# Asian case studies on circular economy – a literature review

Rohit Panchal* and Anju Singh

Environmental Engineering and Management,
National Institute of Industrial Engineering (NITIE),
Mumbai, India
Email: rohit.panchal.2017@nitie.ac.in
Email: dranjusingh@gmail.com
*Corresponding author

**Abstract:** Circular economy (CE) is an opportunity to change the industrial system suffering from the pressure of undesirable waste and resource scarcity. In recent years scholars have come up with insightful cases in this area, but analysis of cases on CE of an Asian region is very limited. The assessment of CE cases in Asia across different sectors, regions, countries via different cycles was done in this study to comprehend the trends. Therefore, a literature review of CE case studies in the Asian region was carried out from 2008 to 2019. The case studies were chosen from relevant company websites, articles, reports, and Circular Asia platform. The most popular method to close the CE loop includes 'recycling'. Importantly, while much work has been done on the technical cycle of CE, future work could look at identifying ways to close the biological cycle of the CE.

**Keywords:** circular economy; Asia; case study; resource recovery; recycling; reuse.

**Reference** to this paper should be made as follows: Panchal, R. and Singh, A. (2022) 'Asian case studies on circular economy – a literature review', *Progress in Industrial Ecology – An International Journal*, Vol. 15, No. 1, pp.15–31.

**Biographical notes:** Rohit Panchal is a Fellow of Environmental Engineering and Management at the National Institute of Industrial Engineering, Mumbai. His research interests include circular economy, reverse supply chain and waste electrical and electronic equipment management.

Anju Singh is an Associate Professor of Environmental Engineering and Management at the National Institute of Industrial Engineering, Mumbai. Her research areas include sustainable development, environmental management, and circular economy.

This paper is a revised and expanded version of a paper entitled 'Asian case studies on circular economy – a literature review' presented at Recycle 2020, IIT Guwahati, 13–14 February 2020).

## 1 Introduction

The circular economy (CE) is an economic system that closes its loop without limiting itself to ‘end-of-life’ of a product by using alternate solutions like recycle, reuse, and recover. It aims to establish sustainable practices within itself to meet the needs of the current generation, while securing future generation (Kirchherr et al., 2017). Moreover, it is an approach towards both industrial production and consumption (Korhonen et al., 2018a). The fundamental principle of CE includes the ‘R-framework’ and ‘systems perspective’ (Kirchherr et al., 2017). The R-framework of the technical cycle is represented by recycling, refurbishing/remanufacturing, reusing/redistributing, along with both maintenance and repair. The systems perspective, on the other hand, is further classified into micro (single object), meso (symbiosis association) and macro (city, province, state) level implementation (EMF, 2015; Su et al., 2013). Studies at global, national, city and regional level are considered as macro-level, whereas studies of eco-industrial parks and industrial symbiosis association are at meso-level. Notably, studies focusing on single firm/industry/company, along with a product are at micro-level. The six challenges identified within the concept of CE include thermodynamic limits, system boundary limits, limits posed by the physical scale of the economy, limits posed by path-dependency and lock-in, limits of governance and management, and limits of social and cultural definitions (Korhonen et al., 2018b).

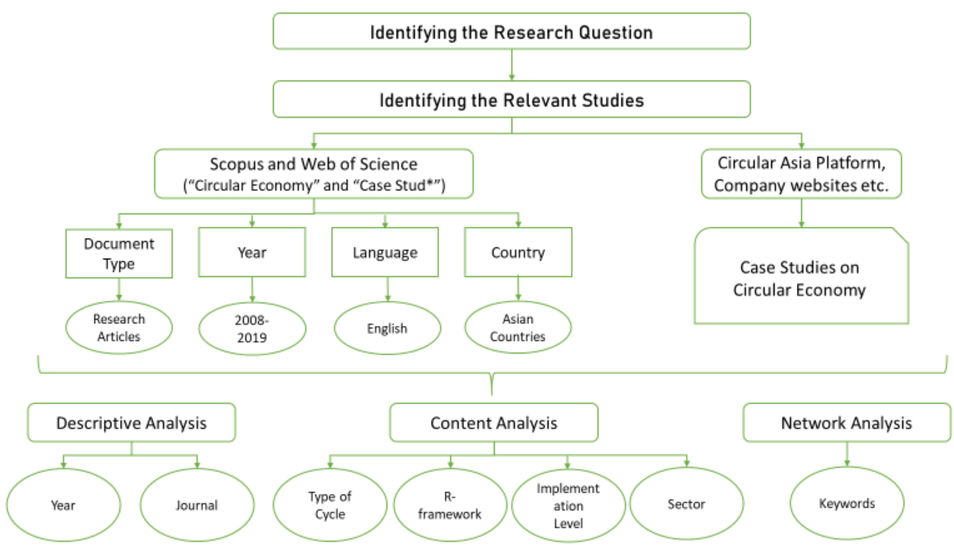
CE may be defined as a powerful system offering solutions to many problems that include environmental degradation, economic growth, sustainable development, and resource depletion. Therefore, policies at the national level are often framed to implement CE principles. The emphasis on CE policies is given by the Republic of China and Europe (Merli et al., 2018). In fact, China is one of the few countries that officially adopted CE, early in 2002; hence, a lot of work has been done in this field since then. The Chinese central government accepted the CE principles as being part of their core strategy to improve both resource efficiency and the environment.

As an early starter, China has made immense progress in implementing and adopting CE, as compared to other Asian countries. For instance, they have developed new cities based on the idea of CE. Further, they have also developed eco-industrial parks, again with successful CE implementation. This has resulted in a considerable decrease in carbon footprint in the past decade. Sustainable eco-industrial parks have led to its phenomenal economic growth among various sectors, whereby they have helped each other in resource utilisation and waste disposal (Zhao et al., 2018; Jiao et al., 2018; Mathews et al., 2018; Liu et al., 2018). Importantly, resource recovery and utilisation lead to significant cost-savings, while waste disposal results in decreased environmental degradation. Lu (2014) discussed developing CE to cater to the marine ecological crisis. Implementing CE for marine ecology is necessary to preserve biodiversity and improve ecological security thereof. In fact, China has been working towards this initiative in order to ensure sustainable economic and ecological development. Notably, China has been pushing CE across sectors and industries, using a top-down strategy, while others tend to adopt the bottom-up approach (Wang et al., 2018). A sampling of CE initiatives at the global level revealed that around 80% CE initiatives are based in Europe, 10% in North America and 10% in East Asia (Petit-Boix and Leipold, 2018). Hence, scholars have worked on CE case studies from China and Europe; but limited work has been done thus far on analysing these cases. Importantly, no work has been done on analysing CE cases of Asia as a whole. Therefore, the present study addresses the following research questions: What is the current status of CE implementation in Asian countries? Which type of cycle (technical or biological cycle) in CE implementation prevails in the Asian region? Which R-imperatives dominate CE implementation in Asian regions? What is the implementation level (micro, meso, macro and policy level) of CE initiatives among Asian countries? What are the different sectors among which CE principles are implemented in the Asian region?

## 2 Research methodology

The methodological framework of literature review given in Arksey and O'Malley (2005) and Batista et al. (2018) is used to study cases of the Asian region. The review includes both research articles and case studies. Research articles are taken from Scopus and Web of Science, while case studies are taken from Circular Asia platform, company websites, etc. Research articles published only in English is considered for the study. The rationale behind using a combination of research articles and case studies is to understand the progress of the work in the domain of CE both theoretically and practically. The literature review process is given in Figure 1.

**Figure 1** Literature review process (see online version for colours)




The present study analyses case studies of the Asian region that have implemented CE at different levels, namely micro, meso, macro and the policy. The analysis is done based on different categories, which are selected keeping in mind various ways to close the CE loop, business models, product design ideology and cross-sector collaborations (EMF, 2013a, 2013b). Notably, there are two ways to close the loop, either through a technical cycle or a biological cycle (Braungart et al., 2007). In the former, the loop is closed by minimising comparative material usage, or maximising the number of times a material is being used before its utility ends, and/or diversifying reuse across the value chain. The R-framework is commonly used to close the technical cycle of the CE (Reike et al., 2018). Scholars have proposed various R frameworks from 4R to 6R (Sihvonen and Ritola, 2015) to 9R (Bocken et al., 2017). However, the latter, (i.e., 9R) is one of the most enhanced, and is elaborated below:

- Refuse – make product redundant by abandoning its function or by offering the same function with a radically different product.
- Rethink – make product use more intensive (for example – product sharing).
- Reduce – increase efficiency in product manufacture or use by consuming fewer natural resources and materials.
- Reuse – when the product utility has not ended, but the consumer discards the product. The reuse of such discarded product by another consumer, which can serve its original function.
- Repair – to maintain the defective product in order to restore it for its original function.
- Refurbish – restoring the old product and update it for further use.
- Remanufacture – the process in which components of a discarded product can be utilised to fulfil the same function in a new product.
- Repurpose – use of discarded products or components with a different function.
- Recycle – utilising the material in another product to obtain the same higher grade or lower grade quality when the original product is discarded and/or its utility has ended.
- Recover – energy recovery by incinerating the product.

In the biological cycle, on the other hand, the various ways to close the loop include the extraction of biochemical feedstock, anaerobic digestion, regeneration, and farming/ collection (EMF, 2015). In fact, these are some of the most common methods that are utilised to treat biological waste, which in turn could be composted or may be used as manures.

Product design ideology is about whether a product is designed in a way to support the CE concept. It is done by reassembling or disassembling a product, considering its future flexibility in terms of its usage. Business models on CE are selected to categorise the cases, and they are as follows:

- Circular supplier – supplier using sustainable and circular practices to provide required material or service.
- Product life extension – models are working on extending the life of the product either by reusing or repurposing.
- Sharing platform – in this model, multiple users share a product or service.
- Resource recovery – this model is about recovering the material after the product utility has ended.
- Product as a service – in this model, the function of the product is based on circularity and hence is used as a service (Accenture Strategy, 2014).

As discussed earlier, CE operates at the micro, meso and macro-levels. These different levels imply the space or the area over which CE concepts are being implemented (Lieder and Rashid, 2016). Thus, the future perspective of the CE implementation over a certain space or area can be categorised as 'policy level'. This category includes all those policies that have been made based on CE and would be implemented over a space or an area in the near future. Wang and Chang (2014) stressed the importance of policymaking and its implementation. Moreover, they analysed the policy instruments meant to support the environment and promote sustainability. Therefore, we have made another classification of 'policy level' and categorised studies into the four levels, i.e., micro, meso, and macro, and at the policy level.

Cross-sector collaboration is also included as a category to recognise the work of industries cooperating with each other to work more circularly and sustainably (for example, eco-industrial parks). Depending upon their way to close the loop, every case study is enlisted (as shown below) under a corresponding category, post which content analysis is performed.

## *2.1 Descriptive analysis*

The descriptive analysis aims to provide an overview of the CE case studies of the Asian region. Moreover, it enables us to understand the trends of Asian case studies across years and countries. The graph of CE initiatives vis a vis the year is given in Figure 2. It is observed that from 2014, there is a rapid increase in CE initiatives taken by multiple organisations in Asia. The reason behind such a trend highlights the focus of both the companies and government to move towards sustainability, thereby reflecting an environment-friendly behaviour. Figure 3 shows the amount of work that has happened in the Asian countries. China tops the list with more than forty-five case studies published in the last few years. Other countries that have started implementing the CE principles are Japan and Singapore.

**Figure 2** Variation of Asian case studies on the CE over the years (see online version for colours)

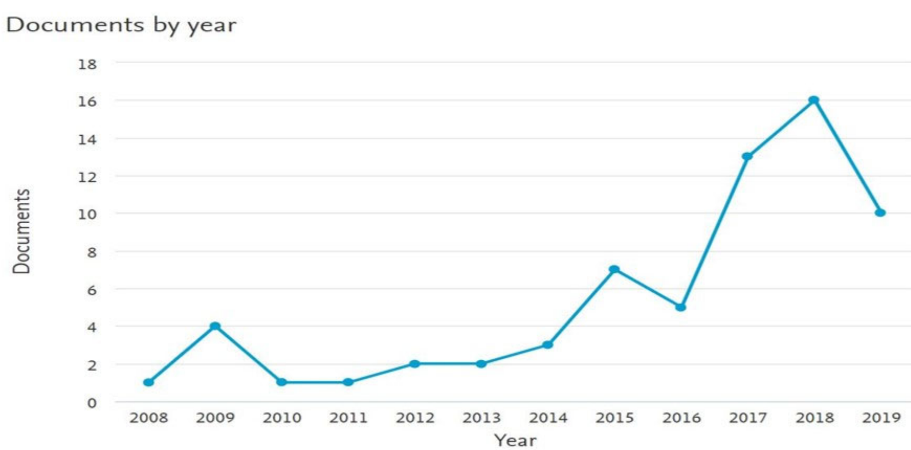


**Figure 3** CE case studies published across Asian countries (see online version for colours)

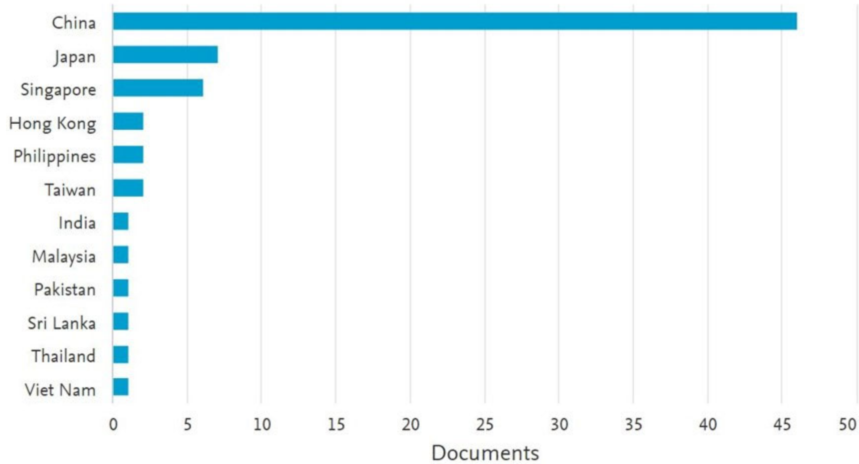
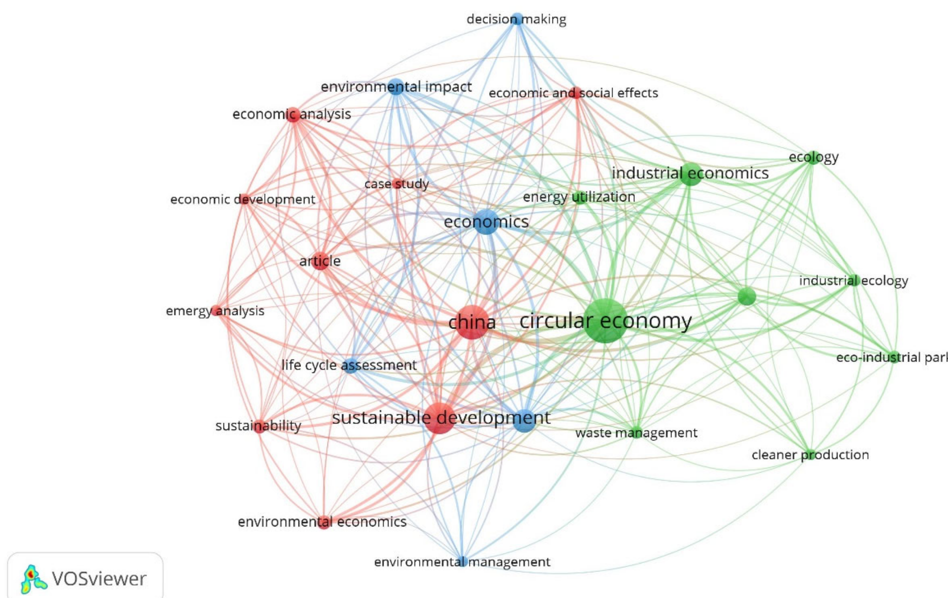



**Figure 4** Network analysis of author keywords (see online version for colours)




## 2.2 Network analysis

The network analysis of keywords (occurrence of keyword equal to or more than 5) is given in Figure 4. It comprises of cluster 1 (colour code – red) (sustainable development, China, economic analysis, case study, economic and social effects, economic development, article, energy analysis, sustainability, environmental economics), cluster 2 (colour code – green) (energy utilisation, CE, industrial economics, ecology, industrial ecology, eco-industrial park, cleaner production, waste management), and cluster 3 (colour code – blue) (economics, life cycle assessment, environmental impact, decision making, environmental management). ‘Sustainable development’ is the most used keyword after ‘CE’ among the studies reviewed. From Figure 4, it is observed that there are strong linkages between economics, CE, sustainable development, and industrial economics. Additionally, CE is the most documented in China across Asia. Furthermore, the network analysis suggests that waste management is the most relevant area for CE implementation in Asia.

## 3 Results and discussion

The development of the concept of CE vis a vis its subsequent implementation in Asia took many years. Notably, it is still not very popular among many Asian countries. Many scholars have written about different phases of CE for various Asian countries, wherein China takes the lead in implementing CE principles, as it officially adopted CE very early in 2002. Industrialisation in China led to massive resource depletion and environmental destruction, which need restoration for the sake of today and future generations. Thus, the concept of CE in China was much like ‘industrial ecology’ that talks about the advantages of waste utilisation in the form of material, energy and/or information. In fact, the best example of industrial ecology is its subset, (i.e., industrial symbiosis), where different industries come together to share their resources like labour, energy, capital and/or technology. It leads to better utilisation of waste, productivity enhancement and reduction in operating costs. China has developed several eco-industrial parks like Shanghai Chemical Industrial Park, Suzhou Industrial Park, etc. to create an environment where industries can flourish at low cost with better productivity. Su et al. (2013) discussed China’s CE from its conception to implementation along with challenges, while implementing the same in cities like Dalian, Shanghai, Beijing, and Tianjin. The Chinese government is encouraging the implementation of re and de-manufacturing due to ever-increasing automobile production. Notably, both re and de-manufacturing helped in resource recovery at an automobile’s end of life. As China is the world’s largest $CO_2$ producer and steel manufacturer, application of CE has indeed become an important solution to preserve depleting resources, while utilising scarce resources more efficiently, and disposing waste more responsibly.

As opposed to China, India is at a very nascent stage of CE implementation. The policy planning body under the government of India, NITI Aayog, is working towards developing a comprehensive strategy to combat resource inefficiency in the steel sector. Emphasis is given on the scrap and slag generated from the steel industries concerning resource efficiency and sustainable consumption (NITI Aayog and Ministry of Steel, 2018). As a matter of fact, many Indian companies have started working individually towards closing their loop, while maintaining sustainability, e.g., Tata Steel (Tata Group Companies’ Case Studies, 2018). Other than the steel industry, a few food organisations have also started taking initiatives to inculcate the ‘closed-loop’ concept to enhance sustainability, both on the economic and environmental fronts. However, there are many obstacles; for instance, there is still no proper government policy; or poor cold chain infrastructure in the food supply chain (Sharma et al., 2019).

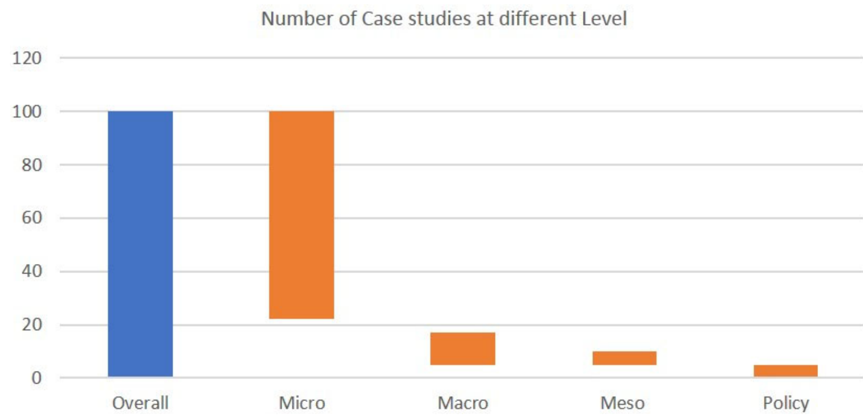
In Mongolia, due to many livestock farms, disposal of animal excreta has been a teething problem. Herein, the idea of a CE combined with the eco-agriculture industry is the probable solution. Through their study, Chang et al. (2011) suggested applying CE in the form of biogas plants. This would smoothen the waste disposal process, increase resource efficiency, and result in both economic and ecological growth. Specifically, this study focussed on different animal husbandries in the inner regions of Mongolia, and analysed potential power generation facilities using biogas plants. Notably, rural biogas is an excellent source of renewable energy. Many scholars have discussed biogas as a key solution of CE in the agriculture industry, especially in rural areas. China has developed policies to encourage the application of biogas in rural areas. It has enacted several laws to promote biogas and CE-friendly policies like renewable energy law and agriculture law act. The other way of treating organic garbage like livestock manure and poultry waste could be the use of earthworms. These small creatures turn all these waste into premium quality organic fertiliser. Earthworms can also provide several other benefits, like animal protein feed. Li et al. (2010) for instance, suggested Vermiculture as an important component of CE in order to promote environment up-gradation and organic resource utilisation.

Japan is fast-tracking its CE adoption projects. For example, Kyocera, a Japanese firm, manufactures solar appliances with long-term reliability and quality. Furthermore, in the country, people tend to apply a huge amount of compost and animal manure directly to the field, which in turn smoothens livestock waste handling along with its disposal. However, they are not able to control the disposal of phosphorous into water bodies that are released from agricultural fields. Shi (2013) suggested a CE model to integrate animal husbandry, livestock management, domestic rural life and waste disposal and recycling. Other Asian countries like Sri Lanka, Bangladesh, Vietnam, etc. have started implementing CE principles too. For example, Beximco, a Bangladeshi company has started mass production of garments with factory leftover, using a new Upmade method (Beximco, 2018; Women's Web, 2019).

## *3.1 Cases analysis*

This paper contains an analysis of 60 case studies from Asian countries, out of which most are from China and India. Concerning 'closing the loops', it is noted that out of all 60 cases, about 85% of them belonged to the technical cycle, while only 15% of the cases belonged to the biological cycle. In the category of business model, 41% of the cases belong to the resource recovery business model, 33% cases belong to the product as a service, 11% to product life extension model, while the rest belong to other business models. Closing the loop does benefit a company or country in several ways, i.e., economically, environmentally, and socially. From the cases analysed, in terms of the three pillars of sustainability, it is noted that 87% of the cases have the 'environment' as their priority for closing the loop. Hence, it can be inferred that the growing trend to 'close the loop' is through the technical cycle. Out of all these cases, the CE concept, when applied at different levels, looks like this: beginning with the micro-level that consists of CE application at individual or company level, the figure stands at 78%. For the meso level, (i.e., eco-industrial parks) the figure stands at 5%, while at the macro-level, the figure stands at 12%, and finally at the Policy level, the figure stands at 5%. Further, the analysis shows that more work needs to be done on both meso and policy levels in Asian countries, other than China.

**Figure 5** CE implementation levels of various case studies (see online version for colours)

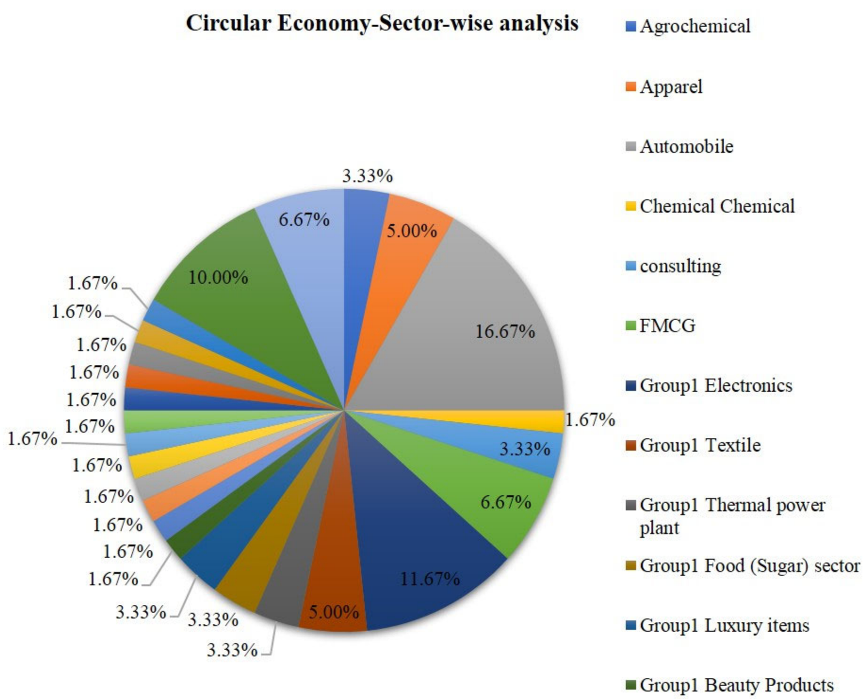



From Figure 5, the authors conclude that most of the work has been done at a micro-level, while limited work has been done both at meso and at the policy levels. Scholars have discussed setting up of new cities adopting CE principles in order to reduce the carbon transition of cities by waste recycling, resource conservation and industrial symbiosis. Through an investigation using ten years of data in the city Guiyang, China which is one of the CE pilot cities, it has been found that resource conservation and carbon footprint reductions can be attained simultaneously (Fang et al., 2017). Solid waste is a serious issue across Asia, and steps should be taken to tackle it both at the macro as well as the policy levels. Sri Lanka's renewable energy project for instance, does address the problem of solid waste to some extent, and hence aids in the consumption of biogas system. The project promotes the distribution of biogas systems at a massive scale for small and medium enterprises in tourism and household sectors. Notably, in order to attain this goal, the project selects the demand and supply of biogas simultaneously by including a financial institution, along with the value chain of the biogas system. This would significantly improve the country's economy, and establish new business opportunities, mainly for MSMEs.

In terms of sector-wise analysis, the sectors that have enabled circular system, and have been working rigorously towards further enhancement, including the automobile, electronics, metalworking and construction, wastewater, and fast-moving consumer goods (FMCG). Notably, other sectors have also been working towards CE, but their developmental rate is slow, accounting for mere 1.67% coverage among all Asian countries. These other sectors include biotechnology, beauty products, luxury items, thermal energy, tourism, consulting, pipe manufacturing, furniture, petrochemical, chemical, flood management, food sector (sugar manufacturing), battery manufacturing, footwear, textile, apparel, and export services (bamboo), among others.

From Figure 6, it can be depicted that a major area of the pie-chart is covered by the automobile sector, which effectively constitutes about 16.67%; next comes electronics, with 11.67%, followed by FMCG with 10% coverage. It concludes that the maximum number of CE cases identified in automobile sector followed by electronics and FMCG sector. Therefore, limited work is done in other sectors like luxury items, beauty products, sugar manufacturer, textile, and biotechnology. Importantly, in the automobile sector, boats, sports parts, aerospace, and wind turbines, there has been an increased utilisation of reinforced composite of carbon fibre (CFRC), and glass fibre (GFRC). These fibre reinforced composites provide high strength and are lightweight; however, it is difficult to handle their composite waste after their end of life. Hence, these materials pose a threat to the environment and to resource conservation thereof. Naqvi et al. (2018) proposed recycling, using pyrolysis as a solution to this problem, as it recovers valuable material, produces fuel and chemicals. Moreover, as noted earlier, a lot of work is still been done in the area of both de and remanufacturing in order to enhance resource recovery, reduce carbon footprint and increase material conservation thereof. Scholars have reiterated that both de and remanufacturing would add a new dimension to recover and reuse material, and enhance sustainability thereof, especially in sectors like automobile, aeronautics, electronics, and consumer goods. Tolio et al. (2017) discussed the methods, challenges, and opportunities in the area of smart de and remanufacturing, using higher automation, flexibility and advanced technologies. Google for instance, launched Google Nexus, which can be easily disassembled to recover the material, as it can be screwed together; while iPads by Apple on the other hand, are glued together, making material recovery thereby difficult. Interestingly, Google Nexus has been rated 8/10 in repairability, while Apple iPad rating is 2/10.

**Figure 6** Sector wise distributions of case studies (see online version for colours)




Indian companies like TVS Sundaram are developing chrome-free coatings for fasteners, which would eliminate the consumption of naturally depleting hazardous elements like chromium. Further, TVS Motors has reduced its steel content up to 1.5 kg in the frames and decreased 3.66 million metric tonnes of $CO_2$ equivalent in the process. Jaguar Land Rover, India started using aluminium to improve fuel consumption and reduce weight. They launched REcycle ALuminium (REAL) cars to close their loops, using recycling at the end of life, EoL (Tata Group Companies' Case Studies, 2018). Mobike, China has developed a business model of Bike-sharing platform to reduce increased consumption of motorcycle and improve the environment.

Expired medicines and Li anode batteries are a potential source of environmental pollution and hazardous waste. Li et al. (2018) proposed a facile hydrothermal route as a solution to recycle expired ferrous sulphate and waste Li foils to make LiFePO4, to enhance resource recovery and hazardous waste treatment. GEM Co. Ltd., a Chinese firm, transforms used battery into power battery material via recycling. GEM reuses important metals and elements like nickel, cobalt, manganese, copper, aluminium, iron, and lithium of used batteries to form new power batteries (Circulate, 2018).

Furthermore, the leather industry is one of the most polluting industry causes degradation of nearby areas. The CE can be a powerful solution for this sector to manage tannery effluents via 4R framework – reuse, reduce, recycle, recover. Hu et al. (2011) discussed in detail tannery effluent treatment according to various operations based on the principles of CE. ECOLEBAN (2014–2018) is a macro-level project under Switch Asia, whose target is to increase resource efficiency in the leather sector in Bangladesh (Switch Asia MAG, 2017). The project deals with up-gradation of the whole value chain of the leather industry, including leather products like footwear, apparel, leather accessories, etc. Additionally, the papermaking industry also produces a lot of pollutants, while utilising a lot of energy. Cleaner production can be an effective way to tackle such heavy polluting industries. For example, GSIL or Guangdong Silver Island Lake is a papermaking park, which performs cleaner production and sustainable disposal of waste (Li and Ma, 2015). This park entails recycling of energy, material, and water. The construction sector is another important economic sector that has a huge impact on the environment in terms of material utilisation, resource recovery and disposal of waste produced. Scholars have discussed alternative construction and demolition wastes management systems and strategies like recycling and reuse of materials. Ghisellini et al. (2018) for instance, developed a cleaner production framework for both construction and demolition framework in order to preserve the environment and thereby contribute towards economic development. The Delhi Government (India) has mandated to put a clause of a minimum 2% use of recycled products in building works, and 10% for road construction works. Further, the government has also encouraged installing on-site recycling units (BMTPC, 2016), for example, Kidwai Nagar redevelopment project. In Jamshedpur, India, the Tata Steel plant follows 4R principle to use by-products produced in steel making. In thermal power plants, the waste generated such as fly ash utilised to produce bricks, cement, and other construction materials, as it provides adhesive property while undergoing reaction with compounds that are present in cement and bricks.

Both scientists and researchers have been working on membrane bioreactor (MBR) technology to treat wastewater, consisting of micropollutants. Goswami et al. (2018) for instance, discussed the onset, state of research, advancement, and augmentation of MBR along with its application under various scenarios. On the other hand, at a macro level, the Suzhou city of China is a highly successful case of an efficient waste collection and processing program. All the restaurants of the city tend to dispatch their waste to Jiangsu Clean Environmental Technology, which is the assigned processor by the city municipality. It is a mandatory exercise else the restaurant's license would get cancelled for the following year. Interestingly, this has resulted in an increased rate of waste collection and has provided consistent feedstock flows to Jiangsu's processing equipment (United Nations ESCAP, 2015).

Concerning the technical cycle which constitutes majorly in closing the loop, the most used R-framework is recycling (used in 46% of cases) to close the loop (refer to Figure 7). Apart from the recycling, the other R-framework used is reuse (29% of cases), refurbish/remanufacture (14% of cases), and repair/maintain (11% of cases).

**Figure 7** Pie-chart of R-framework used to close the technical cycle of CE (see online version for colours)

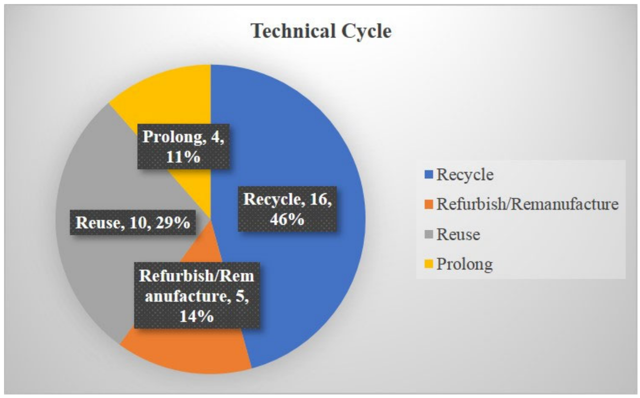
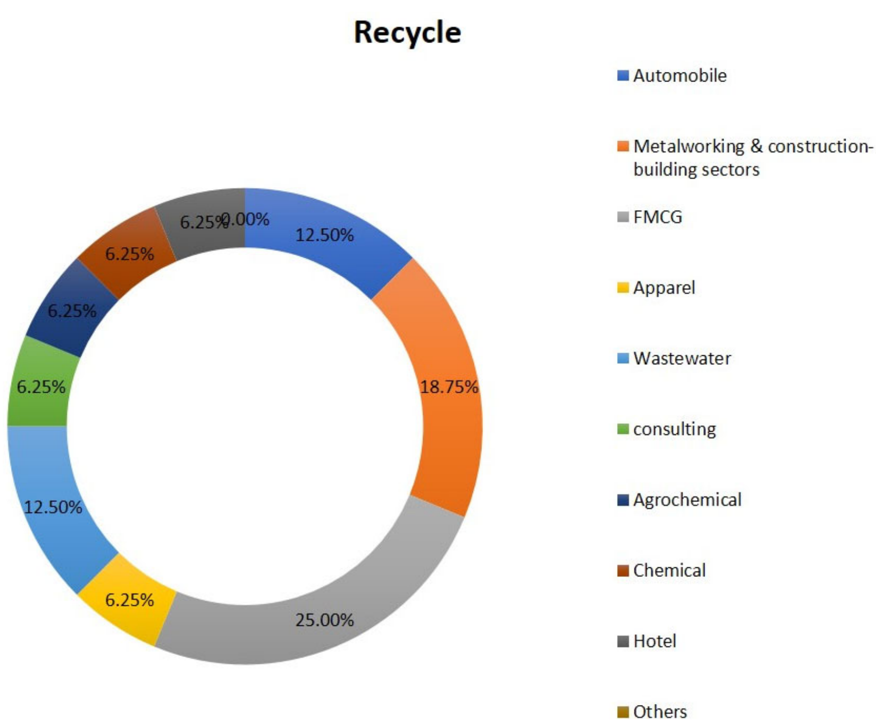



**Figure 8** Pie-chart depicting the share of various sectors using recycling to close the loop (%) (see online version for colours)



Recycling is thereby the most popular process to close the loop; it is necessary to further understand the recycling process. A lot of work is being done on recycling at different levels and different sectors. Lin (2018) for instance, proposed a smart production approach in glass recycling, through Industry 4.0 through data-driven innovation and product decision making information systems. Notably, the common sectors that have been adopting recycling include, FMCG (25% of cases), metalworking and construction (18.75% of cases) and automobile and wastewater (12.5% of cases).

From Figure 8, it may be inferred that most of the companies in the FMCG sector use recycling to increase their resource efficiency by closing their loops. Scholars have done a lot of work in food recycling; yet limited work has been done in the industry as a whole. For instance, in order to combat the problem of unutilised food and wastages, a decomposition analysis framework has been provided, which considers these five factors to prevent food wastages. They are food recycling, volume reduction, energy recovery, waste recovery and prevention, production scale. Further, it has been found that the key driver for food waste management is recycling in the food manufacturing industry (Fujii and Kondo, 2018). On the contrary, a considerable amount of work has been done in the area of sugar production. Sugar production leads to produce by-products and wastes, which in turn are harmful to the environment. Efficient utilisation of sugar industry waste can be used to create energy, which would reduce the dependency on non-renewable resources. For instance, using thermochemical combustion of sugarcane bagasse, cleaner energy can be produced, which in turn would reduce the pile-up on landfills. Further, usage of sugarcane by-products in cement, bricks and other products would result in material recovery, as well as environment conservation. A framework has been developed with the symbiotic approach, using both primary and secondary by-products of the sugar industry in order to promote cleaner energy, construction products and safer environment (Gopinath et al., 2018). Companies like EID Parry in India have received the Bonsucro Production Standard certificate, which essentially is a metric-based standard to improve sugarcane farming and its derived products that promote social, economic, and environmental sustainability. HP Cogen, of Pakistan, works on high-pressure cogeneration (HPC) technology, which emphasises upon the use of sugar bagasse as a renewable energy resource and a waste reduction mechanism (Switch Asia MAG, 2017). The electronics sector on the other hand, produces e-waste, which in essence, are components that can be reused or recycled (Singh et al., 2020). Dell for instance, is a US-based company that facilitates various easy recycling options for customers, so that they could dispose of their electronic items at the end of life safely. This in turn reduces the environmental footprint. It also helps other businesses to responsibly dispose of the waste, while preserving information, lest it fall into wrong hands. Furthermore, the apparel sector has been coming up with new recycling techniques these days. Mark & Spencer for instance is helping its customers to recycle old clothing items by depositing them to any retailer. They began this service in 2015; interestingly, the number of recycling clothing items has reached about 20 million. Notably, the Mark & Spencer store where the used clothing items have been dumped rewards the customer with vouchers and coupons in exchange. Titan in India is a watch and jewellery manufacturing company; they often use gold in many of their products, which in turn is one of the key raw materials that are 100% recyclable. They separate the waste at the source and dispose of it scientifically. They have initiated scientific disposal facility for watch factories. Batteries are collected at the service centres, and then the metallic, non-metallic, and hazardous wastes are segregated at the source, after which it is disposed of safely. Packaging of goods has become an essential value-adding activity, which produces a lot of waste that goes to landfill. Companies like Coca-Cola have pledged to reduce packaging waste by 25% by 2020. They have started recycling 95% PET bottles and have partnered with eco-plastics in order to promote recycling, and reuse the materials, while reducing waste in the process. Hitachi has leveraged upon technology to harness solar power to decrease the dependency on non-renewable power generation. This would help in reducing carbon footprint and upgrade the environment thereof (Hitachi Knowledge Hub, 2019).

## 4 Conclusions

This review analyses CE-based case studies of the Asian region (2008–2019), by broadly classifying them into the technical and biological cycles. At a macro level, it is observed that governments of different countries are taking initiatives towards closing the loops with a vision of saving the environment, and the greater good of society. At a micro-level, several companies have started applying the CE principles too. However, since there is a dearth of studies on both meso and policy levels, this study proposes that appropriate laws and policies should be framed, enforced, and strengthened. Moreover, stringent implementation is required for establishing low carbon-emitting policies, maintaining the global environmental standards and measures, eliminating faulty and out-dated equipment in industries, and using environment-friendly technologies. Companies across Asia should come together on a common platform and develop an environment where they should not only share resources, information, and technology but also can make an impact both environmentally and socially. Like China and India, more governments should take the initiative and develop policies concerning CE and contribute more towards a sustainable future of not only their nation but the earth as well. The most popular way to close the loop has been the technical cycle that includes the R framework. The most trending method from 2008–2019 to close the loop is recycling. The possible reasons for this could be the popularity of 3R and 4R framework among people, awareness, ease of application, and enhanced knowledge source in this area. Hence, it is required to spread awareness regarding the biological cycle and to elevate the knowledge source in this area. Further studies and research are needed on how to close the cycle biologically for all the sectors.

The limitation of this study is that we have not compared the results with those pertaining to CE implementation in European countries. Hence, future work can be done on comparing the results of this study with European case studies. Also, further studies are required to determine the contribution of CE implementation in achieving sustainable development goals (SDG's), propounded by the United Nations.

## References

Accenture Strategy (2014) [online] https://thecirculars.org/content/resources/Accenture_Circular_Advantage_Web_Single.pdf (accessed 15 October 2019).

Arksey, H. and O'Malley, L. (2005) 'Scoping studies: towards a methodological framework', *International Journal of Social Research Methodology*, Vol. 8, No. 1, pp.19–32.

Batista, L., Bourlakis, M., Smart, P. and Maull, R. (2018) 'In search of a circular supply chain archetype – a content-analysis-based literature review', *Production Planning and Control*, Vol. 29, No. 6, pp.438–451.

Beximco (2018) [online] http://www.beximco.com/textile.php (accessed 29 September 2019).

Bocken, N.M., Olivetti, E.A., Cullen, J.M., Potting, J. and Lifset, R. (2017) 'Taking the circularity to the next level: a special issue on the circular economy', *Journal of Industrial Ecology*, Vol. 21, No. 3, pp.476–482.

Braungart, M., McDonough, W. and Bollinger, A. (2007) 'Cradle-to-cradle design: creating healthy emissions – a strategy for eco-effective product and system design', *Journal of Cleaner Production*, Vol. 15, Nos. 13–14, pp.1337–1348.

Building Materials and Technology Promotion Council (BMTPC) (2016) *Utilisation of Recycled Produce of Construction and Demolition Waste* [online] https://164.100.228.143:8080/sbm/content/writereaddata/C&D%20Waste_Ready_Reckoner_BMTPC_SBM.pdf (accessed 23 September 2019).

Chang, I.S., Zhao, J., Yin, X., Wu, J., Jia, Z. and Wang, L. (2011) 'Comprehensive utilisations of biogas in inner Mongolia, China', *Renewable and Sustainable Energy Reviews*, Vol. 15, No. 3, pp.1442–1453.

Circulate (2018) *Circular Economy in China: Six Examples* [online] https://medium.com/circulatenews/circular-economy-in-china-six-examples-2709982763f2 (accessed 30 September 2019).

Ellen MacArthur Foundation (EMF) (2013a) *Towards the Circular Economy: Economic and Business Rationale for an Accelerated Transition* [online] https://www.ellenmacarthurfoundation.org/assets/downloads/publications/Ellen-MacArthur-Foundation-Towards-the-Circular-Economy-vol.1.pdf (accessed 23 September 2019).

Ellen MacArthur Foundation (EMF) (2013b) *Towards the Circular Economy: Opportunities for the Consumer Goods Sector* [online] https://www.ellenmacarthurfoundation.org/assets/downloads/publications/TCE_Report-2013.pdf (accessed 25 September 2019).

Ellen MacArthur Foundation (EMF) (2015) *Towards a Circular Economy: Business Rationale for an Accelerated Transition* [online] https://www.ellenmacarthurfoundation.org/assets/downloads/TCE_Ellen-MacArthur-Foundation-9-Dec-2015.pdf (accessed 20 September 2019).

Fang, K., Dong, L., Ren, J., Zhang, Q., Han, L. and Fu, H. (2017) 'Carbon footprints of urban transition: tracking circular economy promotions in Guiyang, China', *Ecological Modelling*, Vol. 365, pp.30–44.

Fujii, H. and Kondo, Y. (2018) 'Decomposition analysis of food waste management with explicit consideration of priority of alternative management options and its application to the Japanese food industry from 2008 to 2015', *Journal of Cleaner Production*, Vol. 188, pp.568–574.

Ghisellini, P., Ji, X., Liu, G. and Ulgiati, S. (2018) 'Evaluating the transition towards cleaner production in the construction and demolition sector of China: a review', *Journal of Cleaner Production*, Vol. 195, pp.418–434.

Gopinath, A., Bahurudeen, A., Appari, S. and Nanthagopalan, P. (2018) 'A circular framework for the valorisation of sugar industry wastes: review on the industrial symbiosis between sugar, construction and energy industries', *Journal of Cleaner Production*, Vol. 203, pp.89–108.

Goswami, L., Kumar, R.V., Borah, S.N., Manikandan, N.A., Pakshirajan, K. and Pugazhenthi, G. (2018) 'Membrane bioreactor and integrated membrane bioreactor systems for micropollutant removal from wastewater: a review', *Journal of Water Process Engineering*, Vol. 26, pp.314–328.

Hitachi Knowledge Hub (2019) [online] https://social-innovation.hitachi/en-in/knowledge-hub/collaborate/technologies/ (accessed 30 September 2019).

Hu, J., Xiao, Z., Zhou, R., Deng, W., Wang, M. and Ma, S. (2011) 'Ecological utilisation of leather tannery waste with circular economy model', *Journal of Cleaner Production*, Vol. 19, Nos. 2–3, pp.221–228.

Jiao, W., Boons, F., Teisman, G. and Li, C. (2018) 'Durable policy facilitation of sustainable industrial parks in China: a perspective of co-evolution of policy processes', *Journal of Cleaner Production*, Vol. 192, pp.179–190.

Kirchherr, J., Reike, D. and Hekkert, M. (2017) 'Conceptualising the circular economy: an analysis of 114 definitions', *Resources, Conservation and Recycling*, Vol. 127, pp.221–232.

Korhonen, J., Nuur, C., Feldmann, A. and Birkie, S.E. (2018a) 'Circular economy as an essentially contested concept', *Journal of Cleaner Production*, Vol. 175, pp.544–552.

Korhonen, J., Honkasalo, A. and Seppala, J. (2018b) 'Circular economy: the concept and its limitations', *Ecological Economics*, Vol. 143, pp.37–46.

Li, D., Hou, H., Liu, X., Yao, Y., Dai, Z. and Yu, C. (2018) 'The synchronous reutilization of the expired ferrous sulfate granules and waste Li foils for LiFePO4/C cathode', *International Journal of Hydrogen Energy*, Vol. 43, No. 49, pp.22419–22426.

Li, K., Li, P. and Li, H. (2010) 'Earthworms helping economy, improving ecology and protecting health', *International Journal of Global Environmental Issues*, Vol. 10, Nos. 3–4, pp.354–365.

Li, Y. and Ma, C. (2015) 'Circular economy of a papermaking park in China: a case study', *Journal of Cleaner Production*, Vol. 92, pp.65–74.

Lieder, M. and Rashid, A. (2016) 'Towards circular economy implementation: a comprehensive review in context of manufacturing industry', *Journal of Cleaner Production*, Vol. 115, pp.36–51.

Lin, K.Y. (2018) 'User experience-based product design for smart production to empower industry 4.0 in the glass recycling circular economy', *Computers and Industrial Engineering*, Vol. 125, pp.729–738.

Liu, Z., Adams, M., Cote, R.P., Geng, Y. and Li, Y. (2018) 'Comparative study on the pathways of industrial parks towards sustainable development between China and Canada', *Resources, Conservation and Recycling*, Vol. 128, pp.417–425.

Lu, Y. (2014) 'Circular economy development mode of coastal and marine areas in China and its evaluation index research – the example of Qingdao', *International Journal Bioautomation*, Vol. 18, No. 2, pp.121–130.

Mathews, J.A., Tan, H. and Hu, M.C. (2018) 'Moving to a circular economy in China: transforming industrial parks into eco-industrial parks', *California Management Review*, Vol. 60, No. 3, pp.157–181.

Merli, R., Preziosi, M. and Acampora, A. (2018) 'How do scholars approach the circular economy? A systematic literature review', *Journal of Cleaner Production*, Vol. 178, pp.703–722.

Naqvi, S.R., Prabhakara, H.M., Bramer, E.A., Dierkes, W., Akkerman, R. and Brem, G. (2018) 'A critical review on recycling of end-of-life carbon fibre/glass fibre reinforced composites waste using pyrolysis towards a circular economy', *Resources, Conservation and Recycling*, Vol. 136, pp.118–129.

NITI Aayog and Ministry of Steel (2018) *Strategy Paper on Resource Efficiency in Steel Sector through Recycling of Scrap and Slag, India* [online] https://niti.gov.in/writereaddata/files/RE_Steel_Scrap_Slag-FinalR4-28092018.pdf (accessed 3 September 2019).

Petit-Boix, A. and Leipold, S. (2018) 'Circular economy in cities: reviewing how environmental research aligns with local practices', *Journal of Cleaner Production*, Vol. 195, pp.1270–1281.

Reike, D., Vermeulen, W.J.V. and Witjes, S. (2018) 'The circular economy: new or refurbished as CE 3.0? Exploring controversies in the conceptualisation of the circular economy through a focus on history and resource value retention options', *Resources, Conservation and Recycling*, Vol. 135, pp.246–264.

Sharma, Y.K., Mangla, S.K., Patil, P.P. and Liu, S. (2019) 'When challenges impede the process: for circular economy-driven sustainability practices in food supply chain', *Management Decision*, Vol. 57, No. 4, pp.995–1017.

Shi, F. (2013) 'Phosphorus flow analysis of rural circular economy system in Japan: a case study of Nakasatsunai village in Hokkaido', *Journal of Ecology and Rural Environment*, Vol. 29, No. 6, pp.695–699.

Sihvonen, S. and Ritola, T. (2015) 'Conceptualising ReX for aggregating end-of-life strategies in product development', *Procedia Cirp*, Vol. 29, pp.639–644.

Singh, A., Panchal, R. and Naik, M. (2020) 'Circular economy potential of e-waste collectors, dismantlers, and recyclers of Maharashtra: a case study', *Environmental Science and Pollution Research*, Vol. 27, No. 17, pp.22081–22099.

Su, B., Heshmati, A., Geng, Y. and Yu, X. (2013) 'A review of the circular economy in China: moving from rhetoric to implementation', *Journal of Cleaner Production*, Vol. 42, pp.215–227.

Switch Asia MAG (2017) *Advancing the Circular Economy in Asia* [online] https://www.switch-asia.eu/site/assets/files/1207/screen_final_singlepages02.pdf (accessed 15 September 2019).

Tata Group Companies' Case Studies (2018) *TATA Closing the Loop* [online] http://tatasustainability.com/images/NewsLetter/Files/40_circular%20economy%20bro_Final%2019%20June%202018.pdf (accessed 16 September 2019).

Tolio, T., Bernard, A., Colledani, M., Kara, S., Seliger, G., Duflou, J. and Takata, S. (2017) 'Design, management and control of demanufacturing and remanufacturing systems', *CIRP Annals*, Vol. 66, No. 2, pp.585–609.

United Nations ESCAP (2015) *Water and Green Growth* [online] https://www.unescap.org/sites/default/files/WWF_CaseStudies_final.pdf (accessed 30 September 2019).

Wang, N. and Chang, Y.C. (2014) 'The development of policy instruments in supporting low-carbon governance in China', *Renewable and Sustainable Energy Reviews*, Vol. 35, pp.126–135.

Wang, P., Li, W. and Kara, S. (2018) 'Dynamic life cycle quantification of metallic elements and their circularity, efficiency, and leakages', *Journal of Cleaner Production*, Vol. 174, pp.1492–1502.

Women's Web (2019) *Estonia's Reet Aus is Saving the Planet in Style, with Sustainable and Ethical Fashion* [online] https://www.womensweb.in/2019/03/reet-aus-estonia-sustainable-and-ethical-fashion-mar19wk3sr/ (accessed 19 September 2019).

Zhao, H., Guo, S. and Zhao, H. (2018) 'Comprehensive benefit evaluation of eco-industrial parks by employing the best-worst method based on circular economy and sustainability', *Environment, Development and Sustainability*, Vol. 20, No. 3, pp.1229–1253.