem-solving across the plastic value chain. Unlike regulatory and market-based tools, which operate through mandates or financial incentives, collaborative instruments focus on shared responsibilities and cooperative frameworks among stakeholders. These tools enable the co-creation of policies, the exchange of expertise, and the upscaling of innovative practices. Two dominant modes of collaboration are frequently cited in the literature: public–private platforms and cross-sectoral partnerships. These arrangements are instrumental in aligning fragmented interests, enhancing policy coherence, and mobilising resources to address the systemic complexities of plastic waste management.

3.2.4.1 Public and Private Platforms (PPP)

Public and private platforms serve as institutionalised arenas for dialogue and coordination among government agencies, industry actors, research institutions, and civil society organisations. These platforms typically function as strategic hubs for aligning policy objectives, providing technical assistance, and disseminating good practices [27, 37, 39]. Globally, notable examples include the European Plastics Pact, initiated by the Netherlands and France, which unites over 100 public and private organisations across Europe to commit to measurable targets on recycled content, reuse, and reduction of single-use plastics. In Indonesia, the Indonesia National Plastic Action Partnership (NPAP) which established under the auspices of the World Economic Forum, mobilises diverse actors to

implement a roadmap towards reducing ocean plastics by 70% by 2025 [52]. Similarly, Japan and Sri Lanka have operationalised PPPs to mobilise investments in CE infrastructure, implement EPR schemes, and develop circular business models. These platforms demonstrate how PPPs can enable trust-building, knowledge exchange, and collective action, thus reinforcing the governance and institutional dimensions of circular plastic economies.

3.2.4.2 Cross-Sector Collaboration (CSC)

As highlighted by [3] and [17], Cross-Sector Collaboration (CSC) plays a pivotal role in advancing CE objectives by bridging gaps between public institutions, private enterprises, non-governmental organisations, and research institutions. Such collaborations foster holistic problem-solving, unlock innovation across value chains, and enable the scaling of circular solutions beyond sectoral boundaries. CSC is particularly vital in the context of plastics, where complexity in product design, material recovery, and consumer behaviour necessitates shared responsibility and coordinated action. A leading example is the UK Plastics Pact, which unites government bodies, retailers, manufacturers, and recyclers under the Ellen MacArthur Foundation's global Plastics Pact network to deliver collective targets such as eliminating unnecessary plastic packaging and boosting recyclability [47]. In Germany, initiatives like the PREVENT Waste Alliance, supported by the German Federal Ministry for Economic Cooperation and Development (BMZ), encourage partnerships between industry and academia to promote global circular solutions for plastic waste [42]. Meanwhile, in Southeast Asia, emerging collaborations in Brunei, Laos, and Vietnam demonstrate how regional partnerships can strengthen institutional capacities, support technology transfer, and foster policy experimentation. These collaborative dynamics are foundational to ensuring the scalability and resilience of circular interventions across varied governance contexts.

3.2.5 Investment Instruments

Investment instruments play a pivotal role in accelerating the transition toward a CE for plastics, particularly by enabling the development and deployment of advanced technologies, supporting innovation ecosystems, and fostering long-term collaboration across the plastic value chain. This category includes funding and support mechanisms aimed at bolstering Research & Development Platforms, fostering Research Innovation, and advancing Smart Enabling Technologies. These instruments not only attract private capital and de-risk innovation but also align national and regional priorities with sustainability outcomes. The strategic mobilisation of investment plays a transformative role in overcoming systemic barriers and scaling up CE initiatives.

3.2.5.1 Research & Development Platform (R&DP)

Governments play a critical role in establishing and supporting Research & Development (R&D) platforms, which serve as foundational elements in the transition towards a CE, particularly within the plastic sector [7, 8, 27, 44, 46]. These platforms facilitate sustained funding, institutional collaboration, and knowledge generation aimed at developing new materials, circular product designs, and advanced recycling technologies. Unlike economic incentives that are typically market-driven and short-term, R&D platforms are state- or institution-led and focus on long-term systemic transformation. In the EU, Horizon 2020 and Horizon Europe programme is a prime example, allocating billions in funding to CE-related R&D projects, including chemical recycling and eco-design for plastics. These frameworks strengthening cross-broader networks among academia, industry, and policymakers. Meanwhile, Indonesia and China have both made significant progress in developing collaborative R&D platforms supported by national ministries and international organisations. As noted by [46], these platforms often hosted by universities and innovation hubs, aimed at reducing plastic waste through context-specific innovations, such as enzymatic degradation and modular recycling units. Besides, Thailand government has established national platforms focused on the development of biodegradable packaging and smart waste segregation technologies, supported by the Ministry of Higher Education, Science, Research and Innovation. Hence, these regional efforts underscore the strategic role of government-led R&D platforms in driving evidence-based innovation for plastic waste mitigation.

3.2.5.2 Research Innovation (RI)

Research Innovation (RI) represents a core dimension of investment-based policy instruments that accelerates the transition toward a CE by fostering the development and commercialisation of innovative solutions across the plastic value chain [3, 8, 17, 27, 29, 44, 46]. Several world-leading economies have placed strong emphasis on CE-oriented research innovation. The EU, through instruments such as Horizon Europe and the Circular Cities and Regions Initiative, provides dedicated funding for interdisciplinary innovations in packaging alternatives, smart waste tracking systems, and circular product-service models. In South Korea, CE innovation is embedded in the K-Circular Economy Implementation Plan, which supports research hubs and industry-academia collaboration for sustainable plastic alternatives. Similarly, Germany's Federal Ministry of Education and Research (BMBF) funds the "Plastik Innovations Forum" to promote breakthroughs in plastic circularity through applied science and industrial partnerships. Beyond these examples, Thailand's innovation efforts are guided by the BCG framework, which channels government funding into R&D related to plastic alternatives and recycling solutions. Agencies such as the National Science and Technology Development Agency (NSTDA) collaborate with industrial zones and academic institutions to develop scalable innovations. Other Southeast Asian countries including Brunei, the Philippines, and Vietnam have also begun establishing CE research centres and pilot initiatives, often in partnership with international donors and technical agencies. Overall, RI not only bridges the gap between fundamental research and market deployment but also enhances national competitiveness by fostering a knowledge-driven CE ecosystem, ultimately contributing to more resilient and sustainable plastic value chains.

3.5.2.3 Smart Enabling Technologies (SET)

Smart Enabling Technologies (SET) are increasingly recognised as pivotal investment instruments in supporting the transition toward a circular economy (CE), particularly within the plastics sector [5, 25, 17, 27, 32, 37, 39, 46]. These technologies include a range of digital and advanced technologies, such as artificial intelligence (AI), blockchain, the Internet of Things (IoT), and big data analytics that enable more efficient, transparent, and circular plastic value chains.

Globally, leading countries have integrated SET into national CE strategies to optimise resource use and enhance traceability across the lifecycle of plastic products. For instance, the EU, through its Circular Economy Action Plan, promotes digital product passports to improve transparency and recyclability. The Netherlands has implemented AI-driven waste sorting systems and blockchain-based tracking of plastic waste to ensure material traceability and accountability. In Singapore, the government has launched smart recycling kiosks equipped with IoT sensors to incentivise plastic collection and monitor user behaviour in real time [40]. Similarly, Hong Kong and Indonesia have also adopted sensor-based technologies and IoT for waste collection and recycling, supported through collaborative efforts between the public and private sectors. These smart technologies act as enablers that strengthen the implementation of CE principles by improving data availability, decision-making, and operational efficiency. When embedded in national and industrial CE agendas, SET can accelerate innovation, enhance stakeholder collaboration, and support evidence-based policymaking, ultimately fostering a smarter, more resilient plastic economy.

3.6 Comparative Synthesis of Global CE Instruments and Malaysia's Position

While the preceding thematic analysis has provided a detailed account of policy instruments adopted globally to advance the CE for plastics, it is equally essential to contextualise Malaysia's current standing within this global landscape. This section synthesises the key differences and overlaps between leading international practices and Malaysia's existing policy framework, offering a comparative perspective on the breadth and depth of CE instrument implementation.

Globally, countries such as EU member states, Japan, South Korea, Canada, the United Kingdom, Singapore, and China have adopted integrated, legally binding, and multi-faceted CE instruments to govern their plastic value chains. These frameworks encompass a strategic mix of regulatory tools such as mandatory EPR, recycled content targets, eco-design requirements, reinforced by economic

instruments such as plastic taxes, DRS, GPP, and targeted subsidies. Informational tools, including public awareness campaigns, education, and digital knowledge-sharing platforms, further support behaviour change. Furthermore, investment instruments, particularly in smart enabling technologies and innovation ecosystems, have accelerated systemic transitions toward circularity. Collectively, these instruments exhibit a systems-thinking approach and target intervention points across the entire plastic life cycle.

In contrast, Malaysia's adoption of CE policy instruments remains relatively nascent and fragmented. While policy documents such as the Malaysia Plastics Sustainability Roadmap (2021–2030), the Twelfth Malaysia Plan (2021–2025), and the Circular Economy Blueprint for Solid Waste (2025–2035) acknowledge the importance of CE principles, they lack a plastics-specific, integrated policy framework. The country's approach remains predominantly focused on end-of-life waste management, with limited regulatory enforcement and institutionalisation of producer responsibility. Core economic instruments such as MRC, eco-design standards, and plastic taxation have yet to be implemented or still in early stages of consideration. Moreover, informational tools such as public awareness campaigns and educational initiatives are often fragmented, under-sourced, and lacking national coordination. Financial incentives and subsidies for CE research, innovation, and smart technologies remains modest, further constraining Malaysia's capacity to catalyse circular transitions. The EPR framework continues to operate on a voluntary basis, and market-based mechanisms like PAYT remain absent from mainstream discourse or application.

Table 4 presents a comparative overview of global best practices versus Malaysia's current status across the five primary categories of CE policy instruments: regulatory, economic, informational, networking, and investment. This synthesis establishes a critical foundation for identifying gaps and priorities in Malaysia's policy framework, informing the subsequent development of a robust, targeted, and implementable CE framework for plastics.

Table 4: Comparative Summary of Circular Economy Policy Instruments (Global Practices vs Malaysia)

Policy Instruments	Global Practices	Malaysia's Current Status	Identified Gap
Regulatory	Legally enforced EPR eco-design laws, bans on SUPs	Voluntary EPR, no eco-design regulation, soft bans	Lack of enforceable legal mandates
Economic	Plastic taxes, subsidies, DRS, PAYT, GPP	Limited subsidies, no national DRS or PAYT	Weak fiscal incentives and behavioural drivers
Informational-based	Eco-labels, digital CE portals, education, PEF tools	No eco-labelling scheme or national CE portal, fragmented public engagement	Poor information flow and awareness
Collaborative	Institutionalised CE platforms (e.g. Plastic Pact, NPAP)	Project-based partnerships	No national multi-stakeholder CE platforms
Investment	CE-aligned R&D funds, smart tech infrastructure, innovation grants	General R&D, no CE-specific tech or scaling infrastructure	Underinvestment in innovation and enabling technologies

4) GAPS IN MALAYSIA'S CIRCULAR PLASTIC ECONOMY FRAMEWORK:

Despite the growing policy momentum demonstrated through initiatives such as the Malaysia Plastics Sustainability Roadmap (2021–2030), the Twelfth Malaysia Plan (2021–2025), and the Circular

Economy Blueprint for Solid Waste (2025–2035), Malaysia's CE framework for plastics remains fragmented, underdeveloped, and largely misaligned with international best practices. The following analysis explores the critical deficiencies within each category of CE policy instruments and discusses the underlying institutional and structural barriers contributing to the gap.

4.1 Regulatory Gaps

Malaysia's current regulatory instruments lack legal enforceability, specificity, and integration. Most CE-related policies rely on voluntary adoption rather than mandatory compliance. The absence of a formal, enforceable EPR framework illustrates this regulatory weakness. Although EPR is referenced in national policy documents, its implementation remains in pilot phases without statutory obligations for producers, clear compliance structures, or defined performance indicators. Furthermore, eco-design regulations which could encourage recyclable material selection, modularity, and design for disassembly are notably absent. Unlike the EU, where eco-design principles are embedded within directives and product standards, Malaysia has not yet institutionalised such requirements. The lack of legal mandates on product standards, recyclability labelling, or design incentives limits the upstream prevention of plastic waste. Additionally, regulatory fragmentation across agencies contributes to policy incoherence. Responsibilities are often split among multiple ministries and local authorities, leading to overlaps, inconsistencies, and enforcement challenges.

4.2 Economic Instrument Deficiencies

Economic instruments in Malaysia are underutilised and weakly targeted. While some financial incentives exist for recycling businesses, there is no comprehensive package of fiscal mechanisms to influence production and consumption behaviour. Key instruments such as plastic taxes, PAYT schemes, or DRS have not been implemented at a national scale. The current incentive system lacks coherence, often providing one-off subsidies without long-term strategic integration. For example, incentives for recycling technology upgrades exist, but without complementary policies such as guaranteed markets for recyclates or green procurement requirements, their impact remains limited. Moreover, price signals do not reflect the environmental externalities of plastic production and disposal, thereby failing to shift market behaviour toward circularity.

4.3 Informational and Data Gaps

Malaysia also faces critical shortcomings in its informational infrastructure. There is no national eco-labelling scheme for plastic products, nor any mandatory product environmental disclosures. Consumers lack access to reliable information about the recyclability, composition, or environmental impact of the products they purchase, which hinders informed decision-making. Moreover, the absence of a centralised CE knowledge-sharing platform or plastic flow database makes it difficult to track material streams, monitor policy outcomes, or benchmark progress. This impedes transparency, evidence-based policymaking, and stakeholder coordination. Public awareness campaigns on plastic reduction and CE principles tend to be limited in scope, sporadic, and often driven by NGOs or local councils rather than as part of a national strategy. Without sustained educational and communication efforts, behaviour change at the consumer and business level remains slow and inconsistent.

4.4 Weaknesses in Collaborative Governance

Malaysia's CE transition has also been hindered by the absence of formalised, long-term collaborative platforms. While there are instances of public-private partnerships and civil society initiatives, they often operate on a project-based or donor-dependent basis, lacking institutional support, strategic continuity, and long-term funding. This contrasts with international models where multi-stakeholder CE platforms are institutionalised and play a key role in co-developing policies, monitoring implementation, and aligning incentives. In Malaysia, cross-ministerial coordination is limited, and mechanisms for industry-government-academia collaboration remain informal or ad hoc. This results in fragmentation of effort, duplication of initiatives, and poor knowledge exchange.

4.5 Underinvestment in Innovation and Technology

Malaysia's CE framework is undermined by underinvestment in research, development, and innovation specific to circular plastics. Although some funding opportunities exist under national R&D programmes, they are not explicitly aligned with CE objectives and tend to favour broad technological development rather than targeted CE outcomes. There is a lack of innovation grants, technology acceleration funds, or incubator programmes that focus on new plastic materials, digital traceability tools, or advanced recycling methods. Similarly, smart technologies such as AI-based sorting systems, blockchain for waste traceability, and Internet-of-Things (IoT)-enabled waste bins have yet to be mainstreamed or piloted at scale. Without dedicated investment pipelines and public-private co-financing models, Malaysia risks lagging behind regional leaders such as Thailand and China, both of which have aligned their CE and innovation agendas under national development strategies.

5) STRATEGIC RECOMMENDATIONS FOR POLICY INTEGRATION:

To accelerate Malaysia's transition toward a circular plastic economy, this study proposes an integrated policy framework grounded in global best practices and tailored to the local institutional and economic contexts. The recommendations are categorised under five key policy instruments: regulatory, economic, informational-based, collaborative, and investment instruments.

(1) **Regulatory Instruments**: Malaysia must establish a comprehensive and enforceable regulatory framework that specifically addresses plastics across their entire lifecycle, from design and production to post-consumer recovery. Currently, plastic waste is governed under broader environmental legislation, including the Environmental Quality Act 1974 and the Solid Waste and Public Cleansing Management Act 2007. While these provide general environmental oversight, they lack the specificity needed to address the complex dynamics of the plastic value chain. A dedicated plastic regulation should include **mandatory eco-design standards** to promote the production of durable, modular, and recyclable plastic products, as successfully institutionalised in the European Union. In parallel, the introduction of a **mandatory EPR** scheme is essential. This should include clearly defined producer obligations, performance targets, differentiated fees based on environmental impact, and a transparent compliance and monitoring system. Malaysia's current voluntary EPR efforts are fragmented and lack accountability. International models from the EU, Japan, and South Korea demonstrate the effectiveness of legislated EPR in stimulating circularity. Additionally, Malaysia's existing environmental laws should be revised to include core CE principles, including mandatory waste separation, reuse targets, and recovery thresholds. These legal revisions should be supported by plastic-specific instruments, such as the EU's Single-Use Plastics Directive or India's Plastic Waste Management Rules, which provide enforceable guidelines on plastic design, production, consumption, and disposal.

(2) **Economic Instruments**: To reshape production and consumption patterns, Malaysia should implement a mix of **market-based instruments** that internalise environmental costs and reward circular practices. A plastic packaging tax, similar to those introduced in the UK and France, could be imposed on producers using virgin or non-recyclable plastics to encourage the shift toward recycled or biodegradable materials. At the same time, targeted fiscal incentives, such as tax exemptions, soft loans, and performance-based subsidies should be made available, particularly to small and medium enterprises (SMEs), to support investments in circular technologies, recycled plastic manufacturing, and reuse systems. To improve collection rates and strengthen closed-loop recycling, Malaysia should pilot a DRS for PET bottles and food-grade containers, drawing from successful examples in Europe and Australia. Additionally, PAYT schemes, as implemented in China, could be tested in selected municipalities to encourage source segregation and reduce landfill dependency. Lastly, the institutionalisation of GPP across all government agencies would create sustained demand for eco-labelled and circular plastic products. This would not only stimulate green innovation but also align public spending with Malaysia's long-term CE objectives.

(3) **Informational-based Instruments:** Informational instruments are critical to enhancing transparency, stakeholder engagement, and evidence-based decision-making. Malaysia should prioritise the development of a national digital CE platform, modelled on those established in the EU and Vietnam. Such a platform would serve as a centralised hub for data, policy guidance, case studies, and tools related to plastic circularity, while facilitating real-time progress monitoring, inter-sectoral knowledge exchange. A mandatory eco-labelling scheme should also be introduced to provide clear information on recyclability, material composition, and environmental footprint. When combined with Product Environmental Footprint (PEF) tools, such labels can support informed customer choices and stimulate demand for sustainable products. To foster long-term cultural change, public awareness campaigns should be expanded through digital media, formal education, and community engagement. CE principles and plastic-related environmental issues should be integrated into school and university curricula, as seen in Japan and the EU. In parallel, mandatory disclosure requirements for companies on plastic production, usage, and recycling performance would enhance transparency and enhance more effective regulatory oversight and system-level optimisation.

(4) **Collaborative Instruments:** Transitioning to a circular plastic economy requires institutionalised coordination across sectors and governance levels. Malaysia should formalise Public-Private Partnership (PPP) platforms at both national and subnational levels to convene key stakeholders, including government agencies, manufacturers, retailers, recyclers, academics, and civil society. These platforms should be mandated to co-develop co-develop sector-specific action plans, pilot collaborative, and coordinate investments in shared infrastructure such as Material Recovery Facilities (MRFs). International examples from China, Austria, and Sri Lanka show that structured collaboration enhances co-ownership, mutual accountability, and policy coherence. Beyond PPPs, Malaysia's CE governance structure should embed formal mechanisms for cross-sectoral collaboration that span the entire plastic value chain, from upstream design and packaging to downstream logistics, consumption, and end-of-life management. Ensuring the consistent application of circularity principles across all stages is essential to closing material loops and maximising resource efficiency.

(5) **Investment Instruments:** Strategic investments is essential for unlocking CE innovation and enabling systemic change. Malaysia should establish dedicated CE funding mechanisms under the coordination of agencies such as the Ministry of Science, Technology and Innovation (MOSTI), to support collaborative research between universities, technical institutions, and industry. Priority investment areas should include biodegradable material development, chemical recycling technologies, and AI-enabled waste management systems. To promote early-stage innovation, modelled after EU innovation frameworks, to help bridge the gap between research and market deployment. To improve traceability and system performance, targeted investments in smart technologies across the plastic value chain are necessary. This includes AI-powered sorting systems, IoT-based tracking, and blockchain-enabled traceability platforms. Piloting these technologies in urban high-leakage zones can yeild demonstrative impact and scale-up potential. These investments would not only strengthen operational efficiency but also establish the digital and institutional foundation for a transparent, accountable, and data-driven circular plastic economy in Malaysia.

6) CONCLUSION

This study has critically assessed Malaysia's CE policy framework for plastics, revealing significant gaps when benchmarked against internationally recognised policy instruments adopted by both advanced and emerging economies. Although Malaysia has introduced several strategic blueprints aimed at promoting sustainability and reducing solid waste, these initiatives remain largely fragmented, non-binding, and insufficiently aligned with the structural and systemic challenges posed by the plastic value chain. The benchmarking analysis reveals that leading countries have adopted a more comprehensive and integrated approach, combining legal enforceable regulations, market-based incentives, digital infrastructure, multi-stakeholder collaboration, and sustained investments in innovation to facilitate a

systemic transition towards circularity in plastics.

To bridge these policy and implementation gaps, this paper has proposed a comprehensive set of strategic recommendations centred on five key policy instruments for Malaysia: regulatory, economic, informational-based, collaborative, and investment mechanisms. These include the institutionalisation of mandatory EPR schemes, eco-design regulations, green taxation and procurement, mandatory transparency and information disclosure, the development of digital CE knowledge platforms, and strategic investment in R&D and enabling technologies. Furthermore, the paper highlights the importance of fostering cross-sectoral collaboration and multi-level governance to ensure effective policy implementation across all stage of the plastic lifecycle, from design, production, consumption to waste recovery and secondary material markets.

In conclusion, the formulation of a robust and well-integrated CE policy framework, grounded in global best practices yet tailored to Malaysia's social-economic and institutional context is urgently needed to achieve a sustainable, resource-efficient, and low-carbon plastics economy. This framework must be grounded in a strong legislative mandate, supported by inclusive stakeholder engagement, and propelled by innovation and data-driven decision making. Only through such a systemic and coherent policy approach can Malaysia effectively reduce plastic leakage, enhance resource circularity, and realise its broader environmental and economic development goals under the CE paradigm.

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9) CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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