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Summary

Although the circular economy (CE) is recognised as a key climate mitigation strategy, its integration within global climate frameworks, such as those developed by the Intergovernmental Panel on Climate Change (IPCC) in its Assessment Reports, remains unclear. This study provides a systematic analysis of how the circular economy is framed in the climate-mitigation context of the IPCC Sixth Assessment Report using a mixed-methods approach that combines computational text analysis with qualitative content analysis through sentence-level manual coding. Eight Chapters relevant to the mitigation were examined and findings show that CE is most frequently framed as a supporting strategy (44.3%), followed by implicit (29.3%) and primary roles (26.4%), while being unevenly distributed across sectors, with the strongest representation in industry.

Keywords: Circular Economy, Climate Mitigation, IPCC AR6, Decarbonization, Sustainable Development

JEL Classification: Q53, Q54, Q56, Q58

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Mapping and Framing Circular Economy in the Sixth Assessment Report of the Intergovernmental Panel on Climate Change: A Systematic Text Analysis

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Abstract

Although the circular economy (CE) is recognised as a key climate mitigation strategy, its integration within global climate frameworks, such as those developed by the Intergovernmental Panel on Climate Change (IPCC) in its Assessment Reports, remains unclear. This study provides a systematic analysis of how the circular economy is framed in the climate-mitigation context of the IPCC Sixth Assessment Report using a mixed-methods approach that combines computational text analysis with qualitative content analysis through sentence-level manual coding. Eight Chapters relevant to the mitigation were examined and findings show that CE is most frequently framed as a supporting strategy (44.3%), followed by implicit (29.3%) and primary roles (26.4%), while being unevenly distributed across sectors, with the strongest representation in industry.

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1. Introduction

Climate change is emerging as one of the most severe global challenges of the century, largely driven by anthropogenic greenhouse gas emissions (Romero-Perdomo et al., 2022). According to the Paris Agreement, the main goal of international environmental policies is to limit global warming to 1.5°C by the end of this century (UNFCCC, 2015). Achieving this goal requires the significant reduction of greenhouse gas emissions and a transition towards a net-zero economy by 2050 (Devi et al., 2023). However, the *State of Climate Action 2025 Report*, published by the World Resources Institute, indicates that none of the 45 sectoral indicators is progressing towards the target by the end of the current decade (Systems Change Lab, 2025). The challenge lies not only in decarbonising the energy system but also in reducing reliance on resource-intensive, waste-generating production and consumption systems. It highlights the insufficiency of current mitigation pathways and the need for systemic transformations.

Enhancing mitigation potential requires improvements in production efficiency, which are linked to consumption patterns. Thus, there has been increased attention to the demand-side mitigation. The current linear "take–make–use–dispose" production model is recognised as unsustainable, highlighting the importance of transitioning towards a circular economy (Devi et al., 2023). Within the academic and policy context, the circular economy is commonly defined as a regenerative economic system designed to minimise resource use, waste, and emissions by keeping materials, components and products in use for as long as possible through strategies such as reuse, repair, remanufacture and recycle (Gallego-Schmid et al., 2020). However, the CE concept remains heterogeneous, with various definitions and frameworks proposed across the literature, resulting in challenges for consistent policy application (Kirchherr et al., 2023). CE measures in relation to climate mitigation include material demand reduction, improvement of the resource efficiency of products and service provisioning systems (narrowing), extension of product and component lifetimes (slowing), and increased recycling (closing), therefore aiming to avoid raw material extraction and waste and help mitigate GHG emissions (Wiedenhofer et al., 2025). However, the mitigation potential of these strategies is context-dependent and does not automatically imply emission reductions; careful assessment is required (Gallego-Schmid et al., 2020; Romero-Perdomo et al., 2022).

The Intergovernmental Panel on Climate Change (IPCC) provides policymakers with scientific assessments to inform climate policy. The latest IPCC Report, the Sixth Assessment Report (AR6), particularly the IPCC Working Group III contribution, is focused on mitigation pathways. Even though AR6 is the first IPCC report to acknowledge the importance of the circular economy for climate change, its role remains unclear and uneven across sectors.

While CE is increasingly referenced in the Report, it is not systematically integrated into mitigation frameworks, and its role varies significantly across sectors. Even though the number of studies linking the circular economy to climate change mitigation has grown rapidly in recent years (Kirchherr et al., 2023), a limited systematic analysis has been conducted within the IPCC

mitigation framework (Devi et al., 2023; Wiedenhofer et al., 2025).
The paper therefore aims to analyse how the circular economy is framed within the climate mitigation discourse in the IPCC AR6 and to identify the role and positioning of circular economy strategies across sectors. Specifically, it examines whether CE is represented as a primary mitigation pathway, a supporting strategy, or an implicit concept within sectoral narratives.

2. Methods

To analyse the presence and framing of the circular economy within the climate mitigation discourse in the IPCC AR6, a mixed-methods approach, including computational text analysis (using R coding software) and qualitative content analysis (manual coding), was implemented. A *sentence-level approach* was chosen as the unit of analysis because it captures meaning more effectively than keyword-level analysis and avoids the ambiguity of a *paragraph-level approach*. The sentences were identified by the R code and then manually interpreted. The Working Group III contribution to the IPCC AR6 was selected as the reference for the analysis, as it focuses on mitigation strategies directly relevant to the study. The R-based computational text analysis was conducted to automate text extraction and keyword detection.[1] This approach enables systematic and scalable analysis and reduces the risk of manual bias at the detection stage.
To identify how the circular economy is integrated into climate mitigation strategies, the selection rationale considered: where mitigation occurs, how it is implemented, and how it connects across the system. Therefore, based on this logic, the eight most relevant Chapters selected for deeper analysis included: Demand, Service, and Social Aspects of Mitigation (Chapter 5), Energy Systems (Chapter 6), Agriculture, Forestry and Other Land Uses (AFOLU) (Chapter 7), Urban Systems and Other Settlements (Chapter 8), Buildings (Chapter 9), Transport (Chapter 10), Industry (Chapter 11), and Cross-Sectoral Perspective (Chapter 12), thus ensuring comprehensive coverage of the mitigation system.
Sectoral Chapters, Energy (Chapter 6), Urban Systems and Other Settlements (Chapter 8), Buildings (Chapter 9), Transport (Chapter 10), Industry (Chapter 11), are the core mitigation domains as they account for the major emissions and address concrete mitigation strategies. Demand, Service, and Social Aspects of Mitigation (Chapter 5) highlights the importance of demand-side mitigation, including material efficiency, behavioural changes, and sufficiency. These aspects are directly related to consumption patterns and material demand, linking them to the circular economy. The Cross-Sectoral Perspective (Chapter 12) is included, as CE is a system-level concept that operates across the value chain. Other Chapters, including Chapter 1 (Introduction and Framing), Chapter 2 (Emissions Trends and Drivers), Chapter 13 (National and Sub-national Policies and Institutions), Chapter 14 (International Cooperation), Chapter 15 (Investment and

[1] `pdftools`, `dplyr`, `stringr`, `tibble`, `tokenizers`, and `writexl` packages were utilised for PDF extraction, text processing and tokenisation.

Finance), Chapter 16 (Innovation, Technology Development and Transfer), Chapter 17 (Accelerating the Transition in the Context of Sustainable Development) were excluded from the analysis as they are contextual, policy-oriented, or included background information and do not primarily focus on mitigation pathways. Chapter 3 (Mitigation Pathways Compatible with Long-term Goals) and Chapter 4 (Mitigation and Development Pathways in the Near to Mid-term) were excluded because they focus on scenario-based transitions rather than sector-specific or operational mitigation strategies and do not align with the study's *sentence-level* approach.

The specific pages of interest were selected for the Chapters, excluding non-analytical information such as the Cover page, Table of Contents, Executive Summary, FAQ, and Reference List, to ensure consistency and comparability across Chapters (See Table 1).

To ensure the accuracy of the text and sentence integrity, pre-processing steps were applied, including the extraction of selected pages from PDFs, the conversion of a two-column format to a single-column format by moving the right column underneath the left one to avoid sentence fragmentation, and splitting text into lines and, subsequently, into sentences.

To identify sentences containing CE content, a keyword analysis was conducted across selected Chapters. Keywords were identified and grouped based on established circular economy frameworks, particularly the analysis of 221 circular economy definitions by Kirchherr et al. (2023), and complemented with keywords from the Ellen MacArthur Foundation Circular Economy glossary. The keywords were grouped into two categories: (i) *CE principles*, representing main operational strategies (circular economy, reuse, recycling, repair, remanufacture, refurbish, durability, lifespan, value maintenance, reduce), and (ii) *system-level concepts*, reflecting on CE framework (supply chain, value chain, industrial symbiosis, reverse logistics, closed-loop, technical cycle, biological cycle, regenerative, non-virgin materials, renewable materials).

To ensure context relevance and reduce false positives, filtering rules were applied during keyword analysis. The rules for "reduce" excluded the sentences referring to energy, emissions, GHG, CO_2, and carbon, while retaining those related to materials, resources, and waste reduction. Sentences, which included additional keywords aside from "reduce", were also retained in the dataset. The case-sensitivity and keyword variations were considered, including recyclability (recycle), repairability (repair), restorative (regenerative), and terms related to the biological cycle, such as anaerobic digestion and composting.

The second stage of the analysis involved *qualitative content analysis*, with manual coding to interpret the context and meaning of each sentence. First, irrelevant sentences were excluded from the dataset for subsequent analysis. The next step was to distinguish between explicit and implicit CE meaning in each sentence, with explicit sentences further classified by their role (primary or supporting). To reduce potential bias, the manual coding for each sentence was applied consistently using the predefined criteria, as demonstrated in the decision flow diagram (Fig. 1).

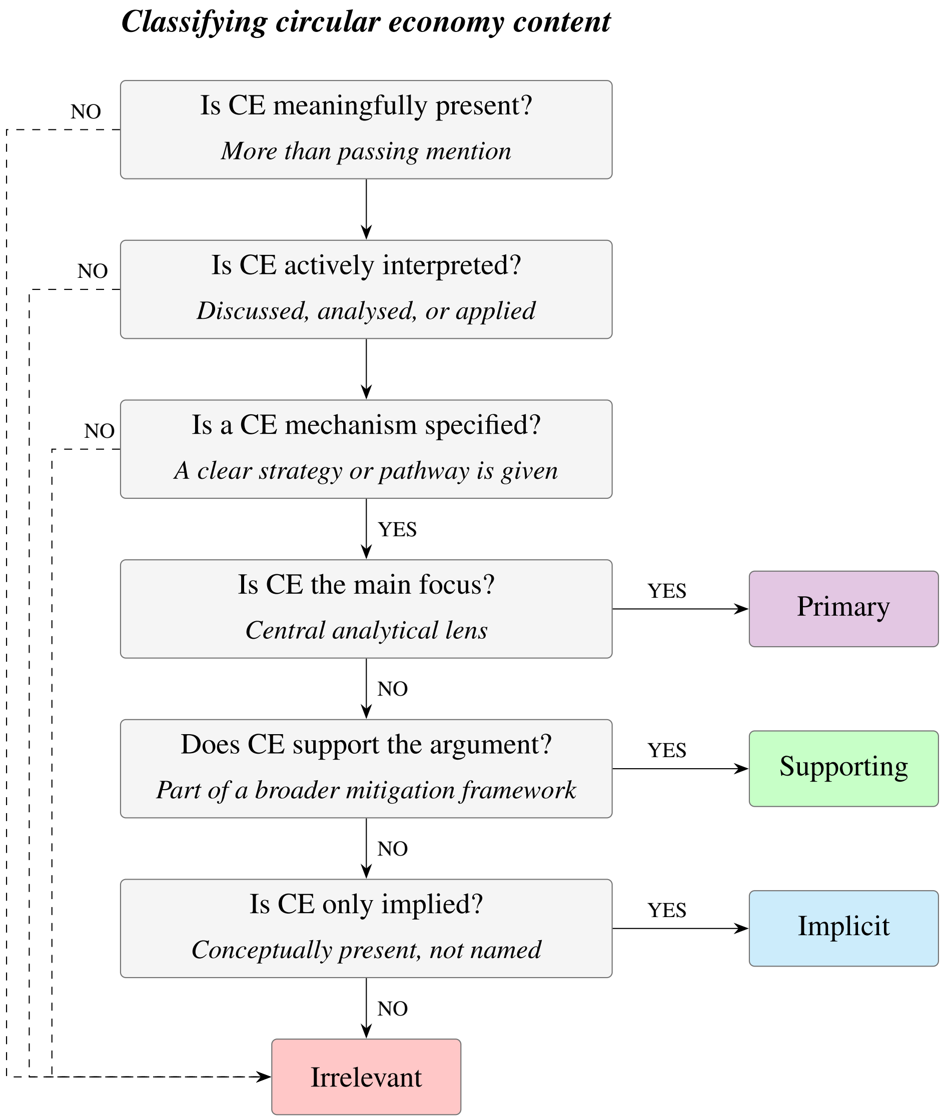

Figure 1. A decision flow diagram implemented for manual sentence coding.

The primary role was assigned when the *CE-related strategy* was presented as the main climate mitigation approach. The supporting role was assigned to sentences that presented CE concepts as one of several elements contributing to broader mitigation outcomes. An implicit role was assigned to sentences in which the CE was mentioned and contextually related, but was not fully developed.

As an output of the manual coding, a sentence-level dataset was generated, including sentence ID, Chapter, sentence text, keyword, keyword group, assigned role, and related comments.

3. Results and Discussion

After completing manual coding and cleansing of irrelevant and repetitive sentences, the sentence-level dataset contained 239 sentences with primary, supporting, and implicit meanings. The largest number of CE-related sentences occurred in Chapter 11 (Industry) – 46.9%. Table 1 shows all the shares by Chapter.

Table 1. Distribution of CE-related sentences across IPCC AR6 WGIII chapters.

Chapter	Title	% of CE-related sentences
11	Industry	46.9%
5	Demand, Services and Social Aspects of Mitigation	16.3%
12	Cross-Sectoral Perspectives	13.8%
8	Urban Systems and Other Settlements	8.8%
10	Transport	6.3%
6	Energy Systems	5.0%
9	Buildings	1.7%
7	Agriculture, Forestry and Other Land Uses (AFOLU)	1.3%

Note: Percentages do not sum to 100% due to rounding.

It is important to note, however, that in Chapters with a small number of selected sentences, the calculated percentages may not provide generalisable insights. Therefore, the results from Chapters with a limited sample size should be interpreted with caution. Fig. 2 represents instead how CE roles (primary, supporting, implicit) are distributed across sectors.

The following outcomes will be discussed for each Chapter, with the aim of showing whether the circular economy is characterised by a primary, and/or supporting and/or implicit role in the climate mitigation framework.

Chapter 5, Demand, Services and Social Aspects of Mitigation

This Chapter focuses on demand-side mitigation strategies driven by changes in social norms, infrastructure use, and technology adoption, which can reduce GHG emissions by 40–70% by 2050.

Primary role (28.2%, $n = 11$ out of 39 obs.). The circular economy domain includes here strategies that reduce energy and primary material demand while maintaining service levels, in contrast to the traditional linear model. CE strategies such as dematerialisation, product-as-a-service models, and design for long lifespan deliver the same services while reducing material demand. For example, in the building sector, extending building lifespans and increasing the

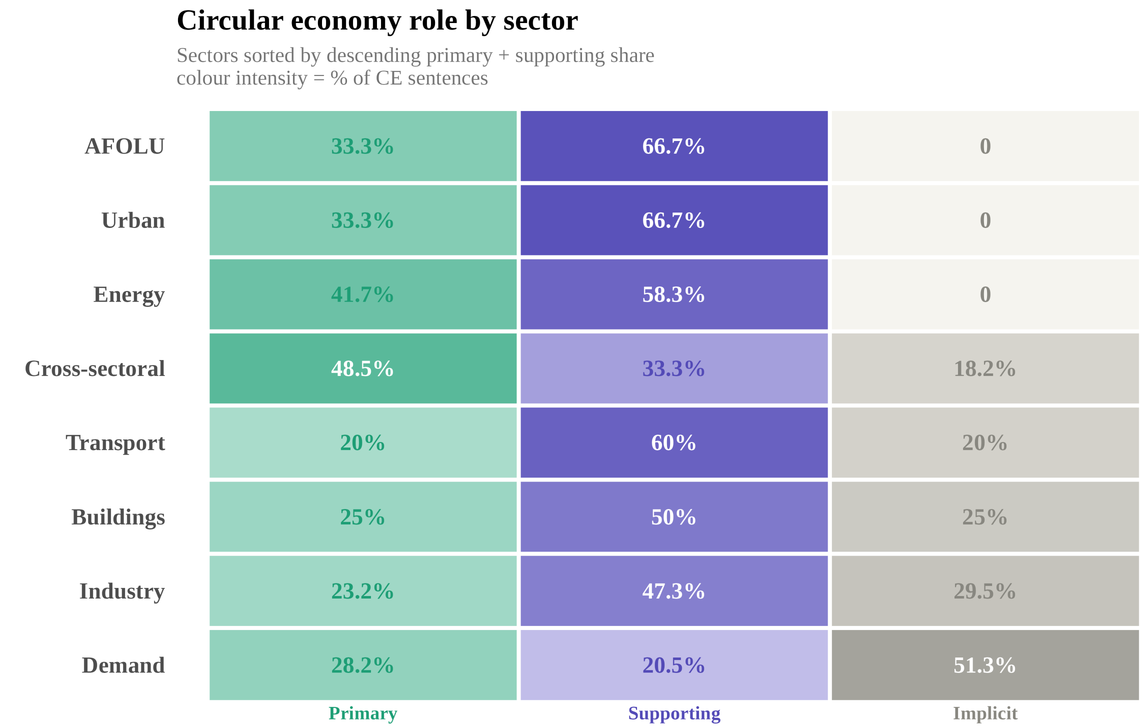

Figure 2. Percentage distribution of circular economy roles across selected Chapters.

use of shared housing reduce the use of carbon-intensive materials. Circular economy strategies address the need to design systems that are circular across the lifecycle. However, CE alone might not always be sufficient, as rapidly growing material demand and systemic constraints may outweigh the gains from efficiency improvements.

Supporting role (20.5%, $n = 8$ out of 39 obs.). CE is integrated into the demand-side and behaviour strategies and implemented within broader socio-cultural, infrastructure, and technological approaches. CE can be considered an infrastructure-related mitigation framework enabling food waste recycling, reuse, and remanufacturing networks in industry. Digital approaches in material management support CE via industrial symbiosis and waste exchange. Policy measures include recycling of construction and demolition waste to support material recovery and low-carbon transition (Nußholz et al., 2020). The constraints of CE are addressed through the low degree of circularity, as reflected in the proportion of processed materials (44%) used to provide energy. Additionally, CE potential is limited unless decision-makers implement measures to reduce material inputs.

Implicit role (51.3%, $n = 20$ out of 39 obs.). CE is framed as a part of broader socio-technical systems and mitigation frameworks. In addition, it is positioned as one of three megatrends, along with digitalisation and the sharing economy. CE practices such as recycling, reuse, and lifespan extension are viewed as part of technological and behavioural systems. On the other hand, CE is indirectly also linked to lifestyle changes, contributing to emissions reductions beyond the technological pathway. In this context, CE is connected to wider governance, social and equity concepts. Finally, CE is discussed conceptually, referencing the *10R framework* and highlighting its limitations.

Chapter 6, Energy Systems

The Chapter emphasises that limiting global warming potential requires rapid reductions in greenhouse gas emissions through a fundamental transformation of the global energy system. The measures include drastic reductions in fossil fuel consumption, shifting to zero-carbon energy sources, electrification, and overall improvements in energy efficiency.
Primary role (41.7%, $n = 5$ out of 12 obs.). In the primary role, circular economy strategies are primarily addressed through material recovery and end-of-life management. The key CE strategy to minimise the environmental impacts of photovoltaic systems is end-of-life recycling, which enables material recovery and waste prevention. For example, recycling photovoltaic modules enables the reuse of 83% of the components of valuable materials (Ardente et al., 2019), while battery recycling prevents the hazards and waste associated with the disposal of used batteries (Harper et al., 2019). Similarly, anaerobic digestion enables the recovery of nutrients by converting by-products into fertiliser (Wainaina et al., 2020), thereby supporting circular resource flows and contributing directly to mitigation through resource efficiency.
Supporting role (58.3%, $n = 7$ out of 12 obs.). In the supporting role, circular economy strategies are discussed as enabling factors for broader sustainability within energy systems. Despite technological progress, low recycling rates limit the overall impact (Li et al., 2020d), suggesting that it is not fully integrated into energy systems. Policy initiatives, such as International Energy Agency (IEA) programmes, are introduced to support recycling by sharing best practices for minimising lifecycle impacts. These policy initiatives will enable large-scale recycling, as the market value of recovered materials (excluding aluminium and copper) remains low (Deng et al., 2019). Here, CE is framed as a part of a broader policy and technological issue. Recycling and reuse support other technologies, such as perovskite solar cells (Petrus et al., 2017; Chang et al., 2018; Wang et al., 2019b; Zhu et al., 2020), by mitigating environmental risk, while recycling of spent fuel and wastewater reuse improve resource efficiency in energy systems (Magneschi et al., 2017; Giannaris et al., 2020b). Finally, changes in consumer behaviour that support a circular, renewable economy, such as reducing waste (e.g., food), sharing products (e.g., cars), and refurbishing (e.g., repairing instead of buying new), will facilitate mitigation through demand reduction.

Chapter 7, Agriculture, Forestry and Other Land Uses (AFOLU)

The Chapter shows that the sector has significant climate mitigation potential through ecosystem restoration and protection, improved agricultural practices, and demand-side measures.
Primary role (33.3%, $n = 1$ out of 3 obs.). The primary role is to support the sustainable management of wood products, which can substitute for other energy-consuming materials and

reduce emissions associated with their supply chains. The extension of lifespans and increased recycling of wood products can enhance carbon storage in them (Brunet-Navarro et al., 2017; Jasinevičius et al., 2017; Xu et al., 2018; Xie et al., 2021). This highlights the importance of CE through material substitution and long-term carbon storage.

Supporting role (66.7%, $n = 2$ out of 3 obs.). In supporting roles, CE is discussed as part of system-level approaches, particularly in bio-based production. The development of a cross-sectoral agenda focused on bio-based production within a circular economy framework can enhance the benefits of bioenergy and bioenergy with carbon capture and storage (BECCS). Moreover, CE is reflected through policy instruments; for instance, mechanisms such as waste pricing are recognised to be effective in increasing recycling rates and overall household waste reduction (Carattini et al., 2018; Rogissart et al., 2019).

Chapter 8, Urban Systems and Other Settlements

The Chapter highlights that urban systems are a rapidly growing source of GHG emissions, making them an important point of intervention. In the urban sector, net-zero emissions can be achieved by systemic transformations in spatial planning, widespread electrification of the energy sector, and integration of green infrastructure.

Primary role (33.3%, $n = 7$ out of 21 obs.). Circular economy strategies, including recycling, material recovery, reuse, and repair, enable a closed-loop supply chain and reduce emissions by lowering upstream production and demand for primary resources. For example, material recycling is the key to reducing the environmental and social impacts of electrification technologies (Church and Crawford, 2018; Gaustad et al., 2018; Sovacool et al., 2020), whose potential should be fully acknowledged. Enhanced reuse and recycling of wood from dismantled timber buildings can help reduce demand for new wood and reduce pressure on forest resources. Urban food production strategies include recycling nutrients from waste and reusing water resources to enable circular resource flows. Policies can serve as catalysts for promoting design for disassembly and material reuse to increase a product's durability.

Supporting role (66.7%, $n = 14$ out of 21 obs.). Wastewater management and recycling measures can yield economic benefits for citizens and local authorities by creating value from waste streams (Bernstad Saraiva Schott and Cánovas, 2015; Gharfalkar et al., 2015; González-Valencia et al., 2016; Herrero and Vilella, 2018; Matsuda et al., 2018; Nisbet et al., 2019), while reducing water use impacts in low-carbon development pathways (Koop and van Leeuwen, 2015; Topi et al., 2016; Drangert and Sharatchandra, 2017; Lam et al., 2017, 2018; Vanham et al., 2017; Kim and Chen, 2018). Here, the circular economy is embedded in urban systems as a resource-efficiency tool and framed as part of technical and economic improvement rather than as a mitigation driver. Waste management and wastewater recycling can facilitate the inclusion of informal sectors in the urban economy (Sharifi, 2021). By formalising waste recycling activities, the distribution of costs and benefits can be improved (Conke, 2018; Grové et al., 2018). Institutional support

and financial mechanisms based on partnerships between producers and consumers can facilitate improvements in recycling efficiency by linking consumers' waste back to producers (Pan et al., 2015; Prendeville et al., 2018; Fratini et al., 2019). In several examples, CE serves as a policy-enabling framework, enabling local governments to support the adoption of electrification technologies by fostering circular-economy practices to reduce potential trade-offs (Pan et al., 2015; Gaustad et al., 2018; Sovacool et al., 2020).
The circular economy is embedded as a supporting concept in the broader framework of urban mitigation systems. CE strategies, such as recycling and wastewater reuse, complement spatial planning, electrification and other system-level approaches.
Behavioural changes are required to manage food waste via recycling and reduction at the source of consumption (Gu et al., 2019).

Chapter 9, Buildings

The Chapter demonstrates that significant emissions reductions in the building sector can be achieved through comprehensive policy transformations guided by the Sufficiency, Efficiency and Renewables framework.
Primary role (25%, 1 out of 4 obs.). The circular economy strategies are discussed in relation to material efficiency measures in the building sector. These measures include lifetime extension, reuse, and scrap recovery, resulting in reduced demand, lower material quantities, and lower GHG intensity of materials (Allwood et al., 2011; Heeren et al., 2015; Hertwich et al., 2019; Churkina et al., 2020; Pamenter and Myers, 2021; Pauliuk et al., 2021).
Supporting role (50%, $n = 2$ out of 4 obs.). The supporting role includes policy instruments, such as tax implementation, which have been shown to promote recycling and reduce waste (Bouvier and Wagner, 2011; Ajayi et al., 2015; Volk et al., 2019), as well as strategies that maximise recycling and avoid premature replacement (Smith et al., 2016).
Implicit role (25%, $n = 1$ out of 4 obs.). The implicit role of CE is evident in the presentation of a trend: traditional reuse practices in construction are declining, indicating non-circular material use (Ajayi et al., 2015; Hongping, 2017).

Chapter 10, Transport

The Chapter highlights that meeting climate mitigation goals requires transformative change in the transport sector, particularly through demand management under the *Avoid–Shift–Improve* framework.
Primary (20%, $n = 3$ out of 15 obs.). The primary role highlights that the circular economy model can affect the operations and emissions of the transport sector. The circular economy is addressed through the concept of dematerialisation, the reduction of material used in production and the weight of transport, thereby improving efficiency and decreasing associated emissions. The reuse and recycling of lithium-ion batteries can reduce demand for new LIB production,

while closed-loop recycling can minimise reliance on critical minerals and improve resource sustainability.
Supporting (60%, $n = 9$ out of 15 obs.). The circular economy, dematerialisation, and the sharing economy are systemic drivers that could reshape the transport sector. The circular economy is pushed by the environmental consequences of resource use (Bleischwitz et al., 2017). To address resource and supply challenges, innovative programs aim to facilitate a shift towards the circular economy. Moreover, the topic of battery recycling and remanufacturing is broadly addressed in terms of the technical and informational barriers (Ahmadi et al., 2017). Recycling systems remain underdeveloped (Habib and Wenzel, 2014; World Bank, 2017; Giurco et al., 2019; Golroudbary et al., 2019), requiring standardisation, regulations, and design for recyclability to improve material efficiency and recovery (Harper et al., 2019). Recycling of batteries is one of the policy priorities, along with material substitution and mining strategies. ***Implicit role*** (20%, $n = 3$ out of 15 obs.). The circular economy is framed as one of the three megatrends, along with digitalisation and the shared economy, that affect demand for services and therefore can influence transport emissions. The principles of CE are reuse, lifetime extension, and recycling.

Chapter 11, Industry

The Chapter argues that achieving net-zero emissions in the industrial sector requires transformative changes in energy and feedstock sourcing. Decarbonization is driven by integrating multiple strategies, including demand reduction, material efficiency, circular economy practices, electrification, and carbon capture and storage (CCS).
Primary role (23.2%, $n = 26$ out of 112 obs.). Circular economy strategies are considered a direct mitigation approach, achieved through demand reduction, material efficiency, and closed-loop material systems. Recycling reduces emissions by substituting for energy-intensive virgin materials, with significant potential for aluminium and steel. In these cases, an increase in recycling will significantly decrease the energy consumption and carbon intensity (IEA, 2019b; Material Economics, 2019; Haraldsson and Johansson, 2018).
Material efficiency strategies, such as dematerialisation and design for lightweighting, further contribute to mitigation by reducing material demand (UNEP and IRP, 2020). Designing products with extended lifespans through reuse and remanufacturing enables short-term emissions savings (e.g., by reusing components) and lifecycle savings by avoiding the production of new goods (Rahimi and García, 2017; De Smet and Linder, 2019).
At the system level, the circular economy includes industrial symbiosis, which decreases demand for virgin materials and enables waste exchange across industries, leading to waste minimisation and reduced emissions. The substantial mitigation potential can also be achieved in eco-industrial parks and urban recycling systems (Liu et al., 2018; Kim et al., 2018b; Park et al., 2019).
Overall, studies suggest that CE measures and resource efficiency could halve the emissions from basic materials by 2060, highlighting significant mitigation potential (Material Economics, 2019).

Supporting role (47.3%, $n = 53$ out of 112 obs.). The circular economy is discussed as a supporting element of industrial mitigation rather than an independent solution. Even though CE, such as higher recycling rates, significantly reduce energy by avoiding energy-intensive primary production, its potential and broader circularity remain largely underutilised due to limited integration into policy frameworks and lack of alignment with climate strategies (Skelton and Allwood, 2017; Gonzalez Hernandez et al., 2018b; IEA, 2019b).
The effective implementation of CE strategies can be further constrained by growing material demand driven by economic expansion, which can counterbalance efficiency even with increased circularity (OECD, 2019a). This emphasises that demand reduction, material efficiency and recycling strategies should be implemented into a broader system approach.
Circular economy strategies can be limited by technical and lifecycle barriers. For example, chemical recycling processes remain energy-intensive and can result in carbon losses, requiring additional solutions such as improved process efficiency or carbon capture and sequestration (CCS) technologies (Meys et al., 2020; Thunman et al., 2019). Moreover, industrial symbiosis can face implementation barriers due to regulatory constraints, coordination challenges, and limited infrastructure.
Within the mitigation framework, CE is integrated into a broader portfolio of strategies, including energy efficiency, electrification, and technological innovations (Material Economics, 2019; IEA, 2019b; Energy Transitions Commission, 2018). Their successful contribution depends significantly on policy support and advanced industrial processes.
Moreover, CE is recognised as a sustainability framework that aligns with multiple Sustainable Development Goals. However, data and policy gaps constrain its effective expansion as a mitigation strategy.
Implicit role (29.5%, $n = 33$ out of 112 obs.). The circular economy is implicitly embedded in analytical and modelling frameworks. CE strategies, such as material efficiency and recycling, along with energy efficiency, electrification, and feedstock changes, are discussed in scenario models (IEA, 2019b; Material Economics, 2019).
Moreover, CE is mentioned in system-level descriptions of material flows. In this context, recycling and material efficiency are viewed as technical parameters (Graedel et al., 2011; Gielen et al., 2020).
The limited potential of current circular practices across sectors, such as steel and plastics, is highlighted by variations in recycling rates across regions (Geyer et al., 2017; IEA, 2021b).
Additionally, CE is embedded in design and lifecycle thinking, where durability, recyclability, and resource-efficiency strategies are considered in the production and use of the product (Hertwich et al., 2019, 2020; Korhonen et al., 2018).
Eventually, CE emerges in discussions of infrastructure lock-in, supply chain dependencies, and differences in mitigation strategies across regions. Moreover, it is reported in frameworks such as lifecycle assessment without a mitigation approach framing (Skelton and Allwood, 2017; Mason et al., 2016).

Chapter 12, Cross-Sectoral Perspectives

The Chapter argues that reducing greenhouse gas emissions can be achieved through cross-sectoral approaches that strengthen synergies and minimise trade-offs across areas such as food systems, land use, and carbon dioxide removal (CDR).

Primary role (48.5%, $n = 16$ out of 33 obs.). The primary role of CE is reflected in material efficiency strategies, including waste treatment, reuse, recycling, and the substitution of emission-intensive materials, which reduce energy demand and maintain material value (Camaratta et al., 2020).

CE is used as a primary concept for closing biological loops. Anaerobic digestion results in digestate that recycles nutrients and carbon back to soil, supporting biological processes (Nag et al., 2019). Anaerobic digestion of wastewater reduces methane emissions and pollution while recovering energy as biogas (Parsaee et al., 2019). By using seaweed and algae as biorefineries, nutrients can be recirculated, enabling the substitution of conventional feed sources (Thomas et al., 2021). Another way to enable nutrient recovery is pyrolysis, which returns nutrients to soil via biochar, supporting circular biomass use (Joseph et al., 2021). Recycling organic waste can reduce emissions by avoiding landfilling of methane and by reducing the need to produce synthetic fertilisers (Creutzig et al., 2015). A circular bioeconomy supports resource sustainability by returning biomass and nutrients to natural systems. This extends CE into a circular bioeconomy as a nature-based mitigation strategy.

CE is framed as a systemic mitigation paradigm that integrates biological and technical cycles, enabling waste elimination, extending material use through reuse and recovery, and regenerating natural systems across the product lifecycle (Mayer et al., 2019a).

Supporting role (33.3%, $n = 11$ out of 33 obs.). CE is embedded within broader mitigation systems. In this context, strategies such as recycling and material efficiency reduce the environmental impacts of mineral extraction through mining, thereby lowering pressure on biodiversity (Sonter et al., 2020b) and decreasing the lifecycle impacts of low-carbon infrastructure (Jensen and Skelton, 2018; Mignacca et al., 2020).

The circular economy is described as a policy-driven concept, although the implementation of CE principles may vary across jurisdictions and levels of policy support.

Circular economy discussions also address limitations, particularly in bio-based systems, where reuse and recycling might not always be feasible.

CE is linked to the broader sustainability framework, including compliance with SDG 12 for sustainable consumption and production, as well as improved climate resilience (The Ellen MacArthur Foundation, 2019).

Implicit role (18.2%, $n = 6$ out of 33 obs.). CE is mentioned as a generic sustainability label, focusing on material efficiency and recycling, highlighting them as important factors without further explanation. Moreover, CE principles are discussed in different contexts, including waste management, policy development, and societal transition (Palahí et al., 2020), but without

operational meaning.
In addition, CE is listed among many frameworks for food system governance, but does not play a distinct role.
CE is described as a conceptual, cross-sectoral approach that extends to the circular carbon economy and is based on carbon management technologies (Lee et al., 2017; Alshammari, 2020; Morrow and Thompson, 2020; Zakkour et al., 2020).

4. Conclusion

This study reveals how the Working Group III climate mitigation discourse of the Sixth Assessment Report of the Intergovernmental Panel on Climate Change currently integrates and frames circular economy strategies. The study applied the mixed-methods analytical approach, including keyword-based computational text analysis and qualitative content analysis through sentence-level coding and role classification.
Circular economy concepts are identified across selected Chapters that address concrete mitigation measures, including Demand, Service, and Social Aspects of Mitigation (Chapter 5), Energy Systems (Chapter 6), Agriculture, Forestry and Other Land Uses (AFOLU) (Chapter 7), Urban Systems and Other Settlements (Chapter 8), Buildings (Chapter 9), Transport (Chapter 10), Industry (Chapter 11), and Cross-Sectoral Perspective (Chapter 12). However, their distribution remains uneven. In 44.3% of cases, circular economy appears as a supporting strategy within a broader mitigation framework, while 29.3% are implicit, and only 26.4% reflect CE as a stand-alone strategy.
Moreover, differences in sectoral distribution are pronounced. The strongest CE representation is found in the industry sector, followed by urban systems, whereas its presence in other sectors remains limited (below 10% of total occurrences). This indicates that CE is mainly associated with a material-intensive domain, while integration into other areas remains partial.
Overall, the findings suggest that while the circular economy is acknowledged within the mitigation discourse, it is not fully embedded as a primary mitigation pathway across sectors. Instead, CE is frequently positioned as a supporting mechanism, typically focusing on traditional strategies such as recycling.
This limited framing constrains the CE's potential to enable systemic transformation in production and consumption systems. Notably, the uneven integration of CE highlights the limited opportunities for cross-sectoral applications that could amplify the mitigation outcomes. Therefore, a more holistic and coordinated approach is required to fully leverage CE beyond sectoral boundaries.
This study, however, is subject to several limitations. The keyword-based approach, which may miss implicitly expressed CE concepts, differs from sentence-level classification in the degree of interpretability of its subjectivity. In addition, the study is limited to IPCC AR6 WGIII. Despite limitations, the results highlight a clear gap between proven CE mitigation potential and its

current integration into the climate policy framework.

Declarations

Declaration of generative AI and AI-assisted technologies in the writing process. During the preparation of this work the authors used AI platform for the English grammar checking and visual editing of figures. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

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