

# **Bibliometric Analysis and Visualization of Waste Management LCAs in Southern Africa**

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## **Abstract**

The intention of this work is to appraise literature on Waste Management in Southern Africa to provide an analysis of sources of publication, citations and authorship using bibliometric analysis techniques (VOSviewer and Scopus). VOSviewer is a software device for building and envisaging bibliometric linkages. Such linkages embrace journals, researchers, or individual publications, and they were used based on citation, bibliographic coupling, co-citation, or co-authorship relations. It was as well utilised to build and visualize co-occurrence networks of important terms extracted from a body of scientific literature.

## **Keywords**

Waste management, South Africa, Reverse logistics, Bibliometric analysis, Bioenergy production, LCA.

## **1. Introduction**

A bibliometry is an investigative technique utilised to get computable outcomes from a systematic production. It is likewise taken as a way to scrutinise publications on statistical approaches, to study a definite theme, and to internally measure the systematic procedure (Algawe, Schiffauerova, Kuzgunkaya and Shiboub 2019). Facts and analysis found on methodical production help discover the progress of a specific theme, diverse study areas, and forthcoming inquiry prospects. It is also supportive for projecting and policymaking the fundamentals considered in a bibliometric investigation, there is official affiliation, dates of publication, journals, books, authors, citations, keywords, titles, and abstracts, amongst other sources of data encompassed in the documents. Such fundamentals are pertinent to gain the evidence of the results in a research field; thus, these will be used to achieve the purpose of this study. Bibliometric examination is regarded as an authenticated exploration practice in numerous discourses, including trade, technology, and info metrics. Bibliometric review in this work was done in the Reverse logistics know-hows to figure out the greatest remaining works and to appraise their evolution and the studies in progress. (Viswanathan and Telukdarie, 2022).

SADC has acknowledged that the region has waste management challenges, which include a growing population that has resulted in increased volumes of waste generated and the increased complexity of the waste stream. As the smallest

province, but with the highest population density, Gauteng contributes about 45% of South Africa's municipal waste at 59 million tons a year, with the largest percentage of it being disposed of in landfill sites (DEA, 2011). In an attempt to divert recyclable waste away from its landfill sites to allow their landfill sites an extended lifespan, City of Johannesburg's waste management entity Pikitup launched a new bulk waste service in March 2015, to remove bulky household waste once a month, free of charge.

Recyclable waste materials, general organic waste and biomass can be converted into various forms of bioenergy such as biogas, bioethanol, and biodiesel. The anaerobic enzyme biogas can be burned directly at the innate and thermal power plant or used as an alternative to natural gas or as an additive. Unlike fossil fuel systems, carbon dioxide, which is released during the production and combustion of biogas, has only recently been incorporated into photosynthesis. These emissions do not lead to a net production of carbon dioxide and therefore the atmosphere is neutral as long as plants continue to absorb carbon dioxide. Biodiesel is mostly harvested from used vegetable oil so as to avoid the food and energy debate and Bioethanol is mostly harvested from the remains of sugarcane after the sugar has been made (Kinobe, 2015).

The proposed research focuses on reverse logistics (RL) and energy production in the waste management sector of South Africa. Relevant stakeholders in the reverse logistics to energy chain will be identified and incorporated in the strategies for sustainable management of plastic waste including the informal waste sector (Samadhiya et al. 2019; Lia et al 2022). The waste flows will be analysed and visualised with Material Flow Analysis (MFA). On this basis a Life Cycle Assessment (LCA) will be conducted to determine and outline the environmental impacts of reverse logistics and bioenergy production in comparison with alternative disposal scenarios. The LCA will not confine itself to intended ways of disposal and energy production but will include the aspect of waste collection as well (ISO, 2006).

## **2. Problem Statement**

The volume of South Africa's climate-warming gases has increased by nearly 25% over the past ten years with emissions from the waste sector, mainly rotting garbage sent to municipal dumps and rotting human and industrial sewage in waste-water treatment plants, increasing by almost 60% and accounting for almost 3% of overall emissions (South Africa DEAT, 2005; Chaves et al. 2014). In October 2014 Innocent Sibeko, managing director of waste management company, Exergy Enviro Group and one of the African Climate Leaders trained by Al Gore's Climate Reality Project reported that landfill now accounts for 13% of all global methane gas emissions. Methane is second only to carbon dioxide in terms of contributing to global warming. South Africa is the highest emitter of greenhouse gas emissions on the African continent and is the twelfth highest emitter globally (Fu et al, 2018; Joshi et.al 2022).

## **3. Research Objectives**

- To explain the sustainability of the waste management industry and identify ways of strengthening it. Opportunities for integration into the fourth industrial revolution based on literature.
- Bibliometric Integration of reverse logistics operations and systems with bio-energy production using 4IR and block chains to maximize and improve efficiency by forming a waste to energy supply chain.
- Identify areas of, or with potential co-occurrence and explain relations in the waste to energy sector and authors.

## **4. Design and Methodology Approach**

Arranged appraisals of collected works ought to be carried out using a procedure of describing keywords, looking for pertinent literature and effecting the scrutiny (Logario et al. 2020). As procedural appraisal, it was thought expedient to use the Scopus databank as it gives a universal vision of research acquaintance with smart tools to fragment, appraise and choose articles using search standards pertinent to the theme (Viswanathan and Telukdure, 2022). Also, it has a comprehensive database that has different publishers like Elsevier, Springer, Inder Science, Taylor & Francis, Emerald and IEEE, and others. The time covered was from 2010 to 2023, and it was warranted that the heading and summary had keywords "logistics costs" and "supply chain". Moreover, utilizing Boolean operators, other keywords such as "optimization" and "transportation" were considered. Related articles that do not address reverse logistics or block chains were excluded. The appraisal was restricted to works written in English and closely linked to logistics and supply chain costs. Alternatives for examination comprised co-authorship, co-occurrence, citation, co-citation, bibliographic coupling. Citation by country mapping is a way of visualizing the scientific output and impact of different countries based on their publications and citations (Viswanathan and Telukdure, 2022).

## **5. Results and Discussion**

The Figure 1 shows absence of waste management research from 1990 to 2016. From 2017 to present the discourse of waste management gained currency. 1274 documents on block chain technology were published in 2017 . A sharp increase of published block chain technology documents were recorded from 2018 to 2023 in which 1601;1602;1694;1797;1968;2832;5986;7812 and 12763 documents were recorded respectively . It should however be noted that such records of incresed emergence of waste managemnt technology documents were in the developed world of Europe , Asia and America. Figure 2 below shows the exact countries that had the above publications. Worth noting is the absence of Southern Africa in the emergence Waste management technology.

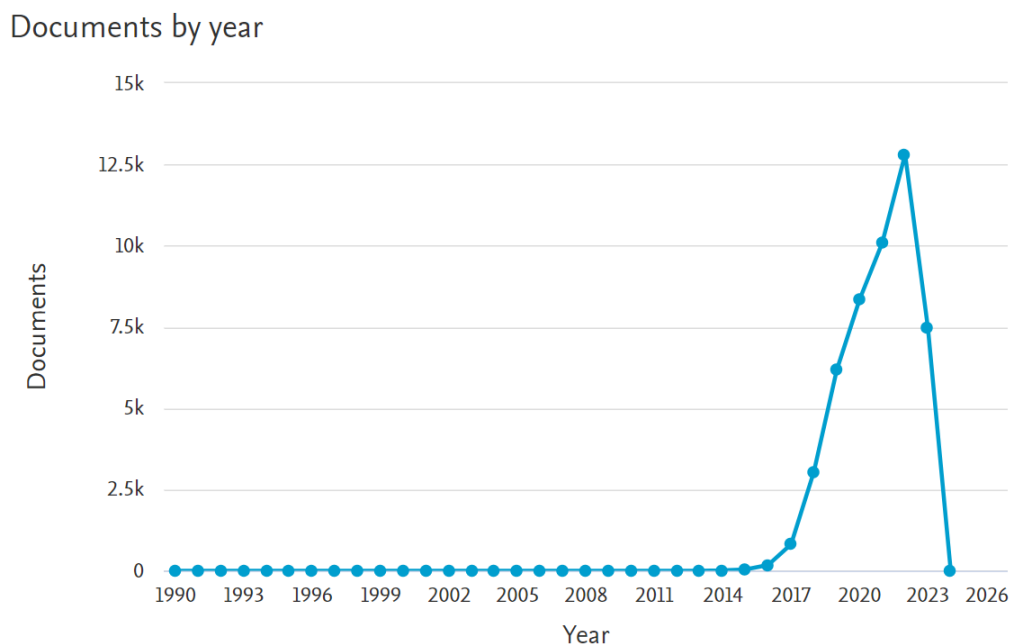


Figure 1. Graph showing waste management documents published by year

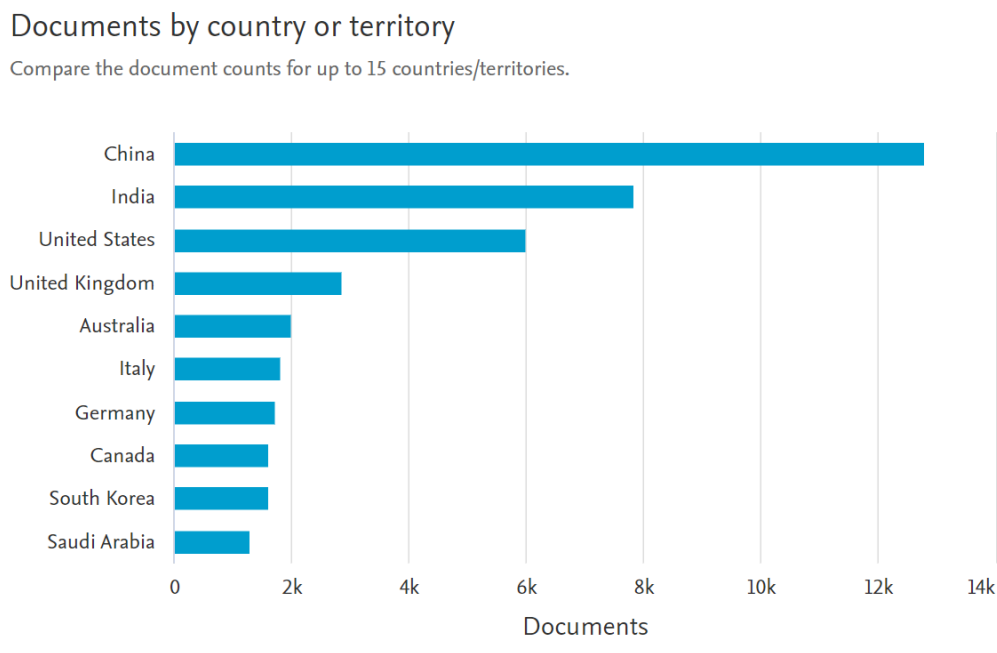


Figure 2. Bar graph showing top ten block chain technology documents by country or territory

China , India, United States, United Kingdom, Australia, Italy, Germany, Canada, South Korea and Saudi Arabia respectively had the highest number of published works on waste management technology. Following the above order, they published 12763;7812;5986;2832;1968;1797;1694;1602;1601 and 1274 documents on waste management technology respectively. No other African country found itself in the league of such giants in the area of block chain technology. A glaringly low level of publication on waste management technology is represented in Table 1 below.

Table 1. above shows number of waste management articles in Southern Africa

| Country/Territory | Documents |
|-------------------|-----------|
| Namibia           | 8         |
| South Africa      | 254       |
| Lesotho           | 1         |
| Angola            | 7         |
| Botswana          | 5         |
| Malawi            | 5         |
| Zambia            | 5         |
| Zimbabwe          | 5         |
| Swaziland         | 2         |

The Table 1 shows a dismal performance of Southern Africa in the publishing of articles on waste management technology as compared to the faring of developed countries presented in Figure 2. South Africa is the leading country in Southern Africa in researching on waste management and block chain technology with 254 articles. Namibia is the second best Southern African researcher in block chain technology with 8 articles. Botswana, Malawi, Zambia and Zimbabwe all have five articles each followed by Swaziland and Lesotho with 2 and 1 respectively. Such lower numbers of research articles on Waste management and block chain technology compared to the developed world shows that Southern Africa is lagging behind in 4iR technology.

Table 2. Number of articles on waste reverse logistics by country in the developed world

| Country/Territory | Documents |
|-------------------|-----------|
| China             | 1036      |
| United States     | 494       |
| India             | 425       |
| Brazil            | 403       |
| Iran              | 236       |
| United Kingdom    | 226       |
| Canada            | 166       |
| France            | 157       |
| Turkey            | 149       |

Table 2 above shows number of articles on waste reverse logistics by country in the developed world. Just like in block chain technology, research on reverse logistics is also largely dominated by the developed world more than Southern Africa. The table above shows that China leads again in reverse logistics research with 1036 articles followed by United States, India, Brazil, Iran, United Kingdom, Canada, France and Turkey with 494; 425; 403; 236; 226; 166; 157 and 149 articles respectively. The leading of these countries in research on reverse logistics points to proper funding and the importance with which such countries give to issues of supply chain management dynamics. That gives a stark contrast to situations obtaining in Southern Africa shown in Table 3 below.

Table 3. Number of articles on waste reverse logistics by country in Southern Africa

| Country/Territory | Documents |
|-------------------|-----------|
| South Africa      | 44        |
| Botswana          | 3         |
| Zambia            | 3         |
| Zimbabwe          | 1         |

Table 3 above shows number of articles on waste reverse logistics by country in Southern Africa. From Table 3 it is evident that there is apparent dearth of reverse logistics technology in Southern Africa. South Africa has 44 articles followed by Botswana, Zambia and Zimbabwe which have 3;3 and 1 articles respectively. South Africa, Botswana, Zambia and Zimbabwe have a combined 51 articles on reverse logistics. That is nearly three times the research done by Turkey which has the lowest articles in the table showing articles on reverse logistics by the group of developed countries. This calls for increased investment in research and knowledge acquisition on the discourse of block chain and reverse logistics in Southern Africa.

## 6. Key words co-occurrence

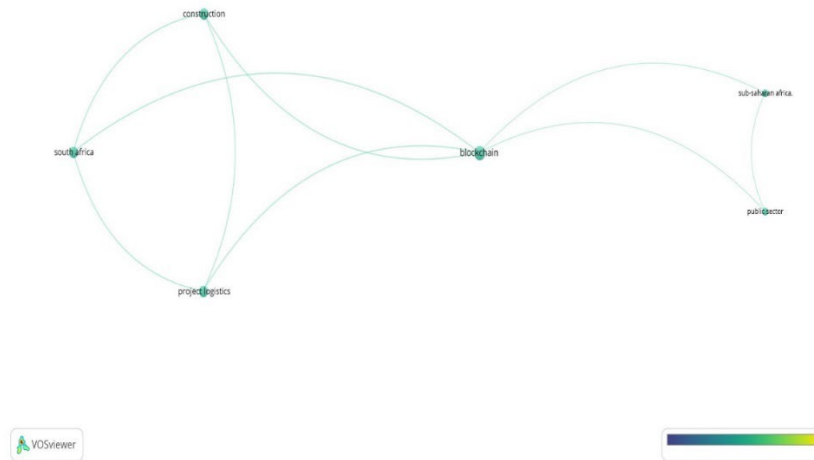


Figure 3. Key words co-occurrence Map

The advanced cluster highlights the network of 4IR innovations, web, data administration, choice making on the squander administration framework with economical circular economy as the directing rule. The grouping of mediation to figure it out savvy squander administration and at long last huge information involving a cluster clearly implies the significance of information gathering on the squander administration exercises.

The Figure 3 shows the countries as nodes and the citation links between them as edges. The size of the nodes reflects the number of publications, and the color reflects the average citation impact. The distance between the nodes reflects the citation similarity, meaning that key words that cite each other more frequently are closer together. Bibliometric coupling is a method of measuring the similarity or relatedness of two publications based on their references. Two publications are coupled if they share common references. The strength of the coupling is proportional to the number of shared references. Bibliometric coupling can be used to identify clusters of publications that belong to the same research topic or field. Concurrence of keywords is a way of analyzing the co-occurrence of keywords in a set of

publications. The concurrence of keywords reflects the frequency with which two keywords appear together in the same publication. The concurrence of keywords can be used to identify the main themes or concepts in a research domain (Viswanathan and Telukdure, 2022).

## 7. Limitations

Given that only Scopus was utilised, further published works obtainable somewhere else could have been overlooked. Other potential publications, like proceedings papers, books and theses were not considered to give insights to this bibliometric study. Clustering from co-citation inquiry merely conveys close to similar aspects and enhances certain ideas and concepts at the expense of other crucial publications. Some perspectives could come from additional dimensions of investigation like co-occurrence examination or bibliographic coupling. Nevertheless, such analyses were not vital to this work.

## 8. Conclusion

A close analysis of the resultant data discovered some intuitions about many features of studies in this area. A case in point, the appraisal noted a dearth of scholarly work on “waste supply chain,” “waste reverse logistics” and “Block chains in relation to supply chain (Christopher and Holweg 2011). The research also reveals that advanced countries like India, United States, China, Japan, and Germany have the greatest pertinent research on the investigated subject. Southern Africa and other less developed nations must also undertake research in reverse logistics and integrate that with inquiries on supply chain management and block chain technology. The funding of studies on reverse logistics integration with supply chain management and block chain technology also need to be considered in Southern Africa. Such funding may be non-existent in Southern Africa. Upcoming research ought to widen the scope of inquiry and expand its findings by integrating other sources, comprising additional renowned databases like Business Source Premier, Science Citation Index, Social Science Citation, and WoS.

## References

- Chaves GDDL, dos Santos JL and Rocha SM, The challenges for solid waste management in accordance with Agenda 21: A Brazilian case review. *Waste Management & Research* 32: 19–31, 2014.
- Fu, B., Z. Shu, and X. Liu. “Blockchain Enhanced Emission Trading Framework in Fashion Apparel Manufacturing Industry.” *Sustainability* 10 (4): 1105. 2018.doi:10.3390/su10041105.
- ISO. Environmental management - Life cycle assessment - Principles and framework. ( No. ISO 14040:2006; Second Edition 2006-06). Geneva: International Organization for Standardization. 2006.
- Joshi, S., M. Sharma, and A. Barve , “Implementation Challenges of Blockchain Technology in closed-loop Supply Chain: A Waste Electrical and Electronic Equipment (WEEE) , 2022.
- Kinobe J.R., Gebresenbet, G, Niwagaba, C.B, Vinnerås B, Reverse logistics system and recycling potential at a landfill: A case study from Kampala City, *Waste Management* 42 82–92, 2015.
- Lai, N. Y. G., A. T. Kuah, C. H. Kim, and K. H. Wong. “Toward Sustainable Express Deliveries for Online Shopping: Reusing Packaging Materials through Reverse Logistics.” *Thunderbird International Business Review* 64 (42022.): 351–362. 2022. doi:10.1002/tie.22259.
- Samadhiya, A., A. Kumar, R. Agrawal, Y. Kazancoglu, and R. Agrawal. “Reinventing Reverse Logistics through Blockchain Technology: A Comprehensive Review and Future Research Propositions, *Supply Chain Forum. An International Journal*. doi:10.1080/ 16258312.2022.2067485. Samson, D. 2020. “Operations/supply Chain Management in a New World Context.” *Operations Management Research* 13 (1–2): 1–3. 2022. doi:10.1007/s12063-020-00157-w.
- South Africa DEAT, National Waste Management Strategy Implementation South Africa - Recycling. Waste Stream Analysis and Priorisation for Recycling. Department of Environmental Affairs and Tourism, 2015.
- Viswanathan V., Arnesh Telukdarie, The role of 4IR technologies in waste management practices-a bibliographic analysis, *Procedia Computer Science*, Volume 200, 2022, Pages 247-256, ISSN 1877-0509, <https://doi.org/10.1016/j.procs.2022.01.223>.

## Biographies

**Tatenda T. Chingono** is a recent PhD graduate from the University of Johannesburg in South Africa. From 2017 till the end of 2019, he gave lectures on modules in operations management, management of training, and logistics at the University of Johannesburg. At Johannesburg’s Regent Business School, he has also given lectures on supply chain management. He has published more than 20 papers, including three book chapters and a book with Emerald Publishing.

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