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VosViewer Analysis of Waste to Energy Management Practices in South Africa in the 4IR Era

Tatenda T Chingono
Researcher
Department of Quality and Operations Management
University of Johannesburg
South Africa
tt.chingono@gmail.com

Charles Mbohwa
Visiting Professor
Department of Quality and Operations Management
University of Johannesburg
South Africa
cmbohwa@uj.ac.za

Abstract

This paper explores Waste management practices through rereading the current literature and debates the existing state of Waste management research, as well as potential research directions using VosView. The paper steered a bibliometric scrutiny of the significant readings of Waste Management in terms of several facets, like research areas, journals, countries/regions, institutions, writers and corresponding authors, highly quoted publications, and author keywords, grounded on reviews and articles gathered from the Scopus, SCI and SSCI databank of the Web of Science (WoS) between 2012 and 2023.

Keywords

Sustainability, 4IR, Waste management, South Africa, Reverse logistics, Landfills, Bioenergy production, LCA

1. Introduction

According to the South African DEAT (2005) 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. 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. The researcher aims to review LCA literature that will highlight social and environmental impacts of bioenergy production so as to mitigate Climate Change and to model cleaner bioenergy production (Frischknet et al. 2007). Global climate change is the greatest challenge of the 21st century, and it affects all aspects of society, including health, commerce, and democracy. Key research focus areas for capacity growth would also include: 1. Decision science (e.g., agent-based modeling), and 2) geospatial science (e.g., data acquisition and integration). This research contributes to resource recovery and sustainable waste management. In terms of sustainable waste management, municipalities are charged with the responsibility of managing these waste types yet they face many challenges such as collection and manpower. The literature review will focus on the identification of success factors for effective waste to energy reverse logistics.

Furthermore it will also focus on the development of appropriate reverse logistics and energy production strategies. Furthermore, life cycle thinking among organisations involved in the project will be increased.

According to Kinobe et al (2015) tremendous increase in urban solid waste in the fast-growing cities of developing and emerging countries has raised public interest in health and environmental implications. The municipal waste from about 3 billion people is still disposed of in an uncontrolled manner. As citizens and decision makers become more sensitive to environmental degradation, pollution, and its impact on their quality of life, efficient and effective municipal waste management is gaining importance on the agendas of local, regional and international discussions.

Historically Kinobe et al (2015), states that landfills were regarded as the most common and convenient method of waste disposal. However, in recent years, there has been a clamour for alternative waste management systems as there is growing awareness of environmental and health hazards arising from landfills. For example, the City of Johannesburg (CoJ) currently advocates the reduction and reuse of waste with the aim of reducing the waste volumes discharged at landfill sites. Possible actions for waste include recycling and energy recovery which will help to effectively tackle greenhouse gas emissions associated with urbanisation. Also on a national level, the diversion of wastes from landfills is promoted (Muzenda 2014).

This research mainly focuses on the overall process of capturing and transporting waste to designated areas for value addition mainly into bioenergy (Lagorio et al. 2020) . This study adopted the life cycle analysis approach because it is the only method that can be applied to estimate the value and impact of the entire process. As a result, the overall environmental performance of bioenergy production depends on the environmental impact of the substrate supply, bioenergy production process, energy input and source for the digestive process, infrastructure, labor, and direct emissions from the process and the use of digests (Borjesson and Berglund 2005). Biomasses, which can be used in anaerobic digestion, produce different amounts of bio-semen due to their different energy components. To improve biogas production, farmers often buy or grow high energy subsets and these often bring up the food versus energy debate. Consequently, this study advocates for the use of waste or remains after human consumption and usage for bioenergy production (Duta et al. 2022).

2. Problem Statement

According to the DEA (2011) South Africa's landfills are running out of space and with about 540 million tons of waste generated by South Africans annually, the only way to reduce the amount of waste sent to landfills is to re-use or recycle the waste generated. South Africa committed itself to the Polokwane Declaration, signed in 2001, stating that by 2022 there will be a 75% diversion of recyclable materials from landfills. The National Waste Management Strategy developed by the DEA aims to ensure all metropolitan municipalities, secondary cities and large towns have initiated separation-at-source programmes by 2016. However, according to Waste Campaign Manager at ground WorkSA, Musa Chamane, not enough awareness about recycling is being created. He stated, "If people are not educated and waste pickers not given space to operate recycling facilities, the goal of the Polokwane Declaration will not be met.

The rapid human population increase and expansion of resource consumption, combined with industrialization, urbanization, mobilization, agricultural intensification and resource intensive life styles are contributing to worldwide environmental, social and economic crisis. The list of environmental damage is endless, from climate changes causing life threatening natural disasters (e.g. floods, droughts, etc.) to species extinction and the destruction of natural ecosystems. Social and economic problems such as inequity in resource distribution and access to health care are also threatening the survival of human beings. In this context, there is need to undertake an LCA and adopt a holistic response to minimize harmful social, economic and environmental effects. This, in turn, will maintain the health of the ecosystem to which human beings are part of (ISO, 2006).

3. Justification and Rationale

The scientific importance of this research is that the bibliometric analysis will be used to determine the literature impact of the currently existing logistics and energy production in manufacturing industries. International databases provides life cycle inventory data for different waste management processes in a European context, datasets for technologies and practices specific to non-industrialized countries are still rare (Chaves, 2014). Such data form an important basis for the implementation of context-specific solutions. A further outcome of the research with major scientific importance will be a novel method to assess the environmental impact of littering. So far, LCA has

considered the intended way of disposal only and accordingly, littering, collection and bioenergy production has not been addressed in LCA (Klöpffer, 2014).

The Research will identify areas and issues affecting sustainability, Block chains, Reverse logistics and Climate Change. Possible mitigation solutions will also highlighted. Industrial symbiosis is often referred to in terms of synergies, which also appears in the definition by researchers such as Corea (2019); Alihmadi and Nazari (2022); Fu et al. (2018); John et al (2017) and Kumaer et al. (2022) will be futher investigated. Projects involving life cycle assessment enable the results of the project to be used in decision-making by industry, government, and non-governmental organizations. Since this research will involve different stakeholders, results from this study will benefit these different groups. The results will also enable guided decisions to be made on investments in recapturing value and proper disposal and renewable energy and other related projects such as formalization of informal sectors. The results of this research will also highlight the key points at which informal and formal waste collectors will have to be incorporated in the system to realize maximum benefits. Policy issues such as legislation on reverse logistics and renewable energy can be influenced after such research. Therefore, the research is a benefit to the sustainable development of South Africa (Sebri et al. 2019).

3.1 Goals and scope

This study aims at assessing the environmental impacts of the current situation of waste management reverse logistics leading to bioenergy production. One of the major goals is the assessment of the performance and importance of reverse logistics in providing biomass for bio-energy production. The literature review will highlight social and environmental impacts of waste management and bioenergy production so as to mitigate environmental degradation, pollution and climate change. Global climate change is the greatest challenge of the 21st century, and it affects all aspects of society, including health, commerce, and democracy. Researcher data would be analysed across spatial and temporal scales in an effort to bridge them and find correlations. Key research focus areas for capacity growth would also include: 1. Decision science (e.g., agent-based modelling), and 2) geospatial science (e.g., data acquisition and integration). The impacts opportunities and challenges within the system leading to bioenergy production will also be highlighted. The goals of this study can be summarized as follows:

- Assessment of the impact of reverse logistics in waste management and bioenergy production bibliography.
- Strengthen reverse logistics operations, waste recovery and optimizing biofuels production potential through literature.
- Highlight key contributors and contributions.

3.2 Research objectives

This research article aims to provide a detailed analysis of work by eminent researchers towards the impact of 4IR technology. The primary objective is to identify researchers of reverse logistics operations within the solid waste management sector and integrate them with bio-engagement production systems to create an integrated, efficient, lean, and agile supply chain (Viswanathan and Telukdarie, 2022). The specific objectives include:

- To identify and understand the reverse logistics chain and its components.
- To identify the barriers to, and opportunities for, reverse logistics in the waste management industry in South Africa.
- To develop strategies for future directions for reverse flow logistics and energy production and identify areas of potential industrial symbiosis in the waste management sector.

3.3 Research Questions

- Have adequate legal arrangements been made to back government policies and targets for reverse logistics renewable energy and bioenergy?
- How best can 4IR AND Block chains in reverse logistics systems in solid waste management lead to bio-energy production?

4. Methodology

This paper explores Reverse logistics through rereading the current literature and debates the existing state of supply chain management research, as well as potential research directions. The paper steered a bibliometric scrutiny of the significant readings of SCM in terms of several facets, like research areas, journals, countries/regions, institutions, writers and corresponding authors, highly quoted publications, and author keywords, grounded on reviews and articles gathered from the Scopus, SCI and SSCI databank of the Web of Science (WoS) between 2012 and 2023.

Utilizing the keywords "Waste management" AND "Industry 4.0," the study conducts a systematic literature review (SLR) utilizing the Scopus database. This approach produced 289 publications over the last ten years, 2012–2023, without the need for any filters. The data is examined for descriptive analysis and then further examined using the VOSviewer software to examine bibliographic coupling analysis, keyword analysis, and citation analysis (author and co-author relationship). The threshold is kept at one (one document is provided per author) when the software is being run for author inclusion under citation, co-authorship, etc.

4.1 Bibliometric analysis

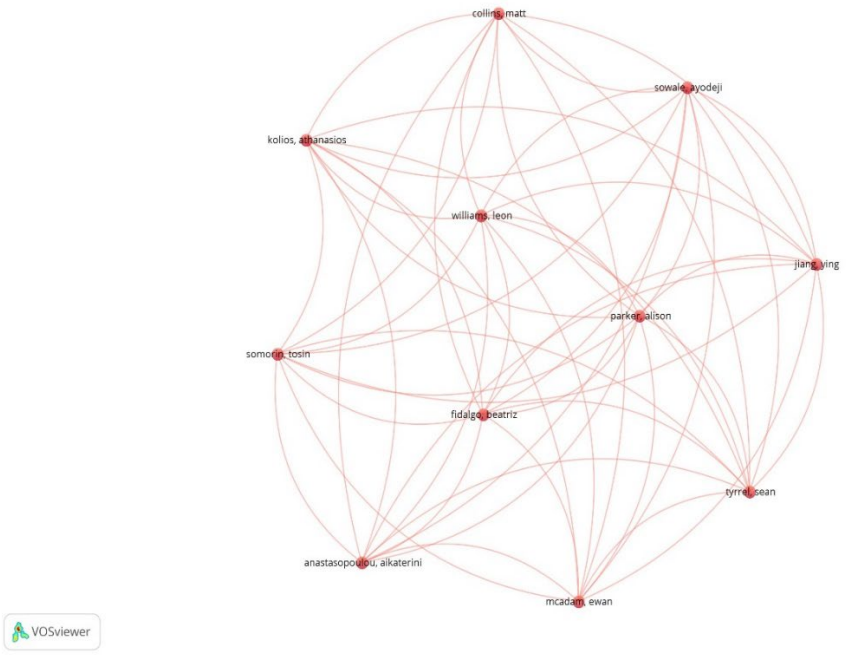

Figure 1. Waste management Reverse logistics and LCA author co-relations in Africa

The way analysts collaborate are seen through co-authorship examination. In co-authorship systems (Figure 1), hubs speak to creators, organizations or nations, which are associated when they share the origin of a paper (Viswanathan and Telukdarie, 2022). The collaboration between creators (weight: archive) are displayed in Figure 1 The outline portrays a sound inquire about collaboration between creators.

The boarder impact of this research is that it will contribute to resource recovery and sustainable waste management. In terms of sustainable waste management, municipalities are charged with the responsibility of managing these waste types yet they face many challenges such as collection and manpower. The identification of success factors for effective reverse logistics in Africa will help to face these challenges and thus contribute to knowledge transfer (Joshi et al, 2022). With the development of appropriate reverse logistics strategies, municipalities' burden on management of plastic waste will be lessened. Furthermore, life cycle thinking among companies involved in the project will be increased.

Biofuels can potentially break the cycle of poverty through energy security, food security, job creation, wage growth and rural reform. However, care is required given that bioenergy could have both positive and negative effects on food security. For instance, expanded bioenergy production may prompt a decrease in land that is used to deliver food crops. In any case, the municipal waste to bioenergy frameworks could enhance food security through changes in agricultural efficiency and effective collection of waste produce for bioenergy conversion. A key issue for future fuel

frameworks is the need to consider the social, economic and work impacts well-coordinated waste collection towards the production of biofuels. Coordinated sustenance fuel providences can join sustainable bioenergy production with food generation to advance social and monetary development as such, to integrate local individuals into future food / fuel frameworks is important in determining whether advanced bioenergy frameworks can benefit South Africa's poorest (Muzenda, 2014).

The importance of the development of the renewable sector is further emphasized by the inclusion of the national infrastructure plan as a comprehensive strategic plan. It is overseen by the President's Infrastructure Coordination Committee and aims to accelerate development and growth in South Africa. The South African government sees renewable energy as a way to address renewable energy climate change, improve energy security by diversifying energy supplies, and promote green growth through localization and empowerment. (DEA, 2011).

Information on existing reverse logistics networks in the municipal waste to energy was collected and the sample size for the survey with bioenergy industries and with other relevant stakeholder groups will be defined. The literature reveal motivating factors for the stakeholders to participate in waste to energy activities. Furthermore, the survey provides the necessary data for the environmental and social impact assessment (Khan et al, 2021).

In order to analyse the benefits of waste reverse logistics from an environmental point of view alternative disposal scenarios need to be defined. In particular, alternative disposal options include incineration (without energy recovery) and landfilling. Life cycle inventories for landfills and waste incineration plants have been issued by (Mololan, 2020). The work of Lia et al (2022) includes Excel calculation tools which can be adapted to specific waste compositions and reusing packaging material through reverse logistics.

5. Conclusions

Waste created from different portions in society requests spry intercessions in all perspectives of waste administration exercises requiring quick observing, information collection and capacity to supply decision support. The elements within the whole chain of occasions in waste administration are set to alter through the usage of Industry 4.0 (4IR) innovations. Understanding this innovation alter and its affect on waste administration viewpoints requires basic assessments.

Recent writing enlightens that waste management being the central adage of 4IR advances and circular economy with a point to realize supportability are the pushed zones in both creating and created countries. The citation examination based on archives utilizing VOSviewer highlights inquire about intrigued on the zones like affect of 4IR in economical squander administration with circular economy, IoT part in realizing savvy city with selection boundaries and part of enormous information in valorisation. The coauthorship network outline uncovers a shared collaboration between analysts resulting in articles/publications as a spin-off of information sharing. Bibliographic coupling based on archives cited assist opened up the discoveries from the quotation investigation showing points like develop waste administration handle integration through IoT, displaying 4IR affect in waste administration and choice making through huge information. The nation based bibliographic coupling are reliable with citation investigation. The keyword co-occurrence network map clearly brings out IoT, artificial intelligence and big data as the key 4IR technologies, internet, embedded systems and digital storage as tools in the waste management process. The cluster highlights the 4IR intervention in supply chain management, waste treatment and valorisation (big data), recycling, and logistics. In order to create a loop economy, this study emphasizes the necessity of integrating waste management with 4IR technology. Data gathering is clearly needed for planning and decision support, and technology intervention is required to manage trash and achieve the Sustainable Development Goals (SDGs) by reducing, recycling, and reusing it.

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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.

Professor Charles Mbohwa is a Professor of Sustainability Engineering and a Visiting Research Associate at the University of Johannesburg. He was previously Pro-Vice Chancellor Strategics Partnerships and Industrialisation at the University of Zimbabwe. He was a Fulbright Scholar 2006/2007 at the Supply Chain and Logistics Institute at the School of Industrial and Systems Engineering, Georgia Institute of Technology and has won many fellowships and awards. He has had research exchange activities with researchers from more than 30 countries.