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REVIEW PAPER

# A Review of Circular Economy Studies in Developed Countries and Its Potential Adoption in Developing Countries

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**Abstract**
Global industrialization has accounted for large amounts of generated waste, which have accumulated over the years. To guarantee that the future generations will have sufficient resources like food, water and prosperity, it is therefore necessary to transition from a linear economy to a circular economy. Circular economy is one concept, which has continued to gain traction over the years as an effective approach to achieve global, national and local sustainability. A systematic review was employed in this research project with the purpose of identifying how the practical contributions of circular economy have been pursued actively in Australia and other developed countries by reviewing existing and relevant published studies on circular economy in these countries. The result produced a total of 70 final articles, which were collected and analysed for the study considering mainly the year of publication, research methodology, geographical context and industrial applications. Furthermore, the study highlighted very little attention is given to circular economy in many low-income and medium-income countries, and thus, this study explored how this transformative notion can be adopted in developing countries with the participation of key stakeholders to solve waste mismanagement problems.

**Keywords** Circular economy · Circularity · Waste management · Developed countries · Developing countries · Stakeholders

## Introduction

The waste problem is generally a global issue, which affects all countries of the world whether developed or developing countries. Global industrialization has accounted for large amounts of

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generated waste, which have accumulated over the years since the era of industrial revolution in an attempt to keep up with the world's growing pace of consumption [1]. More so, the world's population is growing tremendously at a rapid rate, and its impacts are observed in the environment [2]. Waste is generated in many societies across the world from several sources like commercial, agricultural, domestic, municipal and industrial activities. The environmental implications of these wastes are witnessed globally in terms of land and water pollution, for example, ocean plastic pollution. The United Nations Environmental Programme [3] in 2019 stated in its report that approximately 90 billion tonnes of feedstocks are extracted and consumed globally every year. It also highlighted that while the extraction of these resources remains highly unsustainable, the nature of the conventional "take-make-dispose" consumption linear model has great consequences for the ecosystem quality, human health quality and resource provision capability.

The twentieth century's production processes and supply chains were associated mainly with that of a linear economy which mainly involves linear processes [4]. Typically, a linear process is one which is characterized by goods production from raw materials, consumption and final disposal when it is considered to be no longer beneficial [5]. According to Sariatli et al. [5], the linear economy in industrialized nations recorded huge successes in regard to material wealth generation up to the twentieth century. Regardless of this achievement, the linear economy in the new millennium (i.e. twenty-first century) is viewed differently because its weaknesses have been highlighted and its near future breakdown has been forecasted. To guarantee that the future generations will have sufficient resources like food, water, energy and prosperity, it is therefore necessary to move from a linear economy to a circular economy.

In light of the challenges associated with waste generation and accumulation in contemporary times, the alternative "circular economy" has been put in place to help solve the environmental issues accrued from waste mismanagement by encouraging circularity of resources in production processes. Circular economy is one concept, which has continued to gain traction over the years as an effective approach to achieve global, state and local sustainability. Additionally, it has received growing attention from international organizations like the United Nations, etc. [6], as well as from policy makers in advanced countries [7]. Nevertheless, the practicable contributions of the circular economy approach have received very little attention in many low-income and medium-income countries. There is a need to adopt circular economy in many of these countries in order to achieve the sustainable development goals (SDGs). The existing sustainable development goals already accommodate the concept of circular economy. For example, SDG 12 (responsible consumption and production) aligns properly with the circular economy concept and pushing the goal forward through the implementation of the concept will lead to the progress and achievement of other social, economic and environmental development goals [8], as also discussed in the UNEP Circularity Platform, 2019 UNEP Resource Efficiency 2020+.

The purpose of this systematic review is therefore, firstly, to review existing literatures on circular economy in Australia. Secondly, to examine how the notion of circular economy is actively pursued in other developed countries. Thirdly, to identify gaps in published circular economy literatures, and finally, to determine how circular economy ideas can be successfully adopted in developing country's context.

## Theoretical Background

Different definitions of circular economy have been proposed and published by several researchers. Two well-known definitions that are widely accepted are, firstly, by Geng et al. [9], which stated that circular economy is "an economy which is based on spiral-loop system that reduces energy-flow, matter and environmental degradation without hindering the social and technical progress or economic growth". The second definition was put forward by Franklin-Johnson et al. [10], which specified that "the fundamental of circular economy is a closed flow (circularity) of materials, the usage of feedstock and energy through different phases". The concept of circular economy was initiated by the Ellen Macarthur Foundation in 2013 which was supported by its peculiarities to different modern theories like the blue economy, cradle-to-cradle, biomimicry, regenerative design and the performance economy which all made important contributions for additional improvements and advancement of the concept.

Circular economy is a concept that promotes the refurbishment, improvement and redistribution of formerly used goods [11]. Circular economy is principally the idea, which encourages linear processes to be converted to circular processes, which involve use, re-use, recycling, arrangement, assemblage and circulation. It is pertinent to bear in mind that circular economy is not only about recycling, the production process and the products require essential transformation and re-design [11]. According to the Ellen MacArthur Foundation [12], the three circular economy principles incorporate the 3R theory, which involves "*Reduce, Reuse, Recycle*". The first principle of circular economy is the "appropriate design" principle, which emphasizes the significance of the designing stage in proposing solutions for preventing waste discharge. The second principle promotes the reclassification of materials and its separation into "technical" and "nutrients" matter, and finally, the third principle is primarily focused on "renewability". This principle positions renewable energy as the main source of energy for circular economy.

The fundamental idea of the circular model is to fully utilize the re-use of raw materials or feedstocks and products in order to reduce wastage and some of the concerns of the circular economy as depicted by Ellen MacArthur Foundation in Fig. 1. The figure illustrates that the model makes a distinction between two loops, namely, the green loop (biotic nutrients) and the blue loop (technical nutrients). These loops navigate their way into circular economy in two alternative methods and the Ellen MacArthur Foundation argues that the strategy of circular economy becomes more fulfilled if the circles depicted in the figure are tight, given that the products remain in the loop for the longest possible time and redeem the highest significant value as possible [13, 14]. The technical nutrients consist of materials and products like plastics and metals, which are mostly retrieved and stored in the technical cycle. These materials should be re-utilized and remain in the closed-loop in order to effectively minimize the usage of resources that are non-renewable and to avoid possible pollution.

The bio-nutrients, on the other hand, consist of biological materials that return safely to the biosphere through cascading [13]. According to Bezama [15], cascading of bio-nutrients involves three dimensions. Firstly, it measures the present material stock linked with each commodity within the system by estimating the amount of materials and potential type that are accessible for recycling at any point in time. Secondly, it assesses the quality of material streams and provides assessments to better understand the lifecycle of the products and how their alternatives can be efficiently utilized. Finally, cascading considers the lifetime of a specific product and enables the evaluation of likely impacts associated with the specific

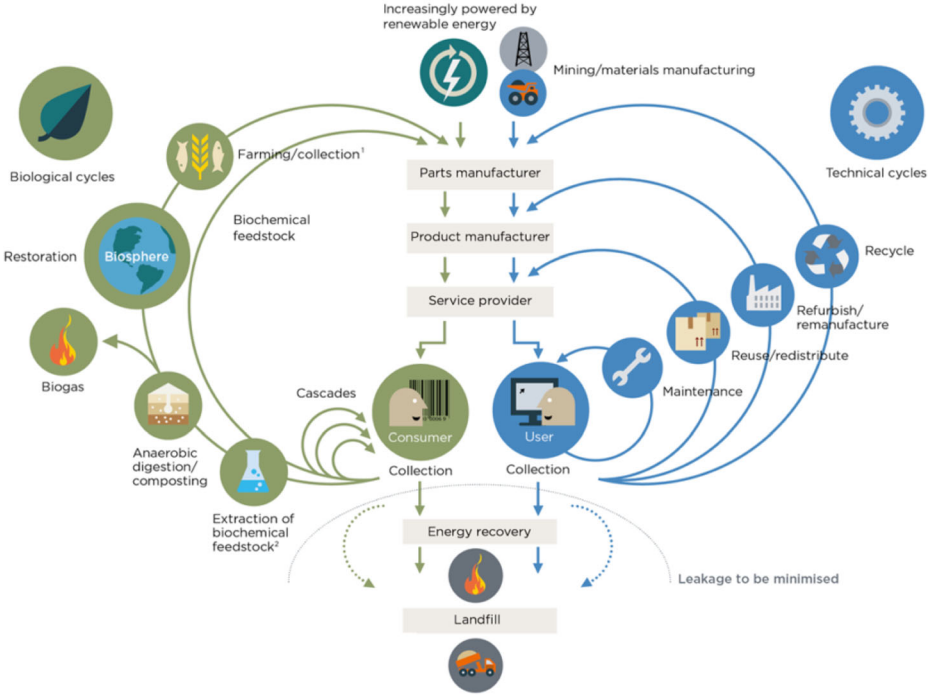


**Fig. 1** Ellen MacArthur Foundation illustration of circular economy [13]

product and helps to evaluate the overall behaviour of the system, thus making it an important aspect for the achievement of circular economy.

## Circular Economy in Developed Countries

According to the World Business Council for Sustainable Development [16], a circular economy has been recognized as a significant commercial opportunity of up $4.5 trillion which could promote the evolution of new industries, create jobs, minimize greenhouse gas emissions as well as improve the efficient use of natural resources. The industrial sector in recent times has adopted the advancement of circular economy. Some interesting examples of these improvements can be observed in the clothing, durable goods and textile industries. More so, many advanced countries like Australia, the USA, the Netherlands, France, the UK, Denmark, Germany, Finland, France, Sweden, Norway, China, etc., have widely accepted and put into practice the concept of circular economy. The concept of circular economy in these countries and others has been researched on extensively, thus leading to the discovery of solutions and latest innovations on the idea of re-use.

The circular economy design and manufacturing approach adopted in Europe emphasizes on the importance of "re-design" as a crucial step in restructuring from a linear economy to a circular economy. Over the last decade in Europe, the European Parliament has argued calls from the European Commission to establish a proposal that is goal-oriented to advocate revolution towards a circular economy [17]. In 2015, Frans Timmermans the Vice President of the European Commission in his speech stated that "Our planet and our economy cannot

survive if we continue to pursue the throw-away approach. We must conserve valuable resources and fully exploit their economic value. A circular economy reduces waste accumulation and protects the environment; but it also means a fundamental change in the functioning of our environment" [18]. The manufacturing industries in Germany especially big brands like Mercedes-Benz are re-designing their products for maintenance, servicing, refurbishment, reconstruction and re-distribution. Additionally, reports from the European Commission in 2014 estimated that the European Union countries transitioning towards a circular economy could generate annual economic gains of about 600 billion euros for the European Union manufacturing industry alone [19].

In Denmark, the approach of industrial aggregation is employed for circular economy. Industrial aggregation or agglomeration is simply the merging of certain companies together mainly through a joint venture style cooperation (JVSC). The first step for circular economy in Denmark is the industrial aggregation which involves from head-to-tail processes in the biological and technological spheres whereby amalgamated suppliers and consumers co-exist to achieve materials and energy efficiency through economies of scale and economies of scope. One case study in Denmark which demonstrated the advantages of industrial aggregation was that of the Kalundborg Denmark Eco-industrial Park [20]. A good example of a tail-to-head industrial aggregation and recycling are carbon trapping cement pellets. In Scotland, big construction companies like MacRebur use pelletised recycled plastic to replace petroleum tars from bitumen in road construction.

In Asia, particularly in China, transitioning from an economy, which was centrally planned to an economy that is market-oriented, brought about a period of remarkable rapid growth in the country. As production and consumption rates accelerated, there were implications for the environment. Concerns for the environment incited China's implementation of a novel national strategy for circular economy in 2005 which had the aim to achieve large energy and resource efficiency using the 3R methodology of "reduce, reuse and recycle" [21]. China's approach to circular economy includes multiple consecutive Five-Year Plans which highlights growing commitments to circular economy [22]. The speed of industrial reform in the country is fast. For example, when free shopping plastic bags were banned in Shanghai, the change took effect immediately with high levels of compliance. Also, China's National Sword Policy in 2017 banned the importation of plastic wastes starting from 2018. The policy triggered shocks in many countries like Germany, Japan, USA and even Australia. Presently, plastics are redirected to Vietnam, Malaysia and Thailand; however, enormous quantities of plastics (i.e. millions of tonnes) are stranded all over the world. Circular economy advancement in China is observed through the promotion of waste material recirculation by setting targets, adoption of policies and legislation as well as financial measures. Other Asian countries like South Korea, Singapore and Japan have also adopted and implemented the circular economy approaches.

In Australia over years, there has been a slow shift towards circular economy compared to other countries which are fully active in processing their own wastes. For instance, the country has for long time exported plastics and other recyclables worth millions of tonnes to other foreign countries for management. However, several of these countries like China have begun to close their borders to these international wastes and have since implemented tougher restrictions. This situation has then pushed manufacturers locally to change their process methods and practices, thus transitioning to a more sustainable approach like circular economy. Furthermore, the principle of circular economy has gained large acceptance in the last few years and has been applied to several industrial sectors like the agri-food sector [23], the mining and extraction sector [24] as well as the construction and demolition sector [25]. The

country has also invested in infrastructures and technologies to convert recyclable items like plastics into several other useful products.

The generation and accumulation of waste around the world has spawned an urgent need to transition to industrial and economic developments that are more environmentally pleasant. Circular economy as a model promotes natural resource resilience to attain sustainability. With this consideration, this paper is focused on circular economy practices pursued in advanced countries in North America, Europe, Asia and Oceania. In addition, it explored how the concept of circular economy can be successfully applied in developing nations in Africa, the Pacific Islands, Southeast Asia and South America. This paper is divided into four sections and they are ordered as follows. Section one (1) is the introduction which highlights the problem statement and establishes the concept of circular economy. This section has a sub-section which summarizes previous literatures written on circular economy and justifies the importance of content evaluation and analysis. Section two (2) presents the methodological design of the research project. In section three (3), the results from the study are collected, analysed and presented. The fourth and final sections discuss the research findings and conclusion of the study, respectively. The research study is illustrated in a framework shown in Fig. 2.

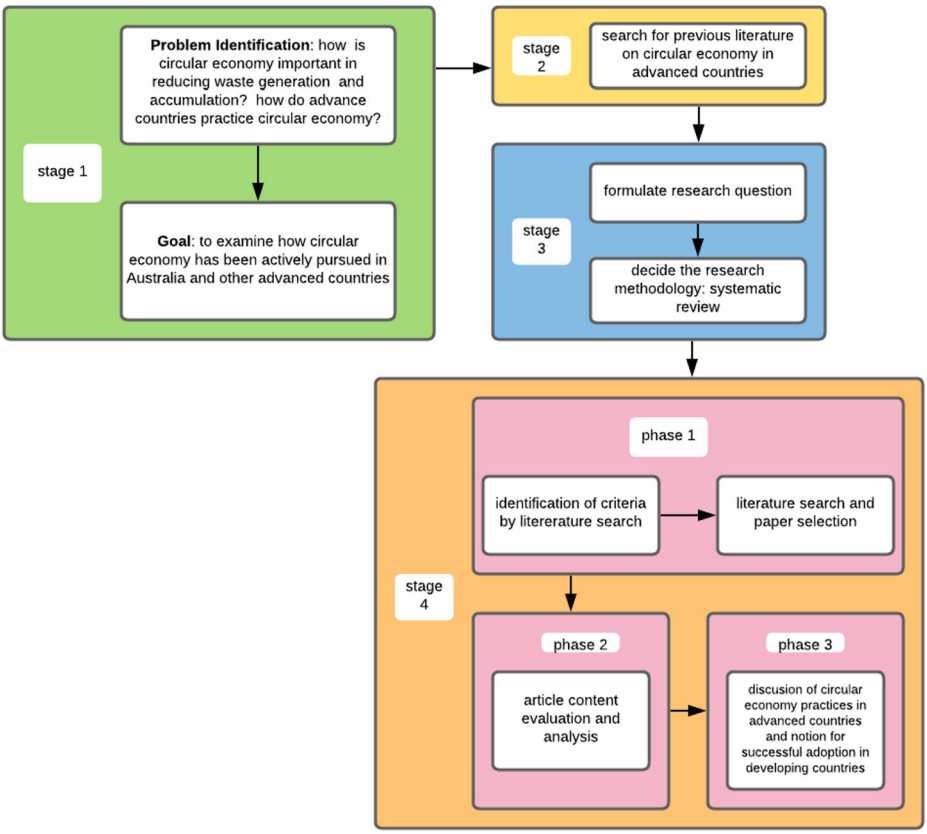


**Fig. 2** Research study

### Previous Literature Reviews

This section justifies the importance for article content analysis by summarizing previous literature reviews on circular economy. In general, a wide range of literatures on circular economy has been in publication within the last 5 years (i.e. from 2016 to date) due to the increasing interest in the subject area. In this section, contemporary and existing research is analysed in order to determine clearly which topic of interest requires further investigation. More so, this section addresses the necessary transitioning from a linear-oriented economy to a circular-based economy. The earliest publication related to circular economy in advanced countries from a timeline of 2010 to 2020 was published in 2011 by Sakai et al. This literature conducted a comparative study of the 3R "reduce, reuse and recycle" theory and waste management policies in different countries of the European Union, Japan, the USA, Korea, China and Vietnam [26]. In comparison to this study, none of the previous literatures has examined how circular economy is being pursued in Australia and other advanced countries (Table 1).

## Methodology

In order to study how the concept of circular economy is actively pursued in many advanced countries from scientific publications given its significant influence on academic literature, a systematic review was employed in the research project. It included a thorough search and rigorous selection process of various relevant literatures and studies published on circular economy. According to the Centre of Reviews and Dissemination [32], systematic reviews are

**Table 1** Summary of literature review

| No. | Title | Author | Year | Summary |
|---|---|---|---|---|
| 1 | European national road authorities and circular economy: an insight into their approaches | Mantalovas K., Di Mino G., Del Barco Carrion A.J. et al. [27] | 2020 | Reviewed the current situation of circular economy within the national road authorities and attempts to assist with transitioning to a more circular way of business within the industry |
| 2 | End-of-life options for bio-based plastics in a circular economy status quo and potential from a life cycle assessment perspective | Spierling S., Venkatachalam V., Mudersbach M. et al. [28] | 2020 | Reviewed a comprehensive overview of contemporary status quo of several end-of-life options for biologically based plastics from an environmental point of view |
| 3 | A review of circular economy development models in China, Germany and Japan | Ogunmakinde O. E. [29] | 2019 | Reviewed critically how circular economy models have evolved in several advanced countries and also how the concept has been employed in different industries |
| 4 | Advancing to a circular economy: three essential ingredients for a comprehensive policy mix | Milios L. [30] | 2018 | Reviewed the policy framework and conceptualization of circular economy employed by policy makers in the European Union and identifies policy areas that have less material resource efficiency |
| 5 | Conceptualizing the circular economy: An analysis of 114 definitions | Kirchher J., Reike D., Hekkert M. [31] | 2017 | Reviewed 114 definitions of circular economy concept and highlights linkages to sustainable development |

forms of secondary investigation which seeks to determine, evaluate, interpret and sum up every significant and accessible research pertinent to a particular research query or subject of interest. Systematic reviews are very distinct from literature reviews. In comparison, systematic reviews use unambiguous methods, which seek to eliminate bias and formulate findings that are reliable, whereas literature reviews employ methods of quantitative and qualitative approaches to evaluate specific topics [33].

The methodology of this research shows how data was gathered, analysed and reported in this paper. The first step in the methodology was to identify the appropriate criteria for the study in order to choose the right papers. The next step was to explore other papers that might be suitable for the study. Step three was to assess the papers and ascertain if the papers were right for the topic and covered the scope. The final step was to examine the collected papers taking note of the paper's year of publication, geographic context, methodology used and industry setting. The search process is demonstrated in Fig. 3.

## Search Criteria

The first step of a systematic review is the identification of which studies should be taken into consideration and which should be rejected. A clear scope of study areas to be investigated must be provided in the review from the beginning of the study. A transparent approach was employed in this study to ensure the authenticity of the data. The search process was carefully refined to select relevant articles relating to the circular economy. The project utilized data retrieved from carefully selected databases which include Scopus, Science Direct, Google Scholar and Web of Science as well as reliable data sources which include *Journal of Cleaner Production*; *Journal of Environmental Management*; *Energy and Management, Sustainability, Renewable Energy*; *International Journal of Environment and Waste Management*; *Science of the Total Environment*; *Waste Management and Research*; *Energies Sustainability and*

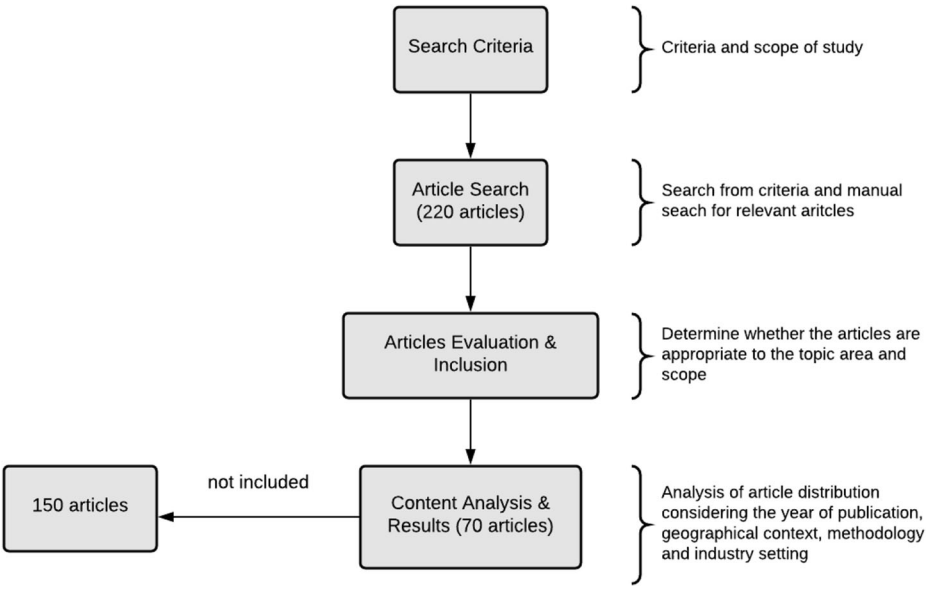


**Fig. 3** Research methodology overview

*Ecological Economies*. Only formal literatures like articles and peer-reviewed literatures (with the exception of books, research reports and other) were included in this research project.

In order to address the research questions proposed in this study, the following factors were carefully considered for the criteria of inclusion. They include:

I. *Access type and document type*: Only articles with open access were selected for the study. Additionally, only published articles and reviewed literatures where searched for in the Scopus and Web of Science databases.
II. *Year of publication:* The search was refined and limited only to articles published from the timeline of 2010 to 2020. This is to ensure that only studies and data that are recent and appropriate are referenced.
III. *Authors:* the study considered different authors who had several years of research expertise and have published several articles.
IV. *Subject area:* Only articles from the subject area of environmental science were selected.
V. *Country/territory:* According to World Bank [34] and the International Monetary Funds (IMF), these countries are considered as advanced or high-income economies Australia, the UK, Netherlands, the USA, Germany, Sweden, Poland, Finland, France, Austria, Belgium, Denmark, Czech Republic, Latvia, Lithuania, Ireland, Singapore, Slovenia, Hong Kong, Norway, New Zealand, Spain, Italy, Estonia, Israel and Luxembourg among others. Papers on circular economy from these countries were included in the study. Additionally, China is not listed as a developed country but it has made huge advancements in circular economy, hence its inclusion in the study.
VI. *Language:* Only papers on circular economy written in English were selected for the study.

## Article Search

This is the second step in a systematic review. The search outcome realized from both SCOPUS and Web of Science (WOS) databases were a total of 182 articles. There were 106 articles and 76 articles from SCOPUS and WOS respectively. All the articles relevant to the subject area and met the criteria for inclusion were collected. For the 106 papers gathered from SCOPUS, there were 70 published articles, 11 review papers and 25 conference papers. Also, 103 of the papers were in the final publication stage while 3 of the paper were article in press. In addition, the 76 papers gathered from Web of Science (WOS) were 66 published articles and 10 review papers.

A manual search was conducted in order to prevent word search limitations and eliminate associated search errors. This search ensured that all studies which were relevant to the topic were included and not overlooked. In regard to the title and scope of the research project, the study focused mainly on “circular economy in developed countries” and the search was further narrowed to “circular economy in Australia”. The search terms “circular economy in Australia” produced a total of 23 articles from Scopus and 28 articles from Web of Science.

This second stage also considered some important circular economy keywords to ensure that all articles that were significant to the topic were not left out. The following keywords for circular economy which includes “circularity”, “end-of-life”, “waste management” and “closed-loop” were to be found jointly in the either the title, abstract or keywords. Other significant circular economy keywords that were accepted during the collection of publications

include “redesign”, “reuse”, recycling”, “reduce” and “remanufacturing” and they were also included in the search process. An additional 38 articles were added to the previous search result. A large number of them had been previously scanned and were found that they initially did not meet the criteria of inclusion.

### Article Evaluation and Inclusion

At this stage, a total of 220 papers were gathered. All the papers were carefully examined and evaluated to ascertain that all the publications considered fit into the scope of the research project. All articles which had no relevance to the subject area or played little or no role were excluded. Furthermore, articles with which the topic appeared as relevant sub-theme were included. After this third stage, a total of 150 articles were removed and a finalized sample of 70 articles were examined.

### Article Content Analysis and Results

This is the fourth and last stage of a systematic review. In this stage, the final sample of 70 articles gathered after the previous stage will be examined and discussed further in the result section, considering the publication year, geographical context, methodology employed and industry settings. The key word search for the final sample of 70 is presented in Table 2.

## Results

This section analysed the finalized selected sample of 70 articles in regard to the methodology employed, the geographical context and industrial setting of each paper and presented the results in Table 3. The table highlighted the number of papers cited under each of the parts and showed each percentage values assigned. The assigned percentile values for the respective part will be discussed further in subsequent sections below.

### Paper Distribution by Year of Publication

Figure 4 illustrates the distribution of all 70 papers. The figure shows that 2010 was the first year of publication and grew slowly up until 2017 with the exception of 2013 and 2015 where no publication was recorded from the samples. The number of publications was observed to increase significantly from 2018 to 2020. The rise in publications demonstrates heightened interest in circular economy across various countries particularly in regard to how the concept

**Table 2** Keywords search for final draft

| No. | Search | Scopus | Web of Science |
|---|---|---|---|
| 1 | “circular economy” AND “developed countries” | 106 (22) | 76 (13) |
| 2 | “Circular economy” AND “Australia” | 23 (10) | 28 (5) |
| 3 | “circularity” AND “recycling” AND “end-of-life” AND “closed-loop” AND “developed countries” | 26 (15) | 20 (5) |
| | Total (70) | 47 | 23 |

**Table 3** Research methodology, geographic context and industry setting cited in database of 70 papers

| | No. of papers | Complete dataset 70 (in %) |
|---|---|---|
| Research methodology | | |
| Literature review | 13 | 19 |
| Case study | 20 | 29 |
| Model | 10 | 14 |
| Survey | 9 | 13 |
| Theoretical and conceptual papers | 13 | 19 |
| Analysis (MDA, CWA, empirical) | 6 | 9 |
| Geographical context | | |
| Oceania (Australia) | 15 | 21 |
| Europe | 30 | 43 |
| North America | 4 | 6 |
| Asia | 15 | 21 |
| Worldwide | 6 | 9 |
| Industry setting | | |
| Technology and innovation | 10 | 14 |
| Urban and municipal | 9 | 13 |
| Metal and steel | 6 | 9 |
| Food and agriculture | 6 | 9 |
| Plastics | 5 | 7 |
| Construction | 4 | 6 |
| Mining | 3 | 4 |
| Glass | 1 | 1 |
| Electronics (house hold appliance and mobile phones) | 3 | 4 |
| Tourism | 2 | 3 |
| Energy (oil and gas, bio-hydrogen) | 6 | 9 |
| Textile | 2 | 3 |
| SMEs | 3 | 4 |
| Transportation and logistics | 3 | 4 |
| Others (material flow, etc.) | 2 | 3 |
| Unspecified | 5 | 7 |

can be applied to help solve waste management problems and promote resource and material efficiency.

## Research Methodology

The result for the methodology used in the selected 70 papers is presented in Fig. 4. Six research methodologies were identified in publications, namely, literature reviews, case studies, models, surveys, analysis and theoretical and conceptual papers. The most commonly used research methodology in published studies of circular economy was case study, followed by literature review, theoretical and conceptual papers, models, survey and lastly analysis. Twenty-nine percent of the publications cited case studies in different geographical regions including Australia, Europe and Asia. In Europe, countries that were cited as case studies include Poland, Italy, Netherlands, Finland, Spain, Germany, Sweden and Latvia. In Asia, a vast majority of the studies focused on China and cited the country as a case study. This clearly shows that the country is very dedicated to the implementation of circular economy which can be attributed as its way of responding to environmental implications that may arise due to its growing population.

Literature reviews and theoretical and conceptual papers are the next category of published articles of circular economy identified and illustrated in Fig. 5. Nineteen percent of selected

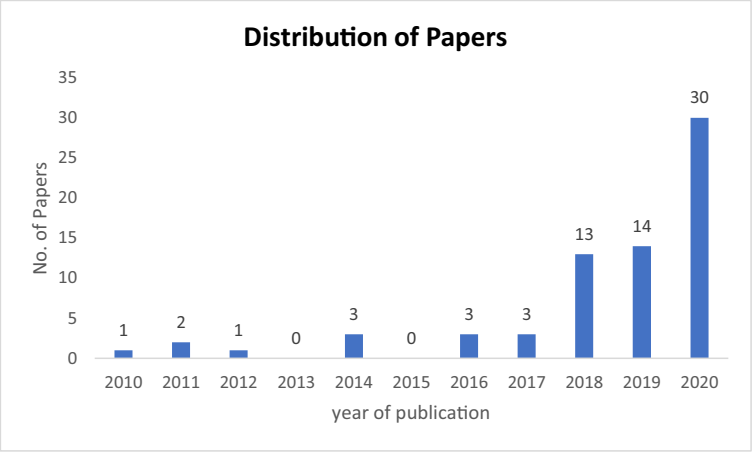


**Fig. 4** Distribution of selected papers by year of publication

papers used literature reviews as the research methodology to review previous studies on circular economy in different geographical regions while another 19% used conceptual papers as methodology to explain the theories and concepts of circular economy in several geographical areas. More so, 14% of the publications cited models as the methodology used, 13% cited surveys including questionnaires and interviews, and finally, analysis which includes multidirectional analysis (MDA), common weight analysis (CWA) and empirical analysis where the least number of methodologies cited in the publications with 9%.

## Geographical Context

The geographical context identifies the country or geographical region in which the study is being carried out generally as well as the different geographical regions cited under each individual year of publication. Four different parts of the world, namely, Oceania (which includes Australia), Europe, North America and Asia, were cited in the paper and are

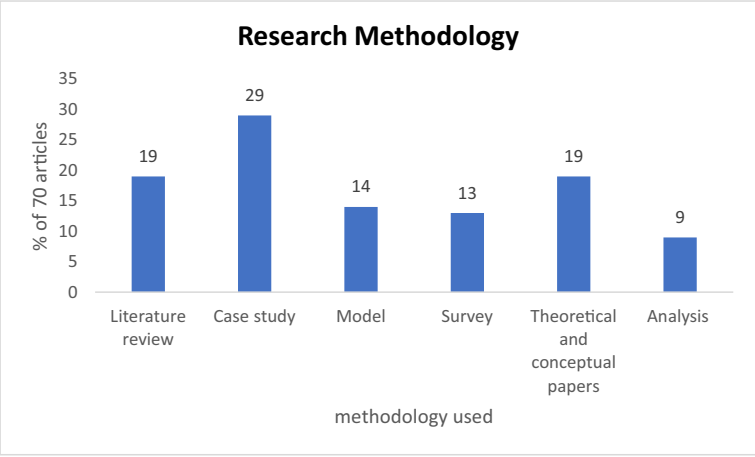


**Fig. 5** Percentage of research methodology cited in selected papers

illustrated in Fig. 5. These regions were divided into this category because many authors, particularly in the papers which cited European countries, used the general term "European Union" to generalize the studies within that region without making particular reference to a single country. However, there were a few exceptions which single countries were cited and they were all included in the study. For Oceania, only papers which cited Australia were included because of the title and scope of the research project. In addition, North America cited papers in the USA while a large number of the papers in Asia cited China. This is because of China's remarkable advancement in circular economy over the years. Furthermore, the term "worldwide" as depicted in the figure refers to articles in which all or a large majority of countries around the world were studied and no reference was made to a particular country (Fig. 6).

The geographical context in relation of each year of publication as illustrated in Fig. 7 shows the different percentage of papers cited in each country and/or region cited during each publication year from 2010 to 2020. The figure shows that Europe has a greater percentage of publications from 2016 to 2020, followed by Oceania (Australia) and finally Asia while North America had the least number of publications. Australia's growing interest in circular economy began to develop in 2014 while publications rose gradually from 2016 up until date. Europe's publications have increased steadily from 2016 to date; this is because many European countries like the Netherlands, Sweden, Poland, Germany, England and Finland have all adopted the concept of circular economy in their production processes; hence, the concept is gaining traction as an effective and sustainable strategy to combat waste management challenges in the region. More so, in Asia, particularly in China, publications on circular economy were present as early as 2011. This correlates with global acknowledgement of China's successful implementation of circular economy at a national level and advancement of the concept over the years.

## Industry Setting

The range of papers identified in Table 3 indicates that several industries are explored among the publications used in this research project. Figure 8 illustrates the various industrial settings

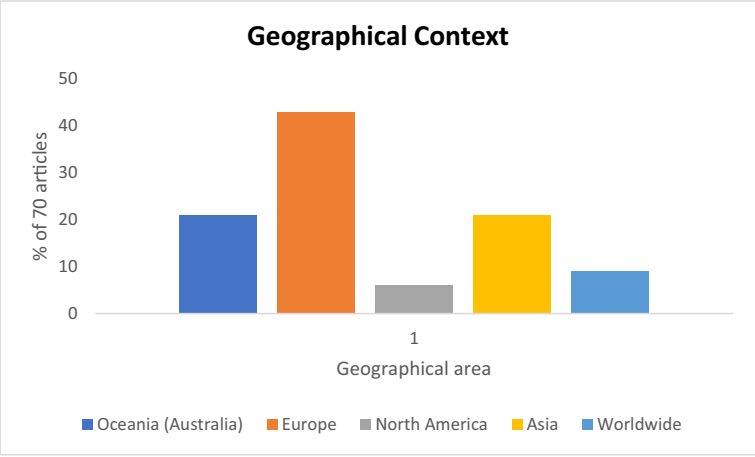


**Fig. 6** Percentage of geographical context cited in selected papers

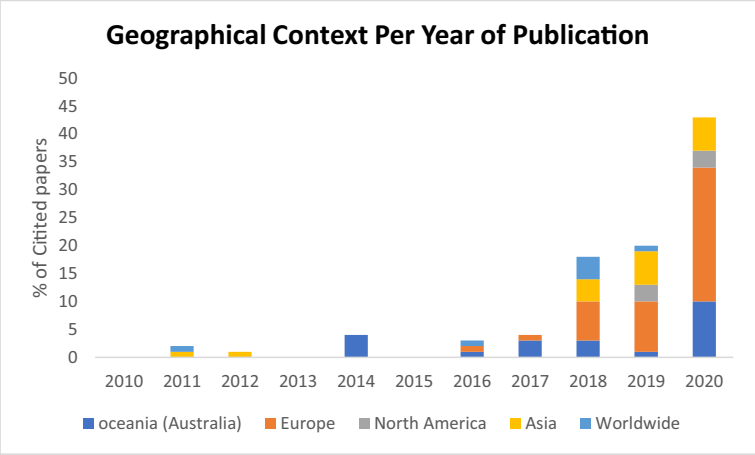


**Fig. 7** Percentage of geographical context of cited papers per year of publication

cited in the publications with technology and innovation being the most cited industry while glass industry had the lowest percentage of publications among the selected papers. Urban, municipal and metropolitan areas were the topics of discussion in a vast number of the articles as there are increasing concerns for implementation and transition of circular economy in these areas. Most of the publications cited countries and cities in Europe as case studies for the implementation of circular economy in urban, municipal and metropolitan areas [35–37].

The third group of industries commonly mentioned in the papers was the metal and steel industries, energy industries and the food and agriculture industries which had a 9% respectively. The metal and steel industry plays an important role in many countries' economy especially in countries like China, where the output realized from this sector increases continuously due to the combination of industrial developments, growth and urbanization [38]. A few papers highlighted the circular economy strategies for the recycling and re-use of metals in the USA, Australia and the European Union [39–41].

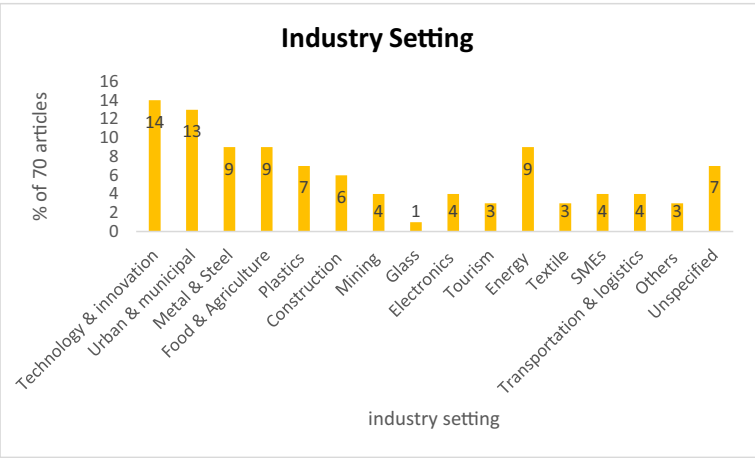


**Fig. 8** Percentage of industry setting cited in the selected papers

Similarly, agriculture and food were also mentioned in a number of the papers employed in this study. The food industry inclusive of agriculture and its manufacturing in general plays a vital role through its contribution to a nation's socio-economic sector. Notwithstanding, this industry is burdened by the environmental consequences generated from the production of food [23]. The food processing and packaging sector has insufficient resources largely due to the difficulty in the re-usage of resources and as a result of greenhouse gas emissions. The agri-food sector was also mentioned in two papers in Australia and Europe which highlighted the sector's transitioning to circular economy to overcome environmental implications [23, 42]. The energy sector including bio-fuels, oil and gas and coal combustion was also cited in several of the publications.

The plastic industry including its production and packaging was mentioned in some of the papers employed in this study. Globally, the current waste practices for single-use plastics contribute to the loss of US$80 to US$120 billion annually [43]. Most of the papers considered the recycling of plastics. Small- and medium-scale enterprises were another category mentioned in 4% of the total publications. These papers reviewed the possibilities of transitioning from a linear economy to a circular economy in this type of businesses particularly in Europe with Italy and Spain as case studies [44–46]. Other range of industries mentioned in the papers used in the study included clothing and textile, mining, construction, transportation and logistics, tourism and electronics, e.g. household appliances, computers and mobile phones. Some papers did not specify a particular industry but they were included in the study because they covered areas that are pertinent to circular economy.

## Discussion

This section discusses the key fundamental elements of this research in line with the scope of the research and in response to the research questions.

### Circular Economy Benefits and Practice in Australia and Other Advanced Countries

Indeed, Australians and several others in the world are acknowledging that their individual microeconomic behaviour is a contributory factor to the rate at which the earth's resources is declining. The recognition births the question of "what is to be done now" and one answer that distinguishes itself is the transition towards the concept of circular economy. Fundamental research informs basic engineering, and according to the results of this study, technology and innovation were the most cited industrial settings as depicted in Fig. 8. This probably explains the emergence of new technologies and innovations because engineers have turned to a design practice that is more human-centred in order to suit human needs. New products and processes emerging from the thriving commercial innovation serve the Australian market of over 25 million people and proceeds overseas to create an economic impact on the global market with a population of over 7 billion [11]. This innovation cycle accumulates prosperity and wealth for the Australian people and also improves their quality of life.

For several parts of the world, the concept of circular economy is beneficial in three major ways, namely, the economy, employment and environment. Regarding the economy, the Ellen MacArthur foundation [13] estimated that a transition towards circular economy could minimize the net spending for resources in the European Union by 600 billion euros annually in 2030. Subsequently, resource productivity would be improved by 3% annually and would

yield a net benefit of 1.8 trillion euros annually. In regard to the environmental benefits of circular economy, Ecofys and Circle Economy [47], in their reports, stated that practices of circular economy such as substitution of materials in the construction sector, agricultural nutrient recovery, chemical leasing and transportation sharing ownership models could reduce equivalently 7.5 billion tonnes worth of carbon dioxide worldwide. In line with the Paris Agreement 1.5C target, such magnitude of reduction would bridge up to half of the existing gap in emissions.

Furthermore, the European Environment Agency [48] in its 2016 report found that greenhouse gas emissions in the EU would be minimized from 422 to 617 million tonnes equivalently if ambitious targets set for reducing landfills as well as recycling packaging and municipal wastes are achieved. For the employment benefit of circular economy, the European Environment Bureau [49] in 2014 estimated that the range of European circular economy employment opportunity in 2025 would be as high as 634,769 to 747,829 for modest and ambitious scenarios respectively. However, a skilled gap was identified in the workforce which was associated to the lack of circular economy programmes being taught academically in universities, hence posing as a barrier towards the transition from a linear to a circular economy [50]. This skilled gap in workforce is likely to be far greater in many developing countries.

## Waste Mismanagement in Developing Countries

Waste mismanagement remains a global problem in regard to economic sustainability, environmental pollution and social integration [51]. However, these issues of unsustainable mismanagement are commonly witnessed in many developing countries. This raises an urgent need to pay attention to issues in these areas by employing holistic approaches and integrated assessments in order to achieve effective solutions [52]. Uncontrolled waste disposal produces severe heavy metal pollution that contaminates the soil, water and plants. Likewise, open burning is the cause of many greenhouse gas emissions and other ozone-depleting emissions that affect the atmosphere.

In many developing countries, open dumping is witnessed in many of the slum areas coupled with issues of high population densities and poverty [53]. Some examples of waste generation and mismanagement in developing countries of Asia could be seen in Cambodia's capital city Phnom Penh in 2008 and 2015 which recorded household waste of 361,000 tonnes and 635,000 tonnes, respectively, for each year [54]. Thailand also estimated that approximately 60% of final solid waste disposal was attributed to open dumping. As of 2004, 330 of the total 425 disposal sites were open dumps which received up to 4500 tonnes of waste per day [55]. In Africa, Nigeria's capital city Abuja in 2010 generated over 250,000 tonnes of waste which was attributed to the closure of four major disposal sites in previous years due to odour and air pollution resulting from the open burning of waste sites [56]. Another example in Africa was observed in Mozambique's administrative centre Maputo, which recorded that it generates approximately 0.5 kg of waste per inhabitant on a daily basis with over 1,200,000 inhabitant population [57].

Other further examples can be seen in India; the Chennai city of Tamil Nadu has been estimated to have generated approximately 3200 tonnes of solid waste per day which highly contributed to the heavy metal leaching in water and soil, therefore imposing serious health risks to the inhabitants of the surrounding [58]. A study conducted on the concentration of heavy metal in soil samples in the area by Parameswari et al. [58] shows that heavy metal

concentration decreases as soil depth increases, thus reflecting the influence of open dumping activities in the area. Many publications have been made concerning environmental contamination from wastes in developing countries; subsequently, many studies have indicated some possible remedies for enhancing waste management in developing countries, for example, implementing waste-to-energy plans [59], waste-to-energy recycling of metals and glasses [60], among others, but only a few have actually discussed about addressing the issue from the source and that is where circular economy comes in through its vital role in encouraging re-use, re-designing, refurbishment, re-manufacturing and re-distribution of materials.

## Circular Economy Notion for Adoption in Developing Countries

Over the years, relatively little attention has been given to the concept of circular economy in many low-income and middle-income countries. However, in recent times, the international development professionals [61] and the academic research community [62] have begun to take notice of circular economy practices in developing countries. A number of papers have been published citing circular economy case studies in developing countries like India, Brazil, Kenya and Ghana, which demonstrate how encouraging circular economy business models can contribute to a three-way win [61]. Firstly, circular economy can enhance productivity and increase economic growth. Secondly, it can improve employment's quality and quantity. Thirdly, circular economy can help to save lives through the reduction of environmental impacts like air and water pollution as well as climate change.

According to Schroder et al. [63], in their research paper published for the circular economy in Latin America and the Caribbean, they identified three major sectors where circular economy can be effectively implemented. The sectors include bio-economy, mineral extraction and mining, and municipal waste management and recycling. The circular economy practices in these sectors can also be applied in similar sectors for other developing countries in Africa, the Pacific Islands and Southeast Asia.

### Circular Bio-Economy Sector

Biodiversity and forest resources are essential for bio-economy. Africa, South America, Southeast Asia and the Pacific islands are home to many of the world's primary forests. In Africa, approximately 22% of the entire continent is made up of forest and woodlands [64]. For example, the Congo Basin alone is the largest adjoining forest in Africa and the world's second biggest rainforest. In South America, approximately 49.5% of the continent's total area is forested according to the United Nations with the Amazon forest in Brazil being the largest rainforest in the world. Additionally, in Asia, the most tropical rainforest in the continent is found in southeastern region particularly in Indonesia, Cambodia and the Malay Peninsular consisting of Malaysia, Thailand and Myanmar [65]. Although these forests serve as the earth's lungs and play a vital role in climate change by trapping the excess carbon in the atmosphere through photosynthesis, issues associated with deforestation are prevalent in many of these forest regions.

Circular bio-economy provides several opportunities for many developing countries to control and reverse deforestation. More so, the principle of cascading as depicted in the Ellen MacArthur Foundation [13] illustration of circular economy in Fig. 1 can be applied to ensure that biomass resources are used efficiently. Additionally, ecosystems rich in biodiversity can be utilized as fresh resources for viable bio-products.

### Mineral Extraction and Mining Sector

The mineral extraction industries play a significant role in economy of many of the developing countries. According to the World Bank [66], approximately 3.5 billion people reside in countries that are rich in minerals and oil and gas. With a management that is transparent and good governance, the revenue obtained from extractive industries can have a significant impact on the reduction of poverty in these regions and improving the prosperity of the economy while also preserving the environment. In Africa, particularly in Nigeria, the petroleum industry accounts for up to 80% of the government revenue and 90% of foreign exchange in country [67]. Nigeria is Africa's largest producer of oil and the eight largest exporters in the world. In South America, petroleum oils and crude oil from countries like Colombia and Ecuador in 2017 accounted for up to 30% of the export revenues [68].

Similarly, the mining industry provides raw materials like aluminium, iron ore, etc., for the equipment we use every day. The mining sector plays a leading role in the economies of many countries like Chile, Brazil, Colombia, India, Ghana, South Africa and Peru. According to Wikipedia [69] and in regard to nuclear fuels and fossil fuels, India is the largest producer of thorium and the second largest producer of coal respectively. For gemstones, Botswana is the second largest producer of diamond. Additionally, in terms of metals, India is the second leading producer of aluminium; Brazil produces the world's largest niobium; Mexico is second in bismuth, mercury and silver production; Chile and Peru produce the largest copper; South Africa is leading in chromium, manganese and platinum production; while Indonesia and Philippines are the largest exporters of nickel.

These primary resources are being extracted in unsustainable amounts which can result in their scarcity. The transitioning to a circular economy will have long-term impacts especially with its focus on re-use, extended usage and recycling which is anticipated to minimize the need for primary material extraction in these developing countries. Circular economy practices in the extractive and mining sector will provide opportunities to address socio-economic risks generated from mining activities. It will also increase the demand for primary materials used in low-carbon technologies as well as develop new technologies and innovations for mining operations in developing countries.

### Municipal Waste Management and Recycling Sector

The major challenges faced in many cities and metropolitan areas are the largely associated municipal solid wastes. For example, the United Nations Environmental Programme [70] estimated that the volume of waste produced in Latin American countries and the Caribbean alone is expected to reach 670,000 tonnes per day in 2050. Generally, many developing countries rely on illegal open dumping and the use of landfills as their final disposal methods. In municipal areas and in cities, the government plays a vital role in circular economy transition. One of the main goals for transitioning to circular economy in many cities of developing countries is to minimize pollution loads in the urban areas and to assist communities affected by mismanaged wastes in particular.

Circular economy practices in municipal waste management and recycling will provide opportunities to develop advanced cooperative models that are inclusive of hidden sectors in recycling and waste management. The circular economy principles can also be applied to the treatment of wastewater and the water can be recycled and used for irrigation purposes. Furthermore, circular economy uses the Industry 4.0

technologies and innovations to enhance collection and recovery of resources, for example, computerized collection and sorting.

### Roles of Circular Economy Stakeholders

Relevant circular economy stakeholders include businesses, industries, national government, local governments and everyone in general. The different stakeholders have important roles to play to ensure the effective transition of circular economy. Circular economy is important for business opportunities just as it is essential for the planet and society; therefore, businesses and industries can encourage investment in new processes, products and technologies that can result in significant transformation in the generation, disposal and management of waste. National and local governments can work together to provide leadership, funding and coordination while promoting innovation, developing product standards and delivering education and awareness programmes, thereby supporting the transition towards a more circular economy. The general public as stakeholders can influence circular economy by improving recycling habits through the proper sorting of wastes into recycling and compost bins. In addition, products which can be used multiple times can be purchased rather than a single-use product. For example, an individual can choose to buy a refillable water bottle than an already packaged bottle water.

## Conclusion

The world's growing population mounts overwhelming pressure on natural resources and this unrestrained growth makes it essential to shift from a habitual linear model, which includes take-make-dispose to a circular model of use-reuse-recycle-refurbish-redistribute. One gap identified in the course of the study is that not a lot of publications were made in 2013 and 2015, hence explaining the absence of papers for those years in the final result. Australia and many parts of the world have heightened interest in the circular economy concept and have begun practicing them in several industries in order to solve waste management problems.

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### Declarations

**Conflict of Interest** The authors declare no conflict of interest.

**Consent for Publication** We also provide our consent to publish the relevant data and results.

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