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SHORT COMMUNICATION

Mission-Oriented Research and Theory of Change: Driving Australia's Transition to a Circular Economy

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Abstract
Australia's linear economic system hinders the collective pursuit of sustainability, equity, and well-being. As demands for housing, food, energy, transportation, and goods escalate, transitioning to a circular economy becomes imperative. Such a transition necessitates a transformation in business and governance models, as well as cultural shifts, to foster sustainable material flows. The proposed change will likely unfold in five phases: envisioning a circular economy future, evaluating options and trade-offs, initiating local actions, amplifying national efforts, and solidifying global agreements. This shift will occur within the context of significant technical, environmental, social, and economic megatrends, and each phase is likely to overlap with the next, with some phases occurring concomitantly and ongoing. It will reshape socio-technical systems and social practices that fulfil our essential needs. Moreover, this transformation process is inherently circular, characterised by continuous cycles of learning, adaptation, and risk management.

Keywords Circular economy · Net zero emissions · Theory of change · Transition management · Economic and policy enablers

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Introduction

In today's rapidly changing global landscape, Australia faces significant environmental, social, and economic challenges that necessitate a transformative approach to sustainability. The traditional linear "take-make-dispose" model has led to unsustainable resource use, environmental degradation, and increased waste, all of which threaten our long-term resilience and prosperity [5, 12, 4]. There is a growing consensus that transitioning to a circular economy is not just beneficial but imperative [37]. A circular economy reimagines waste as a resource, emphasises resource efficiency, and strives for the regeneration of natural systems, aligning economic activities with environmental and societal goals [8, 14].

Australia's journey towards a circular economy is still in its early stages. The country heavily relies on resource extraction and exports to remain competitive in the global economy, and its population is among the highest consumers and waste generators per capita in the world [20]. Recently, however, there has been a targeted shift towards incorporating circular economy principles into sustainability and environmental policies at all levels of government. In October 2022, Australia's Environment Ministers committed to collaborating with the private sector to design out waste and pollution, extend the use of materials, and foster markets to support a more circular economy by 2030 [2]. In addition, the Minister for the Environment established a circular economy advisory group to guide the development of a National Circular Economy Framework. In response to this significant policy shift, this article outlines Australia's strategic roadmap for embracing a circular economy, leveraging insights from the Commonwealth Scientific and Industrial Research Organisation's (CSIRO's) national circular economy roadmap [30] and integrating global best practices [24].

We explore the phased transition towards a circular economy that includes envisioning, planning, implementing, and scaling circular practices across sectors. The development of a transition pathway is grounded in several intellectual traditions that are organized into a coherent framework. This heuristic framework has been tested with workshop participants from the science, policy, and business communities.

Transition pathways [7] and Theory of Change [16, 27] concepts and processes are critical to identifying the strategies, actions, actors, conditions and resources to effectively transition Australia's economy and society towards circularity and a more sustainable future. The core idea is that there are multiple possible transition pathways involving different speeds, sequences and policy mixes for achieving the circular economy transition, which need to be carefully designed, implemented and evaluated based on specific contexts and objectives to create the enabling conditions for a circular economy to emerge and thrive in an otherwise production and consumption-dominant economy [38].

Addressing major societal challenges through mission-oriented research and innovation involves clearly defined, ambitious, and time-bound objectives, such as fundamentally transitioning production and consumption systems to a circular economy. Achieving these objectives requires contributions from multiple scientific disciplines and broad stakeholder engagement, focusing on cross-cutting, transdisciplinary, and participatory research aimed at developing real-world solutions to complex societal challenges through an integrated, outcome-oriented approach [25]. Missions demand a systemic perspective that coordinates research efforts with complementary policy interventions, regulations, investments, and activities across the entire innovation cycle [18, 19, 36]. A systems approach is critical

for enabling Australia's circular economy transition while also ensuring that the country remains competitive in the global economy.

In this discussion, we map the trajectory of Australia's strategic transition towards a circular economy through the lens of transition pathways and Theory of Change. We leverage insights from CSIRO's national circular economy roadmap [30]), integrate global best practices [24], and consider the country's global economic position. The discussion also highlights the role of mission-oriented research and the influence of global megatrends such as technological advancements, demographic changes, and climate dynamics on this transition. We examine the pivotal changes needed in systems of provision, including housing, mobility, food, and energy, as these systems and their associated material supply chains play a crucial role in Australia's socioeconomic fabric [12]. Additionally, we outline the key role of social practices in aligning political economy drivers with important aspects of socially constituted everyday life.

We propose a comprehensive Pathway to Change guide for policymakers, industry leaders, and communities, detailing the strategy and actionable steps towards a circular economy transition. Australia's transition pathway is grounded in global megatrends and the framework of six core elements for its circular economy. The pathway aims to accelerate the transition towards a sustainable and prosperous Australia.

Transition Pathway Theory

Provision Systems

Provision systems, including those for housing, mobility, food, and energy, are complex socio-technical systems that intertwine social elements and technological components [41, 6]. These systems are governed by an intricate framework that includes various actors (such as businesses, government agencies, and consumers), infrastructure, and the flow of bulk materials. Each of these elements plays a critical role in how these systems operate and evolve over time. Understanding provision systems as socio-technical systems highlights the interconnectedness of technology and society. These systems are not just technical constructs but are also shaped by cultural, political, and social dynamics. Managing these systems effectively requires a holistic approach that considers all these dimensions to ensure sustainable and equitable outcomes. Provision systems are also stable in the sense that they can rely on well established relationships between policies, institutions and actors and an often-elaborate infrastructure. To change the way in which these systems are organised depends on experimentation and innovation which needs to be able to challenge the current arrangements. This requires strategic management of the development of niches in which learning, visioning and experimentation can occur [32]. Changing to new ways of providing essential services is also a process of changes in infrastructures, and materials that are required to build, maintain and fuel the infrastructure.

Material Supply Chains

In the context of the circular economy, we commonly distinguish between two types of material value chains: biological materials and technical materials [20]. Considering the

global energy transition and the drive towards decarbonization and net zero emissions, we also recognize energy materials as a critical supply chain for the low-carbon circular economy. Although we categorize these three material supply chains separately, their interdependence must also be considered within the circular economy context.

Effectively managing these biological, technical, and energy material supply chains in a circular economy involves creating closed-loop systems where resource input, waste, emissions, and energy leakage are minimized by slowing, closing, extending, and narrowing material and energy loops. This can be achieved through innovative practices such as redesigning products, optimizing resource efficiencies, and fostering a shift toward sustainable consumption patterns.

The *biological materials* value chain deals with materials that are largely generated through photosynthesis (the fixing of sunlight and CO2 by plants), are biodegradable, and can be safely reintegrated into the environment after use. In a circular economy, biological materials are used in a way that allows them to be cycled back into the system through processes that optimize value while utilizing 100% of the resources (Arsic et al. 2022). This includes utilizing all parts of a plant or animal, i.e., "whole-of-crop" and "whole-of-animal," through stabilization technologies for shelf-life extension and by-product valorisation via biorefineries and high-value product production systems, including synthetic biology and fermentation.

Critically, following a cascading value hierarchy is key for biomass resource efficiency, which prioritizes food first, followed by fibre and feed, ingredients, transportation fuels, composting for nutrient-rich soil amendments, and anaerobic digestion for the generation of bioenergy and other energy and heat production. The management of this value chain is directly relevant to the places and people who utilize bio-based resources, opening up economic and social opportunities for the prosperity and well-being of communities. This approach focuses on maintaining the natural cycle of these materials, ensuring they can regenerate and sustain natural systems, including recovering nutrients from sewage and wastewater [3]. Stakeholder consideration of all material flows across the entire value chain is necessary to establish a circular bioeconomy [33].

Technical materials include non-biodegradable items such as metals, minerals, plastics, and chemicals that need to be designed to be reused, repaired, remanufactured, or recycled instead of being disposed of. The supply chain for technical materials aims to design products for longevity, easy repair, and ultimate recyclability. It involves setting up systems for the return of used products to manufacturers, where they can be broken down and the materials recovered and reused in new production cycles. This supply chain is crucial for minimising waste and reducing the extraction of virgin materials. Different from biological materials, technical materials are non-renewable and cannot be supplied by natural systems. They are confronted by problems of resource availability and can overwhelm the absorptive capacity of ecosystems to deal with pollution and toxicity. A useful starting point is that biological materials can circulate in open loop systems via the environment and technical materials need to circulate in closed loop systems within the economy. This, view, however, overlooks the increasingly linked combination of organic and inorganic materials [40].

As a subset of technical materials, materials used in energy systems within a circular economy focus on the production, distribution, and consumption of energy in ways that maximize efficiency and minimize environmental impact. Renewable energy sources such as solar, wind, and hydro are prioritized to reduce dependency on fossil fuels, but they also

have the potential to disrupt circular economy outcomes due to high material production, consumption, and loss. The aim is to enhance energy storage technologies and smart grid systems to manage energy flows more effectively and integrate decentralized energy production. This approach allows for energy recovery and reuse while ensuring that material circularity is maintained at the highest value, resulting in a net positive outcome for the environment.

Practice Theory

The notion of socio-technical transitions and provision systems need to be accompanied by a theory of consumer behaviour understood as a social choice phenomenon [34]. Practice theory is a conceptual framework that focuses on the routine behaviours and actions of individuals and groups as fundamental elements of social and economic systems [28]. It examines the interplay between these practices and the broader structures within which they are embedded, which includes materials (things and technologies), competences (knowledge and skills) and meanings (motivations, social and symbolic significance) [35]. Taken together, these elements structure the dynamics of social practice. Practice theory is crucial for the circular economy as it provides insights into how sustainable behaviours can be cultivated and maintained within complex socio-technical systems. It helps identify leverage points where interventions might effectively change consumption practices, ultimately leading to a more sustainable and circular use of resources.

Understanding Practices

Practice theory emphasises the importance of everyday practices—how people use products, engage with other stakeholders and services, and make decisions. These practices are often habitual and culturally ingrained, and they significantly impact resource consumption and waste production. By understanding these practices, circular economy strategies can be designed to better align with actual behaviour, enhancing their effectiveness and adoption.

Shifting Practices

In the context of a circular economy, practice theory suggests that it is not enough to change individual attitudes or increase awareness. It is crucial to change the practices themselves. Focusing on broad-scale agency encompassing people, things and social context is necessary to uncover how changes in practice occur [29]. To make changes in practice more powerful and all-inclusive requires changes in all three constitutive elements of social practices of material conditions, competences, and meanings. This includes redesigning processes, products, and services to facilitate new, sustainable practices. For instance, encouraging the practice of repairing rather than discarding items, or choosing shared platforms over individual ownership; business to consumer, and business to business practices.

Link to provision systems

Practice theory directly connects to provision systems. These systems are socio-technical in nature and are constituted by governance, actors, infrastructure, and material flows all of

which influence and are influenced by social practices. Transitioning socio-technical systems to circularity requires simultaneously changing the practices that constitute and reproduce them. For example, food system transformation involves shifting practices around production systems, ways of distribution and diets [1].

Holistic approaches

Practice theory advocates for holistic approaches that consider the multiple components of provision systems. It recognises that changes in technology or policy alone won't lead to sustainable outcomes unless the practices of individuals and organisations also evolve. Therefore, interventions in a circular economy need to be multi-faceted, addressing the links between material flows, infrastructures, and everyday practices.

Australia's Pathway to Change for Circular Economy

We propose a comprehensive Pathway to Change for Australia's circular economy transition to guide policymakers, industry leaders, and communities (see Fig. 1). Australia's transition to a circular economy involves a strategic pathway that unfolds in five distinct phases, each contributing towards an economy based on sustainable resource management and waste reduction. This transition framework is closely aligned with the concept of mission-oriented research and innovation policy [17], which focuses on addressing complex challenges through targeted innovation and collaborative efforts. The Pathway to Change also considers global megatrends and is grounded in established circular economy enablers and the six key elements previously identified for Australia's circular economy transition [30].

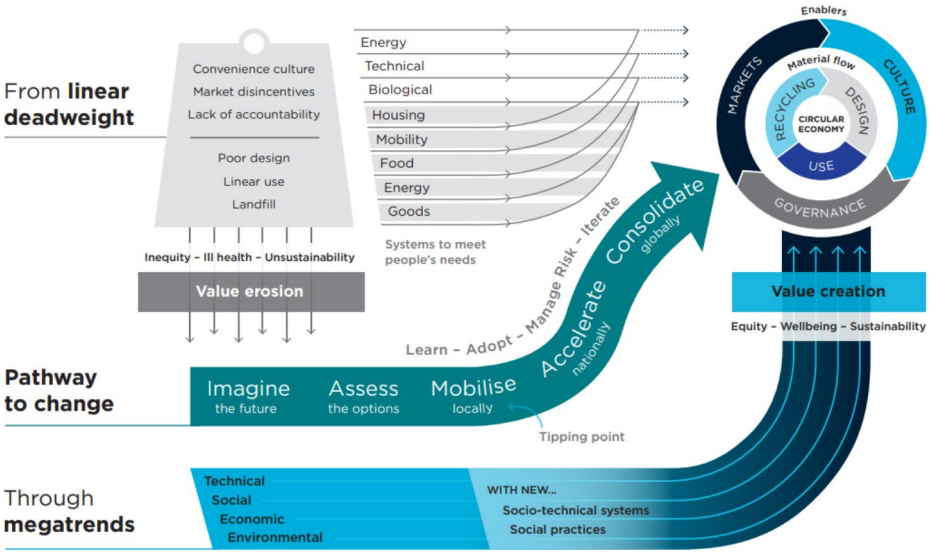

Fig. 1 Circular Economy Theory of Change: How can we meet Australia's needs for a Circular Economy. Source: CSIRO (2023)

The proposed Pathway to Change is system-agnostic and can be applied to any sector or industry to enable circular economy decisions and outcomes. The overarching goal is to transform Australia from a linear economy deadweight into a nation where equity, well-being, and sustainability are central to our way of life. The pathway provides a heuristic framework to link several conceptual approaches into a unified theoretical framework. It is aimed at guiding the transition process for the economy as a whole or for specific economic sector and activities for which it can be spelled out in more detail.

The Five Phases to Change

Imagining a Circular Economy Future

Envisioning a future economy where resources are used more sustainably, and waste is minimized is the precursor to collaborative change. Stakeholders, including researchers, policymakers, and industry leaders, come together to conceptualize what a circular economy could look like and identify key areas where change is necessary. This imaginative process is crucial for setting the direction and ambition of subsequent efforts. At its core, there is a collective understanding of the reasons why change is needed.

Assessing the Options and Trade-offs

Once a vision is established, the next step is to assess the various strategies and technologies available to achieve future goals. This involves a careful analysis of the benefits, costs, and potential unintended consequences of different approaches. Mission-oriented research plays a critical role here, providing the data and insights needed to make informed decisions about which paths to pursue. This step requires the use of multi-criteria assessment methods and frequent interactions with stakeholders to evaluate and further explore the future vision and the assessment of options and trade-offs as well as the identification of key barriers to change [10].

Mobilising Local Actions

With a clear understanding of the options, the focus shifts to implementing circular economy practices at the local level. This includes pilot and demonstration projects, community initiatives, and business models that test and refine circular practices. Local actions are vital for demonstrating feasibility and building the momentum needed for broader changes [23] and to establish local governance and agency for the circular economy transition. Importantly, a change in practices from the old normal to the new normal occurs at the local scale.

Accelerating National Efforts

Successful local models and experiments help to inform and accelerate national policies and initiatives and they also depend on national policies to become viable. During this phase, national governments can enact regulations, provide incentives, and foster environments that facilitate the wider adoption of circular economy practices. Mission-oriented research can support these efforts by developing scalable solutions and engaging a broad range of

stakeholders. Without nationally consistent policies, the acceleration from local initiatives to system changes in provision systems and social practices cannot occur.

Consolidating Global Agreements

The final phase of the Pathway to Change involves extending national efforts to the global stage, where international cooperation and agreements play pivotal roles. By harmonising standards, sharing best practices, and mobilising international resources, countries can ensure a cohesive and effective global approach to the circular economy.

The Role of Megatrends and Mission-oriented Research

Global megatrends, such as technological advancements, demographic shifts, climate change, and globalisation [22], play a critical role in shaping Australia's transition to a circular economy. These broad, influential patterns provide both challenges and opportunities that can drive or hinder progress along the transition pathway. Addressing these megatrends within the circular economy transition pathway requires a proactive and strategic approach to align policy windows and transition arenas [11].

By aligning circular economy practices with these overarching megatrends, Australia can enhance its resilience, sustainability, and economic performance, capitalising on its comparative advantages [31], to turn global challenges into opportunities for innovation and leadership in the circular economy sector. Effectively leveraging the disruptive nature of megatrends and the emergence of policy windows to accelerate Australia's circular economy transition will not happen spontaneously; it requires well-designed policies and a focus on both the material and institutional aspects of the transition enablers.

Throughout the Pathway to Change, mission-oriented research is essential, providing the knowledge and technological innovation necessary to drive each stage of the transition. By focusing research efforts on specific challenges identified along the transition pathway, stakeholders can systematically address the complex issues inherent in shifting towards a circular economy, ensuring that each step is informed by scientific insights and aligned with overarching sustainability goals.

Grounding in Established Circular Economy Enablers for Australia

CSIRO's national circular economy roadmap established six key elements (see Fig. 2) that are crucial for facilitating Australia's transition to a circular economy (Schandl et al. [30]). These elements provide a structured approach to integrating circular principles across various sectors and activities.

Design and Manufacture for the Future

This element emphasises the importance of designing products and systems with future use and reuse in mind. By adopting design principles that prioritise durability, reparability, and recyclability, resources can be more effectively circulated within the economy, reducing waste and the demand for raw materials. This must include the potential substitution of material intensive products and processes by dematerialised forms of service provision and

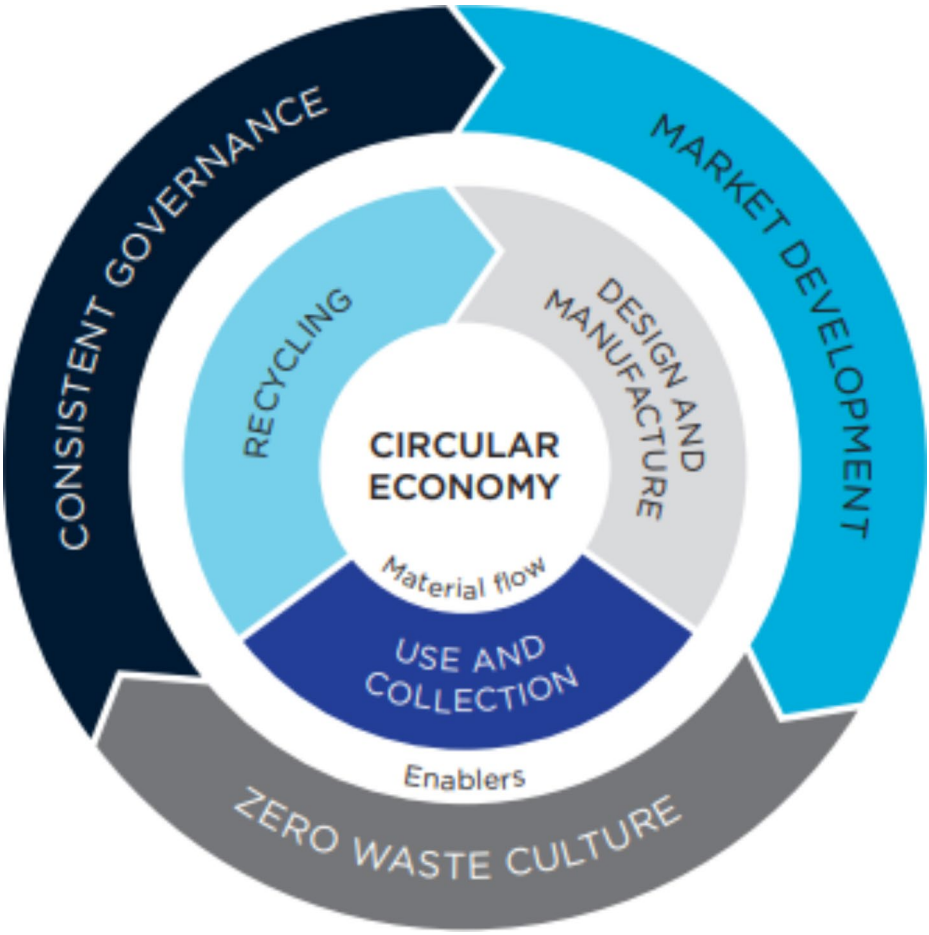

Fig. 2 The six elements of the Australian circular economy roadmap. Source: Schandl et al. [30]

is aligned with all elements of the 10 R model (from refuse, rethink and reduce to recycle and recover). Policy settings that require circularity to be embedded from the start such as extended producer responsibility [15] and the right to repair [13] can incentivise businesses to design for longevity and circularity.

Maintain, Prolong, and Renew

Focusing on the maintenance and prolongation of product life through repair, refurbishment, and remanufacturing, this element helps to maximise the utility of products and to keep products in use. It reduces the overall environmental impact by extending the life cycle of resources and decreasing the frequency of product replacement. Product stewardship is a significant enabling mechanism for scaling up the circularity of products in Australia (Florin et al. 2023).

Leveraging digital technologies such as the Internet of Things (IoT), artificial intelligence (AI), and blockchain can enhance the tracking, management, and optimisation of resource flows. These technologies enable more efficient operations, better quality control in recycling processes, and improved transparency across supply chains. Digital twins can facilitate circular design for the future through digital prototyping and lifecycle simulation [21].

Use Waste as a Resource

Utilising waste as a resource involves identifying and implementing opportunities to reclaim and reuse materials and to keep materials in circulation at their highest value. This can significantly reduce reliance on virgin materials and decrease waste volumes, supporting resource efficiency and reducing environmental footprints. A focus on closing the loop can rely on many short-term economically attractive opportunities for resource efficiency and circular economy and offers, in the long-term, a more prosperous economic model [39].

Rethink the Business Model and Develop New Markets

To make the transition successful requires businesses to redefine their business models and to create economic value of the circular transition. Businesses cannot transition to the circular economy in isolation. They need to transition from firm-centric to networked business models, ones that involve supply chain partners (Planko and Cramer 2021). Implementing networked business models will require businesses to engage in 'coupled' open innovation to develop new markets (Gassmann and Enkel 2004). Established businesses will do so in reaction to diminishing resource availability and changes in the regulatory environment or customer expectations.

Circular business models create the need for new financial models to support the transition. For example, a business can save costs associated with expensive virgin material inputs and reduce waste levies through waste reduction and using secondary materials. This can be enabled and incentivised by policies that put a price on the externalities of the economic process thereby creating a level playing field for circular business models. Public procurement can play an instrumental role in rewarding circular business strategies [42].

Innovating through more open business models that support product-as-a-service, sharing, and leasing can fundamentally change consumption patterns [9]. These models encourage the use of products without the necessity of ownership, which can lead to more sustainable use of resources and greater product longevity.

Consistent Governance The envisioned changes in markets and business models cannot occur in isolation; they must be supported by consistent and harmonized policies, regulations, and standards that create a level playing field for circular economy investments. The distinct responsibilities of federal, state, and regional governments must be embedded within a unified national framework to guide the efforts of different jurisdictions toward a common goal. *Fostering a zero-waste culture*.

A circular economy ultimately needs be underpinned by a shift to a zero-waste culture. A zero-waste culture emphasizes minimizing waste generation by rethinking, reducing, reus-

ing, and recycling materials to prevent them from ending up in landfills or incinerators. This approach fosters a sustainable lifestyle where products are designed for longevity and resource efficiency. Such a shift in culture requires fundamental changes in social practices aligned with socio-technical changes creating an evolutionary environment for households and businesses to engage in the circular economy.

Together, these six elements create a comprehensive framework that addresses different aspects of the circular economy. By integrating these elements into policies, business practices, and community initiatives, Australia can effectively transition towards a more sustainable and economically resilient circular economy. This approach not only creates economic value and enhances social outcomes but also reduces the demand for primary materials and decreases waste and emissions.

Furthermore, the circular economy actively contributes to environmental restoration, including practices like regenerative agriculture, ecosystem restoration, and biodiversity enhancement, which support the health of the planet and provide renewable resources. Building the skills of the workforce to design for the future, prolong product lifecycles, and recover materials is critical for the transition towards circularity.

Transition Management, Transition Partnership and Governance

Embarking on the circular economy transition not only requires a good understanding of the transition process, its key elements and policy enablers but requires a concerted and coordinated effort of multiple economic sectors, agents and communities who align their efforts in a broader transition partnership that is governed by transition management practice [16]. A dynamic that can tip social and economic processes and its interactions with the environment and resources towards greater circularity needs to unfold enabled through concrete interventions [26].

Ultimately, Australia will need to align in an ambitious national mission of a low-carbon circular economy with clearly stated, measurable, and time-bound objectives. Doing so can unleash the research and innovation activities of private and public actors and invoke the cross-disciplinary, cross-sectoral, and cross-actor innovation that this transformative economic and social process relies upon. Since Australia's production and consumption systems are deeply embedded in the global chain, international partnerships are essential for local and national initiatives that are linked to export markets or the import of overseas inputs or materials.

Industries related to the circular economy are developing rapidly, often preceding regulatory guidance or direction. Adaptive governance of these industries and their evolving networks is required to enable innovation and develop policies based on science, shared learnings, and regional contexts. Effective coordination and consistent governance ensure that regulatory and legal frameworks, as well as supporting instruments, are fit-for-purpose and evidence-based. This approach maximizes the opportunities for environmental and social benefits of sustainability and circularity.

Following a network governance model where different actors would engage in experimentation in industries, cities and regional settings and can involve industrial symbiosis, eco-industrial towns, urban living labs and regional innovation hubs is beneficial to accelerating the transition. These initiatives, supported by enabling economic and policy settings, would uncover a multitude of solutions all contributing to Australia's mission to become a

global leader in the low carbon circular economy. This would not only create advantageous economic outcomes but also enhance social cohesion and environmental sustainability.

Conclusions

Australia's pathway to a circular economy is not just an environmental or economic initiative but a holistic change, embracing technological, social, and governance innovations essential for sustainable development in the 21st century. The proposed Pathway to Change for Australia's circular economy transition involves a phased approach, beginning with envisioning a sustainable future, assessing available options and trade-offs, mobilizing local initiatives, accelerating national policies, and finally, consolidating global partnerships.

Australia's transition to a circular economy is a vital strategic response to the pressing global challenges of resource scarcity, environmental degradation, and climate change. By adopting a clear circular economy framework and grounded in the proposed Pathway to Change described here, Australia can realign its economic activities towards sustainability, equity, and resilience.

Such profound changes in the economic structure, as well as in business and household decisions and behaviours, do not occur spontaneously as a result of innovation and technological advancement alone. These shifts require well-designed policies that ensure coordination of efforts and the creation of value at every stage. This highlights the critical role of inter- and transdisciplinary science in building the evidence base and practical knowledge needed for all stakeholders involved in the circular economy transition.

Future research will need to focus on developing effective methods for measuring circular economy progress, fostering innovation in the design of materials, products, and processes that can drive the circular economy, and identifying the economic and policy conditions that enable a successful transition away from the limitations of the current linear economic model.

Abbreviations

AI	Artificial Intelligence
CSIRO	Commonwealth Scientific and Industrial Research Organisation
IoT	Internet of Things
OECD	Organisation of Economic Cooperation and Development
UNEP	United Nations Environment Programme

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Declarations

Conflict of interest The authors declare that there is no perceived or actual conflict of interest.

References

1. Cohen N, Ilieva RT (2015) Transitioning the food system: a strategic practice management approach for cities. Environ Innov Societal Transitions 17:199–217
2. DCCEEW (2022) Environment ministers meeting 21 October 2022 agreed communique. Department of Climate Change, Energy, the Environment and Water
3. Egle L, Rechberger H, Zessner M (2015) Overview and description of technologies for recovering phosphorus from municipal wastewater. Resour Conserv Recycling 105:325–346
4. Feldman J, Seligmann H, King S, Flynn M, Shelley T, Helwig A, Paulomi Burey (2024) Circular economy barriers in Australia: how to translate theory into practice? Sustainable Prod Consum 45:582–597
5. Garnaut R (2013) Dog days: Australia after the Boom. Collingwood VIC, Redback, Schwartz Media
6. Geels FW (2004) From sectoral systems of innovation to socio-technical systems - insights about dynamics and change from sociology and institutional theory. Res Policy 33:897–920
7. Geels FW, Schot J (2007) Typology of sociotechnical transition pathways. Res Policy 36:399–417
8. Geissdoerfer M, Savaget P, Bocken NMP, Hultink EJ (2017) The circular economy a new sustainability paradigm? J Clean Prod 143:757–768
9. Geissdoerfer M, Morioka SN, De Carvalho MM, Evans S (2018) Business models and supply chains for the circular economy. J Clean Prod 190:712–721
10. Gupta H, Kusi-Sarpong S, Rezaei J (2020) 'Barriers and overcoming strategies to supply chain sustainability innovation'. Resour Conserv Recycling 161:104819–104834
11. Harlow J, Johnston E, Hekler E, Yeh Z (2018) 'Fostering sustainability transitions by designing for the convergence of policy windows and transition arenas', *Sustainability*, 10
12. Hatfield-Dodds S, Schandl H, Adams PD, Baynes TM, Brinsmead TS, Bryan BA, Chiew FHS, Graham PW, Grundy M, Harwood T, McCallum R, McCrea R, McKellar LE, Newth D, Nolan M, Prosser I, Wonhas A (2015) Australia is 'free to choose' economic growth and falling environmental pressures. Nature 527:49–53
13. Hernandez RJ, Miranda C, Goñi J (2020) 'Empowering sustainable consumption by giving back to consumers the 'right to repair''. Sustainability 12(3):850–865
14. Kirchherr J, Yang N-HN, Schulze-Spüntrup F, Heerink MJ (2023) Conceptualizing the Circular Economy (Revisited): an Analysis of 221 Definitions. Resour Conserv Recycl 194:107001
15. Liu Z, Wan MD, Zheng XX, Koh SCL (2022) Fairness concerns and extended producer responsibility transmission in a circular supply chain. Ind Mark Manage 102:216–228
16. Loorbach D (2010) Transition management for sustainable development: a prescriptive, complexity-based governance framework. Governance-an Int J Policy Adm Institutions 23:161–183
17. Mazzucato M (2016) From market fixing to market-creating: a new framework for innovation policy. Ind Innovat 23:140–156
18. Mazzucato M (2018) Mission-oriented research & innovation in the European Union. A problem-solving approach to fuel innovation-led growth. European Commission, Brussels
19. Mazzucato M, Kattel R, Ryan-Collins J (2020) Challenge-driven innovation policy: towards a new policy toolkit. J Ind Competition Trade 20:421–437
20. Miatto A, Emami N, Goodwin K, West J, Taskhiri MS, Wiedmann T, Heinz Schandl (2024) Australia's circular economy metrics and indicators. J Ind Ecol 28:216–231
21. Mügge J, Seegrün A, Hoyer T-K, Riedelsheimer T, Lindow K (2024) Digital Twins within the Circular Economy. Literature Review and Concept Presentation. In Sustainability
22. Naughtin CK, Schleiger E, Bratanova A, Terhorst A, Hajkowicz S (2024) 'Forty years in the making: a systematic review of the megatrends literature', Futures, 157
23. Ningrum D, Raven R, Malekpour S, Moallemi EA, Bryan BA (2023) 'Transformative potential in sustainable development goals engagement: experience from local governance in Australia'. Global Environ Change-Human Policy Dimensions 80:102670–102681
24. O'Neill DW, Fanning AL, Lamb WF and J. K. Steinberger. 2018. 'A good life for all within planetary boundaries'. Nat Sustain 1(2):88–95
25. OECD (2022) Tackling policy challenges through public sector innovation

26. Otto IM, Donges JF, Cremades R, Bhowmik A, Hewitt RJ, Lucht W, Rockström J, Allerberger F, McCaffrey M, Doe SS, Lenferna A, Morán N, Van Vuuren DP, Schellnhuber HJ (2020) Social tipping dynamics for stabilizing Earth's climate by 2050. Proc Natl Acad Sci 117(5):2354–2365
27. Palavicino C, Alvial C, Matti, Christoph, Brodnik (2023) Co-creation for transformative innovation policy: an implementation case for projects structured as portfolio of knowledge services. Evid Policy 19:323–339
28. Ropke I (2009) Theories of practice - new inspiration for ecological economic studies on consumption. Ecol Econ 68:2490–2497
29. Sahakian M, Wilhite H (2014) Making practice theory practicable: towards more sustainable forms of consumption. J Consumer Cult 14:25–44
30. Schandl H, King S, Walton A, Kaksonen A, H S, Tapsuwan, Baynes TM (2020) National circular economy roadmap for plastics, glass, paper and tyres. Commonwealth Scientific and Industrial Research Organisation, Canberra
31. Schandl H, Walton A, Okelo W, Kong T, Boxall NJ, Terhorst A, Porter NB (2023) Australia's comparative and competitive advantages in transitioning to a circular economy. A report to the office of the chief scientist. In. Commonwealth Scientific and Industrial Research Organisation, Canberra
32. Schot J, Geels FW (2008) Strategic niche management and sustainable innovation journeys: theory, findings, research agenda, and policy. Technol Anal Strateg Manag 20:537–554
33. Sherwood J (2020) 'The significance of biomass in a circular economy'. Bioresour Technol 300:122755–122762
34. Shove E, Walker G (2010) Governing transitions in the sustainability of everyday life. Res Policy 39:471–476
35. Shove SE, Pantzar M, Watson M (2012) The dynamics of social practice: everyday life and how it changes. Sage, Thousand Oaks, CA
36. Sonnier E, Grit A (2022) A narrative for circular economy in cities: conditions for a mission-oriented innovative system. City Environ Interact 16:100084
37. Stahel WR (2016) Circular economy. Nature 531:435–438
38. Turnheim B, Berkhout F, Geels FW, Hof A, McMeekin A, Nykvist B, van Vuuren DP (2015) Evaluating sustainability transitions pathways: Bridging analytical approaches to address governance challenges. Global Environ Change-Human Policy Dimensions 35:239–253
39. UNEP (2017) Resource Efficiency: Potential and Economic Implications. A report of the International Resource Panel. In. United Nations Environment Programme, Paris
40. Velenturf APM, Archer SA, Gomes HI, Christgen B, Lag-Brotons AJ, Purnell P (2019) Circular economy and the matter of integrated resources. Sci Total Environ 689:963–969
41. Vogel J, Steinberger JK, O'Neill DW, Lamb WF, Krishnakumar J (2021) 'Socio-economic conditions for satisfying human needs at low energy use: an international analysis of social provisioning'. Global Environ Change-Human Policy Dimensions 69:102287–102301
42. Witjes S, Lozano R (2016) Towards a more circular economy: proposing a framework linking sustainable public procurement and sustainable business models. Resour Conserv Recycling 112:37–44