Vol. 1(1): 1-40 (2024)

Journal of Regenerative Economics

DOI: 10.5937/jre2401001C

EXPLORING THE REGENERATIVE ECONOMY: A COMPREHENSIVE REVIEW OF LITERATURE

Saša Čegar
University of Rijeka, Faculty of Economics and Business, Rijeka, Croatia
✉ sasa.cegar@efri.uniri.hr
https://orcid.org/0000-0001-8666-3419

Saša Drezgić
University of Rijeka, Faculty of Economics and Business, Rijeka, Croatia
✉ sasa.drezgic@efri.uniri.hr
https://orcid.org/0000-0002-7712-8112

Dragan Čišić
University of Rijeka, Faculty of Economics and Business, Rijeka, Croatia
✉ dragan.cisic@efri.uniri.hr
https://orcid.org/0000-0001-6235-0987

Abstract: Contemporary global challenges such as climate change, resource depletion, ecosystem degradation, and social inequities require comprehensive and integrated approaches to achieve sustainable development. While existing development and sustainability paradigms address specific aspects of sustainability, they often fall short in driving systemic transformation and ensuring long-term resilience. In response to these limitations, the concept of the regenerative economy emerges as a holistic framework that integrates ecological restoration, social equity, and economic vitality. This study conducts a systematic literature review of 84 scholarly articles to synthesize and cluster existing research within the regenerative economy domain. Utilizing a Large Language Model (LLM) for zero-shot classification, the analysis identifies seven primary clusters—Sustainability and Environmental Impact, Climate Change and Energy, Urban and Built Environment, Economic and Industrial Systems, Education and Social Impact, Technological Innovations and Systems, and Policy, Governance, and Standards—further subdivided into 21 subgroups. Each cluster encapsulates key themes and interdisciplinary approaches essential for advancing regenerative economy practices. The findings highlight the interconnectedness of various sustainability dimensions and underscore the necessity of integrated governance, innovative technological solutions, and inclusive policy frameworks. By mapping the current state of regenerative economy research, this study provides a structured overview that facilitates deeper understanding and informs future strategic initiatives aimed at achieving a resilient and prosperous sustainable future.

Keywords: regenerative economy, systematic literature review, large language model, LLM-based cluster analysis, policy implications

Original scientific paper
Received: 14.12.2024
Accepted: 27.12.2024

1. Introduction

Contemporary global challenges such as climate change, food and energy security, ecosystem degradation, human health, poverty, and the restructuring and green transition of national economies are interconnected and complex. This interconnectedness demands a comprehensive approach, as partial, one-dimensional policies can create additional problems and generate negative feedback across social, economic, and environmental dimensions. To address this, concepts like the green economy, circular economy, and bioeconomy have been developed and integrated into strategic programs, such as those of the European Union, emphasizing their potential to foster development based on renewable resources and environmentally sound processes.

However, these concepts have shown limitations in addressing complex challenges. While the green economy focuses on reducing environmental harm, it often remains within sustainability frameworks, insufficiently addressing systemic transformation and root causes of ecosystem degradation (i.e. Unmüßig et al., 2012). The circular economy prioritizes technical aspects of resource loops and recycling, often overlooking broader social and ecological dynamics crucial for long-term resilience (i.e. Corvellec et al., 2022). The bioeconomy, while potentially innovative, can prioritize exploiting biological resources without sufficient emphasis on regenerative processes that ensure long-term availability (i.e. Allain et al., 2022). A shared weakness of these approaches is their partial application, where progress in one area can negatively impact others. Their technical-economic focus often neglects the fundamental interconnectedness of humans, nature, and economic systems, leading to fragmented and poorly coordinated interventions. In the face of challenges like climate change, resource depletion, and growing social inequality, these limitations are significant.

This necessitates a more comprehensive concept: the regenerative economy. This paradigm offers a holistic approach by actively enhancing the capacity of natural and social systems for long-term resilience and prosperity. It moves beyond simply maintaining the status quo, enabling systemic transformation and renewal to address the needs of contemporary societies and the planet. The regenerative economy is grounded in natural processes, promoting partnership with ecosystems rather than exploitation. This shifts the focus from sustaining existing resources to improving the capacity of fundamental ecological and social systems. The regenerative economy integrates the best aspects of the green, circular, and bioeconomy into a unified approach. It adds active ecosystem restoration to the green economy, situates the circular economy within a broader regeneration strategy, and grounds the bioeconomy in regenerative processes that ensure the long-term health of biological resources. It aims to restore and revitalize environmental, social, and economic capital, improving ecosystem health, strengthening community resilience, and enhancing human well-being. Key aspects include holistic systems thinking (understanding interdependencies), circularity (eliminating waste and regenerating natural systems), resilience (adapting to change), equity (fair distribution of resources and opportunities), and biodiversity (protecting and enhancing ecological health). Therefore, the regenerative economy seeks to create a system where

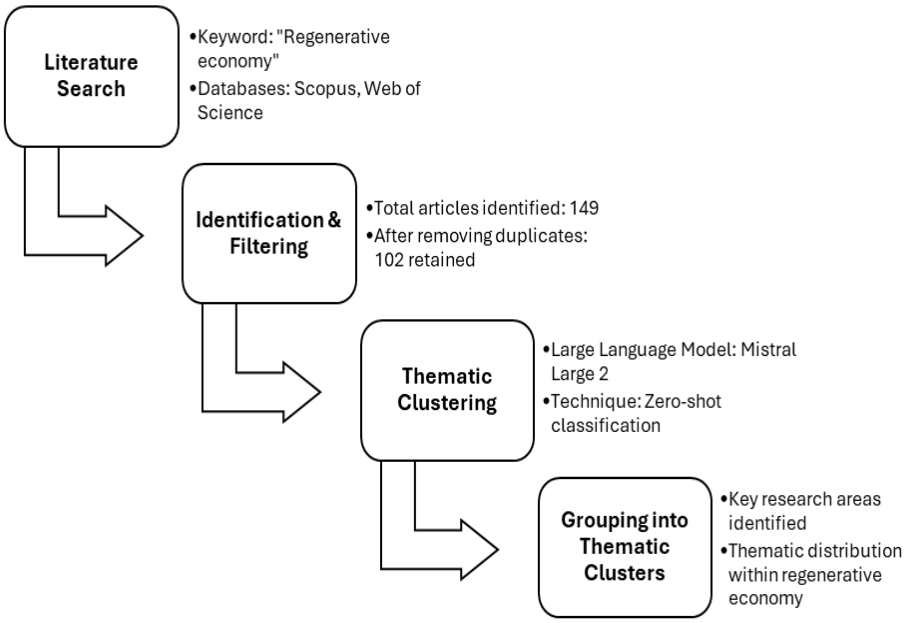
economic activities positively contribute to the world, generating abundance and prosperity for all. It fosters transformative innovations in business and governance, offering a comprehensive solution to contemporary challenges by combining sustainability, innovation, and resilience for a healthier and fairer future (i.e. Konietzko et al., 2023; Fath et al., 2019; Unter et al., 2024).

Nevertheless, existing knowledge relevant to the regenerative economy is dispersed and fragmented across various fields that are often researched independently. This fragmentation hinders a comprehensive understanding of the phenomena and challenges critical to its development. Therefore, this study undertakes an analysis and synthesis of these dispersed findings to facilitate deeper insights. Furthermore, by examining recent articles that directly address the regenerative economy, this study aims to enrich the existing knowledge base and provide a broader context for understanding its key aspects. The purpose of this study is to conduct a systematic review and clustering of the existing literature through the lens of the regenerative economy, demonstrating how it connects and complements previous approaches to offer integrated solutions to contemporary development challenges.

2. Methodology

This study conducts a systematic literature review aimed at providing a comprehensive synthesis of the theoretical foundations, practical applications, and interdisciplinary approaches that define and shape the field of regenerative economy. The following diagram outlines the key steps involved in the process of conducting the literature review.

Figure 1. Methodology applied



Source: Prepared by the authors

In the first step, a comprehensive search and article selection process was carried out. This review critically analysed regenerative economic practices by synthesizing 102 distinct articles indexed in Scopus and Web of Science. A search was conducted using the keyword "Regenerative economy" in titles, keywords, and abstracts. Initially, 149 articles were identified (69 from Scopus and 80 from Web of Science). After removing duplicates, 102 articles were retained for detailed analysis.

In the second step, the thematic structure of the identified articles was analysed. Of the 102 articles selected for detailed analysis, 84 were included in the thematic synthesis, while 18 were excluded due to the absence of author-provided keywords necessary for the analysis. This selective process ensured that the review concentrated on studies with clearly defined keywords, enabling a more accurate and comprehensive examination of regenerative economic practices. The goal was to uncover the underlying thematic clusters within the field of regenerative economy. To achieve this, a Large Language Model (LLM) called Mistral Large 2 was employed.[2] LLMs are advanced neural networks trained on massive datasets of text, capable of understanding and generating human-like text. The Mistral Large 2 large language model was utilized for a method called zero-shot classification, allowing predictions of categories not encountered during training by leveraging pre-trained language models and transfer learning. This method proved particularly useful for smaller datasets, which is often the case in emerging research fields (Gretz et al., 2023).

In the final step, the 84 scientific articles were grouped into distinct thematic clusters. This clustering process facilitated the identification of key research areas and provided insights into the thematic distribution within the field of regenerative economy. These clusters represent significant aspects of research within this emerging field and offer a structured overview of the current state of knowledge. Each cluster is characterized by shared themes and concepts, enabling a more nuanced understanding of diverse perspectives and approaches in the field. Given that some articles address different aspects of the same topic, certain articles were assigned to more than one cluster, depending on the specific focus of each thematic interpretation. This approach allowed for a more comprehensive representation of the articles' contributions, capturing the complexity of the subject matter and reflecting the interconnectedness of the various research dimensions

3. Results and Analysis

In accordance with the methodology described earlier, this chapter presents the analysed results and insights obtained in each research step.

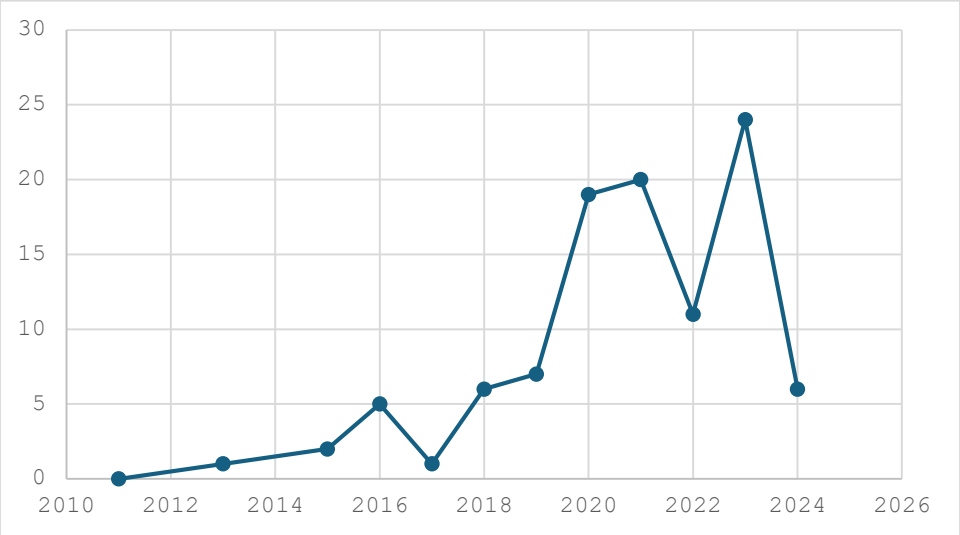
3.1. Trends in Research on Regenerative Economy

To examine the research trajectory of the regenerative economy, the yearly distribution of publications was analysed (see Figure 2). Although the relatively

[2] The model used in this study is available at https://mistral.ai/news/mistral-large-2407/ (accessed on September 24, 2024).

modest total number of publications reflects the early stage of this field within broader academic discourse, the noticeable rise in recent years signals growing interest and recognition of regenerative practices in economic research. This trend aligns with a broader academic shift towards sustainability, driven by heightened awareness of pressing economic, environmental, and social challenges. The increasing engagement with principles of regeneration underscores its relevance as a response to global issues such as resource depletion, environmental degradation, and social inequity.

Figure 2. Number of articles published per year



Source: Prepared by the authors

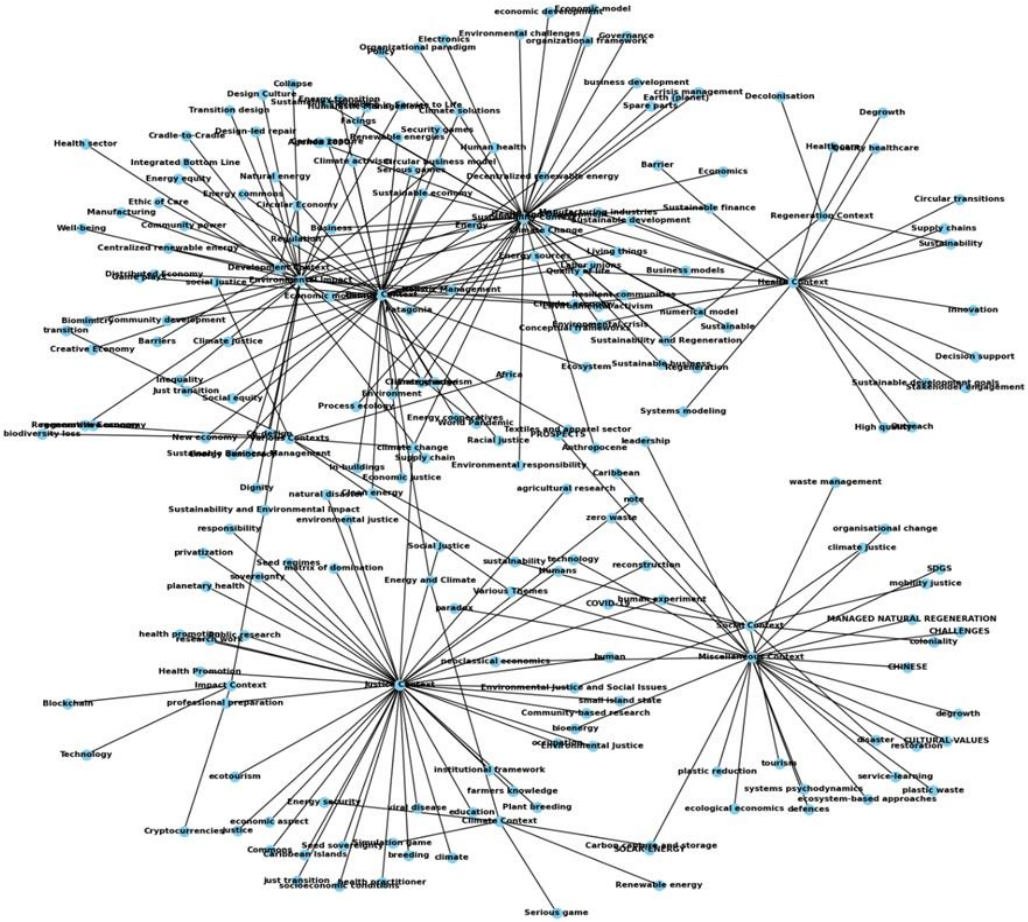
This surge in scholarly attention highlights the field's rising prominence and potential to address global challenges. Growing awareness of environmental and social issues has spurred more research into the regenerative economy, expanding its scope and significance. As the body of literature continues to grow, further diversification in research topics and methodologies is expected, offering scholars, policymakers, and practitioners new opportunities to develop innovative strategies for restoring and sustaining natural and social capital.

3.2. Clusters and Key Terms in Regenerative Economy Research

The analysis conducted using the LLM zero-shot classification method on 84 articles resulted in the categorization of author and index keywords into seven distinct clusters: Sustainability and Environmental Impact, Climate Change and Energy, Urban and Built Environment, Economic and Industrial Systems, Education and Social Impact, Technological Innovations and Systems, and Policy, Governance, and Standards. The interrelationships among these clusters are visually represented in Figure 3. This figure underscores the multifaceted nature of regenerative economy research, illustrating the interconnectedness of economic, technological, social, and

policy-related themes. By offering a holistic view of these clusters, the analysis highlights the complexity and interdisciplinary nature of pursuing a truly sustainable and regenerative economic system.

Figure 3. Keywords cluster graph



Source: Prepared by the authors

The identified clusters provide valuable insight into the thematic diversity and interdisciplinary scope of research in this field. Each cluster represents a core aspect of regenerative economy research, covering topics from economic models and frameworks to industry-specific applications and innovative technological solutions. In the table below, the key terms associated with each cluster are presented, offering a detailed overview of the main topics and keywords that define the different areas of study within regenerative economy.

Table1. Clusters and keywords

Clusters	Keywords
1. Sustainability and Environmental Impact	• **Regenerative economy**: regenerative economy, regenerative sustainability, regenerative design, regenerative development • **Circular Economy**: circular economy, circular business model, end of waste, industrial symbiosis, life-cycle thinking (LCT), material and energy flow analysis • **Sustainable Development Goals (SDGs)**: sustainability, sustainable development, sustainable business management, SDGs implementation • **Environmental Economics**: ecological economics, degrowth, green economy, ecological impact
2. Climate Change and Energy	• **Climate Adaptation and Mitigation**: climate change, resilience, retrofitting buildings, urban microclimate, climate action, energy transition • **Renewable Energy and Energy Systems**: solar energy, renewable energy, clean energy, energy booking, energy system sizing • **Green Technologies and Solutions**: green facades, green finance, green investment, energy savings, energy security
3. Urban and Built Environment	• **Urban Design and Infrastructure**: urban design, built environment, urban buildings resilience, urban farming • **Construction and Building Practices**: construction sites, building certification, wood frame construction, building performance simulation • **Waste Management and Recycling**: waste management, disaster waste, recycling, zero waste
4. Economic and Industrial Systems	• **Economic Models and Systems**: economic inclusion, monetary ecosystem, financial viability, economic transitions • **Industry-Specific Practices**: textiles and apparel sector, bio-industry, industrial ecology, manufacturing industries • **Business and Investment**: environmental projects, investment, business models, green finance
5. Education and Social Impact	• **Learning and Development**: education for sustainable development, problem-based learning, service-learning, transformative learning • **Social Equity and Justice**: social equity, climate justice, environmental justice, social justice • **Health and Wellbeing**: health and wellbeing, indoor environmental quality, thermal comfort, acoustic design
6. Technological Innovations and Systems	• **Information and Communication Technologies (ICT)**: artificial intelligence, big data, digital intelligence, ICT • **Tools and Simulation**: Ladybug Tools, GIS, modeling framework, simulation game • **Materials and Manufacturing**: supramolecular polymers, perovskite solar cells, natural dyes, materials innovations
7. Policy, Governance, and Standards	• **Regulation and Standardization**: standardization, regulation, best available techniques (BAT), integrated pollution prevention and control (IPPC) • **Governance and Policy**: governance, public policy, policy frameworks, environmental regulations

Source: Prepared by the authors

Based on the previously identified clusters and their corresponding keywords, the analysed articles were grouped and sub-grouped to highlight the most critical aspects of research in the field of the regenerative economy. This thematic organization, presented in Table 1, provides a structured framework for exploring the intersections of various dimensions and contributing factors that shape the regenerative economy.

The following chapter summarizes and analyses these themes in greater detail, emphasizing their implications for advancing both theoretical and practical knowledge in regenerative economy research. The analysis highlights the interdisciplinary nature of the studies, focusing on how the identified clusters address global challenges such as climate change, resource management, and social equity.

3.3. Grouping and Sub-Grouping of Key Themes

This chapter further elaborates on the key themes identified in the previous section, categorizing them into relevant subgroups for a more in-depth analysis.

3.3.1. Group 1: Sustainability and environmental impact

Sustainability and environmental impact constitute the foundational keystones in advancing a regenerative and responsible economy. Articles in this cluster broaden our understanding of how ecosystems, social well-being, and economic models intersect in a constantly evolving world. While traditional approaches once focused primarily on mitigating harm or reducing resource use, these works underscore the importance of going further—actively restoring and regenerating ecosystems, promoting circular flows of materials, and aligning economic activities with planetary limits. Multiple theoretical perspectives converge here, from examining how local communities can benefit from more equitable resource management to rethinking the global economic system's fundamental design principles. By exploring the underlying concepts of regenerative economy, circular economy, sustainable development goals (SDGs), and environmental economics, the cluster captures a holistic picture of how we might move from mere sustainability to genuine socio-ecological flourishing.

The Sustainability and Environmental Impact group represents the largest collection of articles in the research. This group is further composed of the following subgroups:

- 1A: Regenerative Economy
- 1B: Circular Economy
- 1C: Sustainable Development Goals (SDGs)
- 1D: Environmental Economics

Subgroup 1A: Regenerative Economy

Regenerative economy proposes an economic model that does not simply minimize harm but rather revitalizes ecosystems, communities, and social systems. Unlike business-as-usual approaches that emphasize limitless consumption and

distant markets, regenerative frameworks seek to realign production and exchange with local, place-based values, ensuring healthier interdependence between humans and the living world. As illustrated in diverse contexts—such as tourism, agriculture, and organizational leadership—regenerative economy can manifest through social entrepreneurship, restorative design processes, and not-for-profit business structures. These perspectives demonstrate a shared vision of an economy that nourishes cultural and biological diversity, prioritizes social equity, and maintains the carrying capacity of our planet. By spotlighting transformative experiences, new institutional arrangements, and innovative metrics, the articles below collectively argue for an "economics of harmony and quality"—one that moves from mere sustainability to active renewal, shared prosperity, and holistic well-being.

Within this group, Tomljenovic & Ateljevic (2017) explore concepts such as "restorative economics" and emphasize the role of transformative tourism and social entrepreneurs in shifting towards healthier local economies. Building on this, Daum (2019) investigates how denial and splitting mechanisms in mainstream businesses mask their damaging social and ecological impacts, advocating for the acknowledgment of these issues as a pathway to genuine regenerative practices and purposeful leadership. Hărmănescu et al. (2018) present activities from COST Action CA16114 "RESTORE," focusing on restorative design that regenerates local natural systems through adaptive urban methods and case studies tailored to various climate scenarios. Similarly, Walls & Vogel (2023) argue for a regenerative economy in Africa, driven by clean innovation, decentralized systems, and African values of horizontal collectivism to ensure sustainable growth amidst rapid economic and population changes.

Agricultural sustainability is addressed in da Silva et al. (2023), which examines different agricultural approaches and suggests that regenerative frameworks can harmonize ecological integrity with equitable food systems. Bellato & Pollock (2023) seek to refine the concept of regenerative tourism by advocating for place-based and community-centric approaches, critiquing the dominance of Western academic perspectives, and promoting plural knowledge systems aligned with regenerative principles.

Institutional initiatives are highlighted in Bexell et al. (2023), which chronicles the establishment of a Regenerative Future Centre at the University of Denver, advocating for holistic worldviews to tackle eco-anxiety, systemic inequities, and ecological destruction. The transformation of the tourism sector is further explored in Ateljevic (2020), linking post-COVID tourism transformations to regenerative approaches and emphasizing the role of transformative travel and regenerative agriculture in resetting global tourism systems.

In the hospitality industry, Inversini et al. (2024) investigate the evolution of hospitality beyond sustainability, introducing the concept of regenerative hospitality that leverages place and people intelligence as foundational elements for the future of travel. Sheldon (2022) challenges neoliberal assumptions by advocating for inclusive capital frameworks and positioning the regenerative economy alongside collaborative, circular, creative, and gift economies to mature the tourism sector.

Island economies are examined in Zisopoulos et al. (2023), which utilize flow-based and network-based indicators to analyse socio-economic metabolism, demonstrating how enhanced internal feedback loops and resilience can support regenerative reinvestment strategies that protect local resources. Additionally, emerging strategies in regenerative economies are suggested in Peia (2021), which, despite limited abstract data, likely focuses on system-changing approaches such as smallholder farming and water management in Mexico's rural communities.

Fair Trade initiatives are discussed in Kiessel (2022b), which calls for expanding Fair Trade beyond traditional sectors to integrate it within a broader movement towards justice and inclusivity in economic systems. The importance of non-profit models is emphasized in Hinton (2022), proposing that a not-for-profit market system can better align financial resource circulation with social benefits, thereby supporting regenerative sustainability ideals. Lastly, Fath et al. (2019) outline ten principles derived from network science and nonlinear dynamics to quantify and guide the regenerative vitality of economic networks, providing a robust toolkit for assessing systemic economic health.

Subgroup 1B: Circular Economy

Circular economy strategies emphasise closed-loop systems where products, components, and materials circulate for as long as possible, thereby minimising waste and environmental harm. In contrast to a linear "take-make-dispose" model, circular approaches seek to extend product lifespans, promote reuse and recycling, and align production processes with ecological principles. The articles in this subcluster delve into various facets of the circular economy—ranging from consumer awareness and digital re-commerce to hazardous waste management and seaweed-based nutrient recovery. Collectively, they illustrate how circularity can serve as a practical pathway to a more regenerative, low-impact economy.

Gonella et al. (2023) is included in this subgroup as it focuses on developing a measurement tool to assess public awareness of the circular economy. By gauging people's understanding, this study underscores the importance of awareness in fostering a more circular and regenerative economic system. Similarly, Stoenoiu & Jäntschi (2024) analyse circular economy indicators across multiple Eastern European nations, demonstrating how a shared focus on circular practices can drive sustainable economic progress at the national level.

Consumer behaviour is also a critical component addressed in Arman & Mark-Herbert (2021), which investigates the role of consumer-driven product resale on platforms like Facebook. This study illustrates how extending product life cycles through re-commerce can promote circular consumption behaviours, thereby reducing waste and enhancing resource efficiency. Additionally, Beamer et al. (2023) highlight the value of indigenous Hawaiian knowledge and ancestral circular economy principles. This research emphasises how these traditional practices can inform and guide universally applicable circular economy policies, particularly within diverse socio-cultural contexts.

Understanding the human dimension of circular transitions is further explored in Gonella et al. (2024), as this study examines how psychological barriers and social

influence impact individuals' adoption of circular economy strategies, shedding light on the behavioural factors that facilitate or hinder circular transitions. In the realm of industrial processes, Sevilla et al. (2022) focus on redesigning hazardous waste management systems to better align with circular principles. By reducing waste and enabling resource recovery, this research demonstrates practical applications of circular economy concepts in industrial settings.

Conceptual clarity is provided by Morseletto (2020), which critically examines the relationship between restoration, regeneration, and the circular economy. This study clarifies the conceptual underpinnings that inform core circular economy frameworks, ensuring a robust theoretical foundation for practical implementations. Lastly, Seghetta et al. (2016) showcase an innovative closed-loop solution through seaweed-based bio-extraction. This approach recovers and recycles nutrients, addressing eutrophication while supporting a regenerative circular economy model.

Subgroup 1C: Sustainable Development Goals (SDGs)

The SDGs represent a global roadmap for reconciling economic, environmental, and social objectives in ways that safeguard future generations. As nations and institutions grapple with climate change, resource depletion, and systemic inequalities, the SDGs provide frameworks to integrate multiple stakeholder needs—from preserving soil health to innovating new metrics that capture regenerative potential. Nevertheless, realising these goals often demands holistic, cross-sector approaches—bridging traditional divides between economics, ecology, and public policy. The works below illustrate this by examining theoretical tensions between reform and revolution, introducing inclusive metrics for environmental and social impact, and outlining nature-based pathways for land degradation neutrality.

Patterson (2011) delves into the debate on whether a restorative economy can be realised through incremental reforms or necessitates revolutionary changes. By bridging sustainable development paradigms with regenerative approaches, this study situates itself within the broader discourse on meeting the SDGs through either gradual or radical transformations, thereby contributing to the understanding of effective pathways for sustainable economic systems.

In Vineis & Mangone (2022), the focus is on developing more inclusive and comprehensive frameworks that encompass climate change, circularity, biodiversity, and health. This article argues for the alignment of new metrics with the SDGs, integrating scientific, economic, and technological perspectives to facilitate a truly regenerative economy. By proposing SDG-aligned metrics that consider climate impact and co-benefits, this study highlights the necessity of evolving measurement tools to better capture the multifaceted nature of sustainability in the Anthropocene era.

Keesstra et al. (2018) examines the integration of SDG-related targets on land use and water systems with regenerative economic practices. Utilizing systems thinking and nature-based solutions, this research explores how land degradation neutrality (LDN) and restoration can be achieved by 2030. By directly referencing the SDGs and emphasising soil-water system management, this study provides actionable insights into how regenerative frameworks can support the restoration and sustainable management of vital natural resources.

Subgroup 1D: Environmental Economics

Environmental economics provides a framework for understanding how economic systems interact with natural ecosystems—informing policies, valuation methods, and strategic decisions that can foster long-term ecological integrity. From applying cybernetics to reshape economic institutions toward regenerative pathways, to quantifying the social cost of carbon under deep uncertainty, this subcluster illuminates the economic tools and concepts necessary to steer away from extractive, growth-based paradigms. This subgroup encompasses studies that bridge the gap between traditional economic models and environmental considerations, emphasising sustainable resource use, carbon pricing, and the development of eco-centric economic frameworks. Additionally, it integrates emerging perspectives such as the "blue economy," highlighting how regenerative principles can be applied to marine-based production and coastal development. In the end, these articles suggest that robust environmental-economic analysis is essential for managing planetary limits, ensuring just transitions, and guiding the evolution of industries and communities toward genuinely sustainable futures.

Perkins & Jessup (2021) employ second-order cybernetics to reimagine economic institutions for a regenerative economy. By merging ecological and economic thinking, this study aligns with ecological economics and degrowth concepts, proposing innovative designs that foster sustainable and resilient economic systems. Similarly, Harbi et al. (2023) delves into the complexities of calculating the social cost of carbon amidst deep uncertainty and the pursuit of robust climate policies. This research links environmental impact with economic assessments, addressing critical aspects of carbon pricing and risk management within environmental economics.

The exploration of marine and ecological resource management is further developed in Nikitenko et al. (2022) as a Basis for Sustainable Development. This article examines the "blue economy" model, applying ecological principles to economic production and aligning with the focus of environmental economics on sustainable resource utilisation. It highlights the integration of agro-ecology and the concept of ecopolises, demonstrating how marine resources can be managed sustainably to support economic growth without compromising ecological integrity. Building on the blue economy framework, Auad & Fath (2022) propose ten nature-based principles for a regenerative blue economy. This study exemplifies the integration of socio-ecological dynamics into economic strategies, addressing the challenges and pathways necessary for developing a resilient and sustainable blue economy. By discussing regenerative and green economic frameworks, it underscores the importance of socio-ecological resilience in achieving long-term sustainability goals.

3.3.2. Group 2: Climate Change and Energy

The urgency of climate change compels societies worldwide to accelerate decarbonisation while reinforcing resilience in the face of increasingly unpredictable conditions. Many of the works in this cluster examine strategies that range from large-scale transitions—such as investing in renewable energy systems and

implementing energy booking frameworks—to localized interventions like green roofs, retrofitting buildings, and adjusting urban microclimates. By blending top-down policy measures with grassroots innovations, these studies demonstrate that sustainable energy solutions can also address social equity, economic growth, and environmental health. The articles in this cluster highlight that tackling climate change goes well beyond reducing carbon emissions; it requires rethinking how we produce, consume, and manage energy in ways that align with regenerative principles.

This group is further structured by the following subgroups:

- 2A: Climate Adaptation and Mitigation
- 2B: Renewable Energy and Energy Systems
- 2C: Green Technologies and Solutions

Subgroup 2A: Climate Adaptation and Mitigation

Climate change demands a twofold response—adapting built environments and societal frameworks to withstand escalating environmental stressors, while reducing or preventing further greenhouse gas emissions. Research in this subcluster underscores that resilience must be woven into the fabric of our buildings, infrastructure, and planning decisions, but not at the expense of long-term climate goals. Instead, these articles illustrate that climate-adaptive solutions often pair seamlessly with mitigation measures, whether through nature-based interventions, the optimisation of building energy performance, or holistic planning tools that consider future climate projections. In doing so, adaptation and mitigation operate in tandem: one addressing immediate concerns such as urban heat islands or extreme weather, and the other ensuring deeper structural changes for a carbon-neutral future. By examining multiple contexts—from tropical to Nordic climates and from densely populated cities to smaller communities—this subcluster illuminates the shared strategies and technologies that can guide us toward a more climate-resilient world.

Majumdar et al. (2023) link the concept of a "just transition" to nature-based solutions, highlighting how climate mitigation efforts in India can be both equitable and environmentally restorative. By focusing on climate justice and the transformation of energy systems, this study underscores the importance of integrating social equity with ecological sustainability in climate action plans. In Naboni et al. (2020), the research investigates how building facade properties can lower outdoor temperatures and reduce urban heat. This study demonstrates the localised mitigation potential of façade-level interventions, contributing to urban microclimate regulation and the overall reduction of mean radiant temperature in built environments. Cirrincione et al. (2021) analyse green roofs as a long-term climate adaptation tool. The study highlights how green roofs can lower building energy demand, improve indoor comfort, and mitigate heat island effects, thereby enhancing the resilience of urban buildings to climate change.

Mauree et al. (2019) provide a comprehensive review of assessment methods that integrate urban climate modelling, outdoor comfort, and energy systems. This article advocates for a more holistic approach to urban climate adaptation and

mitigation, summarising various tools and methods that support the development of effective strategies in urban settings. In Gremmelspacher et al. (2020), the focus is on how informed retrofit decisions under future climate projections can maintain residential comfort while contributing to emission-reduction goals. This study emphasises the importance of strategic retrofitting in enhancing the resilience of buildings and reducing their carbon footprint in the face of evolving climate conditions. De Luca et al. (2021) examine how the layout of tall buildings in Nordic settings can optimise both indoor and outdoor comfort. This research reflects climate-adaptive planning that not only enhances energy efficiency but also curbs energy use, demonstrating the potential of thoughtful urban design in mitigating climate impacts in cold climates.

Finally, Naboni et al. (2019) propose a digital workflow for regenerative urban design that accounts for climate change scenarios. By blending adaptation strategies, such as thermal comfort, with mitigation efforts focused on energy use, this study offers a quantifiable approach to integrating regenerative principles into urban planning, ensuring that cities can adapt to and mitigate the effects of climate change effectively.

Subgroup 2B: Renewable Energy and Energy Systems

In the face of escalating climate concerns, renewable energy sources and efficient energy systems have become essential for decarbonising economies and ensuring resilient, equitable growth. By broadening access to solar energy, internalising the true cost of carbon emissions, or fostering circular approaches to resource use, the articles in this subcluster highlight strategic innovations for an effective clean-energy transition. Based on diverse methodologies—from spatial analyses that prioritise underrepresented communities to accounting provisions that incentivise lower-carbon production—these works examine both technological and socio-economic dimensions of energy transformation. Together, they paint a picture of an evolving global landscape where policy, market forces, and scientific insights converge to redesign how we produce, distribute, and consume power. The basic goal is not simply to replace fossil fuels but to reimagine energy systems in ways that support sustainability, inclusivity, and long-term ecological balance.

Duguma et al. (2020) propose ecosystem-based, regenerative energy supply strategies tailored to the African context. This study emphasises the importance of leveraging natural ecosystems to produce bioenergy in a manner that supports ecological balance and sustainable development, aligning with the broader goals of a regenerative economy. By integrating bioenergy production with ecosystem conservation, the article highlights how renewable energy initiatives can simultaneously address energy needs and environmental preservation, fostering a harmonious relationship between economic growth and ecological integrity.

Schunder et al. (2020) investigate the spatial opportunities and socio-demographic factors influencing the adoption of rooftop and community solar energy systems. Utilising advanced tools such as LiDAR, this research illustrates how renewable energy access can be expanded to diverse populations by identifying optimal locations for solar installations. This article addresses both the technical and social dimensions of scaling solar power infrastructure, demonstrating how targeted

spatial planning and an understanding of socio-demographic dynamics can enhance the uptake of solar energy, thereby promoting broader access to clean energy and reducing reliance on fossil fuels.

In Valayer et al. (2019), a novel cost-accounting mechanism based on thermodynamics is proposed to expedite the shift from fossil fuels to cleaner energy sources. This study introduces a groundbreaking pathway for driving vigorous decarbonisation by providing a robust economic framework that accounts for the full energy costs associated with carbon avoidance. The article emphasises the necessity of integrating thermodynamic principles into energy accounting to create incentives for renewable energy adoption, thereby facilitating a more accurate and effective transition to a low-carbon economy.

Subgroup 2C: Green Technologies and Solutions

Green technologies and solutions play a pivotal role in driving the global economy toward reduced resource consumption and lower carbon emissions. By utilising informatics tools, digital intelligence, and circular manufacturing principles, businesses and policymakers are developing new methods to optimise material use and embed sustainability in product lifecycles. The articles in this subgroup highlight practical and financial levers—ranging from safer chemical selection in solar cell production to distributed manufacturing and green finance—to advance a regenerative economy that benefits both people and the planet. The following papers provide an indication of how technological innovation, economic inclusion, and circular strategies can converge to drive a greener, more resilient future.

Giri et al. (2022) demonstrate how natural language processing (NLP) can guide the environmentally conscious selection of solvents in solar cell manufacturing. By leveraging informatics-driven approaches, this study exemplifies a green chemistry innovation that not only optimises solvent use but also minimises the ecological footprint of solar cell production. The integration of NLP techniques with safer chemical practices highlights the potential of digital tools in advancing sustainable manufacturing processes, thereby contributing to more resilient and eco-friendly energy solution.

In Moreno and Charnley (2016), the research explores how re-distributed manufacturing, coupled with digital intelligence, can foster circular production models. This integrative literature review aligns with green solutions by reducing resource consumption and waste through decentralised manufacturing processes. By incorporating digital intelligence, such as automation and data analytics, the study illustrates how these technologies can enhance the efficiency and adaptability of production systems, supporting the principles of a circular economy and promoting sustainable industrial practices.

The study of van Niekerk (2024) highlights the vital role of green finance in bridging economic inclusion with resource regeneration. This study illustrates a financial pathway to cleaner and more sustainable economies by integrating economic inclusion initiatives with investments in regenerative projects. By aligning green finance strategies with the Sustainable Development Goals (SDGs), this paper

underscores the importance of financial mechanisms that support sustainable practices, thereby fostering economic opportunities while ensuring environmental stewardship. This alignment not only promotes social equity but also drives investments toward projects that regenerate natural resources and enhance ecological resilience.

Lastly, Lieder and Rashid (2016) propose a comprehensive framework for implementing circular economy practices within the manufacturing sector. This review foregrounds the transition to a regenerative economy through the adoption of green technologies and strategic methodologies. By providing a detailed roadmap for integrating circular principles into manufacturing processes, the paper facilitates the shift towards more sustainable and regenerative industrial practices. The study emphasises the importance of systemic changes, including resource optimisation, waste reduction, and the adoption of sustainable materials, to enhance both environmental sustainability and economic resilience within the manufacturing industry.

3.3.3. Group 3: Urban and Built Environment & Energy

Cities and buildings lie at the heart of both energy consumption and opportunities for sustainable innovation. Many of the works in this cluster take a holistic approach to the built environment, exploring how thoughtful urban design, resilient construction practices, and efficient energy systems can mitigate environmental impacts while enhancing liveability. From harnessing nature-based solutions (e.g., biophilic corridors, green roofs) to employing advanced simulation tools that optimise microclimates, these studies illustrate that well-planned urban settings can significantly reduce energy demand and foster climate resilience. At the same time, they show how reimagined building standards, retrofitting methods, and community-oriented infrastructure can directly influence energy transitions, cutting emissions and promoting healthier living spaces.

This group is further divided into the following subgroups:

- 3A: Urban Design and Infrastructure
- 3B: Construction and Building Practices
- 3C: Waste Management and Recycling
- 3D: Energy Integration in the Built Environment

Subgroup 3A. Urban Design and Infrastructure

Urban design and infrastructure profoundly shape the ecological footprint, liveability, and resilience of cities worldwide. In an era of rapid population growth and environmental shifts, innovative approaches—ranging from biophilic design and nature-based solutions to digital workflows—are essential for revitalising urban rivers, repurposing heritage structures, and planning for future climatic scenarios. These articles illustrate how thoughtful, evidence-based methodologies can enhance human well-being, reduce heat island effects, enable local food production, and systematically integrate buildings with surrounding ecosystems. By centring both social and environmental needs, urban planners and architects can create

neighbourhoods that adapt to and even thrive under changing conditions, ultimately moving beyond sustainability toward regenerative urbanism.

Blau et al. (2018) demonstrates how restoring an urban river culvert through nature-based and biophilic design can significantly improve city resilience. By incorporating natural elements and fostering a connection between urban infrastructure and the natural environment, this study underscores the profound impact that thoughtfully designed infrastructure can have on both ecological health and the well-being of city inhabitants. The restoration project in Albufeira serves as a model for how urban rivers can be revitalised to support biodiversity, enhance aesthetic value, and contribute to the overall sustainability of urban areas.

Matacz and Swiatek (2021) showcase the innovative repurposing of underground wartime air raid shelters for hydroponic farming. This study highlights the potential of integrated urban design to renew legacy structures for community benefit, exemplifying how historical infrastructure can be adapted to meet contemporary sustainability goals. By transforming unused underground spaces into productive agricultural sites, this research demonstrates a hallmark of regenerative urban design that promotes food security, reduces urban heat islands, and fosters community engagement through sustainable practices.

Andreucci et al. (2021) emphasises the capacity of biophilic urban design to enhance health and foster a strong sense of place among urban residents. This study links infrastructure decisions directly to both ecological and social outcomes, illustrating how the incorporation of natural elements into urban planning can lead to improved mental and physical health, increased social cohesion, and a heightened appreciation for the natural environment. By addressing the challenges and opportunities associated with biophilic design, this research provides valuable insights into creating urban spaces that are both aesthetically pleasing and functionally supportive of human well-being.

Naboni et al. (2019) propose a digital workflow for assessing regenerative performance at the urban scale, exemplifying how data-driven methods can inform innovative infrastructure solutions. This study illustrates the use of parametric urban design tools to evaluate factors such as microclimate and daylight exposure, enabling planners and designers to make informed decisions that enhance the regenerative potential of urban environments. By leveraging digital technologies, this research provides a quantifiable approach to integrating regenerative principles into urban planning, ensuring that infrastructure developments are both resilient and adaptive to climate change. Finally, Mauree et al. (2018) integrates future climate scenarios into campus-level energy and design strategies. This study highlights the importance of local microclimatic modelling in guiding resilient urban infrastructure development, demonstrating how predictive modelling can inform sustainable design choices that mitigate the impacts of climate change. By incorporating climate projections into the planning process, this framework ensures that urban designs are not only sustainable but also capable of adapting to evolving environmental conditions, thereby enhancing the long-term resilience and functionality of urban spaces.

Subgroup 3B: Construction and Building Practices

Construction and building practices lie at the nexus of environmental responsibility, technological innovation, and social well-being. While energy efficiency, resource optimisation, and low-impact materials have long been central to 'green building', a new paradigm—often termed 'regenerative' or 'circular'—aims to further restore and revitalise natural and social systems. This shift demands not only advanced techniques and materials but also holistic thinking that embraces stakeholder engagement, updated standards, and supportive governance mechanisms. This subgroup encompasses studies that explore both the macro-level transformation of neighbourhoods and the micro-level innovations in building practices, emphasising the integration of sustainability into every facet of construction and urban development.

Haselsteiner et al. (2021) examine the various factors that influence the implementation of regenerative principles in buildings and districts. This study emphasises how cultural mindsets, legislative frameworks, and financial incentives can either propel or hinder the transition toward more holistic and sustainable construction practices. By addressing both the drivers and barriers, this article provides valuable insights into the systemic changes required to foster a paradigm shift toward regenerative sustainability at both the neighbourhood and building levels.

In Quintana-Gallardo et al. (2021), the research focuses on the environmental performance of wood frame construction across different European contexts. This comparative study highlights the life cycle impacts (LCA) of wooden buildings, demonstrating how regenerative sustainability is embodied through sustainable material choices and construction practices. This research underscores the importance of selecting environmentally friendly building materials to reduce the ecological footprint of construction projects, thereby contributing to resource efficiency and the broader goals of environmental stewardship within the construction industry.

Subgroup 3C: Waste Management and Recycling

Waste management and recycling sit at the core of a truly regenerative and circular economy. Moving beyond disposal or one-off bans, the works in this subcluster stress the importance of designing closed-loop systems that minimise resource depletion, reduce pollution, and create new economic opportunities. From innovations in plastic-free business models to post-disaster deconstruction methods, these studies underscore how rethinking 'waste' as a valuable resource can support healthier societies and ecosystems. Moreover, they reveal how policy, social norms, and technological solutions intersect to drive systemic shifts in how materials are consumed and recirculated. This subgroup encompasses studies that explore diverse approaches to effective waste management, resource efficiency, and sustainability across various contexts.

Conlon (2023) investigates zero-waste entrepreneurship in India to demonstrate how plastic reduction efforts and circular economy strategies can significantly minimise waste and transition toward a regenerative model. This study emphasises

the importance of grassroots initiatives and entrepreneurial ventures in driving systemic changes in waste management, showcasing how innovative business models can contribute to reducing plastic pollution and fostering sustainable consumption pattern.

In Pradhananga & ElZomor (2023), the research highlights the role of deconstruction and circular principles in post-disaster scenarios. By focusing on the repurposing and recycling of materials after natural disasters, this study demonstrates how circular economy practices can reduce waste generation, enhance resource efficiency, and build resilience in reconstruction efforts. The adoption of these practices not only aids in sustainable recovery but also promotes long-term ecological and economic resilience within affected communities.

Sulis et al. (2021) highlight the environmental advantages of food donation over landfilling. This study illustrates a significant shift toward circular and regenerative outcomes in large-scale distribution centres by prioritising food donation as a waste prevention strategy. By diverting excess food from landfills and redistributing it to those in need, this research underscores the dual benefits of reducing waste and addressing food insecurity, thereby fostering a more sustainable and equitable food distribution system.

Additionally, van der Velden et al. (2023) explores the importance of independent repair services in reducing electronic waste. By promoting repair as a key waste-reduction strategy, this study bridges circular economy principles with regenerative practices, emphasising the need for accessible repair services, supportive business models, and appropriate regulations. The research highlights how extending the lifespan of electronic products through independent repair can significantly decrease waste generation and enhance resource efficiency, contributing to the overall goals of a circular and regenerative economy.

3.3.4 Group 4: Economic and Industrial Systems

Economic and industrial systems support the world's production, distribution, and consumption patterns and thus wield enormous influence over resource use, waste generation, and social well-being. The articles in this group examine how to reshape these systems through regenerative economic frameworks, industrial ecology, and more inclusive business models, thereby addressing the escalating demands on finite natural resources. By integrating ecological thinking into economic analysis, organisations can move beyond a profit-at-all-costs paradigm to one that balances financial viability with long-term sustainability and social equity. Beyond theory, these studies also offer case-specific insights—whether in textiles, bio-based industries, or manufacturing—on how to reduce environmental footprints, close material loops, and craft equitable economic opportunities. In doing so, they offer a glimpse of what a fundamentally reimagined economic and industrial landscape might look like, one that is more resilient, innovative, and mindful of the planet's boundaries.

This group is divided into the following subgroups:

- 4A: Economic Models and Systems

- 4B: Industry-Specific Practices
- 4C: Business and Investment

Subgroup 4A: Economic Models and Systems

Economic models and systems define the structural rules by which value is created, exchanged, and distributed—shaping everything from social welfare to environmental outcomes. This subgroup investigates theoretical and practical frameworks that challenge conventional approaches, especially those that maintain inequality, ecological harm, or a single-minded pursuit of profit. From reimagining monetary systems rooted in ecological principles to developing community-driven business models within forest economies, these studies demonstrate how emerging paradigms like regenerative finance can reinvigorate the governance of resources, rebalance power, and ensure more equitable and sustainable development. This subgroup encompasses studies that explore innovative economic theories, sustainable business models, and cutting-edge financial technologies, all aimed at fostering economic systems that support environmental integrity, social equity, and long-term resilience.

Alves et al. (2022) propose an ecological theory of money that fundamentally rethinks monetary design as a critical missing link in steering economies toward sustainability and regeneration. This study explores alternative monetary frameworks that integrate ecological principles, emphasising the need for a monetary ecosystem that supports regenerative outcomes. By challenging conventional monetary systems, the article highlights the potential for ecological monetary designs to facilitate economic transitions that are both sustainable and restorative, thereby aligning financial practices with environmental goals. Schletz et al. (2023) explore the transformative potential of blockchain technology, decentralised governance, and digital Monitoring, Reporting, and Verification (MRV) tools in driving "Regenerative Finance." This study examines how these technologies can reshape the governance of global commons and redefine economic paradigms to support regenerative practices. By leveraging blockchain's transparency and decentralisation, the authors highlight innovative financial mechanisms that enhance accountability, facilitate sustainable investments, and promote equitable resource distribution. This research positions blockchain as a key enabler of financial systems that are both resilient and aligned with regenerative principles, offering new pathways for managing and regenerating shared resources.

Harbi et al. (2023) focus on small forest enterprises utilising non-timber forest products (NTFPs) to optimise natural capital. This study demonstrates a locally adaptable regenerative business model that enhances financial viability while promoting the sustainable use of forest resources. By examining the economic transitions in rural forest contexts, the research underscores the importance of community-based enterprises in fostering economic resilience and environmental stewardship. The findings illustrate how NTFP-based businesses can serve as viable models for sustainable economic development, balancing profitability with ecological preservation.

Subgroup 4B: Industry-Specific Practices

Industry-specific practices reveal how regenerative and circular principles can be tailored to address the particular resource needs, waste streams, and market demands of individual sectors. Whether by transitioning from synthetic to natural dyes in the textiles and fashion industry or by designing manufacturing systems that facilitate remanufacturing and reuse, these articles demonstrate the granular, practical measures that companies and supply chains can adopt. By illustrating how environmental, social, and economic considerations align in distinct contexts—from fashion's dye variability to the complexity of metal recycling—these studies collectively highlight the creativity and collaboration required to achieve a net-positive impact at scale.

Doty et al. (2024) examine the practical and cultural factors behind the use of natural dyes in the U.S. fashion industry. This study illuminates the challenges and opportunities that arise when embracing environmentally responsible colourants, addressing both the technical aspects of natural dye application and the cultural shifts required within the fashion sector. By focusing on textiles and natural dyes, the authors highlight the industry's potential to transition towards more regenerative and circular dyeing practices, reducing reliance on synthetic chemicals and minimising ecological footprints.

Salatino et al. (2023) adopt an industrial ecology perspective to demonstrate how remanufacturing and recycling can transform chemical engineering processes. This study emphasises the reduction of material demand and the support of a regenerative economy through the integration of circular economy principles within industrial systems. By highlighting remanufacturing within industrial ecology frameworks, the authors show how chemical engineering can evolve to minimise waste, optimise resource use, and contribute to sustainable industrial practices that align with regenerative economic goals.

Lieder and Rashid (2016) propose a robust framework for adopting circular economy approaches within the manufacturing sector. This comprehensive review bridges the gaps between resource scarcity, waste generation, and economic viability, providing actionable strategies for manufacturing industries to implement circular principles effectively. By addressing the specific challenges faced by the manufacturing sector, the article facilitates the transition to a regenerative economy through enhanced resource management, waste reduction, and the adoption of sustainable production practices that ensure long-term environmental and economic sustainability.

Finally, Daňo et al. (2020) demonstrate how Slovakia's textiles and apparel industry can integrate circular business models. This study reflects the broader shift toward a regenerative economy by showcasing innovative product and process designs that enhance resource efficiency and reduce waste within the apparel sector. By focusing on industry-specific circular economy solutions, the article underlines the potential for the textiles and apparel industry to adopt sustainable practices that not only minimise environmental impact but also drive economic growth through innovative and resilient business models.

Subgroup 4C: Business and Investment

Business and investment strategies play a vital role in driving the transition to a regenerative economy. By aligning financial mechanisms with social and environmental objectives—rather than focusing solely on short-term returns—companies and policymakers can create models that incentivise sustainable resource use, economic inclusion, and long-term ecological health. The articles in this subcluster illustrate how green finance tools, thoughtful funding structures, and collaborative approaches to resource management can simultaneously preserve natural capital and meet human needs. They emphasise the importance of designing financial incentives, channels, and partnerships capable of accelerating global movements towards environmental stewardship and responsible economic growth.

Van Niekerk (2024) demonstrates how green finance can bridge the gap between economic inclusion and environmental preservation. This study highlights that investments aligned with the Sustainable Development Goals (SDGs) not only reduce resource depletion but also promote equitable development. By connecting inclusive business approaches with green investing, the author underscores the potential of financial mechanisms to support projects that are both economically viable and environmentally sustainable, thereby fostering a more inclusive and resilient economic landscape.

Gabriela-Cornelia et al. (2014) propose strategic funding methods for regenerative economic activities. This study emphasises how carefully orchestrated financial flows can ensure the long-term preservation of natural resources while meeting human needs prudently. By focusing on investment strategies and financing for circular economy (CE) projects, the authors provide both theoretical frameworks and practical solutions for mobilising capital towards sustainable and regenerative initiatives.

Schletz et al. (2023) explore the transformative potential of blockchain technology, decentralised governance, and digital Monitoring, Reporting, and Verification (MRV) tools in driving "Regenerative Finance." This study examines how these technologies can reshape the governance of global commons and redefine economic paradigms to support regenerative practices. By leveraging blockchain's transparency and decentralisation, the authors highlight innovative mechanisms that enhance accountability and promote sustainable investments, contributing to long-term ecological and economic resilience.

3.3.5. Group 5: Education and Social Impact

Education and social impact are closely intertwined, as learning environments and community dynamics directly influence people's ability to engage with sustainability and regenerative principles. The works in this cluster highlight how transformative approaches, such as problem-based learning, stakeholder-inclusive governance, and human-centric organisational management, can catalyse both individual behaviour change and broader systemic shifts. By emphasising participatory methods, values-based leadership, and attention to well-being, these studies underscore the power of education to build more equitable, inclusive, and supportive communities. Beyond formal classrooms, the social impact dimension emerges in contexts ranging from

corporate transformations to web-based collaborations outside traditional learning settings.

This group is further divided into the following subgroups:

- 5A: Learning and Development
- 5B: Social Equity and Justice
- 5C: Health and Wellbeing

Subroup 5A: Learning and Development

Learning and development initiatives are pivotal for cultivating the skills, mindsets, and collaborative methods needed to realise regenerative economic and social systems. In higher education, stakeholder prioritisation exercises, digital transformation strategies, and problem-based learning methods can stimulate deeper engagement with sustainability challenges—ranging from mental health and social equity to decarbonisation. Simultaneously, emerging leadership and HR paradigms underscore the importance of prioritising human well-being and ethical reasoning within digital-age organisations. Collectively, these studies illustrate how educational and human-resource reforms can empower future leaders and practitioners to reconcile economic imperatives with holistic, regenerative goals.

Osorio et al. (2024) present a strategic approach to organisational learning and governance. This study introduces a methodology for prioritising stakeholders within the framework of digital transformation and sustainable corporate governance, particularly in the context of Industry 5.0. By emphasising stakeholder engagement and strategic prioritisation, the authors demonstrate how organisations can align their learning and governance structures with sustainability goals, enhancing their capacity to adopt regenerative practices and navigate the complexities of digital and sustainable transformations. Similarly, Cherep et al. (2022) delve into the dynamics of organisational transformation from a learning and human resources (HR) perspective. Their research examines how digital advancements necessitate significant changes in management practices and HR strategies, highlighting the role of continuous learning and adaptability in fostering organisational resilience. This study stresses the importance of cultivating a culture of transformative learning and development to enable organisations to leverage digital tools effectively while maintaining a commitment to sustainability and regeneration.

Sonetti et al. (2019) focus on how universities can embed regenerative principles into their teaching and curricula. This study explores the integration of education for sustainable development (ESD) and transformative learning methodologies within higher education institutions to advance the United Nations Sustainable Development Goals (SDGs). Similarly, Friedrich (2019a) investigates innovative educational methods tailored to sustainability contexts. This study evaluates the effectiveness of peer review processes as a cooperative, web-based learning method, incorporating problem-based learning, role play, and self-study techniques.

Subgroup 5B. Social Equity and Justice

Social equity and justice lie at the heart of creating truly inclusive, resilient, and regenerative societies. Beyond merely reducing environmental harm, the works in this subcluster stress that economic and ecological well-being must be pursued alongside cultural respect, community empowerment, and structural fairness. Whether through co-creating centres for a regenerative future, integrating Indigenous knowledge into circular economy policy, or re-centring Fair Trade principles within broader social movements, these articles highlight the importance of prioritising people and relationships. This approach ensures that the benefits of regenerative efforts uplift everyone, not just a privileged few, and moves us from mechanistic, profit-driven paradigms towards holistic frameworks that honour both local contexts and global responsibilities.

Bexell et al. (2023) chronicle the establishment of a Regenerative Future Centre at the University of Denver. This study illustrates how commitments to social and ecological justice can galvanise university communities towards more equitable and holistic development. By advocating for holistic worldviews, the article underscores the role of educational institutions in addressing eco-anxiety, systemic inequities, and ecological destruction. Similarly, Beamer et al. (2023) examine how Hawaiian ancestral circular economy principles illuminate social and cultural dimensions often absent from mainstream circular economy discussions. This research advances Indigenous economic justice by emphasising the integration of traditional knowledge and cultural values into modern economic practices, thereby promoting a more inclusive and just regenerative economy.

Kiessel (2022a) explores how Fair Trade, once a cornerstone of alternative economics, can reengage the next generation by aligning with other social justice movements. This study demonstrates that Fair Trade can contribute to a just, inclusive, and regenerative economy by integrating its principles with broader social justice initiatives. This alignment fosters a more resilient and equitable economic system, benefiting marginalised communities while supporting environmental goals.

Subgroup 5C: Health and Wellbeing

This subgroup explores how regenerative economic practices and sustainable design can enhance human health, well-being, and overall quality of life. It encompasses studies investigating the interplay between the built environment, ecosystem restoration, workplace health initiatives, and broader economic models aimed at fostering a healthier and more resilient society. By integrating insights from architecture, ecology, organisational management, and economic theory, the Health and Wellbeing subgroup highlights the essential role of sustainability in promoting holistic human and environmental health.

Alba-Patiño et al. (2021) employ the ecosystem service framework to link farming activities with ecosystem restoration within the context of a circular economy. Focusing on semi-arid Mediterranean landscapes, this research uses social sampling to assess how almond tree restoration influences perceptions and preferences for ecosystem services. The study reveals that ecosystem restoration enhances service diversity, such as local identity and erosion control, and translates

social and cultural benefits into measurable indicators of human well-being, including improved health and access to goods. The authors advocate for the inclusion of social indicators in ecosystem restoration policies, emphasising their critical role in achieving circular economy transitions and addressing challenges outlined in the UN Decade on Ecosystem Restoration.

Görgenyi-Hegyes et al. (2021) investigate the relationship between health-related work benefits and employee well-being, satisfaction, and loyalty during the COVID-19 pandemic. Through a large-scale survey of 537 employees, this study examines how internal factors like mental and emotional health and external factors such as healthcare support influence workplace well-being. The findings reveal that while internal factors significantly impact well-being, employer-provided healthcare support plays a crucial role in enhancing employee satisfaction and loyalty.

Kristín Vala Ragnarsdóttir (2024) introduces the concept of the Regenerative Wellbeing Economy (RWE), which designs economic systems based on nature's principles, prioritising human well-being, environmental sustainability, and social equity. This concept challenges neoliberal economic frameworks by advocating for circular economy practices, recognition of natural capital, and the promotion of social and environmental justice. The study outlines eight guiding principles for the RWE, including maintaining a right relationship with nature, fostering innovative and adaptive systems, and emphasising community and place. The study argues that achieving the RWE requires fundamental transformations in economic systems, governance, and policy-making, supported by technological innovation and social mobilisation. By aligning economic activities with regenerative and equitable objectives, the RWE seeks to create a more just and sustainable society, addressing the shortcomings of current economic models exposed by the COVID-19 pandemic.

Torresin et al. (2020) address the evolving focus of the building industry on creating environments that not only meet basic standards of acceptability but also actively support task performance and enhance individuals' health and well-being. By using a thematic analysis of expert interviews, this study investigates indoor soundscapes, emphasising the importance of perceptual and multisensory approaches in designing buildings that positively impact occupants.

3.3.6. Group 6: Technological Innovations and Systems

Technological innovations and systems serve as crucial enablers for advancing sustainability and regenerative practices across multiple sectors. 1 By combining data-driven tools, digital intelligence, and novel materials, these solutions optimise resource use and redesign production processes for minimal environmental impact. In many cases, technology acts as a bridge between theory and action, turning concepts like circularity or regenerative design into tangible outcomes, whether through real-time monitoring, simulation-assisted planning, or new manufacturing methods. 2 These innovations also help empower decentralised approaches, allowing local stakeholders, SMEs, and large organisations alike to collaborate effectively.

This group is further divided into the following subgroups:

- 6A: Information and Communication Technologies (ICT)

- 6B: Tools and Simulation
- 6C: Materials and Manufacturing

Subgroup 6A: Information and Communication Technologies (ICT)

Information and Communication Technologies (ICT) are pivotal in driving the transition towards a regenerative economy by enabling more efficient, transparent, and inclusive systems of production and consumption. By integrating digital intelligence, artificial intelligence (AI), and innovative manufacturing processes, ICT facilitates the optimization of resource use, enhances decision-making, and fosters collaborative environments that support circular and regenerative practices. This subcluster explores how redistributed manufacturing models and human-centric design tools, powered by advanced ICT solutions, can revolutionize industries, promote sustainability, and enhance human well-being. The articles below highlight the transformative potential of ICT in creating resilient and regenerative economic systems, addressing both technological advancements and their socio-economic implications.

Moreno and Charnley (2016) conduct an integrative literature review to explore the concept of re-distributed manufacturing and its potential to deliver more regenerative and resilient systems of production and consumption through circular innovation. The study identifies multiple similarities between the drivers of re-distributed and circular models of production and consumption, emphasising how digital intelligence can foster these similarities. By developing a set of criteria for re-distributed manufacturing and circular innovation, this study analyses 33 existing case studies of consumer goods production, identifying three types of re-distributed manufacturing that integrate circular innovation characteristics.

Sonetti et al. (2018) aim to determine whether technologies and artificial intelligence (AI) can create systems that enhance the relationship between buildings and their inhabitants. The findings suggest that integrating ICT data can inform the design of spaces and smart systems that align with actual user needs, promoting regenerative design practices that consider technological, psychological, cognitive, cultural, social, political, and aesthetic impacts.

Hernández-Chover et al. (2024) examine the application of artificial intelligence (AI) methodologies in the wastewater sector to support the circular economy. The study highlights the potential of machine learning (ML) to project economic scenarios based on variables such as the quality and quantity of treated flows, resource generation, current demands, and substitute goods prices. By guiding the supply and demand of resources generated in wastewater treatment plants, the article demonstrates how AI can enhance resource efficiency and sustainability in urban water cycles.

Marinakis et al. (2021) explore the role of AI and data democratisation in intelligent energy management within the energy sector. Despite the prevalence of technology-intensive organisations, the study identifies a gap in corporate know-how and workforce skills necessary for successful AI service rollouts. The research emphasises the need for inclusive data and analytics processes to empower non-

expert end-users, thereby enhancing intelligent energy management and promoting sustainable energy practices.

Mlynar et al. (2022) critique the current technology-oriented and market-led development mechanisms of AI technologies, advocating for a more human-centred approach. Focusing on urbanism, this study conducts interviews with 16 urban experts to elicit their imaginaries of how AI can and should impact future cities. By integrating discursive standpoints from social sciences, the study aims to align AI development with societal needs and challenges, fostering intelligent systems that contribute to the creation of just, sustainable, and resilient future cities.

Subgroup 6B: Tools and Simulation

Tools and simulations are indispensable in the advancement of a regenerative economy, providing the necessary frameworks and methodologies to design, assess, and optimise sustainable systems. By leveraging advanced simulation software, process modelling, and analytical tools, stakeholders can predict outcomes, enhance resource efficiency, and mitigate environmental impacts before implementation. This subcluster explores how innovative tools and simulation techniques contribute to the circularity and resilience of industrial processes, urban design, and waste management. Through case studies and methodological advancements, these articles demonstrate the critical role of technological solutions in transforming traditional linear models into regenerative, closed-loop systems that support long-term ecological and economic health.

Sonetti et al. (2018) explore the underappreciated role of building facades in mitigating local climate impacts, specifically focusing on the Urban Heat Island (UHI) phenomenon. This study assesses how facade properties, such as window-to-wall ratios and surface finishes like reflectivity and emissivity, influence outdoor temperature ranges. Utilising a simulation workflow with Ladybug Tools, the research models urban canyons in three distinct climate types—temperate warm, temperate cold, and tropical arid.

Preut et al. (2021) delve into the application of digital twins in facilitating the circular economy within product and supply chain management. Digital twins, as digital replicas of physical assets, enable accurate information flow necessary for the effective circulation of materials and products. The research presents a derived and validated definition of digital twins, followed by a stakeholder analysis that outlines the potentials and information requirements for circular supply chains. Additionally, Núñez-Cacho Utrilla et al. (2020) address the integration of Circular Economy (CE) principles within the construction industry. The study introduces a CE-dashboard designed to measure key performance indicators (KPIs) related to circular practices in construction companies. Utilising a Monte Carlo simulation technique, the article assesses the probability of achieving sustainable CE metrics based on KPIs from a leading Spanish construction company.

Charnley et al. (2019) investigate the application of simulation techniques informed by Industry 4.0 and the Internet of Things (IoT) to accelerate circular economy practices in the UK manufacturing sector. The study maps and simulates a remanufacturing process using discrete event simulation to illustrate decision-

making at the shop-floor level. Through interviews and system dynamics modelling, the research develops the concept of Certainty of Product Quality which assesses product conditions to optimise remanufacturing decisions. This simulation-based approach highlights the potential of data-driven methodologies to inform optimal circular economy strategies and intervention timings within product lifecycles.

Subgroup 6C: Materials and Manufacturing

Materials and manufacturing are foundational pillars in the pursuit of a regenerative economy, driving innovations that enhance sustainability, reduce environmental impact, and promote circularity. This subgroup delves into cutting-edge research and practical applications that transform traditional manufacturing processes into eco-friendly, resource-efficient systems. By leveraging informatics, sustainable sourcing, advanced polymer technologies, and waste valorisation, these studies illustrate how industries can move beyond linear models of production and consumption. The focus is on developing safer, biodegradable, and renewable materials, as well as optimising manufacturing practices to align with regenerative principles.

Giri et al. (2022) demonstrate the application of natural language processing (NLP) in guiding the environmentally conscious selection of chemicals used in solar cell manufacturing. This study leverages data-driven approaches to optimise solvent choices, promoting safer and more sustainable material selections.

Guillouzo and Carpentier (2022) showcase the development of plant-based pigments as sustainable alternatives to synthetic dyes in the cosmetics industry. This study highlights innovation in natural material sourcing and green manufacturing processes, emphasising the shift towards regenerative practices in cosmetic formulation. The article illustrates how leveraging renewable plant-based resources can reduce reliance on harmful synthetic chemicals, thereby enhancing the sustainability and environmental friendliness of cosmetic products.

Wang et al. (2024) explore the creation of ultra-tough, recyclable supramolecular polymers that balance mechanical performance with sustainability. This study emphasises advancements in polymer science, focusing on the design of materials that are both highly durable and capable of being recycled multiple times. By developing recyclable and healable materials, the research contributes to the reduction of plastic waste.

Belviso et al. (2020) examine the incorporation of industrial waste (red mud) into the synthesis of zeolite LTA. This study illustrates innovative waste valorisation techniques that contribute to material circularity and reduce landfill dependency. By utilising red mud, a byproduct of the aluminium industry, the article demonstrates how industrial waste can be transformed into valuable materials, enhancing resource efficiency and promoting sustainable manufacturing processes.

3.3.7. Group 7. Policy, Governance, and Standards

Policy, governance, and standards sit at the intersection of collective decision-making and practical implementation of sustainability and regenerative principles. Effective regulation and standardisation can steer industries away from business-as-

usual models and towards more responsible, transparent, and innovative practices. Beyond formal rules, governance frameworks enable collaboration among governments, communities, and private entities, ensuring that diverse interests converge around shared ecological and societal goals. Standards not only set the benchmarks for quality and compliance but also foster early market alignment, reducing uncertainty and driving investments in greener, more regenerative technologies. The articles in this group illustrate how well-designed policies and robust governance structures are essential to transforming concepts like circularity and regenerative development into real-world impact.

This group is further divided into the following subgroups:

- 7A: Regulation and Standardization
- 7B: Governance and Policy

Subgroup 7A: Regulation and Standardization)

Regulation and standardisation are fundamental components in the advancement of a regenerative economy, providing the necessary frameworks and guidelines to ensure that sustainable practices are systematically adopted across various industries and regions. Effective regulatory policies and standardised protocols not only facilitate the integration of circular economy principles but also promote environmental stewardship, social equity, and economic resilience. By establishing clear benchmarks and incentives, governments and institutions can drive innovation, reduce environmental impacts, and create a level playing field that encourages all stakeholders to participate in regenerative initiatives. This subgroup explores how strategic regional planning, early standardisation, and integrated governance models contribute to the preservation of natural resources, the internalisation of environmental costs, and the fostering of sustainable industrial practices. The following articles illustrate the critical role that regulation and standardisation play in shaping policies, enhancing market dynamics, and enabling the transition towards a more equitable and sustainable economic system.

Frank and Marsden (2016) investigate the integration of statutory regional planning with multi-level governance frameworks to embed ecological sustainability and circular economy principles into regional development. This study explores how coordinated governance structures can foster sustainable urban forms by aligning spatial planning with regenerative practices. The article emphasises the role of regional spatial planning as a strategic tool for achieving sustainability goals, highlighting the importance of collaborative governance in addressing complex environmental challenges. By examining case studies and governance models, this research underscores how regulatory frameworks can facilitate the incorporation of circular economy principles into regional development plans.

Gabriela-Cornelia et al. (2014) delve into the strategic funding and regulatory approaches necessary for the effective implementation of circular economy (CE) practices. Although this document is also relevant to the Business and Investment subgroup, its focus on environmental projects and policy aspects makes it a fitting inclusion in the Regulation and Standardization subgroup. The article explores the

need for robust financial mechanisms and institutional frameworks that support the regeneration of environmental resources. The study emphasises how strategic funding, combined with supportive regulatory policies, can drive the adoption of CE practices across industries. By addressing both theoretical and practical dimensions, this research provides a comprehensive overview of how regulations and financial strategies can synergistically promote the preservation of natural resources within a regenerative economy framework.

Friedrich (2019b) analyses the economic impacts of early standardisation in the biobased materials sector. This study demonstrates how regulatory standards can enhance environmental quality, stimulate market demand, and support sustainable industry growth. The article conducts a descriptive policy analysis to explore how early standardisation efforts can shape emerging sectors, particularly focusing on the bio-industry. The research highlights the role of normative market regulations in creating a level playing field, ensuring product quality, and fostering consumer trust. This study underscores the importance of proactive standardisation in guiding the growth of environmentally friendly industries, thereby contributing to the broader goals of a regenerative economy.

Subgroup 7B: Governance and Policy

Effective governance and robust policy frameworks are essential for steering societies and economies towards sustainability and regeneration. In the context of a regenerative economy, governance encompasses the structures, rules, and processes that facilitate coordinated action among diverse stakeholders, ensuring that economic activities align with environmental and social objectives. This subgroup investigates the intersection of governance, policy-making, and sustainable development, highlighting how strategic planning, stakeholder engagement, and adaptive management can drive systemic change. By examining case studies and theoretical frameworks, the articles within this subcluster demonstrate the pivotal role that informed governance and progressive policies play in overcoming barriers, fostering innovation, and promoting equitable resource distribution. These insights are crucial for policymakers, organisational leaders, and community planners aiming to implement regenerative practices that are both effective and inclusive.

Osorio et al. (2024) present a pragmatic qualitative methodology for identifying, prioritising, and consulting stakeholder groups within a higher education institution (HEI) undergoing digital transformation and adapting to Society 5.0. This study emphasises the importance of stakeholder engagement in aligning organisational actions with the Sustainable Development Goals (SDGs). The research highlights how this methodology can lead to improved strategic alignment, enhanced reputation, risk mitigation, and the consolidation of long-term trustworthy relationships.

Cherep et al. (2022) explore the significant shifts required in organisational management and human resources (HR) to adopt a humanistic and adaptive approach in the digital era. This study explores how Information and Communication Technologies (ICT) influence global transformations in HR management, advocating for an anthropocratic model that prioritises people, relationships, and empowerment over traditional bureaucratic structures.

Li et al. (2020) investigate the impact of green technology innovation policies on marine enterprises in China. Utilising Ordinary Least Squares regression analysis based on surveys from enterprises in major regions like Beijing, Guangzhou, Wuhan, and Jinan, this study finds that voluntary agreement tools significantly enhance the environmental performance of green technology innovations. In contrast, other policy instruments do not show a significant effect on the benefits of green technology innovation. This study underscores the need for targeted policy instruments to effectively support green innovations in specific industries, thereby contributing to the broader goals of a regenerative economy.

Meckling et al. (2017) examine the strategic sequencing of policies aimed at decarbonising energy systems. This study critiques the traditional reliance on carbon pricing mechanisms, such as carbon taxes and cap-and-trade systems, and explores how green innovation and industrial policies can complement these approaches. The article analyses the policy pathways of low-carbon leaders like California and the European Union (EU), highlighting how these regions have built support for decarbonisation by fostering economic interest groups and reducing technology costs. This research emphasises the critical role of strategic policy sequencing in overcoming political and economic barriers, ensuring the effectiveness of decarbonisation initiatives, and advancing the transition to a low-carbon economy.

Walravens and Ballon (2017) address the challenges cities face in adopting the "Smart City" concept. Based on a comprehensive value network analysis of 37 international Smart City services conducted in a doctoral study, this research formulates a set of policy recommendations. These recommendations culminate in the development of a new methodological tool that local governments can use to establish their Smart City principles and priorities.

4. Conclusion

This comprehensive analysis underscores the imperative for a paradigm shift towards a regenerative economy to effectively address the multifaceted and interconnected global challenges of our time. The systematic literature review, encompassing 84 scholarly articles, reveals that the regenerative economy framework successfully amalgamates the strengths of the green, circular, and bioeconomy paradigms while addressing their inherent limitations. The identification of seven primary clusters and 21 subgroups illustrates the diverse and interdisciplinary nature of regenerative economy research, encompassing environmental sustainability, climate resilience, urban planning, economic systems, social equity, technological innovation, and governance.

Key insights from the study emphasise the critical role of integrated governance and policy frameworks in embedding sustainability and circularity into regional and industrial development. The findings also highlight the importance of stakeholder engagement, transformative organisational practices, and innovative technological solutions in fostering a resilient and regenerative economic system. Moreover, the analysis reveals that effective regulation and standardisation, coupled with strategic

policy sequencing, are essential for driving green innovation and ensuring the long-term viability of sustainable practices across various sectors.

The study's methodological approach, leveraging advanced machine learning techniques for thematic clustering, demonstrates the potential of artificial intelligence in synthesising and organising complex research landscapes. This approach not only enhances the comprehensiveness of the literature review but also provides a nuanced understanding of the interconnected themes that underpin the regenerative economy.

Moving forward, the regenerative economy framework offers a robust foundation for developing holistic and adaptive strategies that promote ecological restoration, social justice, and economic prosperity. Future research should continue to explore the synergies between different sustainability dimensions, emphasising the need for collaborative and cross-disciplinary efforts. Additionally, empirical studies that evaluate the effectiveness of regenerative practices in real-world contexts will be crucial for refining theoretical models and informing policy development.

Bibliography

Alba-Patiño, D., Carabassa, V., Castro, H., Gutiérrez-Briceño, I., García-Llorente, M., Giagnocavo, C., Gómez-Tenorio, M., Cabello, J., Aznar-Sánchez, J. A., & Castro, A. J. (2021). Social indicators of ecosystem restoration for enhancing human wellbeing. *Resources, Conservation and Recycling*, *174*, 105782. https://doi.org/https://doi.org/10.1016/j.resconrec.2021.105782

Allain, S., Ruault, J. F., Moraine, M., & Madelrieux, S. (2022). The 'bioeconomics vs bioeconomy'debate: Beyond criticism, advancing research fronts. *Environmental Innovation and Societal Transitions*, 42, 58-73. https://doi.org/10.1016/j.eist.2021.11.004

Alves, F. M., Santos, R., & Penha-Lopes, G. (2022). Revisiting the Missing Link: An Ecological Theory of Money for a Regenerative Economy [Article]. *Sustainability (Switzerland)*, *14*(7), Article 4309. https://doi.org/10.3390/su14074309

Andreucci, M. B., Loder, A., Brown, M., & Brajkovic, J. (2021). Exploring Challenges and Opportunities of Biophilic Urban Design: Evidence from Research and Experimentation. *Sustainability*, *13*(8), 24, Article 4323. https://doi.org/10.3390/su13084323

Arman, S. M., & Mark-Herbert, C. (2021). Re-commerce to ensure circular economy from consumer perspective [Article]. *Sustainability (Switzerland)*, *13*(18), Article 10242. https://doi.org/10.3390/su131810242

Ateljevic, I. (2020). Transforming the (tourism) world for good and (re)generating the potential 'new normal' [Article]. *Tourism Geographies*, *22*(3), 467-475. https://doi.org/10.1080/14616688.2020.1759134

Auad, G., & Fath, B. D. (2022). Towards a flourishing blue economy: Identifying obstacles and pathways for its sustainable development. *Current Research in Environmental Sustainability*, *4*, 100193. https://doi.org/https://doi.org/10.1016/j.crsust.2022.100193

Beamer, K., Elkington, K., Souza, P., Tuma, A., Thorenz, A., Köhler, S., Kukea-Shultz, K., Kotubetey, K., & Winter, K. B. (2023). Island and Indigenous systems of circularity:

how Hawai‘i can inform the development of universal circular economy policy goals [Article]. *Ecology and Society*, *28*(1), Article 9. https://doi.org/10.5751/ES-13656-280109

Bellato, L., & Pollock, A. (2023). Regenerative tourism: a state-of-the-art review [Note]. *Tourism Geographies*. https://doi.org/10.1080/14616688.2023.2294366

Belviso, C., Cannas, C., Pinna, N., Cavalcante, F., Lettino, A., Lotti, P., & Gatta, G. D. (2020). Effect of red mud added to zeolite LTA synthesis: Where is Fe in the newly-formed material? [Article]. *Microporous and Mesoporous Materials*, *298*, Article 110058. https://doi.org/10.1016/j.micromeso.2020.110058

Bexell, S. M., Saitta, D., Sher, A., & Sutton, P. (2023). Co-Creation of a Center for a Regenerative Future [Article]. *Sustainability (Switzerland)*, *15*(17), Article 12861. https://doi.org/10.3390/su151712861

Blau, M. L., Luz, F., & Panagopoulos, T. (2018). Urban river recovery inspired by nature-based solutions and biophilic design in Albufeira, Portugal [Article]. *Land*, *7*(4), Article 141. https://doi.org/10.3390/land7040141

Charnley, F., Tiwari, D., Hutabarat, W., Moreno, M., Okorie, O., & Tiwari, A. (2019). Simulation to Enable a Data-Driven Circular Economy. *Sustainability*, *11*(12), 3379. https://www.mdpi.com/2071-1050/11/12/3379

Cherep, A., Voronkova, V., & Androsova, O. (2022). TRANSFORMATIONAL CHANGES IN ORGANIZATIONAL MANAGEMENT AND HUMAN RESOURCES IN THE DIGITAL AGE. *Baltic Journal of Economic Studies*, *8*(3), 210-219. https://doi.org/10.30525/2256-0742/2022-8-3-210-219

Cirrincione, L., Marvuglia, A., & Scaccianoce, G. (2021). Assessing the effectiveness of green roofs in enhancing the energy and indoor comfort resilience of urban buildings to climate change: Methodology proposal and application. *Building and Environment*, *205*, 15, Article 108198. https://doi.org/10.1016/j.buildenv.2021.108198

Conlon, K. (2023). Emerging Transformations in Material Use and Waste Practices in the Global South: Plastic-Free and Zero Waste in India [Article]. *Urban Science*, *7*(2), Article 47. https://doi.org/10.3390/urbansci7020047

Corvellec, H., Stowell, A. F., & Johansson, N. (2022). Critiques of the circular economy. *Journal of industrial ecology*, 26(2), 421-432. https://doi.org/10.1111/jiec.13187

da Silva, E. A., Pedrozo, E. A., & da Silva, T. N. (2023). Agriculture and its interpretation ofplanetary limits under biophysical and social aspects. *Simbiotica*, *10*(3), 31-56. https://doi.org/10.47456/simbitica.v10i3.39458

Daňo, F., Drábik, P., & Hanuláková, E. (2020). Circular business models in textiles and apparel sector in Slovakia [Article]. *Central European Business Review*, *9*(1), 1-19. https://doi.org/10.18267/J.CEBR.226

Daum, M. (2019). Owning our part: From denial-based business to a regenerative economy [Article]. *Organisational and Social Dynamics*, *19*(2), 249-263. https://doi.org/10.33212/osd.v19n2.2019.249

De Luca, F., Naboni, E., & Lobaccaro, G. (2021). Tall buildings cluster form rationalization in a Nordic climate by factoring in indoor-outdoor comfort and energy. *Energy and Buildings*, *238*, 16, Article 110831. https://doi.org/10.1016/j.enbuild.2021.110831

Doty, K., Green, D. N., & Haar, S. (2024). Natural Dyes in the United States: An Exploration of Natural Dye Use Through the Lens of the Circuit of Style-Fashion-Dress

[Article]. *Clothing and Textiles Research Journal*. https://doi.org/10.1177/0887302X241229222

Duguma, L., Kamwilu, E., Minang, P. A., Nzyoka, J., & Muthee, K. (2020). Ecosystem-based approaches to bioenergy and the need for regenerative supply options for africa [Article]. *Sustainability (Switzerland)*, *12*(20), 1-22, Article 8588. https://doi.org/10.3390/su12208588

Fath, B. D., Fiscus, D. A., Goerner, S. J., Berea, A., & Ulanowicz, R. E. (2019). Measuring regenerative economics: 10 principles and measures undergirding systemic economic health. *Global Transitions*, *1*, 15-27. https://doi.org/10.1016/j.glt.2019.02.002

Frank, A., & Marsden, T. (2016). *REGIONAL SPATIAL PLANNING, GOVERNMENT AND GOVERNANCE AS RECIPE FOR SUSTAINABLE DEVELOPMENT?* (Publication Number 978-1-78560-796-7; 978-1-78560-797-4) [; Book Chapter, <Go to ISI>://WOS:000403908900010

Friedrich, D. (2019a). Effectiveness of peer review as cooperative web-based learning method applied out-of-class in a role playing game: A case study by quasi-experimental approach [Review]. *Smart Learning Environments*, *6*(1), 22, Article 19. https://doi.org/10.1186/s40561-019-0102-5

Friedrich, D. (2019b). Normative market regulation by means of early standardization: A descriptive policy analysis for the biobased industry [Review]. *Journal of Cleaner Production*, *232*, 1282-1296. https://doi.org/10.1016/j.jclepro.2019.05.362

Gabriela-Cornelia, P., Iudith, I., & Alexandru, B. (2014, Nov 13-14). New Theoretical And Practical Approaches Of Implementing The Circular Economy For The Preservation Of Natural Resources.*Procedia Economics and Finance* [2nd international conference economic scientific research - theoretical, empirical and practical approaches, espera 2014]. 2nd International Conference Economic Scientific Research - Theoretical, Empirical and Practical Approaches (ESPERA), Bucharest, ROMANIA.

Giri, D., Mukherjee, A., & Rajan, K. (2022). Informatics Driven Materials Innovation for a Regenerative Economy: Harnessing NLP for Safer Chemistry in Manufacturing of Solar Cells. Minerals, Metals and Materials Series, https://doi.org/10.1007/978-3-030-92563-5_3

Gonella, J. D. L., Godinho, M., Ganga, G. M. D., Latan, H., & Jabbour, C. J. C. (2024). A behavioral perspective on circular economy awareness: The moderating role of social influence and psychological barriers. *Journal of Cleaner Production*, *441*, 14, Article 141062. https://doi.org/10.1016/j.jclepro.2024.141062

Gonella, J. D. S. L., Godinho Filho, M., Ganga, G. M. D., Latan, H., & Chiappetta Jabbour, C. J. (2023). Towards a regenerative economy: An innovative scale to measure people's awareness of the circular economy [Article]. *Journal of Cleaner Production*, *421*, Article 138390. https://doi.org/10.1016/j.jclepro.2023.138390

Gorgenyi-Hegyes, E., Nathan, R. J., & Fekete-Farkas, M. (2021). Workplace Health Promotion, Employee Wellbeing and Loyalty during Covid-19 Pandemic—Large Scale Empirical Evidence from Hungary. *Economies*, *9*(2), 55. https://www.mdpi.com/2227-7099/9/2/55

Gremmelspacher, J. M., Sivolova, J., Naboni, E., & Nik, V. M. (2020, Jul 01-04). Future Climate Resilience Through Informed Decision Making in Retrofitting Projects.*Lecture Notes in Computer Science* [Computational science and its

applications - iccsa 2020, pt iii]. 20th International Conference on Computational Science and Its Applications (ICCSA), Electr Network.

Gretz, S., Halfon, A., Shnayderman, I., Toledo-Ronen, O., Spector, A., Dankin, L., Katsis, Y., Arviv, O., Katz, Y., Slonim, N., & Ein-Dor, L. (2023, December). Zero-shot Topical Text Classification with LLMs - an Experimental Study. In H. Bouamor, J. Pino, & K. Bali, *Findings of the Association for Computational Linguistics: EMNLP 2023* Singapore.

Guillouzo, L., & Carpentier, E. (2022, Aug 14-20). Dye plants used for cosmetic applications: a patented world-wide innovation from Le Rouge Francais.*Acta Horticulturae* [Xxxi international horticultural congress, ihc2022: International symposium on natural colorants from plants]. 31st International Horticultural Congress (IHC) / International Symposium on Natural Colorants from Plants, Angers, FRANCE.

Harbi, J., Cao, Y., Milantara, N., & Mustafa, A. B. (2023). Assessing the Sustainability of NTFP-Based Community Enterprises: A Viable Business Model for Indonesian Rural Forested Areas [Article]. *Forests*, *14*(6), Article 1251. https://doi.org/10.3390/f14061251

Hărmănescu, M., Coccolo, S., Naboni, E., & Hansen, P. (2018). Rethinking sustainability towards a regenerative economy (RESTORE) within an adaptive neighbourhood design. PLEA 2018 - Smart and Healthy within the Two-Degree Limit: Proceedings of the 34th International Conference on Passive and Low Energy Architecture,

Haselsteiner, E., Rizvanolli, B. V., Sáez, P. V., & Kontovourkis, O. (2021). Drivers and Barriers Leading to a Successful Paradigm Shift toward Regenerative Neighborhoods. *Sustainability*, *13*(9), 22, Article 5179. https://doi.org/10.3390/su13095179

Hernández-Chover, V., Bellver-Domingo, Á., Castellet-Viciano, L., & Hernández-Sancho, F. (2024). AI Applied to the Circular Economy: An Approach in the Wastewater Sector. *Sustainability*, *16*(4), 1365. https://www.mdpi.com/2071-1050/16/4/1365

Hinton, J. B. (2022). A Not-For-Profit Economy for a Regenerative Sustainable World. In *Transformation Literacy* (pp. 187-201): Springer International Publishing.

Inversini, A., Saul, L., Balet, S., & Schegg, R. (2024). The rise of regenerative hospitality [Article]. *Journal of Tourism Futures*, *10*(1), 6-20. https://doi.org/10.1108/JTF-04-2023-0107

Jain, Y. (2021). Regenerative Economies: A New Approach Towards Sustainability. In No Poverty (pp. 761-771). Cham: Springer International Publishing.

Keesstra, S., Mol, G., de Leeuw, J., Okx, J., Molenaar, C., de Cleen, M., & Visser, S. (2018). Soil-related sustainable development goals: Four concepts to make land degradation neutrality and restoration work [Article]. *Land*, *7*(4), Article 133. https://doi.org/10.3390/land7040133

Kiessel, A. (2022a). Recentring Fair Trade in the movement for a just, inclusive and regenerative economy. *Journal of Fair Trade*, *3*(2). https://doi.org/10.13169/jfairtrade.3.2.0028

Kiessel, A. (2022b). Recentring Fair Trade in the Movement for a Just, Inclusive and Regenerative Economy. *Journal of Fair Trade*, *3*.

Konietzko, J., Das, A., Bocken, N., 2023. Towards regenerative business models: a necessary shift? *Sustainable Production and Consumption* 38, 372–388. https://doi.org/10.1016/j.spc.2023.04.014.

Kristin Vala Ragnarsdottir, J. P. (2024). *Meeting People's Hopes and Dreams – The Wellbeing Economy*. https://schumacherinstitute.org.uk/wp-content/uploads/2024/01/Regenerative-Wellbeing-Economy.pdf

Li, X., Wang, M., Chi, J., & Yang, X. (2020). Policy Effects and Suggestions on Green Technology Innovation of Marine Enterprises in China. *Journal of Coastal Research*, *110*(sp1), 76-79, 74. https://doi.org/10.2112/JCR-SI110-019.1

Lieder, M., & Rashid, A. (2016). Towards circular economy implementation: A comprehensive review in context of manufacturing industry [Review]. *Journal of Cleaner Production*, *115*, 36-51. https://doi.org/10.1016/j.jclepro.2015.12.042

Majumdar, A., Ghosal, S., Ruj, C., & Sen, A. (2023). Why efforts to address India's 'just transition' should support nature-based solutions [Short survey]. *Energy Research and Social Science*, *98*, Article 103021. https://doi.org/10.1016/j.erss.2023.103021

Marinakis, V., Koutsellis, T., Nikas, A., & Doukas, H. (2021). AI and Data Democratisation for Intelligent Energy Management. *Energies*, *14*(14), 4341. https://www.mdpi.com/1996-1073/14/14/4341

Matacz, P., & Swiatek, L. (2021). The Unwanted Heritage of Prefabricated Wartime Air Raid Shelters-Underground Space Regeneration Feasibility for Urban Agriculture to Enhance Neighbourhood Community Engagement. *Sustainability*, *13*(21), 21, Article 12238. https://doi.org/10.3390/su132112238

Mauree, D., Coccolo, S., Perera, A. T. D., Nik, V., Scartezzini, J. L., & Naboni, E. (2018). A New Framework to Evaluate Urban Design Using Urban Microclimatic Modeling in Future Climatic Conditions. *Sustainability*, *10*(4), 20, Article 1134. https://doi.org/10.3390/su10041134

Mauree, D., Naboni, E., Coccolo, S., Perera, A. T. D., Nik, V. M., & Scartezzini, J. L. (2019). A review of assessment methods for the urban environment and its energy sustainability to guarantee climate adaptation of future cities [Review]. *Renewable & Sustainable Energy Reviews*, *112*, 733-746. https://doi.org/10.1016/j.rser.2019.06.005

Meckling, J., Sterner, T., & Wagner, G. (2017). Policy sequencing toward decarbonization. *Nature Energy*, *2*(12), 918-922. https://doi.org/10.1038/s41560-017-0025-8

Mlynar, J., Bahrami, F., Ourednik, A., Mutzner, N., Verma, H., & Alavi, H. (2022). *AI beyond Deus ex Machina – Reimagining Intelligence in Future Cities with Urban Experts* Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems, New Orleans, LA, USA. https://doi.org/10.1145/3491102.3517502

Moreno, M., & Charnley, F. (2016). Can re-distributed manufacturing and digital intelligence enable a regenerative economy? An integrative literature review. Smart Innovation, Systems and Technologies,

Morseletto, P. (2020). Restorative and regenerative: Exploring the concepts in the circular economy [Article]. *Journal of Industrial Ecology*, *24*(4), 763-773. https://doi.org/10.1111/jiec.12987

Naboni, E., Milella, A., Vadalà, R., & Fiorito, F. (2020). On the localised climate change mitigation potential of building facades. *Energy and Buildings*, *224*, 12, Article 110284. https://doi.org/10.1016/j.enbuild.2020.110284

Naboni, E., Natanian, J., Brizzi, G., Florio, P., Chokhachian, A., Galanos, T., & Rastogi, P. (2019). A digital workflow to quantify regenerative urban design in the context of a changing climate. *Renewable & Sustainable Energy Reviews*, *113*, 15, Article 109255. https://doi.org/10.1016/j.rser.2019.109255

Nikitenko, V., Voronkova, V., & Kaganov, Y. (2022). THE CONCEPT OF DEVELOPING A "BLUE ECONOMY" AS A BASIS FOR SUSTAINABLE DEVELOPMENT. *Baltic Journal of Economic Studies*, *8*(5), 139-145. https://doi.org/10.30525/2256-0742/2022-8-5-139-145

Núñez-Cacho Utrilla, P., Górecki, J., & Maqueira, J. M. (2020). Simulation-Based Management of Construction Companies under the Circular Economy Concept—Case Study. *Buildings*, *10*(5), 94. https://www.mdpi.com/2075-5309/10/5/94

Osorio, A. M., Úsuga, L. F., Restrepo-Carmona, J. A., Rendón, I., Sierra-Pérez, J., & Vásquez, R. E. (2024). Methodology for Stakeholder Prioritization in the Context of Digital Transformation and Society 5.0. *Sustainability*, *16*(13), 5317. https://www.mdpi.com/2071-1050/16/13/5317

Patterson, R. (2011). Sustainability development-eco-revolutionary paradigms from binary to continuum constructs [Article]. *Perspectives on Global Development and Technology*, *10*(1), 60-72. https://doi.org/10.1163/156914911X555107

Peia, L. (2021). Nuup: Emergent Blueprints for the Regenerative Economy. *Social Innovations Journal*, *10*. https://socialinnovationsjournal.com/index.php/sij/article/view/1921

Perkins, S., & Jessup, A. (2021). Cybernetics, design and regenerative economics [Article]. *Technoetic Arts*, *19*(1-2), 123-137. https://doi.org/10.1386/TEAR_00057_1

Pradhananga, P., & ElZomor, M. (2023). Revamping Sustainability Efforts Post-Disaster by Adopting Circular Economy Resilience Practices. *Sustainability*, *15*(22), 19, Article 15870. https://doi.org/10.3390/su152215870

Preut, A., Kopka, J.-P., & Clausen, U. (2021). Digital Twins for the Circular Economy. *Sustainability*, *13*(18), 10467. https://www.mdpi.com/2071-1050/13/18/10467

Quintana-Gallardo, A., Schau, E. M., Niemelä, E. P., & Burnard, M. D. (2021). Comparing the environmental impacts of wooden buildings in Spain, Slovenia, and Germany. *Journal of Cleaner Production*, *329*, 21, Article 129587. https://doi.org/10.1016/j.jclepro.2021.129587

Salatino, P., Chirone, R., & Clift, R. (2023). Chemical engineering and industrial ecology: Remanufacturing and recycling as process systems [Article]. *Canadian Journal of Chemical Engineering*, *101*(1), 283-294. https://doi.org/10.1002/cjce.24625

Schletz, M., Constant, A., Hsu, A., Schillebeeckx, S., Beck, R., & Wainstein, M. (2023). Blockchain and regenerative finance: charting a path toward regeneration [Original Research]. *Frontiers in Blockchain*, *6*. https://doi.org/10.3389/fbloc.2023.1165133

Schunder, T., Yin, D. M., Bagchi-Sen, S., & Rajan, K. (2020). A spatial analysis of the development potential of rooftop and community solar energy. *Remote Sensing Applications-Society and Environment*, *19*, 10, Article 100355. https://doi.org/10.1016/j.rsase.2020.100355

Seghetta, M., Tørring, D., Bruhn, A., & Thomsen, M. (2016). Bioextraction potential of seaweed in Denmark - An instrument for circular nutrient management [Article]. *Science of the Total Environment*, *563-564*, 513-529. https://doi.org/10.1016/j.scitotenv.2016.04.010

Sevilla, D. V., Lopez, A. F., & Bugallo, P. B. M. (2022). The Role of a Hazardous Waste Intermediate Management Plant in the Circularity of Products. *Sustainability*, *14*(3), 34, Article 1241. https://doi.org/10.3390/su14031241

Sheldon, P. J. (2022). The coming-of-age of tourism: embracing new economic models [Article]. *Journal of Tourism Futures*, *8*(2), 200-207. https://doi.org/10.1108/JTF-03-2021-0057

Sonetti, G., Brown, M., & Naboni, E. (2019). About the Triggering of UN Sustainable Development Goals and Regenerative Sustainability in Higher Education. *Sustainability*, *11*(1), 17, Article 254. https://doi.org/10.3390/su11010254

Sonetti, G., Naboni, E., & Brown, M. (2018). Exploring the Potentials of ICT Tools for Human-Centric Regenerative Design. *Sustainability*, *10*(4), 14, Article 1217. https://doi.org/10.3390/su10041217

Stoenoiu, C. E., & Jäntschi, L. (2024). Circular Economy Similarities in a Group of Eastern European Countries: Orienting towards Sustainable Development [Article]. *Sustainability (Switzerland)*, *16*(4), Article 1593. https://doi.org/10.3390/su16041593

Sulis, F., Agostinho, F., Almeida, C., & Giannetti, B. F. (2021). Recognizing the wealth of non-marketable food in distribution centres: The environmental benefits of donation. *Journal of Cleaner Production*, *318*, 14, Article 128482. https://doi.org/10.1016/j.jclepro.2021.128482

Tomljenovic, R., & Ateljevic, I. (2017, May 25-27). TRANSFORMATIVE TOURISM, SOCIAL ENTREPRENEURS AND REGENERATIVE ECONOMY.*Medunarodni Znanstveni Simpozij Gospodarstvo Istocne Hrvatske-Jucer Danas Sutra* [6th international scientific symposium economy of eastern croatia - vision and growth]. 6th International Scientific Symposium on Economy of Eastern Croatia - Vision And Growth, Osijek, CROATIA.

Torresin, S., Aletta, F., Babich, F., Bourdeau, E., Harvie-Clark, J., Kang, J., Lavia, L., Radicchi, A., & Albatici, R. (2020). Acoustics for Supportive and Healthy Buildings: Emerging Themes on Indoor Soundscape Research. *Sustainability*, *12*(15), 27, Article 6054. https://doi.org/10.3390/su12156054

Unmüßig, B., Sachs, W., & Fatheuer, T. (2012). Critique of the green economy. Publication series on ecology. Berlin: Heinrich Böll Foundation.

Unter, K., Vogel, L. L., Walls, J. L., Küng, C., & Tamayo, J. (2024). Towards Defining a Regenerative Economy. Institute for Economy and the Environment, University of St. Gallen, Sustainable Development Solutions Network Switzerland

Valayer, P. J., Vidal, O., Wouters, N., & van Loosdrecht, M. C. M. (2019). The full energy cost of avoiding CO2: A clean-energy booking provision for a vigorous energy transition. *Journal of Cleaner Production*, *237*, 10, Article 117820. https://doi.org/10.1016/j.jclepro.2019.117820

van der Velden, M., Maitre-Ekern, E., & Wanja, D. K. (2023). The Role of Independent Repair in a Circular and Regenerative Economy [Article]. *Circular Economy and Sustainability*. https://doi.org/10.1007/s43615-023-00304-y

van Niekerk, A. J. (2024). Economic Inclusion: Green Finance and the SDGs [Article]. *Sustainability (Switzerland)*, *16*(3), Article 1128. https://doi.org/10.3390/su16031128

Vineis, P., & Mangone, L. (2022). The need for new metrics in the Anthropocene era [Article]. *Frontiers in Public Health*, *10*, Article 935743. https://doi.org/10.3389/fpubh.2022.935743

Walls, J. L., & Vogel, L. L. (2023). Renegerative economy: A pathway to a future-ready, sustainable Africa [Article]. *Africa Journal of Management*, *9*(4), 315-337. https://doi.org/10.1080/23322373.2023.2275110

Walravens, N., & Ballon, P. (2017). Policy Recommendations Supporting Smart City Strategies: Towards a New Methodological Tool. In E. Alba, F. Chicano, & G. Luque, *Smart Cities* Cham.

Wang, L. P., Meng, Y. W., & Wang, X. (2024). Sustainable Supramolecular Polymers. *ChemPlusChem*, *89*(6), 6. https://doi.org/10.1002/cplu.202300694

Zisopoulos, F. K., Noll, D., Singh, S. J., Schraven, D., de Jong, M., Fath, B. D., Goerner, S., Webster, K., Fiscus, D., & Ulanowicz, R. E. (2023). Regenerative economics at the service of islands: Assessing the socio-economic metabolism of Samothraki in Greece [Article]. *Journal of Cleaner Production*, *408*, Article 137136. https://doi.org/10.1016/j.jclepro.2023.137136

ISTRAŽIVANJE REGENERATIVNE EKONOMIJE: SVEOBUHVATNI PREGLED LITERATURE

Abstract: Savremeni globalni izazovi kao što su klimatske promene, iscrpljivanje resursa, degradacija ekosistema i društvene nejednakosti zahtevaju sveobuhvatne i integrisane pristupe za postizanje održivog razvoja. Iako se postojeće paradigme razvoja i održivosti bave specifičnim aspektima održivosti, one često ne uspevaju u pokretanju sistemske transformacije i obezbeđivanju dugoročne otpornosti. Kao odgovor na ova ograničenja, koncept regenerativne ekonomije se pojavljuje kao holistički okvir koji integriše ekološku obnovu, socijalnu jednakost i ekonomsku vitalnost. Ova studija sprovodi sistematski pregled literature od 84 naučna članka kako bi se sintetizovala i grupisala postojeća istraživanja u domenu regenerativne ekonomije. Koristeći model velikog jezika (LLM) za nultu klasifikaciju, analiza identifikuje sedam primarnih klastera — održivost i uticaj na životnu sredinu, klimatske promene i energija, urbano i izgrađeno okruženje, ekonomski i industrijski sistemi, obrazovanje i društveni uticaj, tehnološke inovacije i sistemi i Politika, upravljanje i standardi — dalje podeljeni u 21 podgrupu. Svaki klaster obuhvata ključne teme i interdisciplinarne pristupe neophodne za unapređenje praksi regenerativne ekonomije. Nalazi ističu međusobnu povezanost različitih dimenzija održivosti i naglašavaju neophodnost integrisanog upravljanja, inovativnih tehnoloških rešenja i inkluzivnih okvira politike. Mapiranjem trenutnog stanja istraživanja regenerativne ekonomije, ova studija pruža strukturirani pregled koji olakšava dublje razumevanje i daje informacije za buduće strateške inicijative usmerene na postizanje otporne i prosperitetne održive budućnosti.

Ključne reči: regenerativna ekonomija, sistematski pregled literature, model velikog jezika, klaster analiza zasnovana na LLM, implikacije politike.

Acknowledgement

Funded by the European Union, under the GA101136834 - CROSS-REIS. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or European Research Executive Agency (REA). Neither the European Union nor the granting authority can be held responsible for them.