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Resilience and Design Sustainability for Circular Economy: An Exploration of The Global Commitment In Adopting Systems Design Thinking Practices for The Circular Economy Transition

Master's Thesis

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Resilience and Design Sustainability for Circular Economy:

An Exploration of The Global Commitment In Adopting Systems Design Thinking Practices for The Circular Economy Transition

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

MASTER THESIS

This dissertation is submitted in partial fulfilment of the requirements for the degree of

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IDEO bgdv ELLEN MACARTHUR FOUNDATION

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This thesis has been approved by the assigned supervisor(s) and the composition of the academic committee for the Master of Science in Engineering (Design Engineering) at ETSID, Escuela Técnica Superior de Ingeniería del Diseño of the Universitat Politècnica de València in Spain.

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I would also like to thank INGENIO [CSIC-UPV] and by extension the Spanish National Research Council (CSIC) and the Polytechnic University of Valencia (UPV) for the Eu-SPRI Forum and INGENIO PhD Days that among many things provided the environment for researchers to develop professionally and personally. The contributions of your events to the development of research capabilities, presentation, communication skills and networking among researchers soared me to new heights.

I owe a big gratitude to the people, companies, institutions and organisations globally that participated in this research and who were willing to invest their time and energy to take part in the research phases and process, both formally and informally. Without them, it would be impossible to conduct this research. Special thanks to IDEO and The Ellen Macarthur Foundation. The collaborators at IDEO and The Ellen Macarthur Foundation, our collaboration and access granted during this project was both pleasant and insightful. I have learned a lot about the pros (and cons, but mainly the pros) of using the industry relevant hands-on insights to inform scholastic research. The discussions we had about the topic have been extremely helpful to me. Both your interest in and helpful insights on my studies have enabled me to view them from different perspectives, helping me to see the bigger picture of the project, and dare I say beyond. These collaborations made me broaden my scope as well, and have enabled me to publish on different topics than the ones presented in this thesis.

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II

DECLARATION AND STATEMENTS

I declare that this thesis was composed by myself, that the work contained herein is my own except where explicitly stated otherwise in the text, and that this work has not been submitted for any other degree or professional qualification except as specified. To the best of my knowledge and belief, this thesis contains no material previously published or written by another person except where otherwise stated.

In the course of conducting this research, the author has partially utilised Large Language Models (LLMs) as an aid to improve the writing style. He gratefully acknowledges the various open-source communities, researchers, and industry practitioners who have developed and maintained these tools and libraries that were instrumental in this work. As the author is not a native English, Spanish or Valencian speaker, these tools were used as an editing aide during the writing of this thesis to:

1. Identifying the most recent and relevant research on the topics of the thesis
2. Disseminate research content from audio recording with speech-to-text tools
3. Review and amend grammatical and spelling mistakes
4. Ensure linguistic consistency and coherence
5. Test and fine tune the case study wording
6. Standardise the format of the annotated bibliography
7. Data Visualisations

Moreover, to ensure that during these attempts the tools did not introduce plagiarised wording and content, the thesis manuscript has been submitted to the iThenticate plagiarism and similarity checker. The plagiarism and similarity checker results showed a Similarity Index = 0% based on the settings; (1) exclude matches by percentage at <1%, (2) limit match size word count to 9 words, (3) exclude bibliography, (4) exclude quotes, and (5) include abstract, methods and materials.

Harold Ngabo-Woods

Signature: ……

Date: 30tht July 2023

I dedicate this thesis to my wife, Andrea and our children; Laura, and Elijah
for showing me the world, and endless love.

ABSTRACT

The world is currently facing significant environmental challenges, such as climate change, depletion of natural resources, and pollution, due to unsustainable consumption and production patterns. To address these challenges, there has been a growing global commitment to sustainability and the transition to a circular economy. The circular economy is seen as a promising solution to optimise resource use, reduce waste and pollution, and create value for businesses and society. Design thinking and systems thinking have emerged as promising approaches for facilitating this transition. This research thesis explores the adoption of systems design thinking practices in the transition to a circular economy and their contribution to resilience and sustainability. The thesis examines case studies from around the world to identify best practices and successful implementations of circular economy strategies through design thinking and systems thinking and to understand how these approaches can contribute to resilience and sustainability.

Keywords:
Circular Economy, Systems Thinking, Design Thinking, Resilience, Sustainability, CE Transition

IV

RESUMEN

Actualmente, el mundo enfrenta importantes desafíos ambientales, como el cambio climático, el agotamiento de los recursos naturales y la contaminación, debido a patrones de consumo y producción no sostenibles. Para hacer frente a estos desafíos, ha habido un creciente compromiso mundial con la sostenibilidad y la transición a una economía circular. La economía circular se considera una solución prometedora para optimizar el uso de los recursos, reducir los desechos y la contaminación, y crear valor para las empresas y la sociedad. El pensamiento de diseño y el pensamiento sistémico han surgido como enfoques prometedores para facilitar esta transición. Esta tesis de investigación explora la adopción de prácticas de pensamiento de diseño de sistemas en la transición a una economía circular y su contribución a la resiliencia y la sostenibilidad. La tesis examina estudios de casos de todo el mundo para identificar las mejores prácticas y las implementaciones exitosas de estrategias de economía circular a través del pensamiento de diseño y el pensamiento sistémico y para comprender cómo estos enfoques pueden contribuir a la resiliencia y la sostenibilidad.

Palabras Clave:
Economía Circular, Systems Thinking, Design Thinking, Resiliencia, Sostenibilidad, Transición CE

RESUM

Actualment, el món s'enfronta a importants reptes ambientals, com ara el canvi climàtic, l'esgotament dels recursos naturals i la contaminació, a causa de patrons de consum i producció insostenibles. Per abordar aquests reptes, hi ha hagut un compromís global creixent amb la sostenibilitat i la transició cap a una economia circular. L'economia circular es considera una solució prometedora per optimitzar l'ús dels recursos, reduir els residus i la contaminació i crear valor per a les empreses i la societat. El pensament de disseny i el pensament de sistemes han sorgit com a enfocaments prometedors per facilitar aquesta transició. Aquesta tesi de recerca explora l'adopció de pràctiques de pensament de disseny de sistemes en la transició a una economia circular i la seva contribució a la resiliència i la sostenibilitat. La tesi examina estudis de casos d'arreu del món per identificar les millors pràctiques i les implementacions reeixides d'estratègies d'economia circular mitjançant el pensament de disseny i el pensament de sistemes i per entendre com aquests enfocaments poden contribuir a la resiliència i la sostenibilitat.

Paraules clau:
Economia circular, System Thinking, Design Thinking, Resiliència, Sostenibilitat, CE Transició

VI

INCAMAKE

Kuri ubu isi ihura n'ibibazo bikomeye by'ibidukikije, nk'imihindagurikire y'ikirere, igabanuka ry'umutungo kamere, n'umwanda, bitewe n'imikoreshereze idahwitse n'umusaruro. Kugira ngo ibyo bibazo bikemuke, hagiye hagaragara ko isi yose yiyemeje kuramba no kwimuka mu bukungu. Ubukungu buzenguruka bufatwa nkigisubizo cyiza cyo gukoresha neza umutungo, kugabanya imyanda n'umwanda, no guha agaciro ubucuruzi na sosiyete. Gutekereza design hamwe na sisitemu yo gutekereza byagaragaye nkuburyo butanga icyizere cyo koroshya iyi nzibacyuho. Ubu bushakashatsi bwibanze ku iyemezwa rya systems design thinking uburyo bwo gutekereza muguhindura ubukungu bwizunguruka nuruhare rwabo mukwihangana no kuramba. Inyandiko isuzuma ubushakashatsi bwakozwe ku isi hose kugira ngo hamenyekane imikorere myiza no gushyira mu bikorwa ingamba z'ubukungu bw'umuzingi binyuze mu bitekerezo ndetse no gutekereza kuri sisitemu no kumva uburyo ubwo buryo bushobora kugira uruhare mu guhangana no kuramba.

Amajambo yibanze:
Circular Economy, Systems Thinking, Design Thinking, Resilience, Sustainability, CE Transition

VII

ACRONYMS AND ABBREVIATIONS

AI	Artificial Intelligence
APCNF	Andhra Pradesh Community-Managed Natural Farming
CE	Circular Economy
CEAP	Circular Economy Action Plan
CMNF	Community-Managed Natural Farming Regenerative Agriculture Initiative
CSIC	Consejo Superior de Investigaciones Científicas
EPR	Extended Producer Responsibility
ETSID	Escuela Técnica Superior de Ingeniería del Diseño
EU	European Union
IoT	Internet of Things
JASP	Jeffreys's Amazing Statistics Program
LLMs	Large Language Models
NACE	European Classification of Economic Activities
NFFs	Natural Farming Fellows
PKVY	Paramparagat Krishi Vikas Yojna
RNCEAPR	Rwanda National Circular Economy Action Plan and Roadmap
RySS	Rythu Sadhikara Samstha
TOE	Technology-Organization-Environment
UPV	Universitat Politècnica de València
ZBNF	Zero-Budget Natural Farming

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IX

PREFACE

This Thesis describes the research work performed in the context of the Master of Science in Engineering, Design Engineering specialisation that was carried out at ETSID School of Design Engineering (https://www.etsid.upv.es/la-escuela/) of the Universitat Politècnica de València (UPV) (https://www.upv.es/es).

The main focus of the Thesis seeks to explore the complex, multifaceted issue of transitioning to a circular economy through a resilience, sustainability and systems design thinking approach. By examining both the theoretical foundations and real-world implementations, this research contributes to a broader understanding of how these aspects can foster a successful transition to a sustainable circular economy. The pursuit of a sustainable future is a shared goal that unites individuals, industries, and nations. As we stand on the cusp of a critical juncture in human history, there is an urgent need to reassess the way we design, produce, consume, and dispose of products. The circular economy, a model that emphasises recycling, reusing, and reducing waste, presents a promising pathway toward sustainability. However, the transition to a circular economy requires a profound transformation of the existing linear economic models, calling for innovative approaches and global commitment.

The thesis is divided into six chapters, each focusing on a distinct aspect of the research organised as follows:

Chapter 1: The introduction offers an overview of the circular economy and the rationale behind adopting resilience, sustainability and systems design thinking. The chapter sets the context and outlines the scope and objectives of the research.

Chapter 2: The State of the Art presents a comprehensive review of aligning definitions, literature and theoretical frameworks in the field of resilience, sustainability, circular economy and systems design thinking. This chapter helps in understanding the current state of knowledge and identifying the gaps that this research aims to fill.

Chapter 3: Research Design and Methodology details the research methods, design paradigms, and data collection strategies used in the study. The chapter provides a transparent account of the methodological choices, ensuring the rigour and validity of the research.

Chapter 4: Case Studies - The Global Commitments explores the diverse approaches and commitments made by different nations and regions in embracing the circular economy with an emphasis on the four (4) selected case studies; the EU, China, India, and Rwanda. Through in-depth case studies, this chapter sheds light on the unique challenges and successes experienced by these regions.

Chapter 5: Findings synthesises the data gathered through literature review, case studies, and analysis, presenting the key insights, patterns, and observations that emerged from the research.

Chapter 6: Discussion and Conclusion provides a critical analysis of the findings, discussing their implications for theory, practice, and policy. The chapter concludes with reflections on the research's contributions, limitations, and recommendations for future work.

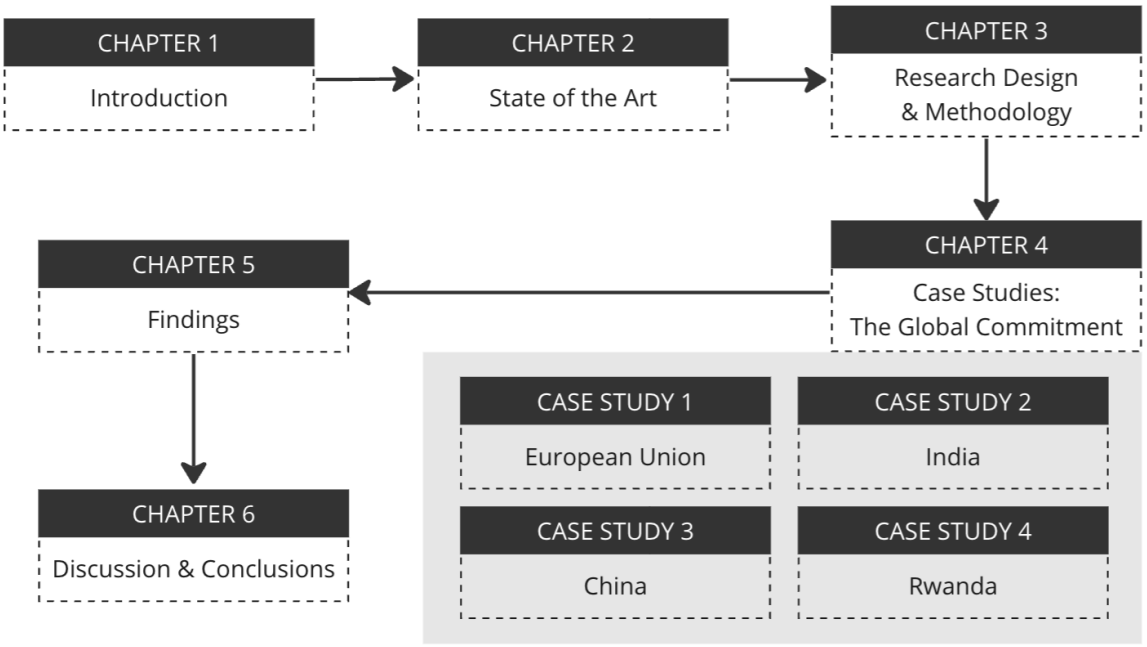

Figure 1.0: Diagram of the thesis chapters

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1

INTRODUCTION

1.1 Background and Context of the Research

The world is facing significant environmental challenges, including climate change, depletion of natural resources, and pollution due to the increasing demands of the global population and unsustainable consumption and production patterns. In response, there has been a growing global commitment by countries and governments to resilience, sustainability and the transition to a circular economy. However, achieving these goals requires a fundamental shift in the way we think, design, produce, and consume goods and services. The circular economy is seen as a promising solution to address these challenges by optimising resource use, reducing waste and pollution, and creating value for both businesses and society (Ellen MacArthur Foundation, 2012). In recent decades, the concept of a circular economy has gained global recognition. The increase in the risk of climate change, the shortage of resources, and the increase in the global population make it an urgent move to a more sustainable development model. Circular Economy is often cited as one of the best solutions for sustainable development. However, this concept's spread and implementation remains relatively slow throughout the world. It is crucial to make sure that the circular transition strategies are resilient, sustainable and not bearing on the cost of future generations.

Systems and design thinking have emerged as promising approaches for facilitating the transition to a circular economy. Design thinking is a problem-solving approach that emphasises empathy, creativity, and iterative prototyping (Brown, 2008), while systems thinking involves a holistic understanding of complex systems and their interconnections (Sterman, 2000). Both approaches have been applied to various aspects of sustainability and circular economy, including product design, business models, and supply chains(Geissdoerfer et al., 2017; Wallat et al., 2022). The adoption of systems design thinking practices for circular economy transition is a global phenomenon, with initiatives and policies emerging from different governments, regions, industries and sectors (Angelis, 2021; Beccarello & Foggia, 2022). For example, the European Union has established a circular economy action plan to promote sustainable production and consumption and to create new business opportunities (European Commission, 2020). In Asia, the circular economy has become a strategic priority for countries such as China and Japan, with the adoption of circular economy policies and strategies in various sectors (Zhang et al., 2021; Ishihara & Hashimoto, 2021). In the United States, circular economy initiatives have been driven by both the public and private sectors, including the Ellen MacArthur Foundation's Circular Economy 100 program and the Closed Loop Fund for circular economy investments (Ellen MacArthur Foundation, 2020; Closed Loop Fund, 2020). Despite the growing interest in systems

design thinking for circular economy transition, there is still a need for further research to understand how these approaches can contribute to resilience and sustainability in the design process. This thesis aims to address this gap by examining case studies from around the world to identify best practices and successful implementations of circular economy policies and strategies that have embraced systems design thinking approaches.

The transition to a circular economy requires the integration of resilience, systems design thinking, and sustainability principles to achieve sustainable and regenerative outcomes. Resilience is crucial in ensuring the ability of systems to withstand and recover from disruptions and disturbances (Brassesco et al., 2021). Systems design thinking emphasises a holistic and interdisciplinary approach, considering the interconnections and interdependencies within complex systems (Nohra et al., 2020). Sustainability principles guide the circular economy transition by promoting the efficient use of resources, whilst minimising waste generation, and fostering long-term viability (Sumter et al., 2020). The implementation of circular economy practices necessitates addressing barriers and enablers at various levels, including SMEs (Caldera et al., 2019). Targeted interventions and support from agencies and professional bodies can facilitate the adoption of sustainable business practices (Caldera et al., 2019). Sustainable design thinking and social innovation play a central role in overcoming barriers and fostering circular economy practices (Deniz, 2021). Moreover, systemic design approaches offer a framework for policy-making and addressing barriers to circular economy adoption (Nohra et al., 2020). The concept of resilience is interconnected with the circular economy and sustainability, particularly in areas such as the mining industry and urban development, among others (Jones & Wynn, 2021). The circular economy has the potential to improve the resilience and sustainability of industries and urban systems (Yazan et al., 2022). Furthermore, the integration of resilience concepts with circular economy and sustainability principles can contribute to the creation of environmentally sustainable socio-economic systems (Yaremchuk, 2021). While there is a recognition of the importance of systems design thinking in circular economy practices, its practical implementation remains limited (Sumter et al., 2020). Therefore, further exploration and application of systems thinking in the context of the circular economy transition are necessary (Sumter et al., 2020). Additionally, innovative approaches, digital technologies, and systems can enhance the circular economy's resilience and sustainability (Brassesco et al., 2021; Jones & Wynn, 2021). In conclusion, the integration of resilience, systems design thinking, and sustainability principles is essential for a successful transition to a circular economy. Understanding the interplay between these concepts can guide the development of effective strategies and interventions to foster sustainable and regenerative practices and systems.

1.2 Problem Statement and Research Questions

1.2.1 Problem Statement

The transition to a circular economy requires a fundamental shift in the way we think, design, produce, and consume goods and services. Though multiple solutions to this transition have been conceptualised, approaches without a systems design thinking practices to facilitate this transition would be neither resilient nor sustainable. There is still a need for further research to understand how these approaches can contribute to resilience and sustainability in the systems design thinking process. This knowledge gap presents a significant problem for governments, businesses, policymakers, and

researchers alike, as the circular economy is seen as a critical solution to address environmental challenges and create value for society.

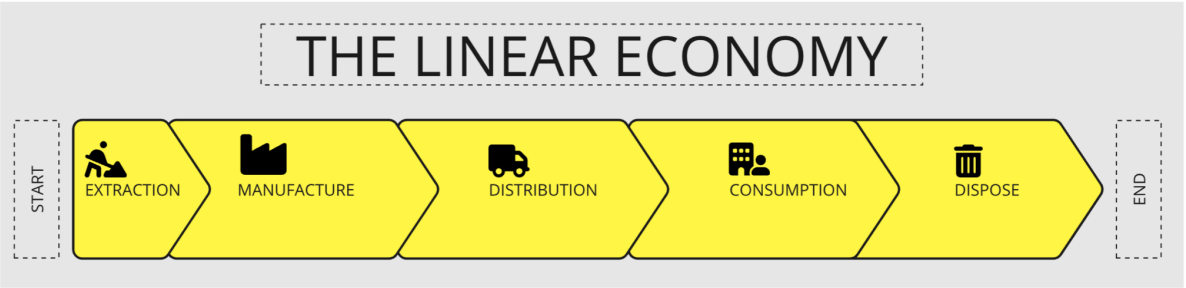

Figure 1.1: Linear Economy Diagram

1.2.2 Research Questions

To address this problem, this thesis explores the adoption of systems design thinking practices in the transition to a circular economy through global implementations. Specifically, it seeks to answer the following research questions:

- Q1: How are systems and design thinking practices applied in the transition towards a circular economy, and what are the key success factors for their adoption?
- Q2: How do these practices contribute to resilience and sustainability for circular economy and transition?
- Q3: What are the implications of these practices for circular economy transition, and how can they be leveraged to create more resilient and sustainable systems for the future?
- Q4: How is success of these practices and the circular economy transition measured and/or assessed?

By answering these research questions, this thesis provides insights into the role of systems design thinking practices in the transition towards a circular economy. It contributes to the growing body of knowledge on systems design, design thinking, resilience, sustainable design and circular economy; and provides recommendations for future research and practice.

1.3 Research Objectives and Scope of the Research

The main objective of this thesis was to explore the adoption of systems design thinking practices in the transition towards a circular economy, and to investigate their contribution to resilience and sustainability in the process by examining current and planned implementations . The research aimed to achieve the following specific objectives:

1. To review the literature on design thinking, systems thinking, resilience, sustainability and circular economy transition to develop a conceptual framework for the study.

2. To identify the key success factors for the adoption of systems design thinking practices in the circular economy transition.

3. To examine the application of systems design thinking practices in the circular economy transition in selected case studies.

4. To analyse the contribution of systems design thinking practices to resilience and sustainability in the circular economy transition.

5. To identify the implications of systems design thinking practices for the circular economy transition and propose recommendations for future research and practice.

The scope of this research was limited to the adoption of systems design thinking and systems practices in the transition towards a circular economy. It included a review of the relevant literature and case studies to explore the application of these practices in the transition process by governments, organisations and industries. The research focuses on the contribution of these practices to resilience and sustainability in the circular economy transition and proposes recommendations for future research and practice.

1.4 Significance and Contributions of the Research

This thesis contributes to the emerging field of the circular economy and transition by exploring the adoption of systems design thinking practices in the process. The research is significant because it provides insights into the role of these practices beyond academia in promoting resilience and sustainability in the circular economy transition applications worldwide.

The first contribution of this research is the development of a conceptual framework that integrates design thinking, systems thinking, resilience, sustainability and circular economy principles. This framework provides a theoretical foundation for understanding the adoption of these practices in the systems design process and their contribution to the circular economy transition.

Secondly, this research identifies the key success factors for the adoption of systems and thinking practices in the circular economy transition. These success factors can inform the development of guidelines and best practices for designers, governments and businesses to adopt these practices effectively.

Thirdly, this research provides empirical evidence from case studies to demonstrate the application of design thinking and systems design thinking practices in the circular economy transition. The case studies illustrate how these practices can be used to identify and address sustainability challenges in the process and transition.

Finally, this research contributes to the ongoing dialogue on the circular economy transition by proposing recommendations for future research and practice. These recommendations include the need for more interdisciplinary research and the development of collaborative networks to promote the adoption of design thinking and systems thinking practices for resilience and sustainable circular economy transition.

In terms of self-criticism, this research has some limitations. Firstly, the case studies were limited to a specific geographic region, and future research could explore the application of these practices in different contexts. Secondly, the research focused on the contribution of these practices to resilience and sustainability and did not address other aspects of the circular economy transition, such as economic and social impacts.

1.5 Structure of the Thesis

This thesis aims to explore the adoption of systems design thinking practices in the transition to a circular economy that facilitates resilience and sustainability. Specifically, it seeks to understand how these approaches can contribute to resilience and sustainability in the design process. The thesis examines case studies from around the world to identify best practices and successful implementations of circular economy strategies through systems design thinking. The thesis will begin with an introduction followed by a state of the art review of the key concepts of this research; sustainability and design, circular economy, resilience theory, and systems design thinking. This will provide a foundation for understanding the current state of knowledge on the subject and will help frame the research questions. The research methodology will be described, including the data collection and analysis methods, as well as any ethical considerations.

The findings of the thesis will be presented, including an overview of the data collected and an analysis of the data in relation to the research questions and objectives. Key themes and patterns emerging from the case studies will be identified, and successful implementations of circular economy through systems design thinking will be highlighted. The discussion section will interpret the findings in light of the state of the art review, drawing connections and identifying areas of agreement and divergence. The implications of the findings for theory and practice will be discussed, as well as recommendations for future research and practice. This thesis aims to contribute to the growing body of knowledge on systems design thinking in sustainable design and circular economy. By examining the use of design thinking and systems thinking practices in the context of circular economy transition, it will provide insights into how we can create more resilient and sustainable systems for the future.

2

STATE OF THE ART

2.1 The Circular Economy

The concept of the circular economy has gained momentum in both academic and practical spheres. However, there is a lack of consensus on its definition, leading to various interpretations and understandings (Kirchherr et al., 2017). Scholars have proposed different definitions and conceptualizations of the circular economy, highlighting its restorative and regenerative nature (Morseletto, 2020). It is often characterised by principles such as closing material loops, reducing waste, and promoting resource efficiency (Geisendorf & Pietrulla, 2017). The circular economy is a concept that aims to transform the linear "take-make-dispose" model of production and consumption into a restorative, regenerative and sustainable system (Kirchherr et al., 2017; Geisendorf & Pietrulla, 2017). It seeks to decouple economic growth from resource consumption and environmental degradation by promoting the efficient use of resources, minimising waste generation, and maximising the value and lifespan of products, materials, and resources (Kirchherr et al., 2017). While there is no single, universally accepted definition, it is broadly characterised as an economic system that seeks to decouple economic growth from resource consumption and environmental degradation. It emphasises the preservation of value and the reduction of waste throughout the entire life cycle of products, from resource extraction to disposal (Morseletto (2020) Cabral et al., 2021). The circular economy aims to maximise the use of resources, promote the reuse, repair, and recycling of materials, and minimise the generation of waste and pollution. It is considered essential for addressing global environmental challenges and achieving sustainability goals such as climate change mitigation and nature conservation (Oduniyi, 2021). Furthermore, the circular economy emphasises the integration of circular economy principles within supply chain management, resulting in what is known as circular supply chains (Angelis et al., 2018). The concept also aligns with resilience and sustainability objectives, although its focus on economic prosperity and environmental quality is more prominent than its impact on social equity and future generations (Kirchherr et al., 2017). The circular economy is closely linked to sustainability objectives and the achievement of sustainable development goals. It addresses environmental challenges, such as resource depletion and pollution, while also considering social and economic aspects (Millar et al., 2019). By promoting circular practices, the circular economy aims to create a more sustainable and resilient economy that minimises negative environmental impacts and fosters long-term economic growth (Millar et al., 2019).

The circular economy goes beyond the traditional "end-of-pipe" approaches of the linear economy and seeks transformative changes across the entire value chain. It emphasises the need for fundamental changes in production, consumption, and waste management practices to retain materials in the

circular economy loop and preserve their value for as long as possible (Rizos et al., 2016). This involves shifting from a focus on the extraction of virgin resources to the reuse, repair, remanufacturing, and recycling of materials (Zink & Geyer, 2017).

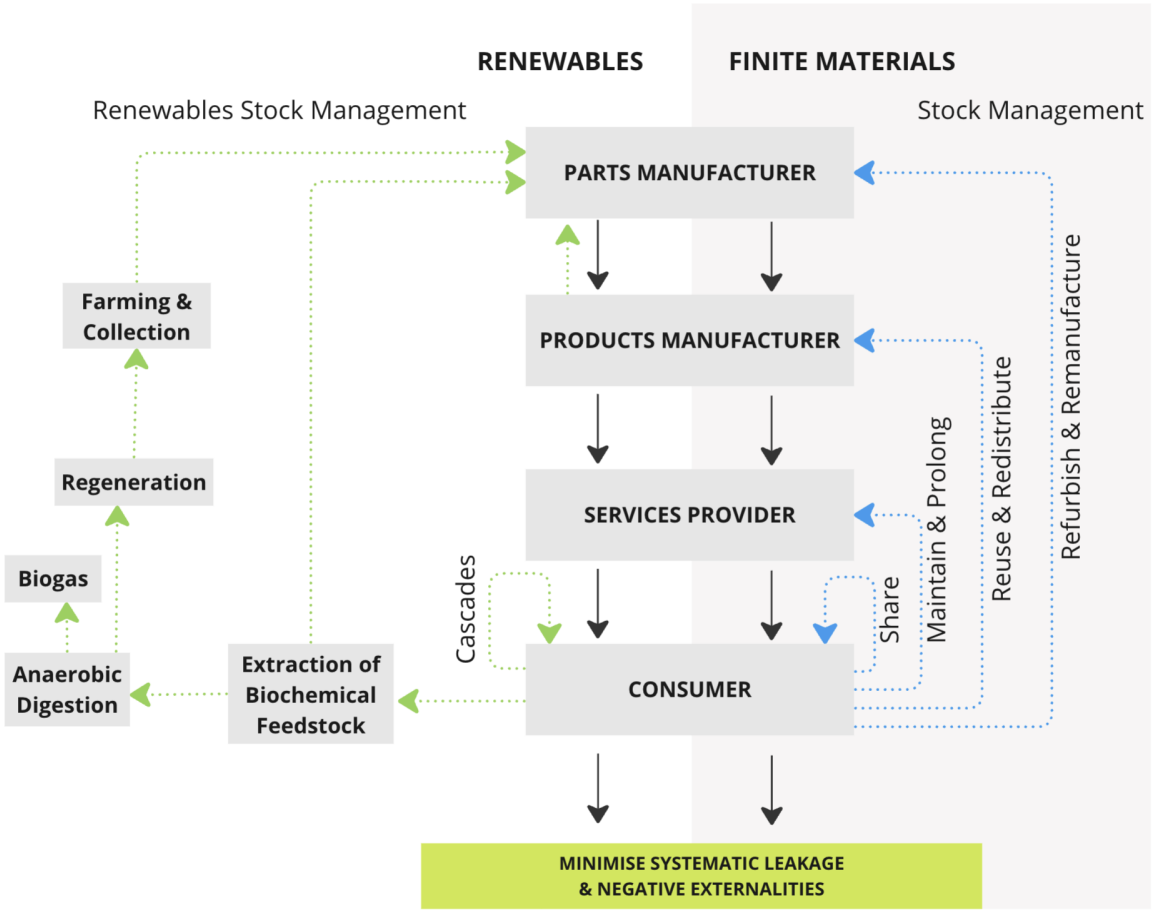

Figure 2.1: Circular Economy Systems Diagram (An adaptation of the Ellen MacArthur Foundation Butterfly diagram, 2019)

Overall, the circular economy represents a holistic and systemic approach to creating a more sustainable and regenerative economic system (Martins & Cooper, 2017; Moreno et al. 2016). Implementing the circular economy requires systemic changes and collaboration across various sectors and stakeholders. It involves rethinking and redesigning products, business models, and supply chains to optimise resource use and minimise waste (Sehnem et al., 2019). The circular economy also encourages the adoption of innovative technologies, such as blockchain and Industry 4.0, to enable more efficient resource management and circular business models (Kouhizadeh et al., 2019; Awan et al., 2021). While the circular economy offers potential benefits, challenges and barriers exist in its implementation. These include the need for supportive policy frameworks, changes in consumer behaviour, and overcoming technological and infrastructural limitations (Dissanayake & Weerasinghe, 2021). Additionally, the circular economy requires a shift in mindset and a transition from a linear to a circular mindset among businesses, governments, and society as a whole (Corvellec et al., 2020). The circular economy represents a transformative approach to economic development that aims to

decouple growth from resource consumption and environmental degradation. It emphasises the efficient use of resources, waste reduction, and the preservation of value throughout the product life cycle. The circular economy requires systemic changes, collaboration, and innovative approaches to achieve its objectives.

2.2 Resilience and Design Sustainability in the Circular Economy

2.2.1 Resilience Theory and Practice

Resilience can be defined as the ability to recover from adversity, adapt to change, and maintain equilibrium in the face of stress (Masten, 2001). It is a dynamic and multidimensional construct that has been applied to various levels, including individuals, families, communities, and systems (Norris et al., 2008). Resilience theory and practice have gained significant attention in various fields, including sustainability, systems design, disaster management, psychology, and social work. Resilience is a multifaceted concept that refers to the ability of individuals, communities, and systems to withstand and recover from adversity, shocks, and disturbances McCleary & Figley (2017). It encompasses both the capacity to bounce back from challenges and the ability to adapt, transform, and thrive in the face of change (Lee et al., 2012). In the context of sustainability and the circular economy, resilience theory and practice play a crucial role in promoting adaptive and transformative responses to environmental, social, and economic challenges. Resilience thinking recognizes the interconnectedness and interdependencies of social-ecological systems and emphasises the need to build capacity and enhance adaptive capacity to navigate and respond to change (Liao, 2012). It encourages a shift from reactive approaches to proactive and anticipatory strategies that promote sustainability and enhance the resilience of individuals, communities, and ecosystems (Hudec, 2017). In the context of sustainability and the circular economy involve several key elements. Firstly, it recognizes the importance of understanding the complex dynamics and feedback loops within systems, including the interactions between social, economic, and environmental factors (Wieland & Durach, 2021). This understanding helps identify vulnerabilities, leverage points, and opportunities for intervention to enhance resilience and promote sustainable practices (Haider et al., 2017). Secondly, resilience theory and practice emphasise the importance of building social capital, fostering collaboration, and promoting adaptive governance to enhance the capacity of individuals and communities to respond to and recover from shocks and disturbances (Aldunce et al., 2015). This involves fostering inclusive decision-making processes, building trust, and promoting social cohesion (Thomas et al., 2018). Furthermore, resilience theory and practice in the context of sustainability and the circular economy highlight the need for adaptive management and learning. It involves continuous monitoring, evaluation, and feedback loops to assess the effectiveness of interventions and adjust strategies accordingly (Thomas et al., 2018). This iterative approach allows for the integration of new knowledge, the identification of emerging risks and opportunities, and the refinement of practices to enhance resilience and promote sustainability (Turner et al., 2022). However, the application of resilience theory and practice in the context of sustainability and the circular economy is not without challenges. It requires interdisciplinary collaboration, as resilience is a complex and multifaceted concept that spans multiple disciplines and perspectives (Haider et al., 2017). It also demands a shift in mindset and organisational culture to embrace long-term thinking, systems perspectives, and adaptive approaches (Godwin & Kreutzer, 2013). Additionally, the measurement and assessment of

resilience can be challenging, as it involves capturing both tangible and intangible aspects of resilience and considering multiple scales and contexts (Liao, 2012). Resilience theory and practice in the context of sustainability and the circular economy provide a valuable framework for promoting adaptive and transformative responses to environmental, social, and economic challenges. It emphasises the capacity of individuals, communities, and systems to withstand and recover from adversity while promoting sustainability and enhancing adaptive capacity. By embracing resilience theory and practice, stakeholders can foster sustainability, promote circularity, and enhance the capacity to navigate and thrive in a rapidly changing world.

The link between resilience and sustainability is complex and multidimensional. While there is some overlap and interplay between the two concepts, there are also inherent conflicts and tensions. Sustainability often emphasises efficiency and long-term viability, while resilience focuses on effectiveness and the ability to withstand and recover from shocks and disturbances (Negri et al., 2021). However, there is a growing recognition of the need to integrate and align resilience and sustainability objectives (Keenan et al., 2021). Resilience strategies have been shown to have a significant impact on economic and environmental sustainability (Singh et al., 2023). Some scholars view resilience as a concept or sub-concept within sustainable development, as it provides a pathway towards achieving sustainability goals (Metaxas, 2021). However, it is important to note that resilience does not necessarily improve at the same pace as sustainability (Mwangi et al., 2021). Further research is needed to fully explore the relationship between resilience and sustainability in different contexts, including supply chains and urban settings (Ji et al., 2023; Romero-Lankao et al., 2016). Overall, understanding and effectively integrating resilience and sustainability is essential for creating a more sustainable and resilient future (Balugani et al., 2020; Corrales-Estrada et al., 2021; Winnard et al., 2014).

2.2.2 Design Sustainability and the Circular Economy

The concepts and approaches of the circular economy have implications on creating more resilient, sustainable and regenerative systems. Sustainable design plays a crucial role in the circular economy by integrating principles of environmental, social, and economic sustainability into the design and development of products, services, and systems. It involves considering the entire life cycle of a product, from raw material extraction to end-of-life disposal, and optimising its environmental performance, resource efficiency, and social impact (Bhamra et al., 2011). Sustainable design aims to minimise negative environmental impacts, conserve resources, promote social equity, and enhance user experience and well-being (Bhamra et al., 2011). The circular economy and sustainable design are closely interconnected and mutually reinforcing. The circular economy provides a framework and guiding principles for sustainable design practices, while sustainable design contributes to the realisation of circular economy goals by promoting the development of products and systems that are designed for longevity, reuse, repair, and recycling (Dam et al., 2020). It involves strategies such as eco-design, design for disassembly, design for remanufacturing, and design for circularity (Dam et al., 2020). The integration of sustainable design principles in the circular economy can lead to various benefits. It can help reduce resource consumption, minimise waste generation, and decrease environmental pollution and emissions (Muiruri et al., 2022). By designing products and systems with a focus on durability, modularity, and recyclability, sustainable design enables the efficient use of resources and the preservation of their value throughout multiple life cycles (Muiruri et al., 2022). It

also promotes the adoption of innovative materials, technologies, and business models that support circularity (Dam et al., 2020). One of the most significant developments in the field of sustainable design and the circular economy has been the emergence of a new sustainability paradigm. Geissdoerfer et al. (2017) argue that the circular economy represents a new sustainability paradigm that can transform the way we design, produce, and consume goods and services. This paradigm emphasises a systemic approach that considers the interconnections between social, economic, and environmental factors to achieve sustainable design and circular economy practices. Key principles of the circular economy include designing for circularity, extending product lifetimes, using renewable energy, and creating closed-loop material cycles.

However, the implementation of sustainable design in the circular economy faces challenges and barriers. These include the need for collaboration and coordination among stakeholders, systematic approaches, the availability of sustainable materials and technologies, the consideration of social and cultural factors, and the integration of sustainable design principles into existing business models and practices (Bansal et al., 2020). One of the challenges facing the implementation of sustainable design and the circular economy is the need for new materials, processes, and infrastructure to support closed-loop systems. Kirchherr et al. (2017) conducted a systematic review of circular economy literature and identified four different approaches to implementing circular practices: resource efficiency, product life extension, sharing economy, and product-as-a-service. They suggest that the implementation of circular practices requires a shift in mindset from a linear to a circular economy, and that this shift requires changes in behaviour and social norms. Additionally, new business models and financing mechanisms are needed to support circular practices. Additionally, there is a need for education and awareness-raising to foster a shift in mindset and promote the adoption of sustainable design practices among designers, businesses, and consumers (Minguez et al., 2021). Particularly, the challenge is the need for consumer education and behaviour change to promote circular consumption patterns. Liedtka (2014) suggests that a design thinking framework can be used to reduce cognitive biases and promote innovation. A similar approach can be used to promote circular consumption patterns by identifying and addressing the cognitive biases that prevent consumers from adopting circular practices. Several studies have highlighted the economic and environmental benefits of sustainable design and the circular economy. Bocken and Short (2016) argue that a sufficiency-driven business model, which focuses on meeting basic needs rather than maximising consumption, can support sustainable design and circular economy practices. They suggest that this approach can reduce the environmental impacts of consumption while promoting social equity and well-being. Additionally, circular practices can create new business opportunities and revenue streams through the development of new products and services.

Both the circular economy and sustainable design are interconnected concepts that aim to transform the current linear model of production and consumption into a regenerative and sustainable system. The circular economy provides a framework for resource efficiency and waste reduction, while sustainable design integrates principles of environmental, social, and economic sustainability into the design and development of products and systems (Bocken et al., 2016; Geissdoerfer et al., 2017). The integration of sustainable design in the circular economy can lead to multiple benefits, but it also requires overcoming challenges, changes in behaviour and social norms, and fostering collaboration among stakeholders. By embracing sustainable design principles, the circular economy can contribute to the achievement of global sustainability goals and the transition to a more sustainable and regenerative future. There are significant economic and environmental benefits to be gained from the

integration of sustainable design and the circular economy. The exploration of the relationship between sustainable design and the circular economy, examining the ways in which sustainable design principles and practices contribute to the development of a more circular and sustainable future is therefore vital.

However, while the literature and the state of the art show that sustainable design and the circular economy are inherently interconnected, several challenges and areas for further research emerge. The successful implementation of sustainable design and the circular economy requires collaboration between designers, engineers, businesses, and policymakers (Korhonen et al., 2018). However, the literature suggests that interdisciplinary collaboration is still lacking, highlighting the need for increased cooperation and knowledge-sharing among stakeholders (Moreno et al., 2016). Consumer behaviour plays a significant role in the adoption of sustainable design and the circular economy, with a growing body of literature focusing on the importance of facilitating sustainable consumption patterns (Lieder & Rashid, 2016). However, further research is needed to better understand the factors that influence consumer behaviour and develop strategies for promoting the adoption of more sustainable lifestyles. Measuring the success of sustainable design and the circular economy is still challenging. There is ongoing debate about the most appropriate metrics and indicators for assessing the success of sustainable design and the circular economy (Pomponi & Moncaster, 2017). Developing standardised measurement frameworks and tools will be crucial for tracking progress and identifying areas for improvement. Challenges are also identified in the literature is the transition from linear to circular systems, which involves overcoming deeply ingrained production and consumption patterns (Tukker, 2015). The literature suggests that a combination of policy interventions, business model innovation, and shifts in consumer behaviour are necessary to drive this systemic change (Bocken et al., 2016). For instance, a study by Masi et al. (2018) found that extended producer responsibility (EPR) policies and eco-design requirements can play a crucial role in promoting the adoption of circular business models and sustainable design practices. The literature highlights the importance and role of design education in fostering a new generation of designers equipped to address the challenges of sustainable design and the circular economy (Niinimäki & Armstrong, 2013). A study by Ceschin and Gaziulusoy (2016) found that embedding sustainability and circular economy principles into design curricula can help students develop the necessary skills and mindsets to contribute to the transition towards a circular economy.

However, there is still a need for further research to identify best practices for integrating sustainable design and circular economy concepts into design education and practice. The literature recognizes the potential of digital technologies, such as the Internet of Things (IoT), artificial intelligence (AI), and blockchain, to facilitate the transition towards a circular economy and support sustainable design practices (Kjaer et al., 2019). For example, digital platforms can enable collaborative consumption and product-service systems, which can reduce resource consumption and extend product lifetimes (Tukker, 2015). However, the literature also notes that further research is required to better understand the potential risks and unintended consequences associated with the widespread adoption of digital technologies in the context of sustainable design and the circular economy (Kjaer et al., 2019). Addressing social dimensions is vital because while much of the literature on sustainable design and the circular economy focuses on environmental aspects, there is a growing recognition of the need to consider social dimensions, such as equity, inclusivity, and well-being (Bocken et al., 2017). For instance, a study by Rizos et al. (2016) argues that in order to achieve a truly sustainable circular

economy, it is essential to consider the potential social implications of design decisions and to ensure that the benefits of the circular economy are distributed fairly among different stakeholders.

2.2.3 The Inter-Relationship of Resilience and Design Sustainability and the CE

The relationship between resilience and sustainability in the context of the circular economy is a critical and interconnected one. Resilience focuses on the ability of systems, communities, and individuals to withstand and recover from shocks, disturbances, and stresses, while sustainability focuses on meeting present needs without compromising the prospects and capabilities of future generations. The circular economy, on the other hand, aims to decouple economic growth from resource consumption and environmental degradation by promoting the efficient use of resources, minimising waste generation, and maximising the value and lifespan of products and materials. Resilience and sustainability are mutually reinforcing concepts in the context of the circular economy. The circular economy promotes sustainability by reducing resource extraction, minimising waste generation, and promoting the reuse, repair, and recycling of materials. By adopting circular practices, systems become more resilient to resource scarcity, price volatility, and disruptions in supply chains Saidani et al. (2021). For example, by designing products for durability and repairability, businesses can reduce their dependence on scarce resources and enhance their resilience to supply chain disruptions (Ruiz-Benítez et al., 2019). Similarly, by implementing circular waste management systems, communities can reduce their vulnerability to waste disposal challenges and environmental pollution (Benites et al., 2022). Conversely, resilience is essential for the long-term sustainability of the circular economy. As the circular economy relies on complex systems and interconnected networks, building resilience is crucial to ensure the continuity and effectiveness of circular practices. Resilience helps systems adapt to changing circumstances, recover from disruptions, and maintain their circularity goals (Renn, 2020).

For instance, resilient supply chains can better respond to unexpected events, such as natural disasters or pandemics, by quickly adapting production processes, sourcing alternative materials, or finding new markets (Best & Williams, 2021). Resilience also supports the development of innovative solutions and the adoption of new technologies and business models that enhance circularity (Aprinawati & Prayogo, 2022). The relationship between resilience and sustainability in the context of the circular economy is not without challenges. Balancing short-term resilience measures with long-term sustainability goals can be complex, as some resilience strategies may have unintended negative environmental or social impacts (Renn, 2020). Additionally, the circular economy transition requires systemic changes and collaboration among various stakeholders, which can pose challenges in terms of coordination, governance, and resource allocation (Benites et al., 2022). However, by integrating resilience and sustainability principles, stakeholders can foster a more robust and sustainable circular economy that can withstand shocks, adapt to changing circumstances, and contribute to long-term well-being and environmental stewardship. Resilience and sustainability are closely intertwined in the context of the circular economy. The integration of resilience and sustainability principles in the circular economy can lead to more robust and sustainable systems that promote resource efficiency, environmental stewardship, and long-term benefit. However, addressing the challenges and trade-offs between short-term resilience and long-term sustainability requires careful consideration and collaboration among stakeholders.

2.3 Systems and Design Thinking

Systems thinking and design thinking are two distinct but complementary approaches that are widely used in various fields, including engineering, business, healthcare, and education. While they have different origins and methodologies, both approaches share a common goal of addressing complex problems and improving outcomes through a holistic and interdisciplinary perspective. Systems thinking is a conceptual framework that focuses on understanding the interrelationships and interdependencies within complex systems. It emphasises the interconnectedness of various components and the dynamic nature of systems, considering the interactions between elements and the system as a whole (Meadows, 2008; Jones, 2014). Systems thinking involves recognizing the complex web of relationships between various components within a system, rather than focusing on individual elements in isolation (Senge, 1990). It provides a holistic perspective on problem-solving by examining the relationships between various elements and considering the potential unintended consequences of interventions (Meadows, 2008). Systems thinking aims to identify patterns, feedback loops, and leverage points within a system to better understand its behaviour and identify opportunities for improvement (Mobach, 2007). It involves analysing the structure, behaviour, and functions of systems, as well as the relationships between different system elements (Ferratt, 2014). By adopting a systems thinking approach, researchers and practitioners can gain insights into the underlying causes of problems and develop more effective strategies for intervention and improvement (O'Garra et al., 2021). Design thinking, on the other hand, is a human-centred approach to problem-solving and innovation. It involves a creative and iterative process that focuses on understanding user needs, generating ideas, prototyping, and testing solutions (Brown, 2008; Altman et al., 2018). It is particularly useful for addressing ill-defined or "wicked" problems, which are complex and have no clear or straightforward solutions (Buchanan, 1992). Design thinking emphasises empathy, collaboration, and experimentation, aiming to develop innovative and user-centric solutions to complex problems ((IDEO, 2015; Brown, 2008; Farao et al., 2020). It involves a mindset that embraces ambiguity, encourages divergent thinking, and values iteration and feedback (Kusuma et al., 2023). Design thinking often employs techniques such as user research, brainstorming, rapid prototyping, and user testing to gain insights, generate ideas, and refine solutions (Espinosa-Gonzalez & Normand, 2019). By adopting a design thinking approach, practitioners can better understand the needs and perspectives of users, identify opportunities for improvement, and develop solutions that are desirable, feasible, and viable (Espinosa-Gonzalez & Normand, 2019). It starts with understanding the problem from a systems perspective, considering the various stakeholders, interactions, and constraints within the system (Magistretti et al., 2023). This understanding informs the design process, where practitioners employ creative techniques to generate ideas and develop prototypes that address the identified user needs and system dynamics (Yang et al., 2022). The iterative nature of design thinking allows for continuous refinement and improvement of solutions based on user feedback and testing. The integration of systems thinking and design thinking can enhance problem-solving and decision-making processes by combining the analytical and holistic perspectives of systems thinking with the creative and user-centric approach of design thinking. This integration allows for a more comprehensive understanding of complex problems and the development of innovative and sustainable solutions (Roche et al., 2021). By considering the broader system

context and the needs and experiences of users, practitioners can design interventions and solutions that address the root causes of problems and have a positive impact on multiple stakeholders (Hayward et al., 2020). The combination of systems thinking and design thinking can also foster collaboration and interdisciplinary approaches, enabling diverse perspectives and expertise to contribute to problem-solving and innovation (Sanford & Naidu, 2016). Systems design thinking recognizes that problems are often interconnected and embedded within larger systems. It emphasises understanding the relationships, interdependencies, and dynamics between different elements of a system to identify leverage points and opportunities for intervention Ferratt (2014). By adopting a systems thinking perspective, practitioners can gain insights into the underlying causes of problems and develop strategies that consider the broader system context. Systems design thinking has been applied in various domains, including healthcare, education, engineering, and sustainability. In healthcare, it has been used to improve patient experiences, enhance healthcare delivery, and drive innovation in medical technologies and services (Altman et al., 2018). In education, it has been employed to develop student-centred learning approaches and foster creativity and critical thinking skills (Thomas et al., 2021). In engineering, it has been utilised to design complex systems and optimise their performance (Kwan et al., 2022). In sustainability, it has been applied to develop solutions that address environmental challenges and promote sustainable practices (Mendoza et al., 2017).

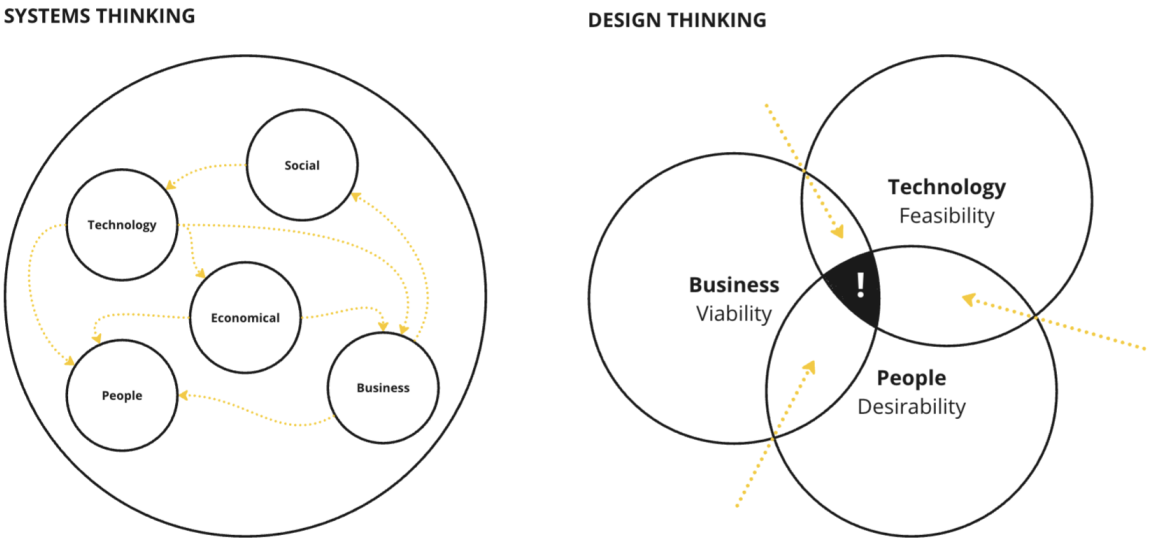

Figure 2.2: The Systems Thinking vs. Design Thinking Frameworks

However, it is important to note that both systems thinking and design thinking have their limitations and challenges. Systems thinking requires a deep understanding of complex systems and their dynamics, which can be challenging to achieve in practice (Thompson, 2009). Design thinking relies on the availability of user insights and may face constraints related to time, resources, and organisational culture (Yang et al., 2022). Additionally, the successful application of both approaches requires a supportive organisational culture, collaboration among stakeholders, and the integration of these approaches into existing processes and practices (López & García-Peñalvo, 2016). Systems thinking and design thinking are valuable approaches that can enhance problem-solving, innovation, and decision-making processes. While systems thinking focuses on understanding complex systems and their interrelationships, design thinking emphasises user-centricity and creative problem-solving.

The integration of these approaches can lead to more comprehensive and effective solutions to complex problems, fostering innovation and sustainable outcomes. However, the successful application of these approaches requires a supportive organisational culture, collaboration, and the integration of these approaches into existing practices. It requires interdisciplinary collaboration, as it involves integrating diverse perspectives and expertise from different fields (Thomas et al., 2007). It requires a supportive organisational culture that values creativity, experimentation, and user-centeredness (Magistretti et al., 2023). Additionally, it requires the development of skills and mindsets that embrace both analytical and creative thinking (Dell'Era et al., 2021). In conclusion, systems design thinking is an approach that combines the principles of systems thinking and design thinking to address complex problems and create innovative solutions. It integrates the analytical and holistic perspectives of systems thinking with the creative and user-centric approach of design thinking. By adopting a systems design thinking approach, practitioners can gain a comprehensive understanding of problems, develop user-centred solutions, and drive innovation in various domains. However, its successful application requires interdisciplinary collaboration, a supportive organisational culture, and the development of skills and mindsets that embrace both analytical and creative thinking.

2.4 Systems Design Thinking in Sustainability and the CE

The transition towards sustainable design and a circular economy requires innovative approaches to problem-solving that can address the complexity of sustainability challenges. Systems thinking for sustainability and the circular economy provides a holistic perspective on sustainability and the circular economy, emphasising the interconnectedness and dynamics within complex socio-ecological systems (Korhonen et al., 2018). By understanding the relationships between different elements in these systems, systems thinking can help identify leverage points for intervention, enabling more effective strategies for promoting sustainable design and the circular economy (Bocken et al., 2016). For instance, a study by Masi et al. (2018) highlights the importance of systems thinking in understanding the systemic barriers to the adoption of circular business models and informing the development of targeted policy interventions. Design thinking for sustainability and the circular economy with its human-centred and iterative approach to problem-solving, has been increasingly applied to address sustainability challenges and promote the circular economy (Bhamra et al., 2011; Niinimäki & Armstrong, 2013). For example, design thinking methodologies can facilitate the development of innovative product-service systems that promote resource efficiency and reduce waste generation (Tukker, 2015). Additionally, design thinking's emphasis on empathy and collaboration can support the engagement of various stakeholders in the development of sustainable solutions, fostering a shared understanding of the challenges and opportunities associated with the circular economy (Ceschin & Gaziulusoy, 2016).

Systems design thinking in the context of sustainability and the circular economy refers to an approach that combines the principles of systems thinking and design thinking to address complex resilience, sustainability challenges and create innovative solutions that promote circularity and resource efficiency (Peterson, 2004; Charter et al., 2022; Bhamra et al., 2008; Adam, 2014; Jaradat, 2015; Hu et al., 2018). It recognizes the interconnectedness and interdependencies of various elements within a system and emphasises a holistic understanding of the system's dynamics and behaviour. At the same time, it adopts a user-centric and creative problem-solving approach to develop solutions that

meet user needs while considering the broader system context. The literature suggests that design thinking can facilitate the development of innovative solutions and foster collaboration among stakeholders in the context of sustainable design and the circular economy (Bhamra et al., 2011). For example, a study by Ceschin and Gaziulusoy (2016) found that design thinking methodologies, such as empathy mapping and prototyping, can enable designers to better understand the needs and preferences of users, leading to more sustainable and circular design solutions. The integration of systems thinking and design thinking in the context of sustainability and the circular economy is crucial for several reasons. Firstly, systems thinking helps identify the underlying causes and interrelationships of sustainability challenges, enabling a comprehensive understanding of the system's dynamics and potential leverage points for intervention Saidani et al. (2017). It allows practitioners to consider the broader impacts and unintended consequences of their design decisions, promoting a more holistic and long-term perspective (Bassi et al., 2021). Secondly, design thinking brings a human-centred approach to problem-solving, focusing on understanding user needs, generating ideas, and prototyping solutions (Sumter et al., 2020). By empathising with users and involving them in the design process, practitioners can develop solutions that are desirable, feasible, and viable, enhancing user acceptance and adoption (Sumter et al., 2020). The application of systems design thinking in the context of sustainability and the circular economy can lead to several benefits. It enables the development of innovative and sustainable solutions that address the root causes of sustainability challenges and promote circular practices (Kurek et al., 2023). By considering the entire life cycle of products, services and systems, researchers and practitioners can identify opportunities for waste reduction, resource optimization, and the integration of circular business models (Corvellec et al., 2020). A systems design thinking approach also fosters collaboration and interdisciplinary approaches, bringing together diverse perspectives and expertise to tackle complex sustainability issues (Bakırlıoğlu et al., 2021). Moreover, it encourages a shift in mindset and organisational culture towards sustainability and circularity, promoting a more systemic and integrated approach to decision-making and problem-solving (Esposito et al., 2018). However, the application of systems design thinking in the context of sustainability and the circular economy is not without challenges. It requires interdisciplinary collaboration and the integration of diverse knowledge and expertise (Choudhury, 2010). It also demands a deep understanding of the complex interactions and feedback loops within systems, which can be challenging to achieve in practice (Bassi et al., 2021). Additionally, the successful implementation of systems design thinking requires supportive organisational structures, resources, and a culture that values creativity, experimentation, and user-centricity (Balanay & Halog, 2016). Systems design thinking in the context of sustainability and the circular economy integrates a holistic understanding of systems dynamics with a user-centred and creative problem-solving approach. By adopting systems design thinking, practitioners can develop solutions that promote circularity, resilience, sustainability, resource efficiency, and user satisfaction. Successful application requires interdisciplinary collaboration, a supportive organisational culture, and a deep understanding of systems dynamics and sustainability principles. The literature indicates that integrating systems thinking and design thinking can lead to more comprehensive and effective solutions to sustainability challenges in the context of sustainable design and the circular economy (Jones, 2014). Systems thinking can provide a broader understanding of the complex dynamics within socio-ecological systems, while design thinking can facilitate the development of innovative and user-centred solutions (Geissdoerfer et al., 2017). A study by Ryan et al. (2016) demonstrated the potential of combining systems thinking and design thinking in the development of a circular product-service system, which led to significant reductions in resource consumption and waste generation.

2.5 The Inter-Relationship of Concepts in the context of the Circular Economy

To understand the interrelationship between resilience, sustainability, and systems design thinking in the context of the circular economy, it is important to consider the insights from various studies. The inter-relationship between resilience, sustainability, and systems design thinking in the context of the circular economy is a complex and interconnected one. Resilience, sustainability, and systems design thinking are all essential components for addressing the challenges and opportunities associated with the circular economy and achieving long-term sustainable development. In the context of the circular economy, resilience is crucial for adapting to changing circumstances, recovering from disruptions, and maintaining circularity goals Renn (2020). It involves building adaptive capacity, fostering collaboration, and promoting inclusive decision-making processes. Resilience thinking recognizes the interconnectedness and interdependencies of social-ecological systems and emphasises the need to enhance adaptive capacity to navigate and respond to change. Resilience enhances the capacity of systems to withstand and recover from shocks and disturbances, which is crucial for maintaining circular practices and achieving sustainability goals. On the other hand, in the context of the circular economy, sustainability involves promoting resource efficiency, minimising waste generation, and fostering long-term viability (Ibn-Mohammed et al., 2021). It encompasses economic, environmental, and social dimensions, aiming to balance economic growth, environmental stewardship, and social well-being (Garrigos-Simon et al., 2018). Sustainability principles guide the transition to a circular economy by promoting the efficient use of resources, minimising waste, and fostering regenerative practices (Ibn-Mohammed et al., 2021). At the same time, sustainability principles guide the development of resilient and regenerative systems that promote resource efficiency and minimise negative environmental and social impacts (Ibn-Mohammed et al., 2021). Systems design thinking integrates the principles of systems thinking and design thinking to address complex problems and develop innovative solutions. It emphasises understanding the interrelationships and interdependencies within systems and adopting a user-centric and creative problem-solving approach. In the circular economy context, systems design thinking helps identify leverage points, opportunities for intervention, and unintended consequences of design decisions . It promotes the development of solutions that consider the broader system context, user needs, and sustainability goals. The relationship between resilience, sustainability, and systems design thinking in the context of the circular economy is mutually reinforcing. Systems design thinking integrates resilience and sustainability principles into the design and development of solutions which fosters innovation and promotes circularity. However, challenges exist in integrating resilience, sustainability, and systems design thinking in the context of the circular economy. Balancing short-term resilience measures with long-term sustainability goals can be complex, as some resilience strategies may have unintended negative environmental or social impacts. Additionally, the successful implementation of systems design thinking requires interdisciplinary collaboration, a supportive organisational culture, and the integration of adaptive management and learning approaches.

The circular economy transition requires systematic systems design thinking to address its complex challenges and ensure sustainable outcomes. Competence in the circular economy encompasses principles such as systems thinking, design thinking, and multi-perspective thinking, which are combined with innovative competencies. However, the implementation of circular economy practices is currently lagging behind in response to pressing issues like climate change due to inadequate

sustainability considerations (Waring & Liyanage, 2022). To overcome existing barriers and facilitate the circular economy transition, systemic design approaches have emerged as a discipline that addresses complex problems and policy-making (Nohra et al., 2020). These approaches aim to tackle barriers at different levels, from the micro-level of small and medium-sized enterprises (SMEs) to the macro-level of global, regional and European transitions towards circularity (Thorley et al., 2018; Ferrulli et al., 2019). However, there is a need for a paradigm shift in circular thinking at the micro level, suggesting the requirement for new skills, resources, approaches, and business models for SMEs to adopt circular practices (Thorley et al., 2018). While literature highlights the significance of systems thinking as a relevant competency for design in the circular economy, its practical application appears limited (Sumter et al., 2020). Additionally, circular economy principles are applied at various levels within products, organisations, and systems, emphasising the importance of a systems thinking framework (Collier et al., 2021). As education plays a crucial role in fostering circular economy practices, approaches such as life cycle thinking, systems thinking, and multidisciplinary approaches are integrated into existing course structures (O'Born & Heimdal, 2022). Furthermore, sustainable design thinking and social innovation are essential frameworks for promoting circular economy principles (Deniz, 2021). Systematic systems design thinking is critical for the successful implementation of the circular economy transition. It requires integrating various competencies, addressing barriers, and adopting a systems design thinking approach to effectively tackle the challenges associated with the transition.

3

RESEARCH DESIGN AND METHODOLOGY

3.1 Research Design

This research employs a qualitative, multi-case study design to explore the global adoption and application of systems design thinking in the circular economy transition for resilience and sustainability. The multi-case study design allows for an in-depth exploration of the phenomenon within its real-life context, using multiple sources of evidence. This design is particularly suitable for this research as it allows for the comparison and contrast of different cases, leading to a more robust understanding of the research problem.

3.2 Case Study Selection

This research utilised a multiple case study approach, exploring various governments, organisations and industries in different parts of the world to understand their adoption of design thinking and systems thinking practices towards sustainable and resilient circular economy transition. The case study approach was most appropriate for exploratory research as it provided in-depth, context-specific insights into the phenomenon of interest. The case studies were selected using a purposive sampling strategy. The criteria for selection included the geographical location, the scale of the circular economy initiative, and the extent of systems design thinking application or maturity. Four case studies were selected; (1) The European Union's Circular Economy Action Plan (2015 and 2020), (2) China's Circular Economy Strategy (2021 14th 5-Year Strategy), (3) India’s Andhra Pradesh Community-Managed Natural Farming (APCMNF) Initiative and (4) Rwanda’s National Circular Economy Action Plan and Roadmap. These cases represent a diverse range of contexts and applications of systems design thinking in the global circular economy transition efforts.

Case Study	Initiative	Years Actived	
		Previous	Current
European Union	Circular Economy Action Plan	2015	2020
China	Circular Economy Strategy	2016	2021
Rwanda	Rwanda National Circular Economy Action Plan and Roadmap	-	2022
India	Andhra Pradesh Community-Managed Natural Farming	2014	2020

Table 3.1: Identified Case Study Countries and their Circular Economy Strategies

3.3 Data Collection and Analysis

3.3.1 Data Collection

The data for each case study was collected from multiple sources to ensure a comprehensive understanding of the case. Sources of data included official documents and reports, academic articles, news articles, and, where possible, interviews with key stakeholders involved in the initiatives. The use of multiple sources of data enhanced the validity of the case studies findings. Data was collected using the following methods:

a) Semi-structured interviews: Key stakeholders from selected governments, organisations and industries, including executives, managers, and design practitioners, were interviewed to gain insights into their experiences, perspectives, and practices.

b) Document analysis: Government and organisational reports, strategic plans, publications and other relevant documents were analysed to understand the governments, organisations and industries' commitment to resilience and sustainability and their adoption of design thinking and systems thinking practices for the circular economy.

c) Observations: Where possible, site visits and direct observations of the governments, organisations and industries' practices were conducted.

3.3.2 Data Analysis

Thematic analysis was used to analyse the data collected from interviews, documents, and observations. This involved coding the data to identify patterns and themes, which were then grouped and interpreted in relation to the research questions. Initially, a within-case analysis was conducted for each case study to identify key themes related to the application of systems design thinking in the circular economy transition. Following this, a cross-case analysis was conducted to identify common themes and differences across the case studies. The analysis was guided by the research questions and the theoretical framework of systems design thinking, resilience and sustainability.

3.4 Research Ethics and Limitations

3.4.1 Research Ethics

a) Informed consent: All participants were informed of the research objectives, procedures, and their right to withdraw from the study at any time. Written consent was obtained before the interviews and documents were accessed.

b) Anonymity and confidentiality: All was anonymized, and participants' identities were kept confidential. Identifying information will be removed from the transcripts and any published findings.

c) Data storage and security: Data was securely stored in encrypted files, with access limited to the researchers involved, and in some cases, the contributing study participants.

3.4.2 Limitations

This research has several limitations. First, the case studies approach, while providing in-depth insights, may limit the generalizability of the findings. As this is an exploratory case studies, the findings may not be generalizable to all governments, organisations and industries. Second, the reliance on secondary data may limit the depth of understanding of the cases, particularly in terms of the motivations and experiences of the stakeholders involved. Finally, the selection of cases may introduce bias. Researcher bias may influence the data collection and analysis process as the cases were selected based on the availability of information, consent for participation, where interviews were involved and the researcher's judgement of their relevance to the research questions. Time and resource constraints: The study was limited by time and resource constraints, which impacted the depth and breadth of data collection and analysis. These limitations are acknowledged and considered in the interpretation of the findings.

4

CASE STUDIES: THE GLOBAL COMMITMENTS

This case studies research aimed to examine government and national level policies toward systematic systems design thinking for sustainability and circular economy transitions. The transition to a sustainable and circular economy is a pressing global challenge that requires innovative approaches and policy interventions. Resilience, sustainability, and systems design thinking are key concepts that play a crucial role in this transition. This research sought to explore the interrelationship between these concepts and the role they play in shaping government policies and strategies.

The urgency to address sustainability challenges and transition to a circular economy has led governments worldwide to adopt policies and initiatives aimed at promoting sustainable practices and resource efficiency. However, the effectiveness of these policies in achieving sustainability and circularity goals can be enhanced by integrating systems design thinking principles. Systems design thinking offers a holistic and user-centric approach to problem-solving, which can help identify leverage points, unintended consequences, and opportunities for intervention in the transition to a circular economy. This case studies research examined government policies and strategies globally, from various countries and regions to understand how they incorporate systems design thinking principles for sustainability and circular economy transitions. It analyses the rationale behind these policies, the challenges faced in their implementation, the outcomes achieved and in some instances, how these outcomes are measured. The research also explores the role of resilience in supporting the transition to a circular economy and how it is integrated into government policies. By examining real-world examples and experiences, this research aimed to provide insights into the relationship between resilience, sustainability, and systems design thinking in the context of the circular economy. It contributes to the existing body of knowledge by highlighting best practices, identifying gaps and challenges, and providing recommendations for policymakers and practitioners. Overall, this case studies research sheds light on the interplay between the concepts in government policies for sustainability and circular economy transitions. It provides valuable insights for policymakers, researchers, and practitioners working towards a more sustainable and circular future.

4.1 European Union: The Circular Economy Action Plan

The EU Circular Economy Action Plan, implemented in 2015 and updated in 2020, has played a crucial role in driving the transition towards a circular economy in Europe. This plan has spurred the development of national circular economy strategies, public investment in research and innovation,

and partnerships across sectors and value chains throughout the European Union. These initiatives have aimed to overcome barriers and encourage governments, companies, consumers, and public authorities to adopt circular practices in their production and consumption patterns. The European Development Plan for a Circular Economy provides practical guidelines for the transition to more systematic, resilient and sustainable patterns of production and consumption (Ratner et al., 2020). The European Union (EU) adopted a comprehensive circular economy policy package in December 2015, known as the European Circular Economy Action Plan (CEAP). The CEAP aimed to boost jobs, growth, and investment, while promoting the transition to a carbon-neutral, resource-efficient, and competitive economy. The CEAP provided one of the first blueprints for implementing circular economy policies across Europe and abroad. The EU Circular Economy Action Plan has been a focal point for addressing the transition to a circular economy within the European Union. The transition to a circular economy is a global imperative to address the challenges of resource depletion, waste generation, and environmental degradation. The plan, first introduced in 2015, aims to promote sustainable and resource-efficient practices throughout the product lifecycle (undefined et al., 2023). It prioritises five key areas, including plastic waste, and sets objectives for waste reduction, increased recycling, and sustainable product design (Małek et al., 2020). The European Union (EU) has been at the forefront of promoting the circular economy through its Circular Economy Action Plan. This case study examined the EU Circular Economy Action Plan in the context of systems design thinking, resilience, and sustainability. It explored how these concepts are integrated into the plan's policies and strategies to foster a resilient and sustainable circular economy. The EU Circular Economy Action Plan embodies the principles of systems design thinking by adopting a holistic and user-centric approach to problem-solving. It recognizes the interconnectedness of economic, environmental, and social factors and aims to transform the linear "take-make-dispose" model into a regenerative and resource-efficient system. The plan emphasises the need for collaboration, innovation, and systemic change to achieve a circular economy. Resilience is a key aspect of the EU Circular Economy Action Plan. The plan acknowledges the importance of building resilience to withstand and recover from shocks and disruptions. It promotes adaptive capacity, collaboration, and inclusive decision-making processes to enhance the resilience of systems, communities, and individuals. By integrating resilience principles, the plan aims to ensure the continuity and effectiveness of circular practices in the face of challenges. Sustainability is a fundamental pillar of the EU Circular Economy Action Plan. The plan aligns with the principles of sustainability by promoting resource efficiency, waste reduction, and the preservation of natural resources. It emphasises meeting current present needs without those of future generations. By integrating sustainability principles, the plan aims to foster long-term viability, environmental stewardship, and social well-being. The EU Circular Economy Action Plan demonstrates the integration of systems design thinking, resilience, and sustainability through its comprehensive approach. It sets clear objectives, targets, and indicators to measure progress and effectiveness. The plan also emphasises the importance of collaboration among stakeholders, the development of innovative technologies and business models, and the adoption of circular practices throughout the value chain.

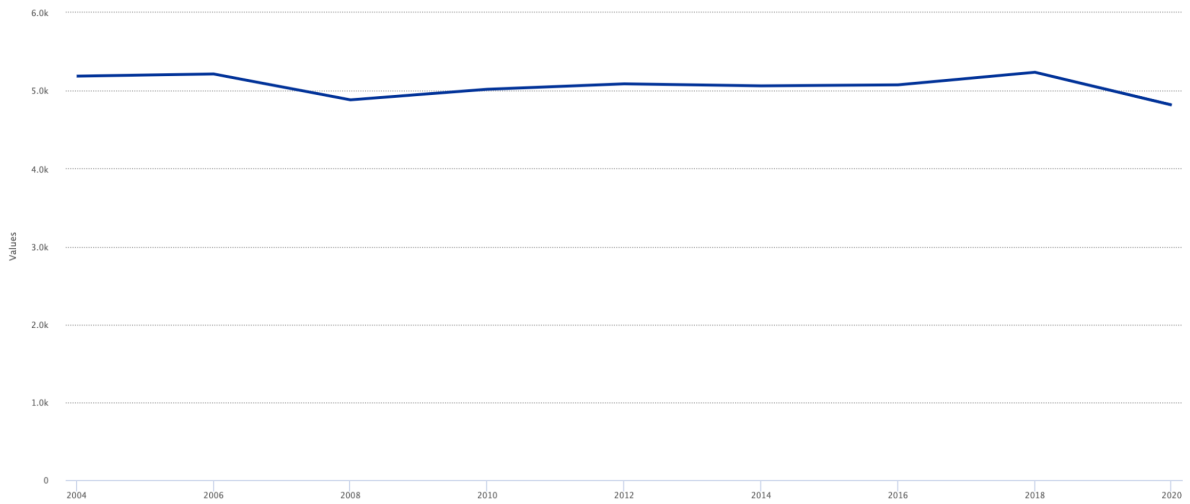

Figure 4.1: Waste generation per capita in the EU 2004 to 2020 (Source of data: Eurostat, 2023) Time frequency: Annual. Unit of measure: Kilograms per capita. Hazard class: Hazardous and non-hazardous - Total Statistical classification of economic activities in the European Community (NACE Rev. 2): All NACE activities plus households Waste categories: Total waste

The CEAP is an example of a systems design thinking approach to circular economy transition. Systems design thinking is an approach that considers the entire system, including its components, interactions, and feedback loops, to identify opportunities for improvement. In the context of circular economy transition, systems design thinking involves considering the entire lifecycle of products, from design to disposal, to identify opportunities for reducing waste and increasing resource efficiency. The CEAP proposes an integrated product policy framework that implements measures along the lifecycle of products to tackle resource-intensive sectors. This approach involves considering the entire lifecycle of products, from design to disposal, to identify opportunities for reducing waste and increasing resource efficiency. The CEAP also aims to foster an internal market for secondary raw materials, which involves designing products with the intention of reusing and recycling materials. Circular economy transition requires resilience and sustainability. The CEAP aims to promote resilience and sustainability by reducing Europe's dependence on raw materials imports and strengthening resource security. The CEAP also aims to reduce waste and increase resource efficiency, which can help to reduce the environmental impact of production and consumption.

This assessment highlights the need to critically examine the extent to which the action plans drive systemic change versus maintaining existing economic structures. As part of the EU's agenda for sustainable growth, the Circular Economy Action Plan has been recognized as an important means to achieve environmental objectives (Marcos et al., 2022). The plan is closely linked to other policy initiatives, such as the Biodiversity Strategy for 2030, highlighting the interconnectedness between circular economy principles and biodiversity (Oberč et al., 2022). Efforts to measure progress and effectiveness in implementing the circular economy are reflected in the monitoring framework introduced by the European Commission (Pla-Santamaria et al., 2020). Monitoring frameworks, known as Circular Economy Monitors (CEM), have been adopted by cities and regions within EU member countries (Sileryte et al., 2022). These monitors provide a means to assess the effectiveness of circular economy initiatives and track waste and resource management progress. While the EU Circular Economy Action Plan has set the stage for promoting a circular economy, there remain challenges related to knowledge gaps and the need for a stronger knowledge base in the field

(undefined et al., 2023). Additionally, research has highlighted the potential of the circular economy in sectors such as agro-industry and fashion, shedding light on the existing measures and legislative frameworks that influence sustainable practices in these industries (Marcos et al., 2022; Jacometti, 2019). The EU Circular Economy Action Plan plays a significant role in driving the transition towards a circular economy in the European Union. It sets priorities for waste reduction, recycling, and sustainable product design while addressing the interconnectedness of various sectors and environmental objectives. Monitoring frameworks and assessments offer insights into the plan's implementation and wider implications for transformative change. However, further research and knowledge development are needed to fully understand the impacts and potential obstacles of the circular economy transition in different sectors and regions.

However, challenges exist in implementing the EU Circular Economy Action Plan. These include the need for supportive policy frameworks, changes in consumer behaviour, and overcoming technological and infrastructural limitations. The plan requires a shift in mindset and a transition from a linear to a circular mindset among businesses, governments, and society as a whole. Additionally, monitoring and evaluation mechanisms are crucial to assess the effectiveness and impact of the plan's policies and strategies. The EU Circular Economy Action Plan exemplifies the integration of systems design thinking, resilience, and sustainability in the transition to a circular economy. It adopts a holistic and user-centric approach, promotes adaptive capacity and collaboration, and emphasises resource efficiency and long-term viability. While challenges exist, the plan sets a clear path for fostering a resilient and sustainable circular economy. By embracing systems design thinking, resilience, and sustainability principles, the EU aims to create a more sustainable and regenerative future.

One of the key aspects emphasised in the European plan is the importance of sustainable consumption as a priority area for circular economy (Ratner et al., 2020). The EU Circular Economy Action Plan exemplifies the application of systems design thinking in the context of circular economy transition. Systems design thinking is an approach that considers the interconnectedness and complexity of systems, recognizing that changes in one part of a system can have ripple effects throughout the entire system. In the case of the EU Circular Economy Action Plan, systems design thinking is applied to address the multifaceted challenges associated with transitioning to a circular economy. The adoption of systems design thinking allows for a holistic understanding of the various stakeholders, processes, and interactions within the circular economy system. This understanding enables the identification of leverage points and opportunities for intervention that can drive systemic change. Moreover, systems design thinking helps to identify potential barriers and unintended consequences that may arise during the implementation of circular economy strategies. By considering the systemic nature of a circular economy, the EU Circular Economy Action Plan aims to build resilience and sustainability into the transition process.

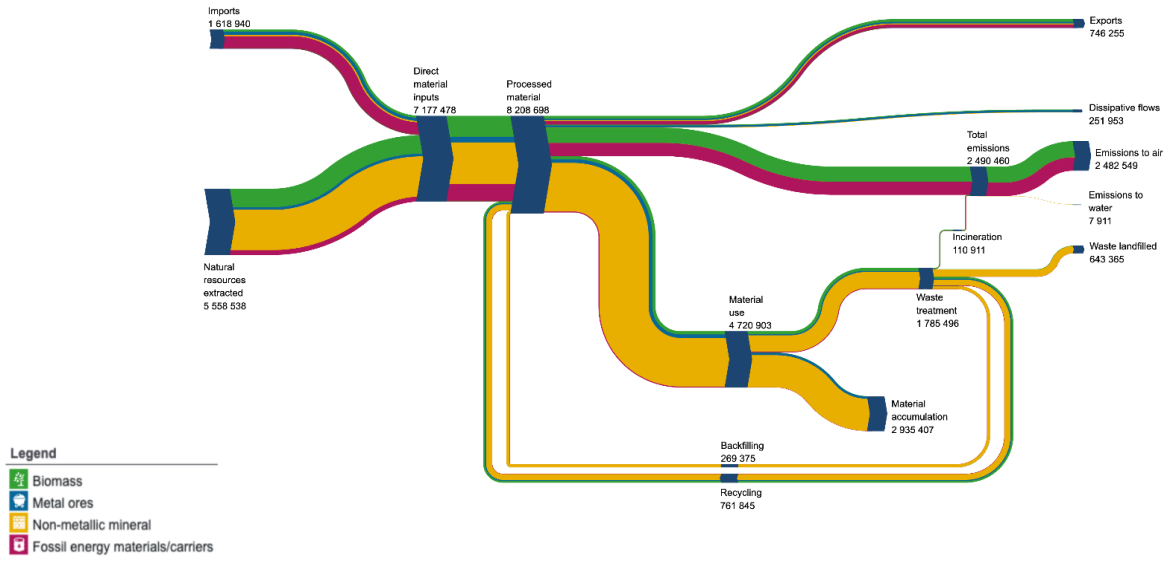

Figure 4.2: EU Material Flow diagram 2010 to 2021 (Source of data: Eurostat, 2023)
Time frequency: Annual. Unit of measure: per 1000 tonnes

One of the key challenges in implementing a circular economy is the immaturity of technology and infrastructure to support pro-ecological behaviour patterns among consumers. This can inhibit the widespread adoption of circular practices, as consumers may not have access to the necessary tools and infrastructure needed to participate in a circular economy. To address this challenge, the EU Circular Economy Action Plan recognizes the need for investment in research and innovation to develop new technologies and infrastructure that support circular practices among consumers. Furthermore, the EU Circular Economy Action Plan emphasises the importance of partnerships across industries, sectors and value chains. These partnerships facilitate knowledge sharing, collaboration, and the exchange of best practices, which are crucial for driving systemic change. The adoption of systems design thinking in the EU Circular Economy Action Plan also contributes to the overall resilience and sustainability of the circular economy transition. By taking a systemic approach, the plan acknowledges that the transition to a circular economy is deep and transformative, requiring cooperation and alignment among all stakeholders at multiple levels - EU, national, regional, local, and international (EC, 2020). This recognition is crucial for building resilience within the circular economy system. The implementation of the EU Circular Economy Action Plan is a significant step in accelerating the transition to a circular economy. Overall, the EU Circular Economy Action Plan aims to overcome barriers and spur companies, consumers, and public authorities towards adopting circular practices. To achieve resilience and sustainability in the circular economy transition, the EU Circular Economy Action Plan adopts a systems design thinking approach. This approach recognizes the interconnectedness of various stakeholders and the need for collaboration and cooperation to drive systemic change. This includes funding research and development projects that focus on sustainable materials, waste management technologies, and resource-efficient production processes. By designing systems that are resilient to shocks and disruptions, such as resource scarcity or market fluctuations, the circular economy can better withstand future challenges and ensure long-term economic growth. The financial sector plays a crucial role in the transition to a circular economy by providing funding and investment opportunities for circular businesses. However, traditional financial systems often prioritise linear economic models and may not fully understand or assess the risks and benefits of

circular economy projects. As a result, there is a need for innovative financial instruments and mechanisms that support circular economy projects and reduce investment barriers.

Overall, the EU Circular Economy Action Plan recognizes that transitioning to a circular economy requires a systemic approach involving various stakeholders. This includes businesses developing circular business models and enabling technologies, policymakers and legislators implementing effective regulations and incentives, the financial sector providing financing for circular projects, and public authorities and civil society increasing public awareness and educating consumers (The EIB Circular Economy Guide Supporting the circular transition, 2020). The successful implementation of the EU Circular Economy Action Plan hinges on collaboration and partnerships across sectors, value chains, and different levels of government. The EU CEAP acknowledges the importance of systems design thinking in facilitating the transition to a circular economy. By taking a holistic view of the entire system, including all interconnected elements and their dynamics, systems design thinking provides a framework for understanding how different components of a circular economy interact and influence each other. This holistic approach allows for the identification of potential barriers and challenges, as well as opportunities for innovation and collaboration. By applying systems design thinking, the EU Circular Economy Action Plan has been able to identify key barriers to circular economy transition and develop strategies to overcome them. For instance, one of the barriers that need to be overcome is the lack of stakeholder engagement. To address this, the EU member countries and their respective governments should create a favourable climate for stakeholder engagement. This can be achieved through the establishment of platforms and forums that bring together businesses, policymakers, civil society organisations, and other relevant stakeholders to exchange ideas and best practices. These platforms can provide technical assistance, mobilise financial resources, and facilitate positive impact investing in circular economy systems.

Future perspectives for enhancing resilience and sustainability in the transition to a circular economy involve continuous learning, adaptation, and innovation. This includes further research and development in areas such as sustainable materials and products, waste management technologies, systems and business models that promote circularity. Additionally, it is important to continue building partnerships and collaboration among stakeholders from various sectors, including industry, government, academia, and civil society. By considering resilience, circular economy systems can be designed to anticipate and adapt to potential shocks and stressors, such as climate change impacts or disruptions in supply chains. This can involve developing redundancies and diversifying resource inputs, as well as building adaptive capacity within the system. With regard to the European Union's Circular Economy Action Plan, it exemplifies the integration of systems design thinking, resilience, and sustainability in the context of the circular economy transition. The European Union's Circular Economy Action Plan is a comprehensive framework that encompasses the principles of systems design thinking, resilience, and sustainability. The Action Plan emphasises the importance of incorporating systems thinking into business practices to ensure that they are aligned with their environmental context. Moreover, the Action Plan promotes the use of innovative design thinking to develop products and systems that are built for circularity from the outset. Systems design thinking, resilience, and sustainability are crucial for the successful transition to a circular economy. In terms of systems design thinking, it is important to consider the interconnectedness and complexity of the various elements within the circular economy system. The future perspectives for integrating systems

design thinking into the circular economy transition are vast and hold great potential. One future perspective is the use of technology and data analytics to enhance systems design thinking within the circular economy. By harnessing the power of big data and advanced analytics, stakeholders can gain valuable insights into the various interconnected elements of the circular economy system. This can enable them to identify areas of improvement, optimise resource flows, and make informed decisions that promote sustainability and resilience. The involvement of multiple stakeholders in the design and implementation of circular economy systems is also beneficial. Engaging diverse stakeholders, including businesses, governments, NGOs, and communities, can foster collaborative efforts in developing comprehensive circular economy strategies that address the unique needs and perspectives of different sectors. This multi-stakeholder approach can ensure that decisions are made holistically, taking into account the social, economic, and environmental dimensions of sustainability.

In conclusion, the EU Circular Economy Action Plan recognizes that the transition to a circular economy requires a systemic approach involving various stakeholders. The EU member countries and their respective governments play a crucial role in creating a favourable climate for stakeholder engagement by providing technical assistance, mobilising financial resources and facilitating positive impact investing in circular economy systems. By incorporating systems design thinking, resilience, and sustainability principles, the EU Circular Economy Action Plan aims to create a circular economy that is efficient, environmentally friendly , and socially and economically sustainable. In this case study, the EU Circular Economy Action Plan emerges as a significant initiative that aims to address the challenges and opportunities associated with transitioning to a circular economy.

4.2 India: The Andhra Pradesh CMNF Initiative

The concept of a circular economy has gained significant attention globally, including India that was ignited by the need for circular economy transition. The demand for resources in India is increasing rapidly due to population growth and economic development. The linear economic model, characterised by a "take-make-dispose" philosophy, is unable to manage the demand and supply balance of natural resources (Goyal et al., 2016). According to the UN Sustainable Development Goals, the demand for resources will require natural resources equivalent to two and three planets by 2030 and 2050, respectively (Goyal et al., 2016). Therefore, there is an urgent need for India to transition to a circular economy to ensure the sustainable use of resources.

However, challenges in adopting a circular economy in India exist. The adoption of circular economy principles and practices in India faces several challenges. Developing nations like India face complex challenges compared to developed nations in adopting circular economy and sustainability aspects (Sharma et al., 2019). These challenges include ill-functioning institutions, sustainability challenges, and poorly designed systems (Härri et al., 2020).

India has been exploring various circular economy business models to promote sustainability and resource efficiency in its circular economy transition efforts. Circular economy business models in developing economies, such as India, focus on the reduce, recycle, and reuse paradigms (Goyal et al., 2016). These models aim to enhance economic, ecological, and social sustainability in supply chains

(Sharma et al., 2019). For example, the acceptance of remanufactured products in the circular economy has been extensively studied in India, with a conceptual model proposed to examine the critical factors influencing consumer acceptance (Singhal et al., 2019).

India' agricultural sector plays a fundamental and indispensable role in the economy of the nation, making a significant contribution to the livelihoods of its millions of people. However, conventional farming practices have led to environmental degradation, soil erosion, and water pollution. In response to these challenges, the state of Andhra Pradesh has implemented the Community-Managed Natural Farming (CMNF) Regenerative Agriculture Initiative. This case study explores the impact and significance of the CMNF initiative in promoting sustainable agriculture practices and enhancing the resilience of farming communities in Andhra Pradesh. The CMNF Regenerative Agriculture Initiative was introduced in Andhra Pradesh as part of the centrally sponsored scheme Paramparagat Krishi Vikas Yojna (PKVY) (Mishra, 2022). The initiative aims to promote Zero-Budget Natural Farming (ZBNF) practices, which involve minimising external inputs and relying on natural processes to enhance soil health and crop productivity (Bharucha et al., 2020). The initiative focuses on empowering farmers to adopt regenerative agriculture practices and reduce their dependence on chemical fertilisers and pesticides.

The primary objective of the CMNF initiative is to promote sustainable agriculture practices that improve soil health, conserve water, and enhance biodiversity (Mishra, 2022). The initiative emphasises the use of indigenous microorganisms, natural fertilisers, and pest management techniques to enhance soil fertility and crop resilience (Duddigan et al., 2022). The implementation of the CMNF initiative involves training and capacity building of farmers, establishment of farmer producer organisations, and the provision of technical support and financial incentives (Mishra, 2022). The APCNF program aims to improve soil health, conserve water, enhance biodiversity, and empower farmers to adopt regenerative agriculture practices. It is facilitated by a centralised organisation called Rythu Sadhikara Samstha (RySS), which provides training and advisory services to farmers through village-based Natural Farming Fellows (NFFs) (Walker et al., 2021).

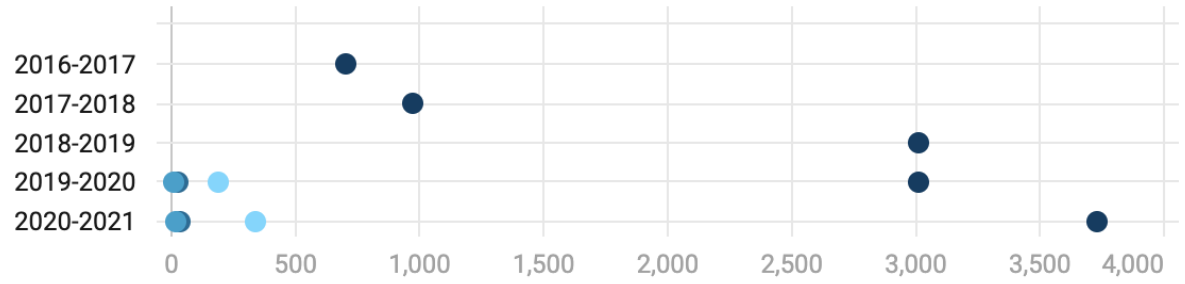

Figure 4.3: Dot plot of Andhra Pradesh CMNF Initiative depicting uptake between 2016 to 2021 mapping number of farmers and villages

The CMNF initiative has had a significant impact on farming communities in Andhra Pradesh. Studies have shown that the adoption of ZBNF practices has led to improved crop yields, reduced input costs, and increased farmer incomes (Duddigan et al., 2022). The initiative has also contributed to the restoration of soil health, increased water retention capacity, and enhanced biodiversity on farmlands (Bharucha et al., 2020). Furthermore, the CMNF initiative has empowered farmers by promoting

farmer collectives, enabling knowledge sharing, and fostering community-led decision-making processes (Mishra, 2022). The CMNF initiative aligns with the principles of resilience and sustainability in agriculture. By promoting regenerative agriculture practices, the initiative enhances the resilience of farming systems to climate change impacts, such as droughts and floods (Bharucha et al., 2020). The emphasis on organic inputs and natural pest management techniques reduces the environmental footprint of agriculture and promotes the conservation of natural resources (Giller et al., 2021). The CMNF initiative also contributes to the socio-economic sustainability of farming communities by improving farmer livelihoods and reducing their dependence on external inputs (Duddigan et al., 2022).

The Andhra Pradesh Community-Managed Natural Farming (APCNF) program aligns with the circular economy transition strategies of India in several ways. The program promotes sustainable agricultural practices that minimise the use of external inputs such as chemical fertilisers and pesticides (Khan et al., 2022). By reducing reliance on these inputs, the program aims to establish a self-contained mechanism that would enable the reutilization of available resources and the reduction of waste to an optimal level. which is a key principle of the circular economy (McCarthy et al., 2019). The program encourages farmers to adopt Zero-Budget Natural Farming (ZBNF) practices, which rely on natural processes and organic inputs to enhance soil health and crop productivity (Khan et al., 2022). This approach aligns with the circular economy's emphasis on resource efficiency and minimising waste. Secondly, the APCNF program focuses on empowering farmers and building community-led initiatives. It promotes the formation of farmer producer organisations and encourages knowledge sharing and collective decision-making processes. This participatory approach aligns with the circular economy's emphasis on collaboration and stakeholder engagement (Goyal et al., 2016). By involving farmers in the decision-making process and fostering community ownership, the program aims to create a more inclusive and sustainable agricultural system. Furthermore, the APCNF program contributes to the conservation of natural resources and the mitigation of environmental impacts. By promoting regenerative agriculture practices, the program aims to improve soil health, conserve water, and enhance biodiversity. These objectives align with the circular economy's goal of preserving and regenerating natural resources (Cheng & Xu, 2021). The program emphasises the use of indigenous microorganisms, natural fertilisers, and pest management techniques, which reduce the environmental footprint of agriculture and promote sustainable resource management (Khan et al., 2022). It also addresses the socio-economic sustainability of farming communities. By reducing input costs and improving crop yields, the program aims to enhance farmer incomes and livelihoods. This focus on economic viability aligns with the circular economy's aim of creating sustainable and resilient economic systems (Kouhizadeh et al., 2019). The program also promotes the formation of farmer collectives and supports the development of local value chains, which can contribute to the circular economy's goal of creating circular and localised economies (Goyal et al., 2016).

Systems design thinking plays a crucial role in facilitating the transition to a circular economy in India. Policymakers and researchers are seeking powerful and easy-to-use tools to represent the perceived causal structure of complex systems and develop effective strategies (Papageorgiou et al., 2019). Integrating industry 4.0 and circular economy principles can also enhance the adoption and implementation of circular economy practices in the manufacturing industry (Sahu et al., 2021). Designers play a key role in developing products, services and systems for a circular economy, and specific competencies are required to successfully design for circularity (Sumter et al., 2020; Sumter et al., 2021). Resilience and sustainability are essential considerations in India's circular economy

transition. Circular economy practices can contribute to the resilience of supply chains by minimising waste, reducing resource dependence, and promoting resource efficiency (Abbas et al., 2022). The circular economy can also address environmental, economic, and social sustainability challenges in India (Beckmann et al., 2020). For example, the agri-biomass-based bio-energy supply model in rural India demonstrates an inclusive sustainable and circular economy approach for self-resilient rural communities (Chaudhary et al., 2022).

The CMNF Regenerative Agriculture Initiative in Andhra Pradesh has emerged as a promising approach to promote sustainable agriculture practices and enhance the resilience of farming communities. The initiative's focus on Zero-Budget Natural Farming practices has led to improved soil health, increased crop yields, and enhanced farmer incomes. By reducing the reliance on chemical inputs and promoting natural processes, the initiative contributes to the conservation of natural resources and the mitigation of climate change impacts. However, addressing challenges related to behaviour change, input availability, and market linkages is crucial for the long-term success and scalability of the CMNF initiative. Despite the positive impact of the CMNF initiative, several challenges remain. The transition from conventional farming practices to regenerative agriculture requires significant behavioural and mindset changes among farmers (Bharucha et al., 2020). The availability of quality inputs, technical support, and market linkages are crucial for the successful adoption and scaling up of CMNF practices (Mishra, 2022). Additionally, the long-term sustainability and circularity of the initiative depends on the continued support of policymakers, financial institutions, and other stakeholders (Bharucha et al., 2020).

In conclusion, the Andhra Pradesh Community-Managed Natural Farming program aligns with circular economy transition strategies in India by promoting sustainable agricultural practices, empowering farmers, conserving natural resources, and enhancing socio-economic sustainability. The program's focus on regenerative agriculture, community engagement, and resource efficiency contributes to the principles and objectives of the circular economy. By implementing the APCNF program, Andhra Pradesh is taking significant steps towards a more systematic, sustainable and circular agricultural system. India's circular economy action transition requires a comprehensive approach that integrates systems design thinking, resilience, and sustainability. The challenges faced by India in adopting circular economy principles are complex, but various circular economy business models and initiatives have been explored. Systems design thinking and the development of circular economy competencies for design are crucial for successful circular economy transition. Resilience and sustainability considerations are essential in ensuring the long-term viability of circular economy practices in India. By embracing the circular economy, India can address resource scarcity, promote sustainable development, and contribute to a more resilient and sustainable future.

4.3 China: Circular Economy Strategy - Circular Systems of Industry, Agriculture and Services

China, as one of the world's largest economies and a major contributor to global resource consumption and waste generation, has recognized the need to transition to a circular economy. This case study explores China's efforts and initiatives in transitioning to a circular economy, the challenges and opportunities it faces, and the impact of these efforts on sustainable development. China has made

significant progress in promoting a circular economy through the implementation of various policies and legislative measures and frameworks. The Circular Economy Promotion Law of the People's Republic of China, which came into force in 2009, has played a crucial role in driving the transition. This law provides a legal basis for the promotion of circular economy practices and encourages the adoption of resource-saving and environmentally friendly technologies (Feng & Lam, 2021). It has also led to the establishment of different sets of principles and strategies for adoption by policy makers, companies, and researchers (Feng & Lam, 2021). China's transition to a circular economy involves the transformation and innovation of industries across various sectors. The integration of circular economy principles into industrial processes and supply chains can lead to significant economic and environmental benefits. For example, in the electronics supply chain, firms can achieve both firm-level and industrial-level value in terms of cost reduction, revenue generation, resiliency, and legitimacy (Park et al., 2010). The development of an industrial circular economy can also promote the efficient recycling of resources, which is crucial for achieving sustainable development (Lu et al., 2020). Effective waste management and recycling systems are essential components of a circular economy. China has implemented various initiatives to improve waste management and promote recycling. For instance, the Circular Economy Transformation of Industrial Park and Urban Mining programs were initiated to pilot and evaluate circular economy practices (Jiao et al., 2018). These programs have introduced approaches such as periodic performance evaluation, contracting, and refunding systems to incentivize and facilitate the transition to a circular economy (Jiao et al., 2018). Additionally, the Chinese government has implemented subsidy policies to support the remanufacturing of products, which contributes to the circular economy by extending the lifespan of products and reducing waste (Peng et al., 2019). The successful implementation of a circular economy in China relies on technological and organisational factors. Technological advancements, such as the development of green and low-carbon technologies, play a crucial role in promoting resource efficiency and reducing environmental impacts (Zhu et al., 2022). The Technology-Organization-Environment (TOE) framework provides a useful framework for investigating the linkage effects of technological and organisational factors on the performance of China's provincial circular economy (Zhu et al., 2022). Organisational factors, such as collaborative efforts between producers and suppliers have the potential to result in a decrease in raw material usage and waste generation (Mamedov, 2015).

Despite the opportunities, China's transition to a circular economy is not without challenges. One of the key challenges is the need to change the mindset and behaviour of businesses and consumers. Shifting from a linear economy to a circular economy requires a fundamental change in the way resources are used and waste is managed. This requires raising awareness, providing education and training, and creating incentives for businesses and consumers to adopt circular economy practices (Nosratabadi et al., 2019). Another challenge is the need for effective coordination and collaboration among different stakeholders, including government agencies, businesses, and research institutions, to ensure the successful implementation of circular economy initiatives (Feng & Lam, 2021). Despite these challenges, China's transition to a circular economy presents significant opportunities. The circular economy can contribute to sustainable development by promoting resource efficiency, reducing waste, and mitigating environmental impacts. It can also drive innovation and create new business opportunities, leading to economic growth and job creation (Dewi & Pratama, 2021). The circular economy can also enhance China's resilience to resource scarcity and price volatility by reducing its dependence on imported resources (Abad-Segura et al., 2020). Furthermore, the circular

economy can contribute to China's commitments to international climate change mitigation and sustainable development goals (Abad-Segura et al., 2020).

China's circular economy transition like most countries is part of the national strategy. In China's 14th 5-year circular economy strategy published in 2021, there are four main components to China's circular economy strategy; (1) production — to embed reduce, reuse and recycling into whole production processes, (2) Green consumption ('circular values') — to guide citizens towards smart, healthy and safe consumption, (3) Growth of recycling industry — to recycle and reuse urban waste streams, focusing on remanufacture and renewable energy, and (4) Circular systems of industry, agriculture and services — to follow the principle of optimising industrial processes, greatly supporting circular production. The latter is the focus of this case study.

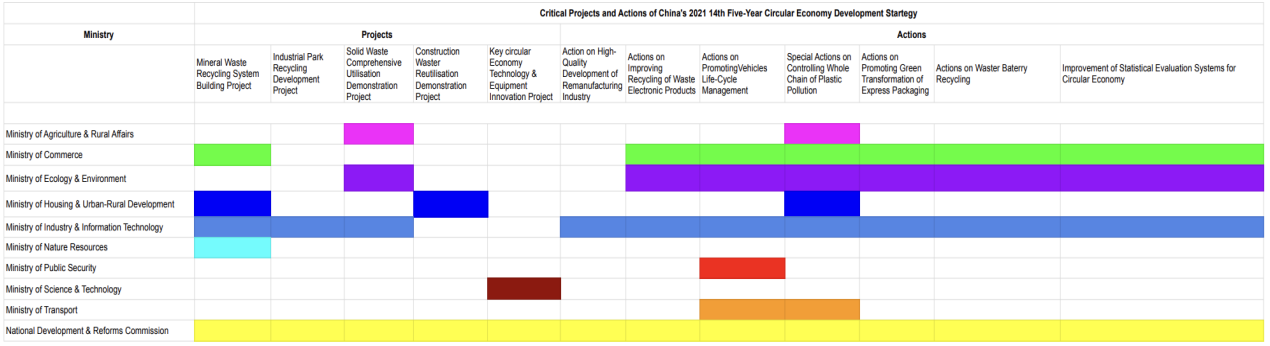

Figure 4.4: The Operational Framework of China's 2021 Circular Economy Strategy (an adaptation of Bleischwitz et al. 2022)

China has recognized the importance of transitioning to a circular economy to promote sustainable development and reduce environmental impacts. One of the key components of China's circular economy strategy is the establishment of circular systems in industry, agriculture, and services. This case study will explore China's efforts in implementing circular systems in these sectors, the objectives and goals associated with this approach, and the impact of these efforts on sustainable development.

1. Circular Systems in Industry:
China aims to optimise industrial processes and promote circular production within its industrial sector. The objective is to minimise waste generation, improve resource efficiency, and promote the reuse and recycling of materials Mathews & Tan (2011). This involves integrating circular economy principles into industrial processes, supply chains, and manufacturing practices. The goal is to create closed-loop systems where waste from one process becomes a valuable input for another process (Mathews et al., 2018). By implementing circular systems in industry, China aims to reduce environmental impacts, enhance resource efficiency, and promote sustainable industrial development.

2. Circular Systems in Agriculture:
China recognizes the importance of implementing circular systems in the agricultural sector to achieve sustainable agricultural practices. The objective is to minimise resource waste, improve agricultural productivity, and promote ecological balance (Li et al., 2021). Circular agriculture involves adopting

practices such as organic farming, agroecology, and the efficient use of resources such as water and nutrients (Li et al., 2021). It also involves the recycling of agricultural waste and by-products, such as using crop residues for bioenergy production or composting them for soil enrichment (Zhang et al., 2022). By implementing circular systems in agriculture, China aims to enhance food security, reduce environmental pollution, and promote sustainable rural development.

3. Circular Systems in Services:
China also focuses on implementing circular systems in the services sector, which includes areas such as transportation, logistics, and waste management. The objective is to optimise resource utilisation, reduce waste generation, and promote sustainable service delivery (Buren et al., 2016). Circular systems in services involve practices such as sharing economy models, resource recovery from waste streams, and the efficient use of energy and materials in service provision (Nosratabadi et al., 2019). For example, the adoption of shared mobility services can reduce the number of private vehicles on the road, leading to reduced resource consumption and emissions (Nosratabadi et al., 2019). By implementing circular systems in services, China aims to improve resource efficiency, reduce environmental impacts, and promote sustainable urban development.

The objectives and goals associated with the implementation of circular systems in industry, agriculture, and services in China are multi-faceted and aligned with the principles of resilience, sustainable development and circularity. Some of the key objectives and goals include:

1. Resource Efficiency: The primary objective is to optimise resource utilisation and minimise waste generation in order to achieve greater resource efficiency (Sauvé et al., 2016). This involves adopting cleaner production technologies, promoting recycling and reuse, and reducing resource consumption in industrial, agricultural, and service processes.

2. Environmental Protection: Circular systems aim to reduce environmental impacts by minimising pollution, conserving natural resources, and promoting sustainable land and water management practices (Liu & Jin, 2017). This includes reducing greenhouse gas emissions, improving air and water quality, and protecting ecosystems and biodiversity.

3. Economic Growth and Job Creation: Circular systems have the potential to drive economic growth and create new job opportunities. By promoting circular production and resource efficiency, China aims to enhance the competitiveness of its industries, stimulate innovation, and create green jobs (Dewi & Pratama, 2021). This can contribute to sustainable economic development and poverty reduction.

4. Sustainable Consumption and Lifestyles: Circular systems also aim to promote sustainable consumption patterns and lifestyles. This involves raising awareness among consumers, encouraging responsible consumption choices, and promoting the adoption of circular products and services (Shao, 2019). By shifting towards more sustainable consumption patterns, China aims to reduce waste generation, conserve resources, and minimise environmental impacts.

5. Social Equity and Inclusion: Circular systems aim to ensure social equity and inclusion by considering the social dimensions of sustainability. This includes promoting fair and inclusive access to resources, ensuring decent working conditions, and addressing social inequalities (Androniceanu et

al., 2021). By integrating social considerations into circular systems, China aims to create a more equitable and inclusive society.

4.4 RWANDA: National Circular Economy Action Plan and Roadmap

Rwanda has been at the forefront of promoting sustainable development and the transition to a circular economy. The country has developed a National Circular Economy Action Plan and Roadmap to guide its efforts in achieving a more sustainable and resource-efficient economy. Rwanda has made significant progress in its transition towards a circular economy. In the context of Rwanda, this transition is driven by the goals of resilience, sustainability, and systems design thinking. This case study explores the various aspects of Rwanda's circular economy transition and its implications for resilience, sustainability, and systems design thinking. This case study explores the key elements and initiatives of Rwanda's National Circular Economy Action Plan and Roadmap and its implications for the country's development in the contexts of this thesis.

The current state of the circular economy in Rwanda is characterised by significant progress and efforts towards sustainability, resource efficiency, and waste reduction. The country has implemented various policies and initiatives to promote the circular economy and address environmental challenges. The ban on single-use plastics, implemented in 2008 and revised in 2019, has disrupted the business models of Rwandan manufacturers but has positioned Rwanda as a proponent of sustainability policies in Africa (Ogutu et al., 2023). This policy, among others, has contributed to reducing plastic waste and promoting the adoption of sustainable alternatives (Ogutu et al., 2023). Rwanda has also been actively involved in regional and international initiatives to promote the circular economy.

The country, along with South Africa and Nigeria, launched the African Circular Economy Alliance in 2017, aiming to transform Africa into a circular economy and achieve economic growth, job creation, and positive environmental outcomes (Vermesan et al., 2020). This alliance, in collaboration with the World Economic Forum and the Global Environment Facility, seeks to facilitate the transition to a circular economy in Africa. Efforts to promote the circular economy in Rwanda extend beyond waste management. The country has recognized the importance of renewable energy and resource efficiency in achieving a circular economy. Rwanda has invested in renewable energy sources such as solar and hydropower, reducing its reliance on fossil fuels and promoting a more sustainable energy system. Additionally, initiatives are being implemented to improve resource efficiency in industries such as agriculture and manufacturing. Stakeholder engagement and collaboration are key elements of Rwanda's circular economy approach. The government has actively involved various stakeholders, including businesses, civil society organisations, and communities, in the development and implementation of circular economy initiatives.

Rwanda's circular economy transition has focused on building resilience by reducing dependence on raw materials and promoting resource efficiency. The country has implemented policies such as the ban on single-use plastics, which has disrupted the business models of Rwandan manufacturers but has also positioned Rwanda as a proponent of sustainability policies in Africa (Ogutu et al., 2023). By reducing reliance on single-use plastics and promoting the reuse and recycling of materials, Rwanda aims to build a more resilient and sustainable economy. Sustainability is a key driver of the circular economy transition in Rwanda. The circular economy model offers a value proposition to firms by

addressing the root issues of bad design and restrictive mindsets (Esposito et al., 2018). Rwanda's circular economy transition aligns with the country's broader sustainability goals. The country has made significant progress in stabilising and reconstructing its economy, with a GDP growth rate of 8% per year between 2001 and 2014 (Muhammad & Hutami, 2021). This economic growth has been accompanied by efforts to promote sustainable development and environmental conservation. The implementation of circular economy policies, such as the ban on single-use plastics, has contributed to Rwanda's commitment to reducing waste and promoting sustainable production and consumption (Ogutu et al., 2023). Systems design thinking is a problem-solving approach that emphasises understanding the interconnections and interdependencies within complex systems. Rwanda's circular economy transition has embraced systems design thinking by encouraging economic actors to review their current models and change their conceptual relationship and thinking about markets, customers, and resources (Esposito et al., 2018). The country has implemented policies and initiatives that promote sustainable production and consumption, such as the promotion of organic farming and the adoption of circular business models (Dimitrov & Ivanova, 2017). By adopting a systems design thinking approach, Rwanda aims to create a more sustainable and circular economy that considers the interconnectedness of economic, social, and environmental factors. The integration of sustainability and resilience mechanisms into supply chain operations has implications and is a key challenge in the circular economy transition. Globally, there are difficulties in finding, recognizing, and weighting sustainable practices and resilience in supply chain performance measures (Abbas et al., 2022). However, the adoption of circular economy principles can contribute to supply chain resilience by promoting resource efficiency, reducing waste, and diversifying supply chain networks. In the case of Rwanda, the circular economy transition has implications for supply chain resilience. The country has implemented sustainability practices and policies, such as the ban on single-use plastics, which have disrupted the business models of Rwandan manufacturers (Ogutu et al., 2023). However, these disruptions have also prompted manufacturers to explore new business models and diversify their supply chain networks, thereby enhancing their resilience to future shocks and disturbances.

Rwanda has made significant progress in recent years in terms of economic growth and development. However, like many developing nations, Rwanda faces challenges related to waste management, resource scarcity, and environmental degradation. In response to these challenges, the Rwandan government has embraced the concept of a circular economy as a means to achieve sustainable development through key elements of Rwanda's National Circular Economy Action Plan and Roadmap:

1. Policy and Regulatory Framework: The National Circular Economy Action Plan and Roadmap provide a comprehensive policy and regulatory framework to support the transition to a circular economy. This includes the development of legislation and regulations that promote sustainable practices, waste reduction, and resource efficiency Blumenstock (2012).

2. Waste Management and Recycling: The action plan emphasises the importance of waste management and recycling in achieving a circular economy. Rwanda has implemented initiatives to improve waste collection and separation, promote recycling, and establish recycling facilities (Ogutu et al., 2023). The aim is to reduce the amount of waste sent to landfills and maximise the recovery of valuable resources.

3. Sustainable Product Design: The action plan encourages the adoption of sustainable product design principles. This involves considering the entire lifecycle of a product, from raw material extraction to disposal. The plan promotes the use of renewable and recyclable materials, designing products for durability and repairability, and encouraging the adoption of circular business models (Frishammar & Parida, 2018).

4. Renewable Energy and Resource Efficiency: Rwanda recognizes the importance of renewable energy and resource efficiency in achieving a circular economy. The action plan includes initiatives to promote the use of renewable energy sources, such as solar and hydropower, and improve resource efficiency in industries such as agriculture and manufacturing (Vermesan et al., 2020).

5. Stakeholder Engagement and Collaboration: The National Circular Economy Action Plan and Roadmap emphasise the importance of stakeholder engagement and collaboration. The government has actively involved various stakeholders, including businesses, civil society organisations, and communities, in the development and implementation of circular economy initiatives (Ogutu et al., 2023). This collaborative approach aims to ensure the plan's effectiveness and sustainability.

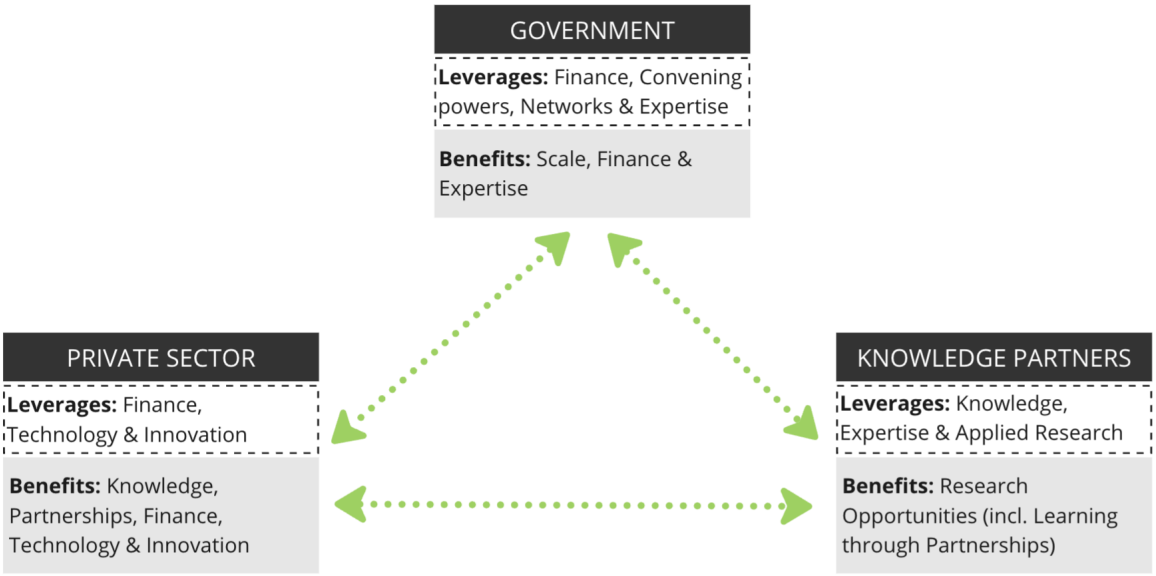

Figure 4.5: Private sector engagement model triangle (an adaptation from the Rwanda National Circular Economy Action Plan and Roadmap, 2022)

Rwanda's National Circular Economy Action Plan and Roadmap have several implications and benefits for the country's development:

1. Environmental Sustainability: By promoting waste reduction, recycling, and resource efficiency, the action plan contributes to environmental sustainability. It helps to minimise the environmental impact of economic activities, reduce pollution, and conserve natural resources (Ogutu et al., 2023).

2. Economic Growth and Job Creation: The circular economy offers opportunities for economic growth and job creation. By adopting circular business models and promoting sustainable practices,

Rwanda can stimulate innovation, attract investment, and create new employment opportunities (Frishammar & Parida, 2018).

3. Resilience and Adaptability: The circular economy approach enhances the resilience and adaptability of Rwanda's economy. By reducing dependence on finite resources and promoting resource efficiency, the country becomes less vulnerable to resource scarcity and price fluctuations (Ogutu et al., 2023).

4. Social Benefits: The National Circular Economy Action Plan and Roadmap has social benefits, such as improved public health and well-being. By reducing waste and pollution, the plan helps to create a cleaner and healthier environment for communities. Additionally, the plan promotes social inclusivity by involving various stakeholders in decision-making processes (Ogutu et al., 2023).

This collaborative approach aims to ensure the systematic effectiveness and sustainability of circular economy practices in the country. While progress has been made, challenges remain in fully implementing the circular economy in Rwanda. These challenges include the need for improved waste management infrastructure, increased awareness and education on circular economy principles, and the development of circular business models (Kabera & Nishimwe, 2019). However, Rwanda's commitment to sustainability and its proactive approach to addressing environmental challenges position the country as a leader in the circular economy transition in Africa. Rwanda's National Circular Economy Action Plan and Roadmap demonstrate the country's commitment to sustainable development and resource efficiency. Rwanda's circular economy transition in the context of resilience, sustainability, and systems design thinking has made significant progress in promoting resource efficiency, reducing waste, and building a more sustainable and resilient economy. The plan encompasses various elements, including policy and regulatory frameworks, waste management and recycling, sustainable product design, renewable energy, and stakeholder engagement. By implementing this plan, Rwanda aims to achieve environmental sustainability, economic growth, and social well-being. The country has implemented policies such as the ban on single-use plastics, which have disrupted business models but have also positioned Rwanda as a proponent of sustainability policies in Africa. The circular economy transition in Rwanda aligns with the country's broader sustainability goals and has implications for supply chain resilience. By adopting dynamic capabilities, reducing dependence on raw materials, and promoting resource efficiency, Rwanda aims to build a more resilient and sustainable economy. The successful implementation of the National Circular Economy Action Plan and Roadmap can serve as a model for other countries seeking to transition to a more sustainable and circular economy.

5

FINDINGS

5.1 Overview of Findings

The EU through its EU Circular Economy Action Plan has actively embraced the concept of the circular economy and has committed significant resources to support the transition. The EU institutions and agencies are raising awareness and encouraging sustainable production and consumption behaviours. The EU Circular Economy Action Plan includes measures to promote resource efficiency, waste prevention, and recycling (Zink & Geyer, 2017; Camilleri, 2020; Colombo & Pansera, 2019; Hagelüken et al., 2016). Rwanda has equally developed a comprehensive National Circular Economy Action Plan and Roadmap to transition to a circular economy. The plan focuses on sustainable production and consumption, waste management, and resource efficiency. It includes initiatives to promote recycling, eco-design, and green entrepreneurship. China's Circular Economy Strategy equally recognizes the importance of the circular economy in achieving sustainable development. The country has implemented a Strategy that aims to promote resource efficiency, waste reduction, and recycling. China's strategy includes measures to improve the circularity of key industries, such as manufacturing and agriculture (Ranta et al., 2018; Zhu et al., 2019; Zhu et al., 2022; Hu et al., 2018). India's Andhra Pradesh Community-Managed Natural Farming (APCNF) program promotes sustainable agriculture practices based on the principles of the circular economy. The program focuses on organic farming, natural resource management, and community participation. It aims to reduce the use of chemical inputs, improve soil health, and enhance the resilience of farmers (Sharma et al., 2019).

In the EU, the reduction of plastic waste and food waste, which are significant contributors to environmental degradation are also a priority. Additionally, the plan addresses the management of critical raw materials, construction and demolition waste, and biomass and bioproducts. These priority areas are chosen based on their potential for economic growth, competitive advantage, and environmental impact. The EU Circular Economy Action Plan also emphasises the importance of effective regulations and incentives at both the EU and national levels. This includes implementing measures such as Extended Producer Responsibility schemes (EPR), which make producers responsible for the entire lifecycle of their products, from production to disposal. By adopting this systems design thinking approach, the EU Circular Economy Action Plan recognizes that transitioning to a circular economy requires engagement and collaboration from various stakeholders. The EU Circular Economy Action Plan also focuses on building resilience and sustainability within the circular economy transition. This involves ensuring that circular practices are not only environmentally sustainable but also economically viable and socially inclusive. The implementation

of the EU Circular Economy Action Plan has led to the development of national strategies and public investments in research and innovation across Europe. These strategies and investments aim to further accelerate the transition towards a circular economy by addressing key barriers and promoting circular practices at both the macro and micro levels.

The key findings of the case study on China's Circular Economy Strategy focused on circular systems of industry, agriculture, and services can be related to resilience, design sustainability, and systems design thinking as;

1. *Resilience:* The implementation of circular systems can contribute to building resilience in the economy and society. Circular systems promote resource efficiency, waste reduction, and the reuse of materials, which can help mitigate resource scarcity and price volatility. By adopting circular practices, China can enhance their resilience to environmental and economic shocks, ensuring the long-term sustainability of their industries and sectors.

2. *Design for Sustainability and Resilience:* Circular systems require a shift in design thinking towards sustainability and resilience. The three aspects form a tripod upon which the inter-relation compliments efforts of the circular economy transition in different industries and sectors across China. Designing products, processes, and services with circularity in mind is crucial for achieving a circular economy. By incorporating principles of design sustainability, such as designing for closed loops and adaptability, China can promote the longevity and recyclability of products, reducing waste and resource consumption. This approach aligns with the principles of circular economy and contributes to sustainable development and resilience.

3. *Systems Design Thinking:* Implementing circular systems in industry, agriculture, and services requires a systems thinking approach. Circular economy strategies involve the integration of various stakeholders, sectors, and processes. Systems design thinking emphasises the interconnectedness and interdependencies of different components within a system. By adopting a systems design thinking approach, China can identify and address the complex challenges and opportunities associated with circular systems implementation. This approach helps in understanding the systemic implications of circular economy strategies and designing holistic solutions.

4. *Transition Management:* Transition takes time. The successful implementation of circular systems requires effective transition management. Transition management involves guiding and facilitating the shift from linear to circular practices, considering social, economic, and environmental dimensions. It requires collaboration among stakeholders, policy support, and the development of appropriate measures and indicators to assess progress. By adopting a transition management approach, China can navigate the complexities of the circular economy transition and ensure the successful implementation of circular systems in industry, agriculture, and services.

In summary, the key findings of the case studies highlight the importance of resilience, design sustainability, and systems design thinking in the implementation of circular systems. These findings emphasise the need for a holistic and integrated approach to achieve a sustainable and successful

circular economy transition in China. The key findings of the case study on Rwanda's National Circular Economy Action Plan and Roadmap highlight the progress and implications of the country's circular economy initiatives. These findings can be related to resilience, design sustainability, and systems design thinking as follows;

1. *Alignment with Circular Economy Principles:* Rwanda's sustainability policies, including the plastic ban, align with the principles of the circular economy. This alignment reflects the country's commitment to resource efficiency, waste reduction, and sustainable practices. The adoption of circular economy principles contributes to the resilience of the economy by reducing dependence on finite resources and promoting sustainable production and consumption.

2. Importance of Stakeholder Engagement: The case study emphasises the importance of stakeholder engagement and collaboration in the development and implementation of circular economy initiatives. This aligns with the principles of systems design thinking, which emphasises understanding the interconnections and interdependencies within complex systems. By involving various stakeholders, including businesses, civil society organisations, and communities, Rwanda promotes a collaborative approach to circular economy implementation, enhancing the effectiveness and sustainability of the initiatives.

3. *Circular Product, Process and Systems Design:* The study Martins & Cooper (2017) highlights the role of circular product design in the circular economy. Circular product design principles, such as designing for multiple use cycles and design for recovery, contribute to sustainability and resource efficiency. This approach aligns with design sustainability, which focuses on creating products that minimise environmental impact throughout their lifecycle. By adopting circular product design principles, Rwanda promotes sustainable and resilient product systems.

4. *Circular Business Models:* The case study Sumter et al. (2018) emphasises the importance of circular business models in the circular economy. Circular business models, such as leasing and refurbishment, contribute to resource efficiency and waste reduction. These models align with the principles of design sustainability and systems design thinking by considering the entire lifecycle of products and promoting the reuse and recycling of materials. By adopting circular business models, Rwanda enhances the resilience of its economy by reducing waste and maximising resource efficiency.

5. *Policy and Regulatory Framework:* Policy and regulatory frameworks play a vital role in promoting the circular economy (e.g. Esposito et al. 2018). Rwanda's development and implementation of policies and regulations that support sustainable practices and waste reduction is crucial for the transition to a circular economy. This aligns with the principles of design sustainability and systems design thinking, which emphasise the importance of policy interventions and systemic approaches to address complex challenges.

Overall, the key findings of the case study on Rwanda's National Circular Economy Action Plan and Roadmap demonstrate the country's policy progress in promoting resilience, design sustainability, and systems design thinking. The alignment with circular economy principles, stakeholder engagement,

circular product design, circular business models, and policy interventions contribute to the development of a more sustainable and resilient economy in Rwanda. The key findings of the case study on the Andhra Pradesh Community-Managed Natural Farming (APCNF) program can be summarised as follows;

1. *Adoption of Zero Budget Natural Farming (ZBNF):* The APCNF program promotes the adoption of ZBNF practices, which aim to reduce farmers' direct costs while boosting yields and farm health.. The study highlights the successful implementation of ZBNF at scale in Andhra Pradesh, leading to improved soil health, increased crop yields, and reduced input costs (e.g. Bharucha et al., 2020; Mishra, 2022).

2. *Resilience and Sustainability:* The APCNF program contributes to the resilience and sustainability of farming systems. By promoting regenerative agriculture practices, the program enhances the resilience of farming systems to climate change impacts and reduces the environmental footprint of agriculture (e.g. Bharucha et al., 2020). The program also focuses on socio-economic sustainability by improving farmer incomes and reducing their dependence on external inputs.

3. *Community Engagement and Design Sustainability:* The APCNF program emphasises community engagement and participatory approaches. It promotes the formation of farmer producer organisations, knowledge sharing, and collective decision-making processes (Mishra, 2022). This community-led approach aligns with the principles of design sustainability, which emphasise the involvement of stakeholders in the design and implementation of sustainable solutions (e.g. Mishra, 2022).

4. *Systems Design Thinking:* The APCNF program incorporates systems design thinking by considering the complex interactions and interdependencies within the agricultural system. It recognizes the need for holistic approaches that address multiple dimensions of sustainability, including ecological, economic, and social aspects (e.g. Mishra, 2022). The program aims to create a closed-loop system by minimising waste, reusing resources, and promoting natural processes .

Overall, the case study highlights the positive impact of the APCNF program in promoting sustainable agriculture practices, enhancing resilience, and fostering community engagement. The adoption of ZBNF practices, the focus on sustainability, and the incorporation of systems design thinking contribute to the program's success in Andhra Pradesh. These findings have implications for the design and implementation of similar initiatives in other regions across India and globally, emphasising the importance of community involvement, regenerative practices, and holistic approaches to sustainability.

These case studies, though focusing on diverse aspects, all highlight the importance of resilience, design sustainability, and systems design thinking in the context of the circular economy transition and are updated continuously for adaptability to stay relevant to current challenges. The circular economy is seen as a key strategy to achieve corporate sustainability and address global challenges such as climate change, resource depletion, and waste generation (Khan et al., 2020; Kotlyarevsky et al., 2021; Goldar, 2021; Kennedy & Linnenluecke, 2022; Schleifer & Sun, 2018; "Circular Economy

in the Framework of Sustainable Development Policy", 2022; Jones & Wynn, 2021; Yates et al., 2021). The transition to a circular economy requires the development of new capabilities and competencies, as well as the adoption of innovative business models and practices (Khan et al., 2020; Kotlyarevsky et al., 2021; Hornbuckle, 2018; Sauerwein et al., 2019; Martins & Cooper, 2017; Sumter et al., 2020; Sumter et al., 2021). It also requires the collaboration and coordination of various stakeholders, including governments, businesses, and communities (Camilleri, 2020; Oliveira et al., 2020; Esparragoza & Mesa-Cogollo, 2019; Jacometti, 2019; Adams et al., 2017; Oliveira et al., 2021; Kafel et al., 2021; Lopes & Videira, 2021). The circular economy has already proven it can contribute to the resilience of economic systems by decoupling economic growth from material consumption and promoting resource efficiency (Kennedy & Linnenluecke, 2022; Jones & Wynn, 2021). Emphasis on the importance of sustainable design, waste prevention, and the circular use of materials and products universal (Esparragoza & Mesa-Cogollo, 2019; Sumter et al., 2018; Martins & Cooper, 2017; Sumter et al., 2020). At the core of the transition, is a mutual desire for a systems design thinking approach. Systems design thinking has demonstrated crucial for understanding the interconnectedness of different elements in the circular economy and identifying opportunities for innovation and optimization (Kennedy & Linnenluecke, 2022; Nohra & Barbero, 2019). Overall, these case studies provide valuable insights into the implementation and impact of circular economy strategies in different contexts, highlighting the potential for sustainable development and resilience during the circular economy transition. They also demonstrate that the circular economy transition and initiatives are a global goal, with different countries and governments setting pathways to achieve them, and also a benchmark for guidance to other countries.

6

DISCUSSION AND CONCLUSION

6.1 Discussion and Conclusion

The case studies provide valuable insights into the role and value of integrating systems design thinking practices in the transition towards a circular economy and its relation to resilience, design sustainability. Resilience is a key aspect of the circular economy transition. The EU Circular Economy Action Plan aims to enhance the resilience of the European economy by decoupling economic growth from material consumption and promoting resource efficiency. Similarly, the circular economy strategies in China, Rwanda and India focus on improving the resilience of their respective strategies and economies by reducing waste, enhancing resource efficiency, and promoting sustainable practices. The APCNF program in India specifically aims to enhance the resilience of farmers by promoting sustainable agricultural practices and reducing their dependence on chemical inputs. Design sustainability is an equally important consideration in the circular economy transition. The case studies highlight the role of design in promoting circularity and sustainable processes and practices. The EU Circular Economy Action Plan emphasises the importance of sustainable product design and waste prevention. The circular economy strategies in China and India also recognize the need for sustainable design and the circular use of materials and products. The APCNF program in India promotes organic farming and natural resource management, which are key elements of sustainable design in agriculture.

Measuring the success of the circular economy transition and the implementation of circular systems in industry, agriculture, and services in the case studies requires a comprehensive assessment of various factors. While the sources and findings of the study offer insights into the circular economy in the countries, they do not explicitly address the measurement of implementation success. However, they provide valuable information on the progress, challenges, and potential benefits of circular economy implementation. Some highlight the gap between the firms' awareness and actual behaviour in implementing circular economy practices. This suggests that there may be challenges in translating awareness from theory and initiatives into concrete actions. The importance of successful implementation of the circular economy concept to overcome environmental damages is crucial. It suggests that successful implementation can help countries leapfrog past the negative environmental impacts typically associated with industrialization. The circular economy has also been described as a transformation from the traditional "resources-products-pollutions" mode to the "resources-products-regenerated resources" mode (e.g. Wang et al. 2015) which suggests that the success of circular systems can be measured by the extent to which resources are effectively regenerated and reused.

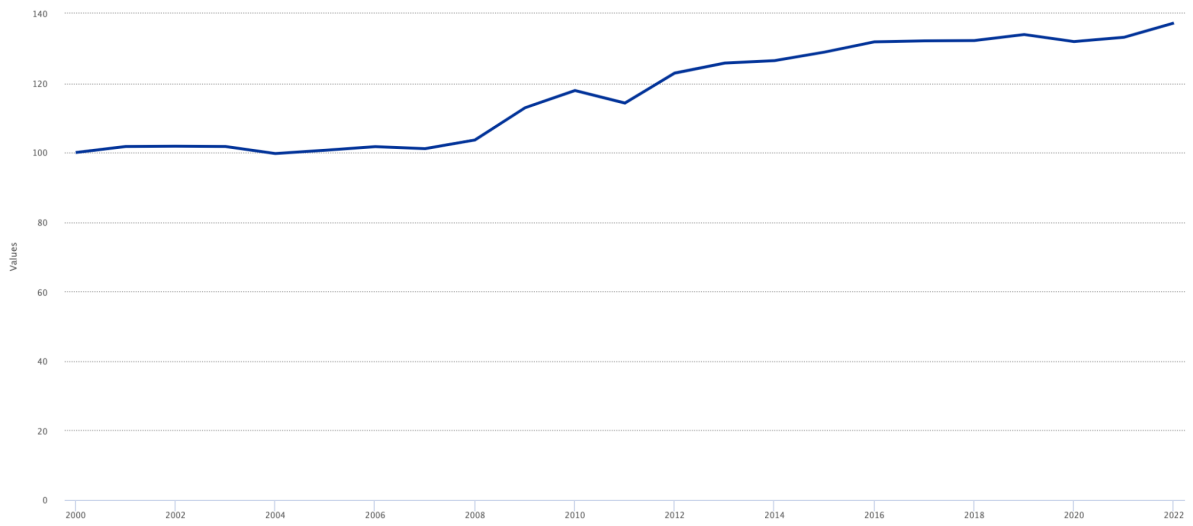

Figure 4.6: Resource Productivity in the EU 2000 to 2022 (Source of data: Eurostat, 2023) Time frequency: Annual. Unit of measure: Index, 2000=100

The multiple environmental and economic goals of the circular economy implementation are vital to the success of circular systems, and this can be measured by their ability to address complex environmental problems, contribute to a prosperous and equitable society, and lead industrialization efforts. The four countries have made progress in developing and implementing the circular economy concept and review their strategy often. China and the EU have experience in developing and implementing the circular economy concept, while Rwanda and India might be new to this initiative. The success of circular systems can be measured by their ability to establish a mutually supportive relationship between economic expansion and ecological sustainability.

The success of circular systems can be measured by many factors; for example, their ability and potential to reduce and contribute to sustainable waste management (e.g. Androniceanu et al. 2021); contribution to climate change mitigation and resource conservation (e.g. Lee et al. 2020); sustainable agricultural development (e.g. Li et al. 2021); based on its contribution to resource efficiency and environmental sustainability (e.g. Fan et al. 2018; Cerqueira-Streit et al. (2021); evaluated based on its ability to achieve these goals (e.g. Wei et al. (2017); by their impact on regional circular economy development (e.g. Levicky et al. 2021; Wang et al. 2022; Wang et al. 2023); the evaluation of environmental disclosures of circular economy listed companies (e.g. Qu et al. (2022); based on its contribution to sustainable development (e.g. Bigano et al. 2016; Batista et al. 2018). Implementation of circular economy models also needs measures to assess their effectiveness (Chengzhi et al. 2015; Nikitaeva & Shestopalova 2022; Najmaei & Sadeghinejad 2022). This suggests that the transition to a circular economy requires effective measurement of circularity activities. The implementation of circular business models can contribute to sustainable waste management, for example, as demonstrated in China's mobile electronics industry (e.g. Marke et al. 2020; Dewi & Pratama 2021).

The performance of the circular economy is multifaceted and can hence be measured and influenced by various factors. The objectives and goals associated with these systems are aligned with the principles of sustainable development, including resource efficiency, environmental protection, economic growth, sustainable consumption, and social equity. By implementing circular systems,

countries aim to achieve a more sustainable and resilient economy, reduce environmental impacts, and promote social well-being. The successful implementation of circular systems in these sectors will require collaboration among stakeholders, policy support, technological innovation, and changes in consumer behaviour. Counterarguments to the circular economy transition have included concerns about the feasibility and economic viability of circular business models, as well as potential challenges in implementing circular economy strategies in different contexts. Some critics argue that the circular economy may require significant upfront investments and may not always be cost-effective compared to traditional linear models (Özçatalbaş, 2023). Additionally, the transition to a circular economy may require significant changes in infrastructure, supply chains, and consumer behaviour, which can be challenging to achieve.

Systems design thinking is crucial for the successful implementation of circular economy strategies. The case studies uniformly emphasise the need for a holistic and systemic perspective in policy planning and decision-making (Nohra et al., 2020). The EU Circular Economy Action Plan calls for innovative policy-planning with a systemic perspective to foster a smooth transition to circular business models (Nohra et al., 2020). The case study on circular urban transitions in post-industrial cities, for example, in the EU highlights the importance of systemic design thinking in fostering circular economy frameworks (Nohra & Barbero, 2019). The APCNF program in India also emphasises the importance of community participation and collaboration, which are key elements of systems design thinking . Overall, the case studies demonstrate that the transition to a circular economy requires a multidimensional approach that considers resilience, design sustainability, and systems design thinking. The EU Circular Economy Action Plan, Rwanda's National Circular Economy Action Plan and Roadmap, China's Circular Economy Strategy, and India's APCNF program all provide valuable insights and examples of how these concepts can be integrated into circular economy strategies. By embracing these principles, countries and regions can promote systems design thinking approach to sustainable development, enhance resource efficiency, and build more resilient economies. The findings from these case studies highlight the importance of resilience in the circular economy transition and prove that design for sustainability and resilience is a key aspect of the circular economy transition. While there may be counterarguments and challenges to overcome, the case studies demonstrate the potential for sustainable development, resource efficiency, and economic resilience through the adoption of circular economy strategies.

This research has revealed significant differences in the progress and commitment to the transition to a circular economy between China, the EU and developing nations such as India and Rwanda. These differences are largely rooted in the varying impact, fault and cause, financial hardships, contextual priorities and technological inequalities across these regions.

1. *Impact, Fault, and Cause:* The European Union has traditionally industrialised faster than developing countries and hence had a significant role in global production and consumption patterns, contributing to a substantial share of the world's degradation, waste and pollution. Hence, they bear a larger responsibility for transitioning to a circular economy. This sense of responsibility, coupled with public awareness and demand for sustainable practices, has propelled the EU to make substantial strides towards a circular economy. Contrary to the EU’s demands, these huge efforts from the EU do not necessarily mean that developing countries like India and Rwanda must replicate at the same level of effort, speed, priority and urgency as the EU. In contrast, developing nations, while dealing with the effects of climate change and

waste, have historically had a lower direct impact. However, they often bear the brunt of the consequences of a linear economy due to global trade dynamics, such as the import of non-recyclable waste. The consequences of the unsustainable and irresponsible actions driven by financial gain during industrialisation to-date are most felt in developed countries than in developing countries.

2. *Financial Constraints:* Developing countries often face financial constraints that impede their ability to invest in the infrastructure needed for a circular economy. Without sufficient recycling facilities, sustainable manufacturing technologies, and green logistics solutions, their transition towards circularity becomes challenging. On the other hand, European countries typically have more resources to invest in the required infrastructure and technologies, giving them a head start in the transition.

3. *Technological Inequality:* Technological capabilities significantly influence a country's progress towards a circular economy. Advanced technologies enable waste reduction, facilitate recycling, promote sustainable consumption, and drive innovative business models based on circularity. The EU's strong technological capabilities have enabled it to leverage this advantage to advance towards a circular economy. Developing nations, however, often struggle with a technological gap. Without the necessary technological know-how and resources, they face hurdles in implementing advanced recycling processes, developing green products, and promoting sustainable consumption and production.

Despite these challenges, it's important to acknowledge the efforts made by developing nations like India and Rwanda, often driven by necessity and resource scarcity, such as grassroots recycling initiatives, frugal innovation, and traditional practices that inherently align with circular economy principles. Additionally, there is a growing commitment among developing countries to transition towards a circular economy, as evidenced by policy initiatives and increased investments in sustainable practices so that they may not suffer the same consequences as witnessed among industrialised countries. While the journey towards a circular economy has seen differing levels of progress and commitment between developed and developing nations, it is crucial that global cooperation is fostered. This cooperation should aim at sharing knowledge, technological advancements, financial resources, and policy insights. Only through collective effort can the goal of a global circular economy be realised, bringing forth a future of sustainable and resilient economic growth but at every country's pace of capability.

6.2 Implications for Knowledge, Policy and Practice

The case studies on the four countries have important implications for knowledge, policy, and practice in the context of the circular economy transition. In terms of knowledge, these case studies contribute to a deeper understanding of the circular economy and its potential for sustainable development and resilience. They provide insights into the strategies, initiatives, and best practices that can be adopted to promote resource efficiency, waste reduction, and sustainable production and consumption. The case studies highlight the importance of interdisciplinary research and collaboration in advancing

knowledge on the circular economy. They also emphasise the need for a comprehensive and holistic understanding of circularity, taking into account diverse perspectives and approaches.

From a policy perspective, these case studies demonstrate the importance of developing and implementing effective circular economy policies at the national and regional levels. The EU Circular Economy Action Plan serves as a policy framework for promoting the circular economy in Europe. Rwanda's National Circular Economy Action Plan and Roadmap provide a roadmap for transitioning to a circular economy in the country. China's Circular Economy Strategy outlines the country's approach to promoting resource efficiency and waste reduction. The APCNF program in India focuses on sustainable agriculture practices based on the principles of the circular economy. These policies highlight the need for regulatory frameworks, incentives, and support mechanisms to facilitate the adoption of circular economy practices at different levels and angles of the transition.

In terms of practice, the case studies provide examples of successful circular economy initiatives and projects. They showcase the implementation of circular business models, sustainable design practices, and community engagement in various sectors such as manufacturing, agriculture, and waste management. The case studies highlight the importance of collaboration between different stakeholders, including governments, businesses, and communities, in driving the circular economy transition. They also emphasise the potential of social economy enterprises in contributing to the circular economy and the green transition.

Overall, the case studies have significant implications for knowledge, policy, and practice. They contribute to the growing body of knowledge on the circular economy, provide insights for policymakers in developing effective circular economy policies, and offer practical examples and lessons for businesses and organisations to implement circular economy practices. These case studies highlight the potential of the circular economy to promote sustainable development, resilience, resource efficiency, and environmental protection.

6.3 Limitations

Despite the insightful findings of this research, it is imperative to acknowledge several limitations, which opens avenues for future research.

1. *Geographical Limitation:* The primary limitation is geographical, as the study concentrated only on the EU, China, India, and Rwanda. While these regions are significant in terms of their respective roles in the global economy and sustainability challenges, the results may not be universally applicable, especially to countries with different socio-economic contexts.

2. *Methodological Limitation:* The study primarily relied on case studies as the research method, which, while providing in-depth insights, may limit the generalizability of the findings. A larger-scale quantitative study could enhance the statistical robustness and offer broader generalizability of results.

3. *Data Accessibility:* Another significant limitation was the uneven accessibility and reliability of data, particularly in Rwanda and parts of India. Some long-existent initiatives, for example

in Rwanda, were not well documented or reported previously. This limitation may have inadvertently biased some aspects of the analysis and findings.

4. Temporal Dynamics: The dynamic nature of policy, economic landscapes, and technology innovations imply that the findings are rooted in the current temporal context. Changes in these areas could potentially alter the conclusions drawn from this research.

5. *Scope of Circular Economy Practices:* The study focused on design sustainability for the circular economy transition, thereby not addressing other aspects such as the role of consumer behaviour, the impacts of governmental policies, and the importance of infrastructure for the circular economy.

6. *Sector-specific Limitation:* The study doesn't provide a comprehensive sector-wise analysis. The implementation and impacts of circular economy principles can vary considerably across different sectors (e.g., agriculture, manufacturing, service), thus limiting the comprehensive applicability of the findings.

These limitations do not diminish the value of the findings but should be considered when interpreting the results. They also point to areas for further research to refine our understanding of resilience and design sustainability in the context of a circular economy. Future research and practice could expand on multiple aspects like the geographical scope, incorporate more diverse methodologies, conduct sector-specific studies, and explore other aspects of circular economy practices, including policy impacts, infrastructure requirements, and consumer behaviour.

6.4 Recommendations for Future Research and Practice

This thesis has provided a comprehensive exploration of resilience and design sustainability in the context of the circular economy, focusing on the case studies of the EU, China, India, and Rwanda. While these findings contribute significantly to the literature, they also shed light on the areas that require further examination and application. In this section, the thesis delves into a series of recommendations that are derived from the study's conclusions and its identified limitations. These recommendations serve two purposes. Firstly, they provide a roadmap for future research, suggesting ways to expand the current understanding and address gaps in the field of systems design thinking and circular economy transition. Secondly, they provide practical guidelines for various stakeholders including policymakers, practitioners, educators, and the business community, to aid in their actions towards adopting and promoting resilient and sustainable practices within the framework of the circular economy.

The suggestions for future research and practice are designed to build upon this study's findings, embracing the dynamism and complexity of the field, and to propel more decisive action towards global sustainability and circular economy transitions. Through iterative investigation and implementation, the knowledge and practices concerning the circular economy, resilience, and sustainability can continuously evolve to meet the needs of a rapidly changing world. The subsequent

sections detail specific recommendations for future research directions and practical applications that can help accelerate the global commitment to the circular economy transition.

6.4.1 Recommendations for Future Research

Broadening Geographical Scope: Future research could focus on expanding the geographical scope to include more diverse socio-economic and political contexts. This could enhance our understanding of the nuances in implementing and managing circular economy transitions across different contexts.

1. *Mixed-Method Approach:* Adopting a mixed-method approach that combines quantitative and qualitative methodologies could provide a more holistic and robust understanding of resilience and design sustainability in the circular economy. For example, combining case studies with large-scale surveys or experimental designs could improve the generalizability of findings.

2. *Longitudinal Studies:* Given the dynamic nature of the circular economy, longitudinal studies could provide insights into the evolving trends and patterns of resilience and sustainability over time. This could help identify both the immediate and long-term impacts of adopting systems design thinking.

3. *Sector-Specific Studies:* Future research could also delve deeper into sector-specific studies to understand the unique challenges and opportunities each sector presents in the circular economy transition.

4. *Consumer Behaviour Studies:* More research is needed on the role of consumer behaviour in promoting or hindering the circular economy transition. This could provide vital information for developing effective strategies to encourage consumer participation in the circular economy.

5. *Policy Analysis:* Research could focus on the impact and role of policy in facilitating the transition to a circular economy. This could involve comparative studies of different policy approaches and their effectiveness.

6. *Developing a Standardised Measurement for Resilience:* There is a need to develop more comprehensive and standardised measures of resilience in the context of the circular economy. This would help in reliably assessing and comparing the resilience of different systems.

6.4.2 Recommendations for Future Practice and Implications

1. *Collaborative Efforts:* Stakeholders across different sectors need to collaborate more effectively to drive the transition towards a circular economy. This could involve sharing best practices, pooling resources, and fostering innovation through collaborative research and development.

2. *Policy Implementation:* Policymakers should consider the findings of this study and similar research when developing and implementing policies related to the circular economy. They

should also provide incentives to encourage businesses to adopt systems design thinking and sustainable practices.

3. *Education and Training:* There is a need for more education and training in systems design thinking and sustainable practices. This could be achieved through academic courses, professional development programs, and public awareness campaigns.

4. *Infrastructure Development:* Governments and businesses should invest in developing the necessary infrastructure to support the circular economy. This could include waste management facilities, recycling centres, and sustainable production technologies.

5. *Consumer Awareness Programs:* Public and private entities should undertake consumer awareness programs to educate the public about the importance of the circular economy and how they can contribute to it. Encouraging responsible consumer behaviour is a critical part of achieving a sustainable circular economy.

The shift towards a circular economy presents profound opportunities for economic growth, environmental preservation, and social progress. However, the complex and dynamic nature of this transition demands ongoing research and evolving practices. The recommendations provided herein aim to guide the direction of future research and inform practical applications to navigate the challenges that accompany this transition. While this study has shed light on the resilience and design sustainability for circular economies in the EU, China, India, and Rwanda, it has also highlighted the need for research that extends its geographical and sectoral reach, adopts varied methodologies, and delves deeper into areas such as consumer behaviour, policy analysis, and standardising measures. On the practical front, these recommendations underscore the importance of collaborative efforts, policy implementation, education and training, infrastructure development, and consumer awareness. These areas are crucial for creating a conducive environment that facilitates the transition towards a circular economy. As we look forward to a future characterised by heightened sustainability challenges, these recommendations serve as a compass, guiding efforts to embed resilience and sustainability into the design of our economies. By building upon these insights, we can foster the development and implementation of innovative solutions that drive the global transition towards a sustainable and resilient circular economy. The journey towards a circular economy is not a sprint but a marathon, one that requires constant learning, adaptation, and collective effort. It is my hope that this thesis and its recommendations will inspire and guide future endeavours in this important journey towards a sustainable future.

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