

Circular Economic Model of Waste Bank Based on Technological Innovation: A Comprehensive Bibliometric Insight

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Abstract

The circular economy contributes to increasing environmental resilience and the social welfare of society. This study aims to identify the development of an effective waste bank circular economy model through technological innovation. The method used is bibliometric analysis with VOSviewer software. The research results show that the main challenges faced are lack of infrastructure, public awareness, and inadequate regulations in several countries. However, this research also highlights the enormous opportunities offered by circular economy models, such as the creation of new jobs, reduced dependence on non-renewable resources, and increased global competitiveness.

Keywords: Circular Economy Model, Technology Innovation, Waste Bank.

Introduction

One economic approach that is starting to be widely adopted is the circular economy model, which focuses on the principles of sustainable resource management (Palle *et al.*, 2022). This term was first relevantly and relatedly introduced by British economist Kenneth Boulding in a book *The Economics of the Coming Spaceship Earth* (1966), which describes the limitations of planet Earth in providing unlimited resources. From an environmental perspective, the circular economy highlights sustainability issues related to resource use, waste management and emission reduction (Dwiningsih *et al.*, 2022). In this model, products that have been consumed are not simply thrown away, but are reprocessed through a series of efforts such as reduction, reuse, recycling, replacement and repair (*Reduce, Reuse, Recycle, Replace, Repair*) which supports the sustainability of the product's lifespan (Purwanti, 2021).

Based on these conditions, the waste produced can be minimized, reducing negative impacts on the environment. Products that have been used can be remanufactured into new products or used as raw materials for other products, thereby extending the life cycle of goods and optimizing resource use. The focus on the concept of product recycling through 5R can increase resource efficiency, active participation from various parties *stakeholder* and building integrated production patterns and consumption patterns (Hidayati *et al.*, 2021). The implementation of a circular economy can contribute to increasing environmental resilience, social welfare of society, reducing the impact of environmental damage, and encouraging the formation of added value of new products. Apart from that, the circular economy also supports green economic growth which is in line with sustainable development goals (Sitinjak, 2024).

The implications of implementing a circular economy model in sustainable development support increasing the efficiency of resource use, creating new jobs and strengthening economic resilience. However, challenges such as changes in business paradigms, the need for supporting infrastructure, and the development of appropriate regulations must also be overcome (Sitinjak, 2024). Various potentials and obstacles that can arise from implementing a circular economy model can involve production patterns, consumption patterns and the role of technological innovation related to waste banks as a place for waste management.

According to research from (Siregar, 2023), the challenges in implementing the circular economy model in Indonesia are related to limited infrastructure, lack of public awareness and understanding, regulations that

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are not yet strong and business paradigms that need to be adjusted. Meanwhile, potential opportunities in implementing the circular economy model include the creation of new jobs, reducing dependence on non-renewable resources, increasing global competitiveness and green economic growth. In order to create acceleration in the application of the circular economic model, this can be done through effective waste management. One important aspect of waste management is a circular economy, especially in creating more efficient product cycles and reducing waste that ends up in landfills.

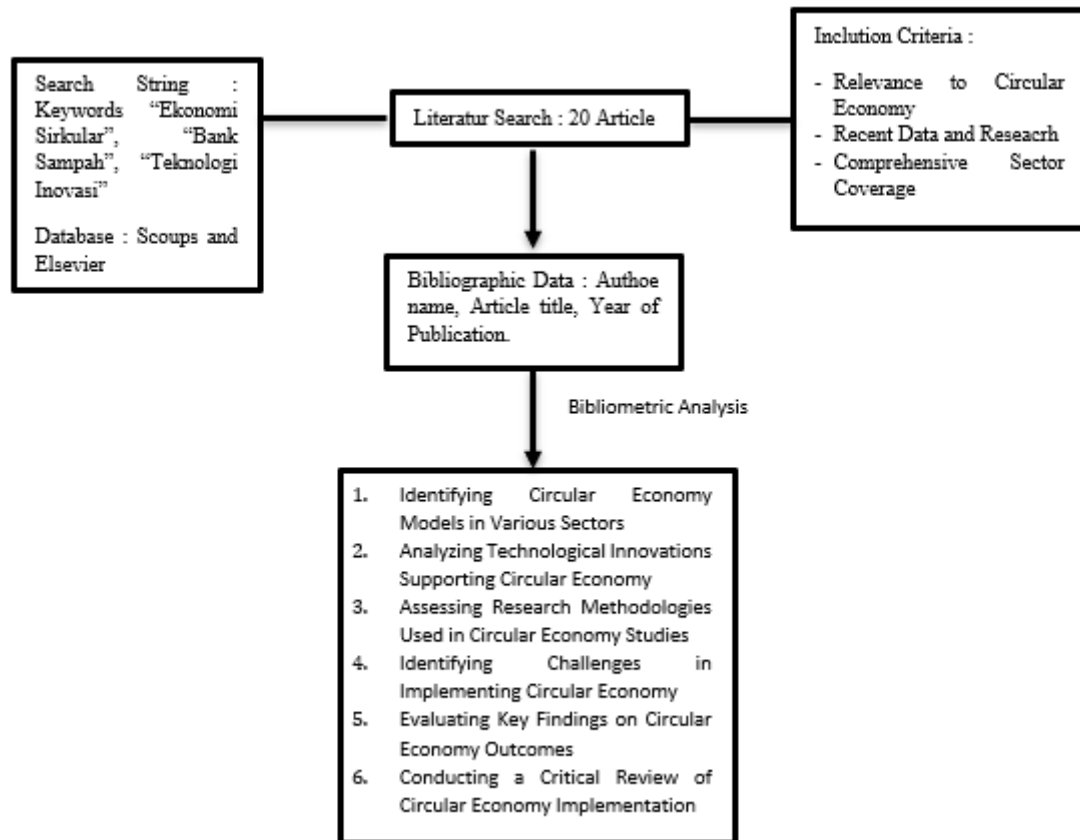
In this context, sustainable waste management includes the process of sorting, recycling and processing organic waste which can produce new products, energy or fertilizer. For example, waste banks in several cities in Indonesia play an important role in collecting and managing economically valuable inorganic waste to be reprocessed into industrial raw materials. An effective approach to environmentally friendly and efficient waste management involves the application of various strategies and technologies to manage, reduce, and utilize waste generated by human activities. This approach aims to transform waste into valuable resources, both for the environment and society. One effective implementation is through a Waste Bank, where people can exchange sorted waste for recyclable materials, thereby generating economic benefits while reducing environmental impacts. The Waste Bank not only supports waste reduction but also empowers communities by providing economic incentives and creating awareness of the importance of sustainable waste management (Desty Febrian & Solihin, 2024).

The article discusses circular economy models applied in various countries to identify patterns of spread and development of discussions regarding the circular economy. It is hoped that this article will provide findings on a circular economy model that is relevant to the waste bank concept, as well as the effective implementation of technological innovations.

Research Methods

Bibliometric analysis was applied in this study. Bibliometric analysis aims to identify the distribution of articles per year based on volume, topic distribution, level of collaboration between authors, authorship patterns, and institutional affiliation patterns. Apart from that, this analysis reveals the process of written communication and its development in a scientific discipline. There are several benefits from using bibliometric methods, including the ability to estimate the completeness of secondary literature and identify subjects or fields within a scientific discipline.

The stages of bibliometric analysis are as follows:



The first stage is to determine search keywords, which in this study include "Circular Economy," "Waste Bank," and "Technological Innovation." Apart from these keywords, the year the article was published is also considered, with a publication deadline in the 2019-2024 period in the Scopus Database. The second stage is to review the initial search results based on articles spanning the 2019-2024 time period regarding bibliometric data such as citation information, abstracts, keywords and reference information. The third stage is filtering search result data, which is adjusted to the research focus, namely the circular economy model of waste banks based on technological innovation. By using Elsevier's Scopus database, newer data is expected to provide a more accurate picture of current trends and challenges. The fourth stage is the process of compiling data that is in accordance with the related search results and the data clusterization process. The data can be continued for bibliometric analysis using VOSviewer 1.6.20. Fifth Stage Bibliometric analysis using VOSviewer 1.6.20 Software for interpretation and identification of relationships between keywords, journals, articles, countries and institutions related to a database of 20 articles in CSV format with keywords in "Circular Economy Model, Waste Bank and Technological Innovation".

This research was conducted in four countries, namely Indonesia, China, Germany and Australia.

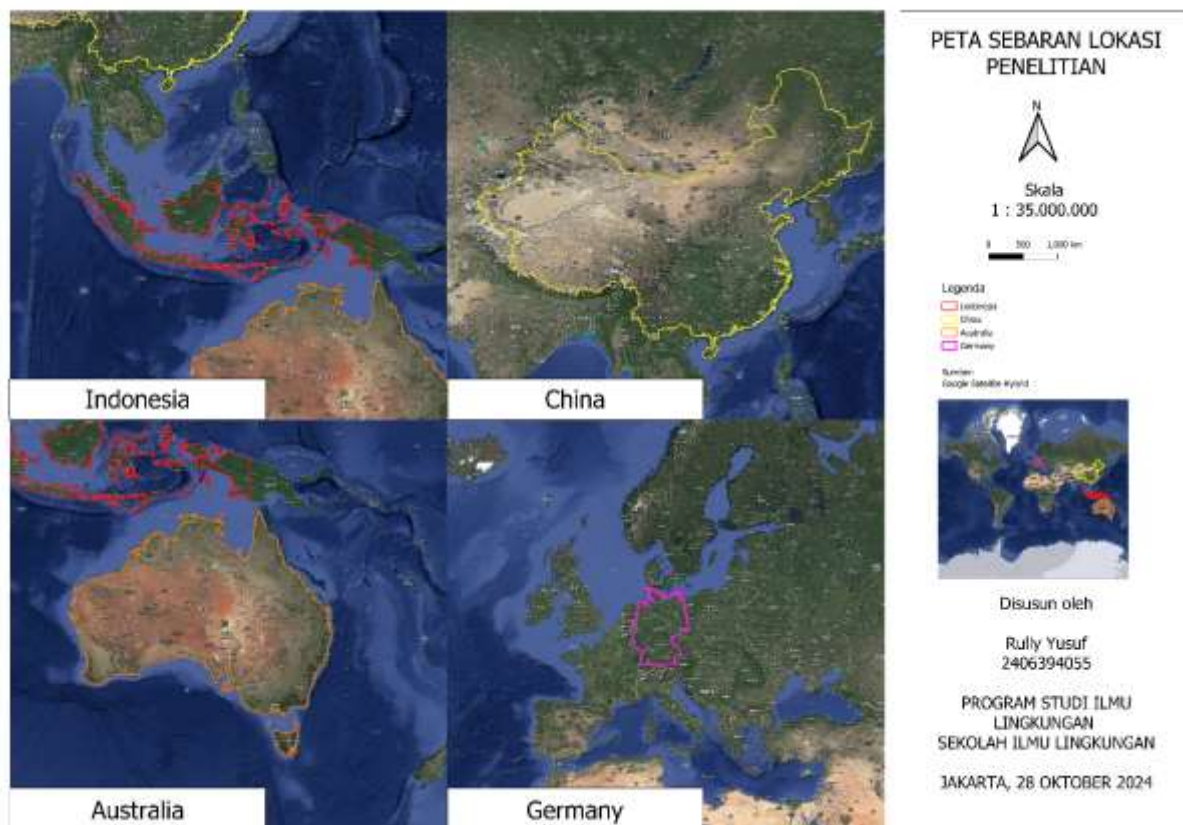


Figure 1. Research Location

Source: Created via Arcgis

The selection of these countries is also based on various challenges faced regarding infrastructure and public awareness of the circular economy. Indonesia and Australia, for example, have challenges related to recycling infrastructure and low community participation. In China, the biggest obstacle is the lack of enforcement of environmental laws in rural areas, while Germany is experiencing challenges with efficiency and sustainability in certain material recycling cycles. A deep understanding of these challenges will help craft circular economy models that are more responsive and adaptive to the specific constraints of each country.

The four countries have unique approaches to implementing a circular economy that provide a comprehensive picture of the adaptation of this model in various contexts. Indonesia, for example, is at an early stage with a primary focus on education and community participation in waste management, while China has integrated the circular economy into the industrial sector with policy support and subsidies. Germany has a focus on technological innovation and bio-based resources, and has strict regulations to support the transition to a circular economy. Australia, on the other hand, is strengthening regulations and trying to build awareness of the importance of recycling among the general public. This approach provides an important comparison of how the circular economy can be applied in various social, economic and political contexts.

The four countries were also chosen because of the great opportunities to integrate technological innovation in their circular economic systems. China has utilized technology for energy efficiency in the recycling process, while Germany has successfully used a high-tech waste sorting system that increases the recycling of household waste. Indonesia is starting to explore digital technology for monitoring waste banks, while Australia is implementing a technology-oriented approach to plastic waste and construction waste

management. This analysis will provide important insights into how technology can act as a key driver in creating a more efficient circular economy in each country

Results and Discussion

Journal Year Publication Analysis

In the period 2018 - 2024 publication of articles related to the circular economy model with analysis using *tools* in the database *Scopus* based on keyword searches "Circular Economy Model", "Waste Bank" and "Technological Innovation". The article data used is 20 articles that represent the application of the circular economy model in various countries. The article analysis graph per year shows the development of the number of publications from 2018 to 2024. This graph represents the number of documents published each year and shows a clear trend in publication activity. This graph shows a fluctuating pattern with a decline in 2019 but then followed by a consistent upward trend in the number of publications. The significant jump in 2024 indicates intensive efforts to increase research and publication productivity.



Figure 2. Year of Publication

Source: Researcher,2024

Factors such as institutional support, research collaborations, and regulatory changes may be the main causes of this pattern. Overall, this trend reflects positive growth in the number of publications over the period under review, although there were some fluctuations in between. The spike in 2024 shows the potential for continued publication growth in the future.

Keyword Linkage Analysis

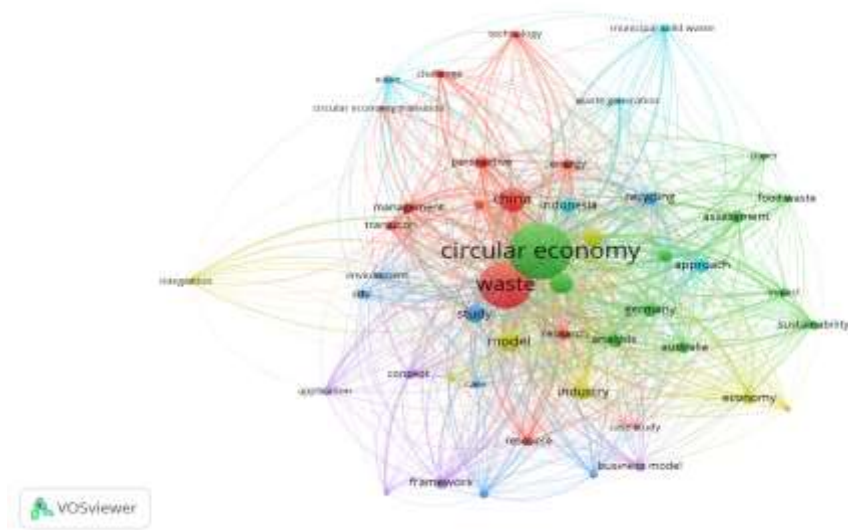
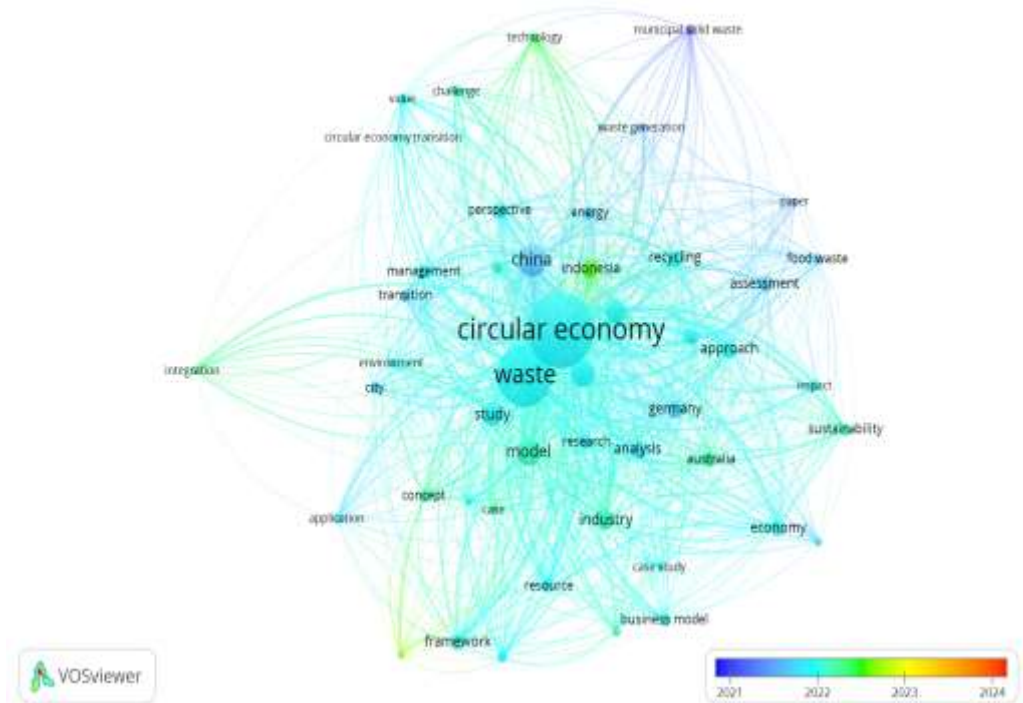


Figure 3. Networking Analysis by VosViewer

Source: Researcher, 2024

Based on bibliometric analysis using VosViewer, several identifications of related keywords between articles provide an understanding that there are similar meanings grouped between articles. These keywords are "Waste, Circular Economy, Recycling, Food Waste and Technology" which is the point of full connection. The word "Waste" is directly related to the main topic "*Circular Economy*" with the relevance of the discussion *perspective, management, technology* And *energy*. However, the challenges faced regarding implementation involve various technical, social, economic and environmental aspects that must be considered simultaneously to achieve sustainability goals (Marsh *et al.*, 2022). This explains that waste which is closely related to the circular economy model is closely related to discussions regarding stakeholder perspectives, production management, technological innovation that supports the implementation of the circular economy model. The application of a circular economy model is in line with sustainable practices that support technological innovation for resource optimization, waste management and material recycling (Rabbi *et al.*, 2024). Based on networking analysis, Indonesian keywords are related to *recycling, waste generation, study*, And *value*. This indicates that Indonesia is in the education stage for waste management and increasing the value of waste products.

Keyword Novelty Analysis**Figure 4. Overlay Analysis**

(Source: Processed data)

Based on overlay analysis related to the article *Circular Economy*, the focus of the discussion is on the relationship between *circular economy*, *waste*, *recycling*, and *perspective*. The period for discussing these keywords is between 2021 and 2022. Analysis related to the development of a circular economy model is developing with keywords *model*, *concept*, *industry*, and *sustainability*. The development of a sustainable circular economy model requires an effective form of governance that must be adapted to the context of activities and resources held by the stakeholders involved (Minoja *et al.*, 2024). Based on the results of this analysis, discussions related to these keywords will increase on a time scale in mid-2022. Furthermore, the circular economy will develop into a *circular economic principle* in 2023. Discussion of this principle can be part of answering implementation challenges such as the lack of responsibility in implementing the circular economy model in the industry due to the lack of tax regulations and public awareness such as conditions in Australia (Milios, 2021).

Analysis of Circular Economy Model Research Articles

This research content analysis focuses on publications related to the circular economy spread across various countries, with main attention to issues of sustainability, waste management, as well as the challenges and opportunities faced in implementing the circular economy in countries such as China, Germany, Australia, and Indonesia. Each article highlights the specific context of its respective country and provides insight into the potential and obstacles faced in achieving sustainability goals through a circular economy approach.

Table 1. Literature Analysis Content Articles

No	Title	Authors	Source	Country	Year
1	Barriers to sustainable food consumption and production in China: A fuzzy DEMATEL analysis from a circular economy perspective	Yanping Liu, Venkatesh, Lincoln C. Wood, V.G. Zhang, Farooque	Elsevier, Journal Sustainable Production and Consumption Page 1114 - 1129	China	2021
2	Impact of Subsidies on innovations of environmental protection and circular economy in China	Xiaofeng Xu, Tao Wang, Yi Xu, Huanzheng,	Elsevier Journal of Environmental Management	China	2021
3	The affecting factors of circular economy information and its impact on corporate economic sustainability Evidence from China	Lopin Kuo, Bao-Chang	Elsevier, Journal Sustainable Production and Consumption	China	2021
4	Toward the construction of a circular economy ecocity: An emergy-based sustainability evaluation of Rizhao city in China	Junli Li, Wei Sun, Ruiping Li, Junqing Hao, Huaming,	Elsevier, Journal Sustainable Cities and Society	China	2021
5	The circular economy in China: Achievements, challenges and potential implications for decarbonisation	Raimund Bleischwitz, Miying Yang, Beijia Huang, Xiaozhen XU, Jie Zhou, Will McDowall, Philip Andrews-Speed, Zhe Liu, Geng Yong	Elsevier, Journal Resources Conservation and Recycling	China	2022
6	Insight Into Plastic Food Packaging Waste Sorting Behavior: A Focus group study among consumers in Germany	Ellen Meilinger, Romana	Elsevier Journal Waste Management	Germany	2024
7	The Circular Economy and The Bio-Based Sector Perspective of Europe and German Stakeholders	Sina Leipold, Anna Petit	El Journal of Cleaner Production	Germany	2018

8	Challenges and Perspectives of the Circular Economy in the European Union: A Comparative Analysis of the Member States	Francisco Jose Castillo Diaz, Belmonte Urena, Fernando Dianzer Martinez Luis J.	Elsevier Journal Ecological Economics	Germany	2024
9	Unpacking Pathways to a Circular Economy: A Study of Packaging	Machteld Catharina Simoens	Elsevier Sustainable Production and Consumption	Germany	2024
10	Understanding the effect of market orientation on circular economy practices: The mediating role of closed-loop orientation- in German SMEs	Corinna, Bastian, Cassian, Tessa	Journal Faculty Business Economics and University Dortmund	Germany	2021
11	Circular economy barriers in Australia: How to translate theory into practice?	Jessica, Sarah King, Matthew, Tristan, Helwig, Hannah, Paulomi (Polly)	Elsevier, Journal Sustainable Production and Consumption 45 Page 582-597	Australia	2024
12	Circular Economy: A Sustainable Management Strategy For- Rare Earth Elements Consumption in Australia	Mejame Palle Paul Mejame, Zsuzsa Banhalmi-zakar, Yinghe King,	Elsevier, Journal Current Research in Environmental Sustainability Page 100 -157	Australia	2022
13	Empirical Evidence On Circular Economy Adoption in Australian Small and Medium Enterprises	Ayon, Fabiane Leticia, O'Loughlin, Andrew,- Harpeet S. Can- dra	Elsevier, Journal of Cleaner Production 467	Australia	2024
14	Full circle: Challenges and prospects for plastic waste management in Australia to achieve circular economy	Rumana Hossain, Md Tasbirul Islam, Anirban Ghose, Veena Sahajwalla	Elsevier, Journal of Cleaner Production 368	Australia	2022

15	Transformation towards a circular economy in the Australian construction and demolition waste management system	Salman Shooshtarian, Tayyab Maqsood, Savindir Caldera, Tim Ryley	Elsevier, Sustainable Production and Consumption	Australia	2022
16	A Sustainable Circular Economy Approach for Smart Waste Management System to Achieve Sustainable Development Goals: Case Study in Indonesia	Yun., Kannan Govindan, Agus Setiawan, Rochiyati	Journal Of Cleaner Production	Indonesia	2020
17	Toward a Circular e-economy: A System Dynamic Model of Recycling Framework for Aseptic Paper Packaging Waste in Indonesia	Tsai Kuo, Ni-Ying, I-Hsuan Hong, Chin-Jung, Reza	Journal Of Cleaner Production	Indonesia	2021
18	Circular Economy and The Hospitality Industry: A Comparison of The Netherlands and Indonesia	Nina Bittner, Thomas B. Long Nicole Bakker,	Journal Of Cleaner Production	Indonesia	2024
19	Unlocking Synergies Between Waste Management and Climate Change Mitigation to Accelerate Decarbonization Through Circular Economy Digitalization in Indonesia	Tonni K, Abd-Elkader, Praskash Sarangi, Buntora Pasaribu, Imran Ali, Christina Meidiana, Hui Goh, Dongdong Zhang, Mohd Dzarfan Othman, Faissal	Journal Sustainable Production and Consumption	Indonesia	2024
20	Reverse Logistic Toward a Circular-Economy: Consumer Behavioral Intention Toward Polyethylene Terephthalate (PET)	Yuniar, Siswan-to, Iwan Vanany	Case Studies in Chemical and Environmental Engineering	Indonesia	2024

(Source: Scopus Database Analysis)

Based on *Literature analysis content article* from 20 articles representing 5 countries each, it was identified that the discussion of the circular economy model regarding waste management through waste bank practices was more dominant in Indonesia, while in China the circular economy model had been implemented for the sustainability of various sectors that support industry in China.

Table 2. Literature Analysis Comprises Four Countries

Aspect	China	Germany	Australia	Indonesia
Circular economy model	The circular economy model in China is implemented through a 3R approach with a focus on recycling and efficient use of resources, both in the food sector, industry, and through government policies supported by subsidies.	Circular economy for decommissioned wind turbines, plastic waste recycling, circular economy for household waste, bio-based CE for resource processing	Implementation of the circular economy model in the stage of strengthening commitment and regulations. There needs to be special incentives from the government. This supports material efficiency through the industrial sector with production designs that focus more on reducing waste.	The application of the Circular Economy Model has a focus on reducing waste, reusing resources, and achieving a more sustainable system.
Technology Innovation	The technological innovations used are technology, processing waste into energy, and renewable energy technology,	waste sorting equipment, wind turbine recycling systems, bioplastics, plastic waste. and fossil to bio-based	Limited technological innovation in recycling facilities and complex circular economy models	The use of the Internet of Things (IoT) enables more efficient waste monitoring and management,
Method	The methods used in the five journals include content analysis, Fuzzy DEMATEL, emergy analysis, literature review, expert interviews, and multivariate regression.	Qualitative and participatory, LCA, material flow analysis and secondary data,	Methods used in analysis <i>case</i> circular economic models such as <i>systematic literature review</i> and <i>questionnaire survey method</i> ,	The method used is the Case Study Approach. while dynamic system simulation and survey methods.

Challenge	Challenges in implementing a circular economy in China include lack of environmental law enforcement, limited infrastructure in rural areas.	lack of models that best contribute to a sustainable economy, infrastructure for processing recycled materials, increased emissions, separation.	Challenges in implementing a circular economy in Australia include: regulations and policies that are not yet supportive, not yet a priority for industry and low recycling rates	The main challenges in implementing a circular economy in Indonesia include the lack of adequate infrastructure, low community participation with consumers, and weak coordination between stakeholders.
Finding	Key findings show that the circular economy is successfully driving increased productivity and resource recycling in China. However, major challenges remain, especially in terms of law enforcement, dependence on non-renewable resources.	focused more on technological models than social or organizational innovation, Source separation optimization can increase recycling rates from 38% to 50%. focusing more on the biogeochemical circular economy.	The findings from the articles analyzed are that in various sectors such as plastic waste and construction, it was found that low recycling rates, high costs, unsupportive policies, and inadequate infrastructure are the main obstacles.	Findings from the article analyzed the use of smart technology to increase efficiency and the role of consumer attitudes in recycling. The use of IoT and ICT has been proven to improve waste management significantly.

Critical Review	A critical review shows that although the circular economy in China shows significant progress, there are still weaknesses in the integration of long-term strategies, decarbonization policies and local innovation.	Needs define which cycles are more important for future economic sustainability. There are still challenges in achieving higher material recycling targets.	Based on the conditional analysis of the implementation of the circular economy model in Australia, it is still in the initial implementation stage due to regulations that are not yet comprehensive, limited infrastructure and lack of priority in various industrial sectors.	Based on an analysis of how the circular economy and digitalization can be a long-term solution for waste management in Indonesia.
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Based on the *Literature analysis comprising four countries*, there are differences in the implementation of the circular economy model from the four countries analyzed. For example, the comparison between implementing a circular economy in Australia still requires strengthening commitment and regulations as well as building recycling habits at the consumer level.



Picture 5. China Map

(Source: Google Earth)

Meanwhile, the implementation of the circular economy model in China shows the success of the circular economy in increasing industrial productivity which is supported by effective recycling technology. China has made significant progress in the circular economy, particularly through recycling programs supported by government policies and subsidies in strategic sectors such as industry and energy. The circular economy in China focuses on resource efficiency through the 3R (Reduce, Reuse, Recycle) approach applied in various sectors, including food and industrial goods production. The main challenges still faced are limited infrastructure in rural areas and uneven enforcement of environmental laws. However, strong support from the government has made China a country with a rapidly developing circular economy.



Picture 6. Map of Germany

(Source: Google Earth)

Meanwhile, the implementation of a circular economy in Germany focuses on a systematic approach in reusing resources, especially for industries such as wind turbines, plastic waste recycling and household waste management. The application of a circular economy in these sectors includes various methods such as bio-based processing for materials from biological sources, the use of sophisticated waste sorting equipment, and the development of special systems for recycling wind turbines that are no longer functioning. Meanwhile, the model applied in Germany still tends to focus on technology, with little attention to social innovation or organizational development. By improving waste separation systems, recycling rates are expected to rise from 38% to 50%. However, Germany still needs to balance the focus between biogeochemical cycles and sustainable material cycles for the future, as well as define the priorities of the cycles that are most influential in supporting economic sustainability.



Figure 7. Map of Australia

(Source: Google Earth)

The circular economy in Australia is currently in the early stages of implementation, with the main focus on strengthening commitment and developing more supportive regulations. Special government incentives are needed to encourage material efficiency, especially in the industrial sector through production design aimed at reducing waste. However, the implementation of the circular economy model in Australia is still hampered by limited technological innovation in recycling facilities and the complexity of the circular economy model itself. The main challenges faced include a lack of supportive regulations, minimal industry prioritization of the circular economy, and low recycling rates. Based on findings from various sectors,

including plastics and construction, significant challenges that arise are high costs, inadequate policies, and recycling infrastructure that has not developed optimally. Overall, the implementation of a circular economy in Australia still faces many obstacles, ranging from regulations that are not yet comprehensive to limitations.



Figure 8. Indonesian Map

(Source: Google Earth)

The implementation of the circular economy model in Indonesia focuses on reducing waste and reusing resources. In order to achieve sustainability, Indonesia's system has been supported by the use of Internet of Things (IoT) technology, which can enable more efficient monitoring and management of wastewater. The implementation of the circular economy model in Indonesia itself has challenges, especially in terms of infrastructure, low community participation and weak coordination between stakeholders. Combining circular economy principles with the digitalization process has the potential to be a long-term and effective solution in dealing with waste management problems in Indonesia and creating better sustainability in the future.

Cross-sector collaboration and increased attention to domestic technology also need to be strengthened. The existence of training and monitoring programs in waste management can be integrated with technology to support sustainable waste management (Del *et al.* 2020). A comparison of the application of the circular economy model can provide an overview of further development regarding implementation in Indonesia. Currently, Indonesia is still in the stage of focusing on waste reduction and education at the community level to form a system that focuses on reusing materials. Although both have advantages in offering new approaches, the challenges faced in policy implementation, infrastructure, and public awareness are obstacles that need to be overcome. With the right strategy, collaboration between government, industry and society will be critical to achieving a successful transition.

Conclusion

Bibliometric analysis of circular economy models and technological innovation using VOSviewer software to map publication trends, collaboration between authors, and topic developments in various countries. This analysis finds that the circular economy model is increasingly developing through the use of innovative technology, especially in waste management and emission reduction.

The application of the circular economy model in China, Germany, Australia and Indonesia shows different advantages and challenges. China focuses on recycling with the support of subsidies, but is still hampered by law enforcement and infrastructure. Germany is successful in renewable energy waste recycling, but focuses more on technological rather than social innovation. The combination of various strategies for plastic management still faces the challenge of material efficiency trade-offs. The interconnection between circular and bio-based economies needs to be further explored for sustainability priorities. Australia is strengthening regulations, but recycling rates and infrastructure remain low. Indonesia is still in its early stages with infrastructure challenges and low community participation. To adopt best practices, Indonesia

needs to improve infrastructure, public education and collaboration between sectors to support a more sustainable circular economy transition.

In the context of waste banks, technology plays an important role in increasing the efficiency of recycling and waste management. The research results show that the main challenges faced are lack of infrastructure, public awareness, and inadequate regulations in several countries. These obstacles are exacerbated by a lack of education and public awareness, as well as dependence on traditional methods of waste management. However, this research also highlights the enormous opportunities offered by circular economy models, such as the creation of new jobs, reduced dependence on non-renewable resources, and increased global competitiveness.

To support the development of a circular economy through waste banks based on technological innovation in Indonesia, several solutions can be implemented, such as the integration of waste banks with the recycling industry which needs to be improved through digital platforms that connect suppliers and recycling factories, thus speeding up the recycling process and educating the public regarding sorting and recycling. the economic benefits of recycling must be reinforced with campaigns that utilize digital and social media.

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