Trend and Direction of Circular Economy Research in Indonesia

Muhammad Habiburrahman and Rahmat Nurcahyo
Department of Industrial Engineering
Faculty of Engineering
Universitas Indonesia
Depok, Indonesia
m.habiburrahman@ui.ac.id, rahmat@eng.ui.ac.id

Hotmatua Daulay
National Research and Innovation Agency
Jakarta, Indonesia
hotm001@brin.go.id

Abstract

The number of studies on the circular economy continues to increase by researchers from various countries, including Indonesia. This study's objectives are to map the literature on the circular economy and make suggestions for industrial engineering-based circular economy research in Indonesia. A thorough analysis of the circular economy research publications in Indonesia was conducted to accomplish that. Research trends, authors who receive the most citations, research partner nations, papers that receive the most citations, mapping of research objects, journals that publish the most articles, and keywords used are among the findings. Researchers planning studies on the circular economy, particularly in Indonesia, should find this research beneficial.

Keywords
Circular Economy, Indonesia, Sustainability, Review and Industrial Engineering.

1. Introduction
The Government of Indonesia is further strengthening its commitment to the Sustainable Development Goals and targets for reducing greenhouse gas (GHG) emissions according to the Paris Agreement and efforts to tackle economic, social and environmental problems (Kementerian PPN/Bappenas 2021). The Ministry of Industry (Kemenperin) for example, continues to strive to optimize the industry which in its production process prioritizes efficiency and effectiveness in using resources in a sustainable manner (Rantung 2021). In addition, one of the efforts to fulfill this commitment is to carry out economic transformation towards a more “green” direction or often referred to as a circular economy (Limanseto 2021). Currently, there are 5 sectors that have been designated by the Government of Indonesia as priority sectors because they have great potential to adopt a circular approach, namely the food & beverage, textile, construction, wholesale & retail trade and electrical & electronic equipment sectors (Kementerian PPN/Bappenas 2021).

Previous research has found that the circular economy approach is theoretically effective for sustainably improving the economy in developing countries such as Indonesia (Rishanty and Suryahadi 2020). For example, the circular economy concept is useful in the recycling industry, including to meet the needs of raw materials for the manufacturing sector and suppress imports of raw materials (Kementerian Perindustrian Republik Indonesia 2021). The potential of the plastic recycling industry in Indonesia, for example, has a capacity of 1 million tons per year and absorbs a workforce of 20,000 people. For the potential of the steel recycling industry, currently there are 60 companies that use mostly imported raw materials (70-90%) recycled (scrap) with a capacity of 9 million tons per year. The current production utility is only 40 percent, so it requires 4 million tons of recycled raw materials per year. Besides being able to increase Indonesia's GDP growth, the application of the green/circular economy concept could also potentially generate 4.4 million additional jobs in 2030 (Limanseto 2021).

One of the important sources in research design is to review scientific publications from universities and research institutes. Publication is an important indicator of the performance of scientific activities, knowledge production, and achievement of recognition among the public (Aboagye et al. 2021). For this reason, the literature review method is one of the most common and accepted techniques for analyzing the evolution, productivity, and quality of research publications. This study maps research on the circular economy in Indonesia from industrial engineering perspective, compares it with research on the circular economy in other countries, and proposes recommendations for developing circular economic research, especially in Indonesia. This review adds value to existing works in two ways. First, this study reports the extent to which the development of circular economic research in Indonesia from the literature, thus providing a clear and general understanding of the achievements of research on the circular economy in Indonesia. Second, by comparing with global research, this study proposes recommendations for developing circular economic research, especially in Indonesia.

Therefore, in supporting the development of the CE research in Indonesia, this study answers the following research questions:

RQ1. How is the development of research on the circular economy in Indonesia?
RQ2. What are the recommendations that can improve research on the circular economy in Indonesia??

1.1 Objectives

Based on the problems, this study aims to map the literature on the circular economy and propose recommendations for research on the circular economy in Indonesia from industrial engineering perspective. This research is related to the national research scheme, implementing the green economy concept while bolstering the nation's environmentally friendly transportation sector. This research is expected to benefit researchers when designing research on the circular economy, particularly in Indonesia.

2. Literature Review

2.1 Circular Economy

The circular economy model is a concept that is currently very popular throughout the world (Ghosh 2020a). The circular economy is a way of rethinking the actor's approach to each stage of the product life cycle (United Nations Industrial Development Organization (UNIDO) 2017). Ghosh (2020b) developed the following definition of a circular economy and found it to be one of the most appropriate definitions covering all related aspects:

"Circular economy is a systems-level approach to economic development and a paradigm shift from the traditional concept of linear economy model to an elevated echelon of achieving zero waste by resource conservation through changed concept of design of production processes and materials selection, conservation of all kinds of resources, and at the end of the life cycle for a specific use of the product will be still fit to be utilized as the input materials to a new production process in the value chain with a close loop materials cycles that improves resource efficiency, resource productivity, benefit businesses and the society, creates employment opportunities and provides environmental sustainability"

Several previous studies have examined the benefits of a circular economy. It is widely assumed that the movement towards circularity will bring substantial economic benefits, in terms of cost savings for firms and increased competitiveness, stimulation of innovation and new industrial opportunities, and macroeconomic benefits in terms of increased output and employment (Ekins et al. 2019). This new paradigm has been warmly welcomed by governments, sustainable development agencies, academia, and, perhaps most importantly, business as a win-win approach to sustainable development, capable of delivering not only large-scale environmental benefits, but also significant efficiency gains, multiple economic benefits, and positive social implications (Tonelli and Cristoni 2019). Research in Europe found that creating circular loops in manufacturing could result in material cost savings of up to US$ 630 billion.

2.2 Industrial Engineering

Industrial engineering is concerned with the design, improvement, and installation of integrated systems of people, materials, information, equipment, and energy, according to the Institute of Industrial and Systems Engineers. To

specify, predict, and assess the outcomes to be attained from such systems, it makes use of specialized knowledge and abilities in the physical, social, and mathematical sciences as well as the principles and techniques of engineering analysis and design. There are fourteen knowledge areas in the Industrial and Systems Engineering Body of Knowledge (ISEBoK).

3. Methods

The selection of the available databases, their suitability, and the effects of using one another is the first step in conducting a literature review of the research area. They are a crucial component of an investigation because they make it possible to analyze the scientific work done by researchers, institutions, nations, and regions as well as to spot trends in the field. Since it is well known that Scopus is a database that is regarded as the most complete data source, this study refers to it.

To achieve the objectives of this work, a comprehensive analysis of the circular economy research publications in Indonesia was carried out. The investigation begins by collecting high-quality scientific publications. To ensure that the downloaded data fits the research objectives, we use these criteria:

- Type of publication: Publications include research articles, conference papers and reviews.
- Publication Quality: High quality content ensures the validity and reliability of research results. Here, publications are only retrieved from the Scopus indexed database.
- Affiliates: This study selects publications featuring affiliated Indonesian universities/research institutions (at least one affiliated Indonesian institution).
- Time period: No timeframe was applied in this study.
- Contents: The title, abstract, and keywords contain the words “circular economy” and “Indonesia”. Then filter only papers from the subject of business and management, social sciences and economics.

4. Data Collection

Search criteria were defined based on the research questions to determine which articles to be included or excluded from the analysis. The criteria can be directly applied in the Scopus filtering section. The study used search query of “circular economy” AND indonesia in the first search and “circular economy” AND AFFILCOUNTRY indonesia for the second search.

The first search extracts all documents that have the words "circular economy" and "Indonesia" in their titles, abstracts, and keywords. This search found 64 documents. Then, the documents were filtered only articles from the subject of business and management, social science, and economics, which resulted in 27 documents. All documents are in the final stage of publication. A second search extracted all documents from Indonesian affiliates that had "economy circular" in their titles, abstracts, and keywords. Documents collected on August 11, 2022, have harvested 114 publications. Then, the documents were filtered only articles from the subject of business and management, social science, and economics, generating 42 documents. Two documents have not yet entered the final stage of publication, so they are not included. All 67 papers found from the first and second searches were then checked for duplication, leaving 52 documents. Then all the documents were downloaded, but only 42 documents had full access. Finally, 42 articles were used in this work. The process and its criteria in Scopus can be seen in Figure 1.

As a comparison, research data on the circular economy was also collected by researchers from all countries by applying the criteria TITLE-ABS-KEY (“circular economy”) AND (LIMIT-TO (SUBJAREA , "SOCI") OR LIMIT-TO (SUBJAREA , "BUSI") OR LIMIT-TO (SUBJAREA , "ECON")) AND (LIMIT-TO (PUBSTAGE , "final")) resulting in 5,916 document results. Then, only the most recent 2000 articles were taken for comparison.

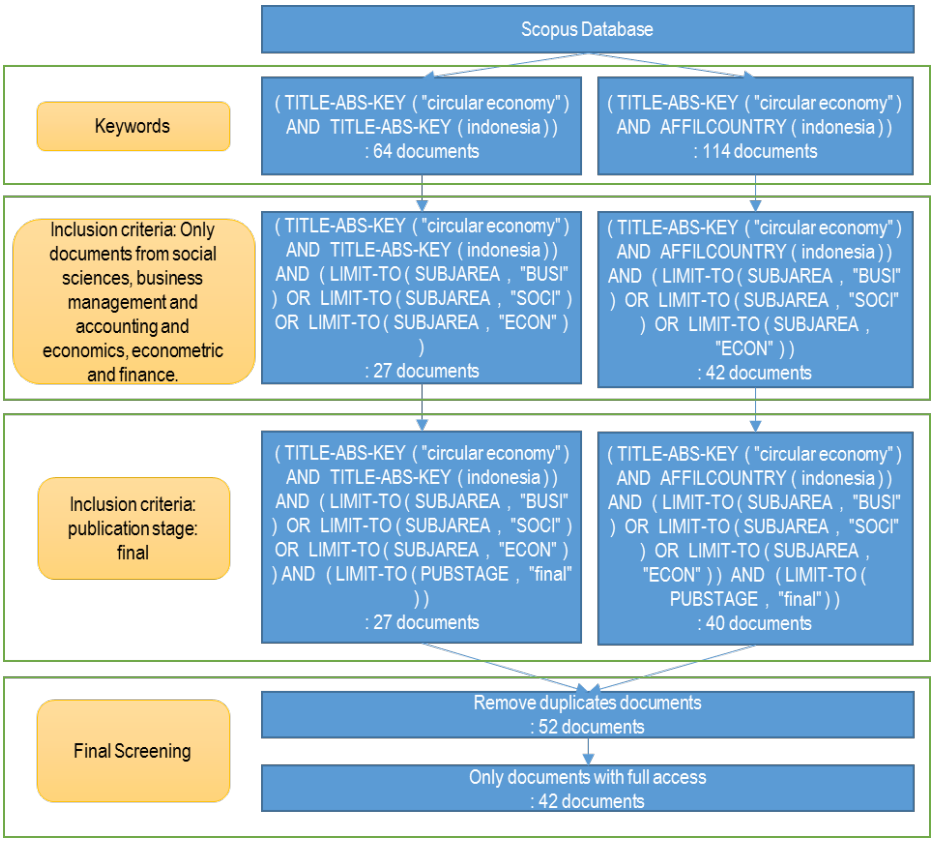
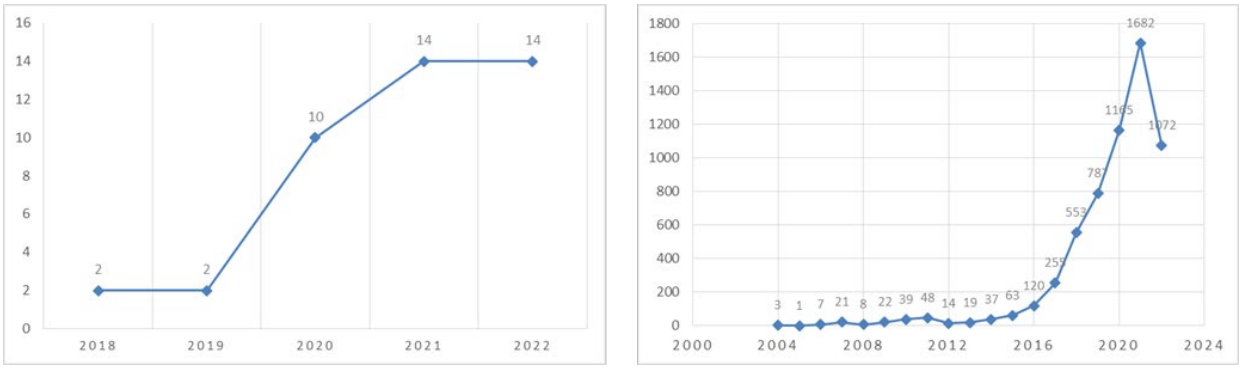


Figure 1. Article search process

5. Results and Discussion

5.1 Research trends



(a) (b)

Figure 2. Number of articles on circular economy; a) in Indonesia, b) worldwide

Figure 2a shows the number of articles published over the years. Research in this field began in 2018 with 2 articles, equal to the number of articles in 2019. The first published paper came from Bernon et al. (2018), which develop an exploratory framework for aligning retail reverse logistics practice with circular economy values, and Eneng et al. (2018) which discusses a water balanced utilization through a circular economy. Consistently, articles continue to increase to 10 articles in 2020, 14 articles in 2021, and by the middle of 2022, has equaled the number of articles in

2021. In the future, it is predicted that circular economy research will increase in popularity and be studied massively by researchers from Indonesia.

Compared to global research (Figure 2b), researchers from Indonesia are 14 years late because other researchers have carried out research on this since 2004. Globally, articles on the circular economy have consistently increased starting from 2015, with a peak of 1682 documents in 2021.

5.2 Authors

Table 1. Authors with the most articles in circular economic research in Indonesia

Rank	author	Affiliations	Docs.	citations
1	tjahjono b.	Centre for Business in Society, Coventry University, Coventry, United Kingdom	5	125
2	kurniawan t.a.	Key Laboratory of the Coastal and Wetland Ecosystems (Xiamen University), Ministry of Education, College of the Environment and Ecology, Xiamen UniversityFujian 361102, China, Faculty of Social Work, Health and Nursing, Ravensburg-Weingarten University of Applied Sciences, Weingarten, 88216, Germany	3	34
3	ripanti e.f.	Department of Informatics, Universitas Tanjungpura, Pontianak, Indonesia	2	108
4	jugend d.	Department of Production Engineering, Sao Paulo State University – UNESP, Bauru, Brazil	2	39
5	latan h.	Department of Accounting, STIE Bank BPD Jateng, Semarang, Indonesia	2	39

Tjahjono B. is the researcher with the most papers with 5 articles and recorded 125 citations. Of the five researchers presented in Table 1, only Ripanti and Latan are affiliated with institutions in Indonesia, the rest are researchers affiliated with institutions outside Indonesia. with 2 articles, Ripanti has a total of 108 citations, recording a better average than other researchers.

5.3 Research partner countries

Table 2 shows the author's country of affiliation of the 42 papers collected in this study. There are 33 papers written by at least one person affiliated with an institution in Indonesia. The remaining 9 papers were written by authors who were all from outside Indonesia, but conducted research in Indonesia or used comparative data from Indonesia. For example, the paper where all the authors are from Thailand but studied 4 countries, Malaysia, Indonesia, Thailand, and Singapore. Another interesting finding is that Five of the six papers that have authors with institutional affiliations from the UK are those of Tjahjono B.

Table 2. The affiliation country of the articles

No	Country	Docs.	Citations
1	Indonesia	33	404
2	United Kingdom	6	128
3	China	5	149
4	Malaysia	5	50
5	Japan	4	39
6	Thailand	4	24
7	united states	3	8

Table 3 shows article producers from various countries, with Italy ranking first with 809 documents. Researchers from Indonesia are suggested to look for research partners from the countries listed in Table 3 with the hope that researchers

from these countries are currently doing numerous studies on the circular economy, especially from an industrial engineering perspective.

Table 3. Countries with the most papers on circular economy

Rank	Country	Docs.	Rank	Country	Docs.
1	Italy	809	5	Netherlands	445
2	United Kingdom	768	6	United States	385
3	China	616	7	Germany	351
4	Spain	500	8	Sweden	348

5.4 Paper with the most citations

Table 4. Top 10 articles with most cittaions

Rank	Reference	Journal	Cited by	Keywords
1	Fatimah et al. (2020)	Journal of Cleaner Production	115	Industry 4.0; Internet of thing (IoT); Maturity model; Smart waste management; Sustainability; Sustainable circular economy; Sustainable development goals (SDG's)
2	Bernon et al. (2018)	Production Planning and Control	70	Circular economy; retail; returns management; reverse logistics; supply chain management
3	Ripanti and Tjahjono (2019)	International Journal of Logistics Management	38	Literature review; Reverse logistics; Sustainability
4	Arora et al. (2020)	Resources, Conservation and Recycling	34	Built environment; Housing; Material flow analysis; Resource efficiency; Sustainable development; Urban metabolism
5	Pinheiro et al. (2019)	Management Decision	32	Barriers; Circular design; Drivers; New product development; Stakeholders; Sustainable design
6	Brunnhofer et al. (2020)	Forest Policy and Economics	31	AHP; Analytic hierarchy process; Biorefinery; Delphi method; Pulp and paper industry; SWOT-analysis
7	Kurniawan et al. (2021)	Journal of Cleaner Production	24	Circular economy; Economic instruments; Polluters pay principle; Resource recovery; Zero-waste
8	Salleh et al. (2021)	Journal of Cleaner Production	16	Agricultural wastes; Industrial wastes; Pore-forming agent; Sustainable porous ceramics; Waste management; Waste-based porous ceramics
9	Susanty et al. (2020)	Production Planning and Control	15	circular economy; economic performance; environmental performance; supply chain cooperation; Traditional wooden furniture
10	Jayakumar et al. (2020)	Journal of Modelling in Management	13	Circular economy; Circular economy; Industry 4.0; Modelling; Multi objective mixed-integer linear programming; Network design; Optimization; Sensitivity; Sharing networks; Sustainable production

Ten articles that have been cited more than ten times are shown in Table 4. This table's objective is to identify the publications that the vast majority of researchers worldwide think to be of interest. Fatimah et al. (2020) conducted research on Industry 4.0 using a sustainable circular economy approach for intelligent waste management systems. Her work received 115 citations. Fatimah's work is similar to the article by Jayakumar et al. (2020), which applies a

circular economy using the industry 4.0 approach. This finding demonstrates that researchers study industry 4.0 and other digital technology approaches in the circular economy implementation. The second most cited article by Bernon et al. (2018) shares the same keywords as the article by Ripanti and Tjahjono (2019), that is, reverse logistics.

Another exciting finding is that three of the ten papers in Table 4 were published by the Journal of Cleaner Production, which recorded a total of 155 citations. In addition, there were two articles published by the Production Planning and Control journal, which recorded a total of 85 citations. This shows the quality of the articles published in the two journals, as evidenced by the number of citations received.

The article produced by researchers with affiliations from Indonesia and whose research was carried out in Indonesia are a study from Fatimah and Susanty. Fatimah's study of Waste management which examined the smart waste management system using the Industry 4.0 approach and was conducted the study in Indonesia (Jakarta, Magelang, Semarang, Yogyakarta). Fatimah is affiliated with the University of Muhammadiyah Magelang, Faculty of Engineering, Magelang, Indonesia. Then, Susanty, who is affiliated with the Industrial Engineering Department, Diponegoro University, Semarang, Indonesia, researched an investigation into circular economy practices in the traditional wooden furniture industry and conducted her research in Central Java, Indonesia.

5.5 Research objects

Based on the research objects mapped in Table 5, there are 6 papers that examine the circular economy in Organizational Performance, 5 papers examine the circular economy for Farm and Food and 5 papers examine the circular economy in Waste management.

Table 5. Research objects

Object	Reference
Automotive	Chinen and Matsumoto (2021); Sopha et al. (2022)
Building	Arora et al. (2020)
Organisational Performance	Pinheiro et al. (2019); Tahu et al. (2020); Jermsittiparsert et al. (2020); Muafi (2021); Pinheiro et al. (2021); Bastos Lima (2022)
Ceramic Industry	Salleh et al. (2021)
Cities	Nurdiana et al. (2021)
Clothing Industry	Jain et al. (2021)
Education	Nugraheni et al. (2021)
Electronic	Jayakumar et al. (2020)
Energy	Ngetich et al. (2022)
Farm and Food	Nattassha et al. (2020); Wicaksono and Kaswara (2021); Kusumowardani et al. (2021); Kusumowardani et al. (2022);
Logistics	Ripanti and Tjahjono (2019); Torasa and Mekhum (2020)
Landfill Mining	Burlakovs et al. (2021)
Paper Industry	Brunnhofer et al. (2020); Kuo et al. (2021)
Plastic	Neo et al. (2021); Mihai et al. (2022)
Port	Gurning and Tangkau (2022)
Recovery Facility	Budihardjo et al. (2022)
Restaurant and Retail	Bernon et al. (2018); Auwalin et al. (2022)
Soil	Vincevica-Gaile et al. (2021)
Transportation	Nasution et al. (2022)
Waste Management	Fatimah et al. (2020); Farizi and Sari (2021); Kurniawan et al. (2021); Kurniawan, T. A. et al. (2022a); Kurniawan, T. A. et al. (2022b)
Water	Eneng et al. (2018); Sugiyono and Dewancker (2020); Kurniawan, S. B. et al. (2022)
Wooden Furniture	Susanty et al. (2020)

5.6 Journal with the most articles

Table 6 shows the journals with the most articles. The favorite journal for the publication of circular economy by researchers from Indonesia is Sustainability, with a total of 9 documents and 28 citations recorded. In second place was the Journal of Cleaner Production, which recorded 162 citations, with an average of 27 citations per paper. In the third position is the journal Production Planning and Control, with two papers and a total of 85 citations with an average of 42 citations per document. The number of citations here suggests that the quality of the paper published in the Journal of Cleaner Production and journal Production Planning and Control is outstanding, so researchers widely cite it.

Table 6. Journal with the most articles (Indonesia)

Rank Indonesia	Journal/Proceeding Title	Publisher	Scopus Quartile	Sjr	Docs	Citations
1	Sustainability (Switzerland)	MDPI AG	Q1	0.66	9	28
2	Journal of Cleaner Production	Elsevier Ltd.	Q1	1.92	6	162
3	Production Planning and Control	Taylor and Francis Ltd.	Q1	1.66	2	85
4	Resources, Conservation and Recycling	Elsevier	Q1	2.59	2	43
5	Forest Policy and Economics	Elsevier	Q1	1.06	2	32

Journal Of Cleaner Production, Sustainability (Switzerland) and Resources Conservation And Recycling are among the top three journals who publish research on the circular economy. Other journals that publish studies on the circular economy by global researchers can be seen in Table 7. Researchers can also consider submitting to the journals in Table 7.

Table 7. Journal with the most articles (Worldwide)

Rank Global	Source	Publisher	Scopus Quartile	Sjr	Docs.
4	Journal Of Industrial Ecology	Wiley-Blackwell	Q1	1.73	124
5	Business Strategy and The Environment	John Wiley and Sons Ltd	Q1	2.24	100
6	Foods	MDPI	Q1	0.73	62
7	Water Switzerland	MDPI	Q1	0.72	50
8	Ecological Economics	Elsevier	Q1	1.78	41
9	International Journal of Production Research	Taylor and Francis Ltd.	Q1	2.78	36
10	Resources Policy	Elsevier Ltd.	Q1	1.46	36

5.7 Keywords

Table 8 shows the ranking of keywords used by researchers in Indonesia and compared to the global rankings. In general, researchers from Indonesia have conducted similar research to those from other countries, such as “waste management”, “recycling” and “decision making”. However, there are keywords that seem to have been overlooked by researchers from Indonesia, such as “life cycle” with the method of life cycle assessment and analysis and “economic aspects”, both “environmental economics” and “economic conditions”. Other keywords that researchers from Indonesia have not studied are “innovation”, “climate change”, “manufacturing”, and “business”. Those keywords that have not been studied are an opportunity to research the circular economy. Researchers from Indonesia are recommended to study the life cycle, economic aspects, innovation, climate change, manufacturing and business in the circular economy.

Table 8. Keywords used in research

Keyword	Rank Indonesia	Rank Global	Keyword	Rank Indonesia	Rank Global
circular economy	1	1	industry 4.0	16	25
indonesia	2	-	literature review	17	14
sustainability	3	2	waste treatment	18	59
sustainable development	4	3	environmental impact	29	7
waste management	5	5	life cycle assessment	34	16
recycling	6	4	life cycle	-	6
decision making	7	9	environmental economics	-	10
economic analysis	8	27	economic conditions	-	11
supply chain management	9	21	economic aspect	-	12
barriers	10	87	life cycle analysis	-	13
climate change	11	18	economics	-	15
conceptual framework	12	53	innovation	-	17
economics	13	15	climate change	-	18
implementation process	14	-	manufacturing	-	20
industrial economics	15	41	business	-	22

6. Conclusion

This study aims to map the literature on the circular economy and propose recommendations for research on the circular economy in Indonesia from industrial engineering perspective. To achieve the aim of this work, a comprehensive analysis of the circular economy research publications in Indonesia was carried out. The findings show that research in this field began in 2018. It is predicted that circular economy research will increase in popularity and be studied massively by researchers from Indonesia. Authors with most articles is Tjahjono B., with 5 articles and recorded 125 citations. Regarding the object of research, there are 6 papers that examine the circular economy in Organizational Performance. The favorite journal for the publication of circular economy by researchers from Indonesia is Sustainability, with a total of 9 documents and 28 citations recorded. In general, researchers from Indonesia have conducted similar research to those from other countries, such as “waste management”, “recycling” and “decision making”.

Researchers from Indonesia are suggested to look for research partners from the countries listed in Table 3 and study the life cycle, economic aspects, innovation, climate change, manufacturing, and business in the circular economy.

References

Aboagye, E., Jensen, I., Bergström, G., Brämberg, E. B., Pico-Espinosa, O. J., and Björklund, C., Investigating the association between publication performance and the work environment of university research academics: a systematic review, *Scientometrics,* vol. 126 no. 4, pp. 3283-3301, 2021. doi:10.1007/s11192-020-03820-y

Arora, M., Raspall, F., Cheah, L., and Silva, A., Buildings and the circular economy: Estimating urban mining, recovery and reuse potential of building components, *Resources, Conservation and Recycling,* vol. 154, pp. 104581, 2020. doi:https://doi.org/10.1016/j.resconrec.2019.104581

Auwalin, I., Rumayya, Rahma Sari, F., and Maulida, S. R., Applying the Pro-Circular change model to restaurant and retail businesses’ preferences for circular economy: evidence from Indonesia, *Sustainability: Science, Practice and Policy,* vol. 18 no. 1, pp. 97-113, 2022. doi:10.1080/15487733.2022.2027121

Bastos Lima, M. G., Just transition towards a bioeconomy: Four dimensions in Brazil, India and Indonesia, *Forest Policy and Economics,* vol. 136, pp. 102684, 2022. doi:https://doi.org/10.1016/j.forpol.2021.102684

Bernon, M., Tjahjono, B., and Ripanti, E. F., Aligning retail reverse logistics practice with circular economy values: an exploratory framework, *Production Planning & Control,* vol. 29 no. 6, pp. 483-497, 2018. doi:10.1080/09537287.2018.1449266

Brunnhofer, M., Gabriella, N., Schöggl, J.-P., Stern, T., and Posch, A., The biorefinery transition in the European pulp and paper industry – A three-phase Delphi study including a SWOT-AHP analysis, *Forest Policy and Economics,* vol. 110, pp. 101882, 2020. doi:https://doi.org/10.1016/j.forpol.2019.02.006

Budihardjo, M. A., Ardiansyah, S. Y., and Ramadan, B. S., Community-driven material recovery facility (CdMRF) for sustainable economic incentives of waste management: Evidence from Semarang City, Indonesia, *Habitat International,* vol. 119, pp. 102488, 2022. doi:https://doi.org/10.1016/j.habitatint.2021.102488

Burlakovs, J., Pilecka-Ulcugaceva, J., Grinfelde, I., Arbidans, L., Arina, D., and Hendroko, R. *Sustainable landfill fine fraction of waste reuse opportunities covering layer development* 2021.

Chinen, K., and Matsumoto, M., Indonesians' Perceptions of Auto Parts Remanufactured in China: Implications for Global Remanufacturing Operations, *Sustainability,* vol. 13 no. 7, pp. 3968, 2021.

Ekins, P., Domenech, T., Drummond, P., Bleischwitz, R., Hughes, N., and Lotti, L., The Circular Economy: What, Why, How and Where *OECD/EC Workshop*, Paris, 2019.

Eneng, R., Lulofs, K., and Asdak, C., Towards a water balanced utilization through circular economy, *Management Research Review,* vol. 41 no. 5, pp. 572-585, 2018. doi:10.1108/MRR-02-2018-0080

Farizi, T. S., and Sari, R. F., Implementation of Blockchain-based Electronic Waste Management System with Hyperledger Fabric, *Proceedings of the 2021 2nd International Conference on ICT for Rural Development (IC-ICTRuDev)*, 27-28 Oct. 2021, 2021.

Fatimah, Y. A., Govindan, K., Murniningsih, R., and Setiawan, A., Industry 4.0 based sustainable circular economy approach for smart waste management system to achieve sustainable development goals: A case study of Indonesia, *Journal of Cleaner Production,* vol. 269, pp. 122263, 2020. doi:https://doi.org/10.1016/j.jclepro.2020.122263

Ghosh, S. K. (2020a). Introduction to Circular Economy and Summary Analysis of Chapters. In S. K. Ghosh (Ed.), *Circular Economy: Global Perspective*. Singapore: Springer.

Ghosh, S. K. (2020b). Introduction to Circular Economy and Summary Analysis of Chapters. In S. K. Ghosh (Ed.), *Circular Economy: Global Perspective* (pp. 1-23). Singapore: Springer, Singapore.

Gurning, R. O. S., and Tangkau, D. I., The Analysis of the Conceptual Framework of Green Port Implementation in Indonesia Using Circular Economy: The Case Study of Benoa Public and Fishing Terminals, *Sustainability,* vol. 14 no. 10, pp. 6083, 2022.

Hofstetter, J. S., De Marchi, V., Sarkis, J., Govindan, K., Klassen, R., Ometto, A. R., . . . Vazquez-Brust, D., From Sustainable Global Value Chains to Circular Economy—Different Silos, Different Perspectives, but Many Opportunities to Build Bridges, *Circular Economy and Sustainability,* vol. 1 no. 1, pp. 21-47, 2021. doi:10.1007/s43615-021-00015-2

Jain, V., O'Brien, W., and Gloria, T. P., Improved solutions for shared value creation and maximization from used clothes: Streamlined structure of clothing consumption system and a framework of closed loop hybrid business model, *Cleaner and Responsible Consumption,* vol. 3, pp. 100039, 2021. doi:https://doi.org/10.1016/j.clrc.2021.100039

Jayakumar, J., K, J., K.E.K, V., and Hasibuan, S., Modelling of sharing networks in the circular economy, *Journal of Modelling in Management,* vol. 15 no. 2, pp. 407-440, 2020. doi:10.1108/JM2-05-2019-0101

Jermsittiparsert, K., Pamornmast, C., and Sriyakul, T., SUSTAINABLE DEVELOPMENT AND CIRCULAR ECONOMY: FUNCTIONAL VS. ECONOMIC WELLBEING IN ASEAN, *Journal of Security and Sustainability Issues,* vol. 10, pp. 414-425, 2020. doi:10.9770/jssi.2020.10.Oct(33)

Kementerian Perindustrian Republik Indonesia. (2021). Penerapan Circular Economy Berpotensi Dorong Substitusi Impor Sektor Industri [Press release]. Retrieved from https://kemenperin.go.id/artikel/22260/Penerapan-Circular-Economy-Berpotensi-Dorong-Substitusi-Impor-Sektor-Industri

Kementerian PPN/Bappenas. (2021). *Manfaat Ekonomi, Sosial, dan Lingkungan dari Ekonomi Sirkular Di Indonesia*. Indonesia.

Kuo, T.-C., Hsu, N.-Y., Wattimena, R., Hong, I. H., Chao, C.-J., and Herlianto, J., Toward a circular economy: A system dynamic model of recycling framework for aseptic paper packaging waste in Indonesia, *Journal of Cleaner Production,* vol. 301, pp. 126901, 2021. doi:https://doi.org/10.1016/j.jclepro.2021.126901

Kurniawan, S. B., Ahmad, A., Imron, M. F., Abdullah, S. R. S., Othman, A. R., and Hasan, H. A., Potential of microalgae cultivation using nutrient-rich wastewater and harvesting performance by biocoagulants/bioflocculants: Mechanism, multi-conversion of biomass into valuable products, and future challenges, *Journal of Cleaner Production,* vol. 365, pp. 132806, 2022. doi:https://doi.org/10.1016/j.jclepro.2022.132806

Kurniawan, T. A., Avtar, R., Singh, D., Xue, W., Dzarfan Othman, M. H., Hwang, G. H., . . . Kern, A. O., Reforming MSWM in Sukunan (Yogjakarta, Indonesia): A case-study of applying a zero-waste approach based on

circular economy paradigm, *Journal of Cleaner Production,* vol. 284, pp. 124775, 2021. doi:https://doi.org/10.1016/j.jclepro.2020.124775

Kurniawan, T. A., Dzarfan Othman, M. H., Hwang, G. H., and Gikas, P., Unlocking digital technologies for waste recycling in Industry 4.0 era: A transformation towards a digitalization-based circular economy in Indonesia, *Journal of Cleaner Production,* vol. 357, pp. 131911, 2022a. doi:https://doi.org/10.1016/j.jclepro.2022.131911

Kurniawan, T. A., Liang, X., O'Callaghan, E., Goh, H., Othman, M. H. D., Avtar, R., and Kusworo, T. D., Transformation of Solid Waste Management in China: Moving towards Sustainability through Digitalization-Based Circular Economy, *Sustainability,* vol. 14 no. 4, pp. 2374, 2022b.

Kusumowardani, N., Tjahjono, B., Lazell, J., Bek, D., Theodorakopoulos, N., Andrikopoulos, P., and Priadi, C. R., A circular capability framework to address food waste and losses in the agri-food supply chain: The antecedents, principles and outcomes of circular economy, *Journal of Business Research,* vol. 142, pp. 17-31, 2022. doi:https://doi.org/10.1016/j.jbusres.2021.12.020

Kusumowardani, N., Tjahjono, B., and Priadi, C. R., Circular economy adoption in the upstream agri-food supply chain: Understanding the implications of the two theoretical lenses, *Proceedings of the 11th Annual International Conference on Industrial Engineering and Operations Management, 2021*, Singapore, 2021.

Limanseto, H. (2021). Pemerintah Mendorong Ekonomi Sirkular bagi Pencapaian Nationally Determined Contribution Indonesia [Press release]. Retrieved from https://www.ekon.go.id/publikasi/detail/3328/pemerintah-mendorong-ekonomi-sirkular-bagi-pencapaian-nationally-determined-contribution-indonesia#:~:text=Ekonomi%20sirkular%20merupakan%20model%20industri,daya%20primer%20dan%20produksi%20limbah.&text=Ekonomi%20sirkular%20akan%20memberi%20kontribusi,Determined%20Contribution%20(NDC)%20Indonesia.

Mihai, F.-C., Gündoğdu, S., Markley, L. A., Olivelli, A., Khan, F. R., Gwinnett, C., . . . Molinos-Senante, M., Plastic Pollution, Waste Management Issues, and Circular Economy Opportunities in Rural Communities, *Sustainability,* vol. 14 no. 1, pp. 20, 2022.

Muafi, The influence of green culture and green strategy on the circular economy implementation: The moderating role of green intellectual capital, *International Journal of Sustainable Development and Planning,* vol. 16 no. 6, pp. 1101-1108, 2021. doi:https://doi.org/10.18280/ijsdp.160611

Nasution, N. A. S., So, I. G., Furinto, A., and Setiowati, R., Circular Economy In Courier Express Parcel in Indonesia, *Proceedings of the ICBIR 2022 - 2022 7th International Conference on Business and Industrial Research*, Bangkok; Thailand, 2022.

Nattassha, R., Handayati, Y., and Simatupang, T., Linear and circular supply chain: SCOR framework stages, actor analysis and the illustrative case of cassava farming, *International Journal of Business and Globalisation,* vol. 26, pp. 3, 2020. doi:10.1504/IJBG.2020.109823

Neo, E. R. K., Soo, G. C. Y., Tan, D. Z. L., Cady, K., Tong, K. T., and Low, J. S. C., Life cycle assessment of plastic waste end-of-life for India and Indonesia, *Resources, Conservation and Recycling,* vol. 174, pp. 105774, 2021. doi:https://doi.org/10.1016/j.resconrec.2021.105774

Ngetich, B., Yakin, N., and Nurul Qamari, I., How Research in Sustainable Energy Supply Chain Distribution Is Evolving: Bibliometric Review, vol. 20, pp. 47-56, 2022. doi:10.15722/jds.20.07.202207.47

Nugraheni, A. R. E., Prasongsap, B., and Srisawasdi, N., Targeting Chemistry Competencies on Plastic Circular Economy with Technology-assisted Citizen Inquiry: A Proposal of Learning Matrix, *Proceedings of the 29th International Conference on Computers in Education*, Thailand, 2021.

Nurdiana, J., Franco-Garcia, M. L., and Heldeweg, M. A., How Shall We Start? The Importance of General Indices for Circular Cities in Indonesia, *Sustainability,* vol. 13 no. 20, pp. 11168, 2021.

Pinheiro, M., Jugend, D., Jabbour, A., Jabbour, C., and Latan, H., Circular economy-based new products and company performance: The role of stakeholders and Industry 4.0 technologies, *Business Strategy and the Environment*, 2021. doi:10.1002/bse.2905

Pinheiro, M. A. P., Seles, B. M. R. P., De Camargo Fiorini, P., Jugend, D., Lopes de Sousa Jabbour, A. B., da Silva, H. M. R., and Latan, H., The role of new product development in underpinning the circular economy, *Management Decision,* vol. 57 no. 4, pp. 840-862, 2019. doi:10.1108/MD-07-2018-0782

Rantung, F. (2021). Penerapan Ekonomi Sirkular Beri Banyak Keuntungan Sektor Industri. *Sindo News*.

Ripanti, E. F., and Tjahjono, B., Unveiling the potentials of circular economy values in logistics and supply chain management, *The International Journal of Logistics Management,* vol. 30 no. 3, pp. 723-742, 2019. doi:10.1108/IJLM-04-2018-0109

Rishanty, A., and Suryahadi, A., Circular Economy And Productivity In A Large Developing Country: Empirical Evidence From Indonesia, *Working Papers, Bank Indonesia,* vol. WP/10/2020, 2020.

Salleh, S. Z., Awang Kechik, A., Yusoff, A. H., Taib, M. A. A., Mohamad Nor, M., Mohamad, M., . . . Teo, P. T., Recycling food, agricultural, and industrial wastes as pore-forming agents for sustainable porous ceramic production: A review, *Journal of Cleaner Production,* vol. 306, pp. 127264, 2021. doi:https://doi.org/10.1016/j.jclepro.2021.127264

Sopha, B. M., Purnamasari, D. M., and Ma'mun, S., Barriers and Enablers of Circular Economy Implementation for Electric-Vehicle Batteries: From Systematic Literature Review to Conceptual Framework, *Sustainability,* vol. 14 no. 10, pp. 6359, 2022.

Sugiyono, and Dewancker, B., Study on the Domestic Water Utilization in Kota Metro, Lampung Province, Indonesia: Exploring Opportunities to Apply the Circular Economic Concepts in the Domestic Water Sector, *Sustainability,* vol. 12, pp. 8956, 2020. doi:10.3390/su12218956

Susanty, A., Tjahjono, B., and Sulistyani, R. E., An investigation into circular economy practices in the traditional wooden furniture industry, *Production Planning & Control,* vol. 31 no. 16, pp. 1336-1348, 2020. doi:10.1080/09537287.2019.1707322

Tahu, G. P., Yuesti, A., Manek, D., and Verawati, Y., Implications of Circular Economy, Supply Chain Management Innovation and Sustainability on Organisational Performance, *International Journal of Supply Chain Management,* vol. 9 no. 2, 2020.

Tonelli, M., and Cristoni, N. *Strategic Management and the Circular Economy*. New York: Routledge 2019.

Torasa, C., and Mekhum, W., Impact of Green Logistics Activities on Circular Economy: Panel Data Evidence from ASEAN, *International Journal of Supply Chain Management,* vol. 9 no. 1, 2020.

Trisyulianti, E., Prihartono, B., Andriani, M., and Suryadi, K., Sustainability Performance Management Framework for Circular Economy Implementation in State-Owned Plantation Enterprises, *Sustainability,* vol. 14 no. 1, pp. 482, 2022.

United Nations Industrial Development Organization (UNIDO). *Driving Towards Circularity: International Conference on Circular Economy in The Automotive Industries,* 2017. Europe. Retrieved from:

Vincevica-Gaile, Z., Teppand, T., Kriipsalu, M., Krievans, M., Jani, Y., Klavins, M., . . . Burlakovs, J., Towards Sustainable Soil Stabilization in Peatlands: Secondary Raw Materials as an Alternative, *Sustainability,* vol. 13 no. 12, pp. 6726, 2021.

Wicaksono, P. A., and Kaswara, D., Environmental Impact Reduction in Broiler Chicken Farm Using Life Cycle Assessment in The Implementation of Circular Economy, 2021.

Acknowledgements

This work is supported by grant from HIBAH DIKTI PDD through Universitas Indonesia No. NKB-1014/UN2.RST/HKP.05.00/2022

Biography

Muhammad Habiburrahman is currently a doctoral student at the Department of Industrial Engineering, Universitas Indonesia. He received his undergraduate degrees in Naval Architecture as well as his master degree in Industrial Engineering from Faculty of Engineering, Universitas Indonesia. His research interests are in engineering management and automotive industry.

Rahmat Nurcahyo is a professor in the Department of Industrial Engineering, Universitas Indonesia, Depok, Indonesia. He earned a Bachelor's in Mechanical Engineering, Universitas Indonesia, Depok, Indonesia, and a master's in the University of New South Wales, Australia. Then he obtained his Doctoral degree from Universitas Indonesia. His research interests include management systems and business management.

Hotmatua Daulay is a member of Indonesian Researcher Union and a Principal Engineer at National Research and Innovation Agency of Indonesia. Mr. Daulay holds a Doctor of Engineering degree in Mathematical Engineering from College of Industrial Technology - Nihon University, Japan. He has taught courses in operation research, technology readiness level, and innovation for researchers and engineers. He has concern about circular economy, remote sensing and supply chain.