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Review article

Circular economy model for developing countries: evidence from Bangladesh

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ABSTRACT

From environmental and sustainable development perspective, circular economy model is rarely applied in developing countries compared to developed nations. The aim of this paper is to review the overall scenario of the circular economy (CE) model in Bangladesh toward sustainable development. The study relies on the descriptive analysis of both qualitative and quantitative data, collected mostly from secondary sources with some in-depth interviews of the experts in the relevant field. The overall environmental status of Bangladesh, prospects, practices, and challenges of the circular economy model were thoroughly discussed in this paper. Though there are prospects to switching towards CE, the study reveals that the CE model's applicability is very limited in Bangladesh, being exercised mostly through recycling processes in some industries. Most importantly, we attempted to explore what is holding the CE practice in Bangladesh back, and iterated some policy, technical, and public participation barriers existing in Bangladesh. This paper will benefit the policymakers in developing countries in general and Bangladesh in particular to look more into the matter and hope to present ideas for future researchers to work on the idea of CE in the context of particular sectors and subsectors of Bangladesh.

1. Introduction

The circular economy (CE) is defined to be a method to manage resource circularity, efficiency, and optimization that advocates the use of wastes as resources to generate value (Azizuddin et al., 2021). The system that the world follows currently is a linear economy model. This is mainly the take, make, and dispose model. Alternatively, production, consumption and dispose of wastage (Figure 1a). Aside from polluting the environment, this model also results in huge waste and inefficient use of resources. The circular economy model, on the other hand, involves production, consumption, dispose of wastage to recycle it for further production (Figure 1b) and it is governed mainly by Recycling, Reduce and Reuse (3Rs) concept (Manickam and Duraisamy, 2019). Thus, the circular economy (CE) model is one of the most environmentally friendly and sustainable development ways (Andersen, 2007).

Furthermore, shifting to CE provides prospects to eliminate poverty (Constant et al., 2013). It is possible to achieve Sustainable Development Goals (SDGs) through a circular economy because the model replaces production with sufficiency, reuses what we can, recycle what cannot be reused, repairs what is broken, and remanufacture what cannot be broken.

According to a report by (UNEP) United Nations Environment Programme, the extraction of natural resources increased by three folds in the last 40 years (UNEP, 2016). UNEP also reports that, if the resources are used prudently, it could generate an additional $2 trillion to the global economy by 2050 (Panel, 2017).

Additionally, Circular economy practice can be related to some of the SDG goals, such as - SDG-6 (Clean Water & Sanitization), SDG-7 (Affordable Clean Energy), SDG-12 (Reasonable Consumption & Production), and SDG-15 (Life on Land) (Schroeder et al., 2019). In this system, the companies provide services rather than selling physical products (Biswas et al., 2019).

Further, if we observe the environmental status of Bangladesh in the context of fine particle air pollution (PM 2.5), Bangladesh is listed as the world's most polluted country (Figure 2); this pollution is six times the recommended level of WHO (World Health Organization). According to WHO, Bangladesh suffered 572,600 deaths by non-communicable diseases in 2018, where air pollution was the most risk factor (Koop, 2021). Additionally, according to the report of world development indicator, by

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a) Linear Economy Model

b) Circular Economy Model

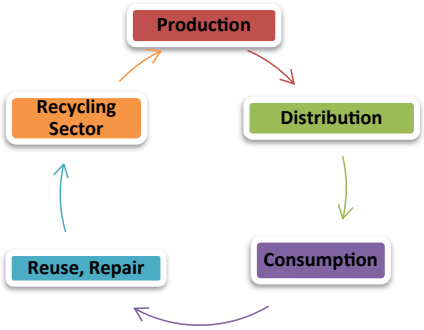
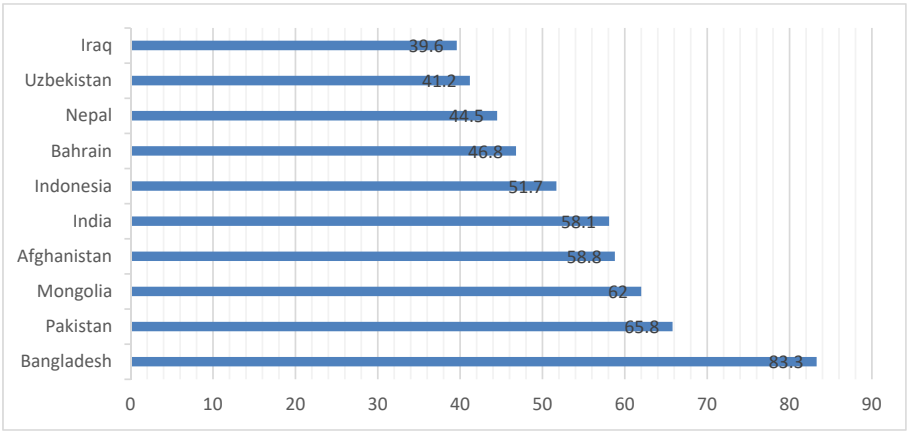


Figure 1. Linear economy model and circular economy model.



Source: IQAir 2020, World Air Quality Report

Figure 2. World's top ten polluted countries 2019. Source: IQAir 2020, World Air Quality Report.

the World Bank, CO_2 emission in Bangladesh (metric tons per-capital) was seen to increase steadily with a positive slope. In 1976, the value was 0.0777, this figure increased dramatically to 0.533 in 2016 (608 times higher than it was in 1976).

It is worth mentioning that the persisting urbanization process in southeast Asia is unsustainable (Arfanuzzaman and Dahiya, 2019). In the perspective of Bangladesh, the increasing rural to urban migration, resulted from existing rural-urban gap, has caused the population in urban areas to rise (Biswas et al., 2019). Several studies have observed the positive relationship of urbanization with environmental pollution Ahmed and Islam, (2014); Hossain and Hasanuzzaman, (2012); Rahman et al. (2020).

Ahmed and Islam, (2014) found that the urbanization factor is responsible for creating the environmental problem. It causes problems in water supply, solid waste management, waste disposal, traffic congestion, sound pollution, and waterlogging. Moreover, the acceleration of economic growth triggered by urbanization causes the increase of energy consumption, resulting in increased pollution (Rahman et al., 2020).

Moreover, according to Trading Economics, in Bangladesh, the unemployment rate is projected to be 4.2% in 2020. As a developing country with a demographic dividend, Bangladesh needs to create employment opportunity. In addition, Bangladesh needs sustainable industrial development and input resources to meet the Sustainable Development Goals (SDGs). In such situations, the circular economy model, which incorporates the 3Rs (Recycle, Reduce, and Reuse) concept as a guiding value for implementing circular economy in practice, may be a more realistic option (Yong, 2007).

Such that, Scientific studies on the environment's existing status and the circular economy model's applications is an immediate need to achieve SDGs in Bangladesh. The number of research articles we have on the concept of CE in the context of developing countries, especially that of Bangladesh, is exceptionally limited (Kirchherr and van Santen, 2019). Most of the articles in the context of developing country deals with mostly on waste management (Abalansa et al., 2021; Ali et al., 2021; Khan and Ali, 2021), and other including in fashion (Atalay Onur, 2020), and renewable energy perspective (Angulo-Mosquera et al., 2021).

And in particular for Bangladesh (Table 1), literature is focused on recommerce, leather, textile, and renewable energy perspectives (Islam et al. (2021); Moktadir et al. (2018); Saha et al. (2021)). Moreover, Some of the articles also discuss the risk of CE practice implementation in the supply chain, and more broadly in the context of SDGs (Azizuddin et al.

Table 1. Findings from recent literature in the context of Bangladesh.

Authors (Year)	Context	Methodology	Findings
Dulia et al. (2021)	Evaluating the risk towards implementing CE model in supply chain	Fuzzy Synthetic Evaluation (FSE) based on primary data	• The risk associated with the framework and quality degradation of the recycled product was found to be the barrier in this case.
Repp et al. (2021)	Global employment shift due to EU's transition to CE	Social life cycle assessment (SCLA)	• The adverse effect could be faced by Bangladesh, due to loss of jobs
Moktadir et al. (2018)	Drivers of implementing CE practice in the leather industry of Bangladesh.	Graph theory and matrix approach (GTMA)	• Having the knowledge and awareness regarding CE among the stakeholders is the most important factor to apply CE practices.
Saha et al. (2021)	CE practice in the Textile and Clothing Industry (TC).	Mixed method approach: statistical analysis of survey data, content analysis of the focus group, and survey comments	• Challenge in implementing CE practice includes reluctance of management, lack of proper financial, human resource, technological support and the consciousness of consumers. • A combined effort of government, industry, and consciousness among the buyer is required. • Knowledge sharing sustainable practice among the value chain is also necessary.
Azizuddin et al. (2021)	The implication of CE for sustainable development in Bangladesh	Review of literature, and Delphi approach interview (Semi-structured)	• The mashup of government and private initiatives can help to attain sustainable development by implementing CE practices in different sectors of Bangladesh. • Aside from lack of awareness among the public regarding CE, Bangladesh lacks logistic and efficient technological support; which pose an impediment for the implementation of CE
Arman and Mark-Herbert (2021)	The implication of re-commerce for CE practice	Review of literature, and focus group discussion	• Re-commerce practices in Facebook plays a role to remove the taboo of using the second-hand product. • Re-commerce promotes consciousness regarding CE practices among the general population.
Islam et al. (2021)	Generation of renewable energy from livestock waste	Scenario analysis, and GHG quantification model	• The use of commercial biogas generation can help generate a new renewable energy source for Bangladesh. • For increasing the use of biogas, a measure to provide soft-loan to the lower-income household was suggested by the author.

(2021); Dulia et al. (2021)). Nonetheless, there is a paucity of research that seeks to highlight the entire situation of CE implementation and contemporary environment, as well as the possibilities, practice, and obstacles of CE implementation in various industries for a developing country, especially Bangladesh.

Thus, this paper aims to explore the circular economy model in Bangladesh and its applicability to achieve sustainable practice in the industries of Bangladesh. Methodologically, the present study is a descriptive analysis of quantitative and qualitative data, collected mostly from secondary sources with some in-depth interviews of the experts in the relevant field. The secondary data sources used in the study are newspaper articles, editorials, magazine, journal articles, and grey literature.

In the following parts, in section 2 and section 3 a brief review of recent literature in the perspective of developing country, including Bangladesh has been added, and the methodology of this study has also been depicted, respectively. In section 04, the overseas practice of CE is showed, which aims to offer readers an insight into how CE is being widely used throughout the world so that the readers can compare the practice of CE in Bangladesh with the contemporary world. The subsequent sections include sector-wise current practices and prospects of CE in Bangladesh. The study then finds out the prevailing challenges to apply CE model in Bangladesh based on interviews with the experts (Section 6). Finally, a comparative discussion of the findings was made to conclude the study in Section 7.

2. Review of recent literature (2018–2021)

The literature review in this study followed a systematic approach based on papers published in the Scopus Indexed journals between 2018 and 2021. We narrowed down our search with two keywords "Circular Economy", and "Developing Country", giving us 22 papers, which have been used to review the recent works on CE in section 2.1; afterward we further narrowed down our search of Circular Economy to only "Bangladesh"; and accumulated a total of 7 papers; which is presented in Table 1.

2.1. Literature review: developing country perspective

JW Kirchherr and van Santen (2019) emphasized the study of CE, especially for emerging and developing countries, as there are very few articles (only 5%) that focuse on the concept of CE for developing countries (Kirchherr and van Santen, 2019).

For the developing countries becoming sustainably developed, shifting towards CE practice is required in almost all sectors, most importantly: waste collection and management. Therefore, cost-effective sophisticated technologies are required to smoothen the transition (Khan and Ali, 2021; Serrano et al., 2021; Winterstetter et al., 2021). Further, the governments of the developing countries are facing daunting impediments in proper management, policymaking, policy implementation, and technological barriers (Ding et al., 2019). However, the industries in the developing countries are moving towards cleaner production and CE practices so that they can produce goods that are environment friendly, cheaper in costs and will be demandable to the communities of the developed countries. In this context, Shayganmehr et al. (2021) emphasized the use of industry 4.0 technologies, which may catalyze the way towards increasing CE practices.

The developing countries most often lack an efficient and structured approach to address climate objectives to their policy decisions and overall development approaches (Serrano et al., 2021). The countries should go towards policies that will help in decoupling growth; thus continuing the economic growth with the inclusive development

perspective to reduce poverty as well as protect the environment (Scheel et al., 2020). The progress in the economic performance of a country and the awareness among the population towards CE importance can play a catalyst towards implementing CE practices in developing countries (Ngan et al., 2019). Moreover, in the context of Pakistan, Khan and Ali et al. (2021) said that the problem of waste management comes mainly from mismanagement due to weak regulations. The author added that aside from managing the waste properly, the country should focus on investing in technologies (IoT, and ICT) to effectively convert its waste management practice into a CE one.

For the case of waste-water treatment Chrispim et al. (2020), showed that resource recovery is quite low, and for the study country Sao Paulo at least one resource recovery is done by only 26% of the plants, and that practice is more prominent among large plants in comparison to the small plants, the sludge extracted can be used as compost fertilizer or building material; some are also trying to recover energy using the biogas. Notably, in this context, Amoah et al. (2021) proposed the use of nutrients wastewater as fish feed. Also in the iron and steel industry for waste management, developing countries are facing barriers, in this case, an effective system engineered zero-waste circular economy perspective is needed for proper management of waste, besides the increase of investments in solution and technology (Schoeman et al., 2021). Yadav, Soni, and Kumar (2021) iterated key challenges in waste management which include, failure to effectively benchmark processes, lack of effective financial policies, and management plans by the government. Wastage of food is one of the major causes for global hunger (dealt by SDG 02), even though the knowledge of the CE model can be useful in resolving this issue, there are some important political, cultural, and technical challenges to overcome (Ali et al., 2021).

Due to the unfriendly recovery practice of traditional energy, Angulo-Mosquera et al. (2021) called for using biomass or solid biofuel as a sustainable energy source. E-waste, in particular, is thought to be processed primarily in developing countries, with most of it exported from developed countries. For developing countries, e-waste processing has both positive and negative aspects; positive aspects include the creation of new jobs and the use of raw materials for other production purposes, while negative aspects include environmental degradation and a reduction in worker health safety and overall condition. However, the author iterated that these negative outcomes could be mitigated if the countries follow CE practices in processing the E-waste (Abalansa et al., 2021).

Wu et al. (2021) and Bening et al. (2022) also showed the positive side of CE; the authors described the implementation of circular practice in the plastic industry could create new job opportunities, and new business opportunities thus inducing economic growth. However, in Ghana it is seen that the prime collectors of plastic waste known as 'the waste pickers' are living in poverty and failing to meet their day-to-day needs (Bening et al., 2022).

Moreover, a revolutionary change is appreciated in the education curriculum in the fashion industry incorporating CE practices ensuring that future fashion stakeholders would apply environmentally friendly techniques to their work (Atalay Onur, 2020). In comparison to the rich population, the poor people with less life expectancy are found to be producing a lower amount of waste and emit less CO_2. Moreover, they were engaged more in waste management in the form of recycling practices in compared to their counterparts (Caruso and Gattone, 2019).

To deal with the challenges of implementing CE practices, a multifaceted and inclusive collaborative approach coming from stakeholders is necessary (Gunarathne et al., 2019; Mishra et al., 2019; Radelyuk et al., 2021). A collaborative method concentrating on valuation, interactive and flexible tradeoff, and Shapley value is required to manage solid waste in a CE manner (Oliveira Silva and Morais, 2021).

In addition, we conducted a systematic literature review of seven articles published in Bangladesh relevant to the CE model in the recent three years (2018–2021), which are listed in Table 1. This review shows that there is a gap in the existing literature when it comes to examining current CE practices in Bangladesh's various economic sectors.

3. Methodology

3.1. Data

The study is based on both primary and secondary data. Secondary data sources include published data from the World Bank, Trading Economics, World Air Quality Reports, and other published documents from various industries. However, primary data was collected using a semi-structured questionnaire as per qualitative data collection tools- Key Informant Interviews (KIIs) and in-depth interviews with the experts and professionals in the field of environment and economy of Bangladesh (The questionnaire schedule is attached in the appendix). For a specific review of recently published work (2018–2021), we collected published articles from the SCOPUS and Web of Science (WoS) database on 7 January 2022.

3.2. Analytical tools

The study has followed a descriptive analysis mostly. The secondary information regarding the environmental status of Bangladesh has been presented through graphical illustration. Moreover, with relevant facts and figures, the practices of the circular economy model in different industries in Bangladesh have been described in the findings section. However, the qualitative primary data collected through KIIs and in-depth interviews followed the content analysis approach.

3.3. Ethical considerations

The ethics of the research has been maintained strictly. At the beginning of interviews, respondents and KIIs were informed that the data and information gathered through this process would be used for research purposes only, and no harm or benefit would be done to the respondents. Those who refused to have their names published were given fictitious names.

4. Circular economy practices around the world

A significant number of applications of the circular economy model are visible through many innovative works such as making carpet out of plastic (Possioble, 2010), transferring bioplastic products to biogas (Vasmara and Marchetti, 2016), manufacturing paper out of elephants waste (Nishat, 2019). Even some companies are producing plastic highways (Bendix, 2019), making homes using old shipping container (Megan, 2020), manufacturing biodegradable cutlery (Barrett, 2019), producing lather bag using fish skin (Timmins, 2019), growing mushroom from coffee waste (Sayner, 2012), making of jeans from a waste plastic bottle (Webb, 2013), and turning of carpets to bikes (Braw, 2015). Table 2 presents major practices of CE model around the world.

The circular economy model is becoming more popular in developing countries, such as India. where Atterio is collecting e-waste, HaatiChaap making Papers from Elephant manure (Goyal et al., 2018). A company founded by some of India's youths, WVI (Waste Ventures India) collects organic wastes and turns them into compost. In Kolkata, there is also a bus service that runs on renewable biogas, which resulted in a cost-effective and sustainable method of transportation (Maassen and Altamirano, 2017).

As per a European Commission report, a shift to the circular economy in the EU could increase GDP an additional 0.5% and create 700,000 jobs by 2030 (Commission, 2020). EU found that a circular economy would help to increase its workforce by 4%. By 2030 it would result in a net benefit of 1.8 trillion Euros, decreasing CO_2 emission by 48%, and increasing household income by 3000 Euros (Company, 2015). However, these practices could induce the loss of jobs for developing countries like Bangladesh (Kirchherr, 2021; Repp et al., 2021).

In South Africa, the scrap tires collection rate rose from 3% to 70%. It would start a midsize recycling company by 2020, which would convert waste into high-value material recovery processes. In Sweden, most

Table 2. Major practices of CE Model around the world.

Continent	Country	Major Practices of CE Model
North America	United States	Making of carpet out of plastic; making of homes using old shipping containers; making of jeans from waste plastic bottle; recycling, and reusing used clothes; Walmart investing to bring green practice to its suppliers.
	Canada	Making of reusable, recycling, and compostable plastic packaging, recycling of cartons.
Europe	UK	Making of plastic highways.
	Poland	Making of biodegradable cutlery.
	France	Using circular economy concepts in all stages of its agricultural production.
	Belgium	C&M collecting only organic cotton.
	Portugal	Growing of mushroom from coffee waste.
	Sweden	Use and making of reusable crates and pallets; recycling, and reuse of used clothes.
South America	Brazil	For the composition of mortar and, concrete the use of recycled construction material; recycling of paper and plastic.
	Uruguay	Collection of wastes for recycling.
	Argentina	Collection of solid wastes for recycling; making of trash-filled street furniture.
	Chile	Recycling, and reuse of wastewater; recycling of solid wastes.
Australia	Australia	Making of lather bag using fish skin; making of reusable palates, crates & containers.
	New Zealand	Making of carpets to bikes.
Africa	South Africa	Recycling by collection of scrap tires.
Asia	Japan	Collection, and recycling of used clothes.
	China	Collection, and recycling of used clothes.
	India	Making of paper out of elephant dung; collection of E-waste; collection of organic wastes, and turning them into compost fertilizer; bus service running on renewable biogas.
	Singapore	Using food waste to produce fertilizer; collection of wastes, and recycling, sending of waste to energy plants.
	South Korea	Recycling of plastic wastes, producing recyclable paper cups.

Source: Authors' collection.

manufacturers rely on reusable crates and pallets of Svenska Retursystem that develops and operates an effective reusable system and expands their customer's logistics and distribution of goods. Brambles, a service company in Australia, supplies reusable palates, crates and containers to more than 60 countries. On the other hand, a French Food and Water company Danon uses circular economy concepts in all its agricultural production stages. In Xiangyang, China, an innovative practice (Sludge to Energy Programme) was initiated to produce bichar and compressed natural gas out of sludge from the wastewater and local food waste. In Capetown, South Africa an initiative was made to online marketplace for exchanging waste material named Integrated Waste Exchange (Maassen and Altamirano, 2017). While Germany collects three-quarters of all used clothing, they reuse half portion and recycle one-quarter. Other countries like US contains 15%, Japan 12% and China about 10% of all used cloths.

Major brands like- H & M & Levis in association with I: CO collects clothing and footwear for recycling and reuse. Patagonia collects used cloths for recycling or reusing and provides service to repair the apparel for extending the life of the products. A clothing retail chain C&A has launched a campaign to collect only organic cotton. In 2016, Walmart foundation announced to the selected five universities for R&D on a sustainable initiative in the apparel sector. They are also concerned about their suppliers; by 2017 they took a plan to buy supplies from factories that have energy management plans, they also provide software support to suppliers for using resources & energy efficiently (Bouton et al., 2016).

A study found that on a global stage, the circular economy in the apparel industry can Unlock USD 560 billion opportunity side by the side to protect the environment from pollution. In developed countries, it is seen that cloths are no more purchased based on fashion and comfort, consumers are demanding more eco-friendly products (Doboczky, 2019). About 32 major fashion companies signed a pact to bring a net-zero carbon footprint by 2050 in fashion industries (Hacker, 2019). Major apparel brands like- H&M, Burberry, and Chanel are emphasizing and investing in research for sustainable apparel production. H&M has currently introduced a service of renting expensive cloths, reducing pollution by lowering clothing wastage (Pandey, 2019).

Textile dying is one of the most chemical-intensive industries using more than 8000 chemicals in various processes; it was found that 30–50 L of water is used for dying per kg of cloth (Kant, 2011). The world's first digital thread dyer startup named Twine developed the TS-1800, that is just 2 m by 1.5 m in size which can do the job in minutes, eliminating the need for manual labor as well as its risks. Further, it uses a minimum amount of water and saves on logistics by bringing the dyeing process in-house to manufacturers, designers, and apparel producers.

5. Current practice and prospects of circular economy in Bangladesh

Among the components of the circular economy model (Figure 1, b), recycling is mainly followed in Bangladesh. However, the concept of re-use has recently gained attention among Bangladesh's general public, with re-commerce practices on Facebook helping to break down the taboo of utilizing second-hand goods (Arman and Mark-Herbert, 2021).

Many industries and manufacturers are likewise concerned about reducing resource usage, resulting in less waste production. The recycled waste, however, is potentially insignificant compared to the produced waste. One of the most common recycling procedures is that garbage produced in cities is primarily collected by the urban poor, who are part of Bangladesh's informal sector. In the capital city Dhaka alone, 0.12 million poor people are involved with recycling waste directly or indirectly. In around 522 cities and towns of Bangladesh, the production and discharge of garbage is 13,332 tons per day, and yearly it stands to 4.86 million tons causing severe environmental pollution (Chowdhury et al., 2014).

However, it was found that waste collection efficiency in different urban areas of Bangladesh is on average 55%, which is not satisfactory for building an environmentally friendly city. Thus, for the continuous generation of waste, Bangladesh's government initiated the 3R strategy for waste management in 2010. It aims to reduce waste generation and promote the recycling practice of waste. A recycling training center was established in 2005 with an association of UNDP (United Nations Development Programme), SEMP (Sustainable Environment Management Programme) and MoEF (The Ministry of Environment and Forests) to train a different professional class of people regarding waste recycling & energy conservation (Bangladesh, 2010).

Figure 3, Table 3, and Table 4 summarizes the practices, and prospects of 3Rs in Bangladesh and further below, we will discuss the applicability of the circular economy model in different sectors of Bangladesh elaborately.

a. Garments Sector

The garments sector is the biggest earner of foreign currency for Bangladesh. According to private statistics, about 5,000 garments factories offer up to 4.2 million jobs. A study conducted in Narayanganj found that every day 120–125 tons of Garments waste are generated in this area (Alom, 2016). Another research says that Bangladesh's textile industries produced about 1.80 million metric tons of fabrics, generating around 217 million m3 of wastewater. They estimate that by 2021, Bangladesh's textile industries will produce about 2.91 million metric tons of fabrics, causing around 349 million m^3 of wastewater (Brett, 2018).

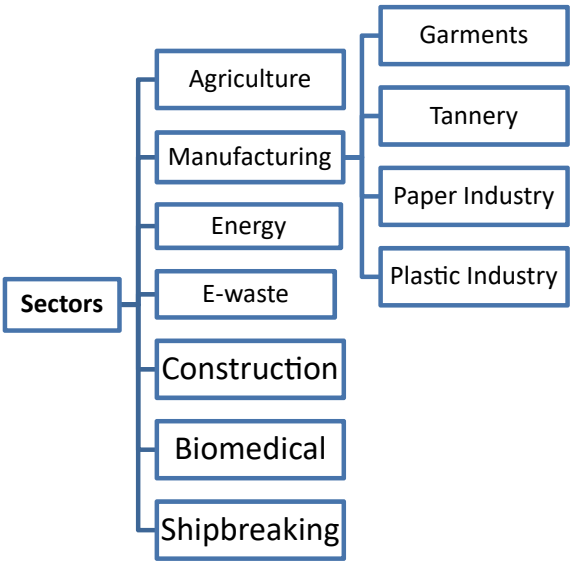


Figure 3. Practices of 3Rs in Bangladesh.

Bangladesh has a huge opportunity as we do not directly sell to the consumers; thus, we could co-create the circular economy model with big apparel and fashion chains that are ready to look for a circular business model (M. Uddin, 2018). Moreover, the waste recycling of this sector has a huge impact on our economy as it is the only income source for many people. There are many shops which usually process garments waste.

Table 3. Practices, and opportunities of CE in Manufacturing Sectors.

Industry	Current Practices	Opportunities
Garments	✓ Collection of garments wastes ✓ Reverse resources are trying to build market place for garments waste ✓ Simco spinning, and textile is producing yarns from discarded cotton clips ✓ Filotex Ltd is the first company in Bangladesh working in the Circular fashion concept.	✓ Bangladesh can co-create the Circular economy model with big apparel & fashion chains ✓ If the bi-products of garments waste are recycled inside Bangladesh, the income in this sector can get double adding $4 billion to the industry, and will create new job opportunities
Tannery	✓ Initiation of green supply chain ✓ The building of CETP (Central Effluent Treatment Plant), and SPGS (Sludge Power Generation System) in Savar of Bangladesh to process harmful wastes, and to produce electricity from those wastes.	✓ No mentionable prospects
Paper	✓ Less than half of the total used papers are recycled in Bangladesh ✓ Additional to recycling, paper packets are made by reusing used papers ✓ The Karnaphuli paper mill of Bangladesh uses less than 10% or less recycled fibers in the total furnish, though the private factories use a significant portion of recycled fibers with virgin fibers	✓ No mentionable prospects
Plastic	✓ Only 9.2% plastic wastes of Bangladesh are recycled every year ✓ In Dhaka city of Bangladesh; 137.57 tons of plastic is recycled per-day, but the health and environmental issues are not properly looked after.	✓ The collection of plastic waste can help to reduce pollution and save a significant amount of money in foreign exchange.

Source: Secondary data sources.

As can be seen in Table 5, the waste amount, the prices, and the salaries typically differ with the size of the shop where the salary of the workers ranges from 2,500–6,000 Taka. In small shop the number of workers is typically around 3 to 5, however in large shops it seems to get double or thrice the time. Moreover, by observing the buying and selling price of waste we can see that large shops are earning much higher per kg in compared to the small shops. Their sold *jhut* (fabric, or fiber related waste coming from garments), are mostly used to cleaning dust, making pockets; making cotton to use for producing bobbin, pillow and mattress. Moreover, the large rejected cloths are used by small factories to make comparatively low quality clothing (Tabassum et al., 2017).

An Estonia based software company is (Reverse Resources) trying to develop a marketplace for garments waste in our country. Moreover, Simco Spinning and Textiles Limited, located in Mymensingh, can produce 15 tonnes of yarns a day from cotton clips discarded during the garments stitching process.

According to Textile Today, Filotex Ltd. is the first factory in Bangladesh working with the 'Circular Fashion' and 3R (Reduce, Reuse, Recycle) concept (Team, 2018). At present, *'jhut'* sold by garments mainly sold to countries like India and China, which can turn the waste into fines Yarn (Devnath, 2017). According to the officials in the apparel sector's top management stated to the media, if the bi-products of garments are recycled, the income would double, additionally it could be an industry of $4 billion (Ovi, 2014). If the industry expands, it will generate plenty of new job opportunities (Rahman et al., 2020).

In this sector, the prime challenge in implementing CE practice includes reluctance of management, lack of proper financial, human resource, and technological support. Moreover, the lack of preference among the consumers towards environment-friendly product consumption is also a major drawback (Saha et al., 2021). To fight back these challenges, a combined effort of government, industry, and consciousness among the buyer is required. Furthermore, knowledge sharing sustainable practice among the value chain is also necessary (Saha et al., 2021).

b. Tannery Sector

The Tannery Industry is the second largest contributor of foreign currency in Bangladesh, after the garments sector. According to the Export Promotion Bureau (EPB) data, exports of leather and its related goods contributed US 1.08$ billion to the country's economy in 2018–19.

The tanneries pollute the environment at a very high rate. But there is no practice of recycling and reuse in those tanneries. In tanneries using ETP (Effluent Treatment Plant) the harm to the environment is somehow reduced. To reduce damage to the environment, Bangladesh's government has relocated the tannery's from Hazaribag to Savar, where the population is lower and area are larger compared to Hazaribag (Paul et al., 2013).

Moreover, the government has established CETP (Central Effluent Treatment Plant) in Savar to process tanneries' harmful waste (Schroeder et al., 2019). The CETP will be combined with SPGS (Sludge Power Generation System), which can generate an energy of 5 MW/h (Alamgir et al., 2017). Furthermore, for complying with government rules, regulations, and buyers requirements, the green supply chain is being initiated in some cases (Moktadir et al., 2018).

c. Paper Industry

There are approximately 100 paper mills in Bangladesh, producing 6–8 lac tons of paper each year. After meeting the national demand, the country exports paper to more than 30 nations. Less than half of the total used papers are recycled in Bangladesh. In a study of Dhaka city, about 6,500 *tokais* (Waste Collector) and 3,600 *feriwallas* (Hawker) are working to collect used paper. They buy cartoons for taka 15/kg and sell in taka

Table 4. CE practices and opportunities in energy, agriculture, construction, E-waste, and biomedical sector.

Industry	Current Practices	Opportunities
Energy	✓ Use of solar-generated electricity; mostly among the rural population ✓ The biggest Solar Power Plant in Teknaf's Hnila is currently active and generating electricity of 28 MW ✓ Biomass or Biogas, Wind-power contribute by 1%, and 0.5% of total renewable energy production in Bangladesh. ✓ Renewable Power Plant produces electricity from water known as Karnaphuli Hydroelectric Power Station generating 230 MW of power ✓ A private company financed by World Bank operated in Kapasia, Gazipur of Bangladesh, is producing electricity using biomass. ✓ In Gazipur of Bangladesh, a furniture manufacturer uses a biomass run boiler, which resulted in the saving of Tk. 52.5 lacs per year	✓ No mentionable prospects
Construction	✓ No mentionable practices	✓Research in Bangladesh found that recycled brick has the potential to satisfy international standards like- ASTM C33 and have a strength of about 2,500–5,000 psi
E-waste sector	✓ E-waste recycling is contributing to the economy of Bangladesh by generating employment opportunity ✓ In Dhaka city, about 15% of the total generated E-waste is recycled every day, which amounts to 475 tones ✓ In the year of 2006, Bangladesh saved about US $ 4.73 million by recovering lead from the used lead-acid battery. ✓ One of the largest lead-acid battery producing companies of Bangladesh has built a smelting plant on recycling battery in an environmentally friendly way, expecting to recycle 660000 batteries, including reclaiming 33000 tons of hard lead every year	✓ No mentionable prospects
Ship-breaking	✓ About 20 lakh metric tonnes of obsolete ships are recycled every year in different yards of Bangladesh. Most of the parts of vessels are recyclable, which constitute mostly steel. ✓ This industry is also creating huge revenue and created huge employment opportunities.	✓ No mentionable prospects
Biomedical	✓ In Dhaka city, biomedical waste & disposal service to private hospitals is offered by an NGO.	✓ No mentionable prospects

18/kg. Old books are brought at taka 30/kg and sold at taka 40/kg. Paper packets are made by reusing used paper and sold at about 40–60 taka/kg (Chakraborty and Aaqib Javed, 2018).

The Karnaphuli Papermill is the largest state-owned integrated pulp paper industry in Bangladesh. It uses 10% or less recycles fiber in the total furnish. Recycled fiber accounts for 45 percent of all raw materials utilized in the paper industry around the world. In private factories, most of the fiber used is recycled fiber with a mix of virgin fiber (Quader, 2011). The Karnaphuli papermill is said to be polluting the Karnaphuli River in large amounts because it does not have an effluent treatment plant (Tribune, 2016).

Given that one ton of paper consumes around 90 tons of water, every paper manufacturing facility must have its own Effluent Treatment Plant to limit water consumption and safeguard biodiversity from harm (Debnath, 2018).

d. Plastic Industry

According to Emerging Credit Rating Limited, Bangladesh ranked 89th in the world ranking of plastic export; the growth rate was 20% each year in the last two decades. Bangladesh consumed 3.5 kg of plastic per capita in 2014, according to the Waste Concern. Only 9.2 percent of total plastic consumption was recycled, implying that the remaining is discarded, damaging the environment in the process (Moazzem, 2016).

Ovi and Mahmud (2019) found that if the waste is collected from Dhaka with modern technology, about 75 percent can be turned into new products saving 7 billion in foreign exchange. This savings in foreign exchange will help to strengthen the economy, thus creating more job opportunities (Rahman et al., 2020). Furthermore, 137.57 tons of plastic are recycled per day in Dhaka, but the unfortunate truth is that health and environmental issues are not adequately addressed (Bangladesh, 2010).

e. Energy Sector

Bangladesh's government aims to generate 10% of its total energy from renewable sources by implementing large-scale projects such as solar power plants (Nabi, 2019). In addition, the use of solar power is very prominent among rural people. The Solar Home System (SHS) helps reduce poverty by income-generating activities; the number of installations was found to be 5.8 billion by 2018.

People are keen to install SHS because of its lower price. Zohurul Islam, an executive of Rahimafrooz, a Bangladeshi solar panel maker, said to The Daily Star that people could install 120 W SHS with only 20,000 taka to 25,000 taka. With this capacity, a customer can use 3–4

Table 5. Price of wastages in the woven sector of Bangladesh.

Shop Type	No. of worker	Salary (Taka/month)	Wastes Types	Buying Price (Taka/Kg)	Selling Price (Taka/kg)	Amount (Tons/month)
Small Shops	3–5	2,500–3,000	Woven and Net	25–30	40–50	3–3.5
Large Shops	10–15	3,500–6,000	Woven, Net, Shirtin, etc.	50–250	100–350	10–15

Note: Mainly, there are two types of wastes- Woven cloths and Net cloths.
Source (Tabassum et al., 2017).

LED bulbs, one solar-powered running fan and a television, which is enough for an average family in Bangladesh.

The biggest Solar Power Plant in Teknaf's Hnila is currently active and generating electricity of 28 MW. This Solar Power Plant is the government's first step toward meeting the 2021 target, producing 2000 MW of solar power (Correspondent, 2018).

Apart from SHC, Biomass, and Biogas, Wind power accounts for 1% of total renewable energy production and 0.5 percent of total renewable energy output, respectively. Karnaphuli Hydroelectric Power Station, a renewable power plant, generates 230 MW of electricity from water (Mozumder, 2003). The commercial use biogas generation can help to generate a new renewable energy source for Bangladesh (Islam et al., 2021). A private company financed by World Bank operated in Kapasia, Gazipur of Bangladesh, is producing electricity using biomass. The raw material for this biogas generation is husk; three bags of rice husk per hour can generate about 30–40 KW energy. In addition, a furniture manufacturer in Gazipur, Bangladesh, utilizes a biomass-fueled boiler, which saves Tk. 52.5 lacs per year (Bangladesh, 2010). Islam et al. (2021) propose an approach to provide soft-loans to lower-income households to increase the use of biogas.

f. Agricultural Sector

In some areas of Bangladesh, wastewater is used to irrigate the land. In Rajshahi, it is being practiced since 1976. Farmers like to use wastewater because it helps to lower fertilizer cost and scarcity of freshwater. A survey conducted on Rajshahi found 70% of the farmers reported that they need less fertilizer expenditure due to wastewater (Kumar et al., 2008). In the rural areas, agricultural wastes are mostly decomposed to form compost fertilizers used in agricultural land, side by the side of inorganic fertilizer (Ara et al., 2020). Additionally, the use of organic fertilizer was encouraged by the national 3R strategy.

Cities generate waste of 13,332 tons per day which are mostly organic. Organic wastes such as -45 million tons of straw, 35 million tons of dung, and 5 million tons of poultry litter are produced annually in our country, which are the key components for making organic fertilizer (Islam, 2015). In the initial phase, the Department of Environment took the initiative to start a composting operation in Bangladeshi municipalities (T. B. Yousuf, 2014). From the wastes of Khulna city, about 30 tons of compost fertilizer is produced per month by an NGO named RUSTIC (Roy et al., 2013). In Dhaka city, one small private composting company collects organic waste and transfers it into compost fertilizer which is sold to the farmers (Chowdhury et al., 2014).

It is to be noted that Bangladesh's livestock sector emits 26.55 million tons of carbon dioxide equivalent greenhouse gases. According to K. N. Islam et al. (2021), applying circular economy-based concepts can result in a 37.5 percent reduction in emissions when compared to BAU levels. Moreover, in poultry farming, the 3R strategy is not followed in Bangladesh but rearing on the basis of reverse supply chain and 3R strategy can generate more income with the protection of the environment from pollution (Shamsuddoha et al., 2011).

g. Construction Sector

As Bangladesh is a developing country, construction practice is seen in every part of the country. Unfortunately, waste management practice is not followed properly in construction work. Landfilling is mostly used for the disposal of construction waste, which affects the environment and wastes resources because recycling and reuse are not practiced.

The major material in the construction industry is bricks. Clay is burned at a temperature of about 1,100 °C to produce bricks, causing huge amount of environmental pollution. About 40% of fine particles in Dhaka City's air come from the brick industry. In a research project in Bangladesh, it was found that the recycled bricks satisfies international standards like-ASTM C33 and have a strength of about 2,500–5,000 psi (D. M. T. Uddin, 2019). Therefore, the use of recycled bricks can help Bangladesh to reduce Environment pollution and exploitation of resources.

h. E-waste Sector

E-waste contains highly harmful materials that could harm our ecosystem and have an impact on the people who live near the dumping place (D. Yousuf and Reza, 2011). Due to Bangladesh's rapid digitalization, E-waste has increased to a rapid high level (Aowsaf, 2019). Such that, in the year 2019 total E-waste generated in Bangladesh was 199 kilo tonnes[1]. According to a study of the Bangladesh University of Engineering and Technology (BUET), the E-waste generation's growth rate was 20% per year and the volume is projected to be 4620 kilo tonnes in 2045 (Aowsaf, 2019).

The E-waste recycling industry is contributing hugely to the economy. It has created many employment opportunities. As the use of E-waste is increasing so will the employment opportunities. The rapid production of E-waste is causing the government to enact new laws to ensure the proper management of it.

In Dhaka city alone, about 15% of the total generated waste is recycled every day, which amounts to 475 tones (S. Hossain et al., 2010). In 2006, Bangladesh saved around US $ 4.73 million by recovering lead from the used lead-acid battery.

At present, there is only one privately owned battery buyback company. Encouraged by a government decision to promote environmentally friendly production, one of Bangladesh's largest lead-acid battery manufacturers built a smelting plant to recycle batteries in an environmentally friendly manner, with the goal of recycling 660,000 batteries and reclaiming 33,000 tons of hard lead each year (Bangladesh, 2010).

i. Ship-breaking Industry

The ship recycling yards are mostly seen in the southern part of Bangladesh in the Chittagong area. A report released by the NGO shipbreaking platform stated that in 2018 Bangladesh had the world's highest volume of shipbreaking activities (Patwary, 2019). As a matter of fact, about 20 lakh metric tonnes of obsolete ships are recycled every year in different yards of Bangladesh. Most of the parts of vessels, mostly made of steel, are recyclable. This industry is also creating huge revenue and employment opportunities. Unfortunately, proper environmental and safety issues are not followed properly in these yards (K. Hossain, 2017).

According to the European Commission, 40% of Chittagong's coastline is utilized for shipbreaking, and the wind from the sea pollutes the city's air. For protecting the environment, the Environment regulation should be followed, the dismantling of the ship, which will harm the environment mostly, should not be imported and environmental laws should be enacted properly (Sejan, 2019).

j. Biomedical Waste Collection and Disposal

A large expansion in the number of health care facilities and their disregard for waste management poses a threat to Bangladesh's health sector because this trash can cause serious environmental pollution as well as the spread of several infectious illnesses such as hepatitis and HIV. In Dhaka city, biomedical waste and disposal service to private hospitals is offered by an NGO. This NGO aims to motivate the health care facilities to improve their internal environment, reduce urban environmental pollution, reduce public health risk by addressing occupational health hazards in the medical sector (Bangladesh, 2010).

6. Challenges to implement CE in Bangladesh

The Government of Bangladesh has prioritized environmental protection. According to Bangladesh's constitution, Article 18A states that

[1] See https://ewastemonitor.info/gem-2020/.

the state shall endeavor to protect and improve the environment and preserve and safeguard the natural resource, biodiversity, wetlands, forests, and wildlife for the present and future citizens. Whereas the Article 12 of the Environment Conservation Act 1995 mentions that every industry must have Environment Clearance Certificate from the director-general. Moreover, the Environment Conservation Rule 1997 categorized different lists of projects for issuing the Environment Clearance Certificate. The four categories are Green, Orange A, Orange B, and Red.

However, the Environmental Clearance Certificate companies in Bangladesh are breaking the law and destroying the environment at an alarming rate, turning farmland into wasteland. (M. Yousuf, 2019). Even the concentrations of most polluting parameters in the effluents are too high compared with the respective allowable discharge limits (Azizul Haq, 1989). Research reveals that industries pollute air and water through smoke emission, inadequate solid waste management, and dumping of untreated effluent to lakes, rivers, and groundwater (Alam, 2009).

Moktadir et al. (2020) found that the lack of financial facilities is a big impediment to establishing circular economy Model in Bangladesh. Dulia et al. (2021) mentioned that the main risk associated with CE practices is the quality degradation of recycled products.

We also questioned Dr. Muhammad Saiful Islam, a faculty member of the Department of Civil & Environmental Engineering at Bangladesh's Shahjalal University of Science & Technology, about the challenges of establishing a circular economy model in Bangladesh during our conversation. (Dr. Muhammad Saiful Islam, personal communication, December 01, 2020).

According to him, there are three most important technological barriers in implementing this model: lack of knowledge skills in new technology, unclear benefits of applying this environment-friendly technology and lack of public awareness. He also added the policy barriers such as lack of research-based knowledge and user-friendly technology, improper policy framework and guidelines on how to implement the model, lack of skilled manpower to monitor and evaluate whether the model is applied in the field properly, lack of organizational skills and knowledge to implement the model in the field, lack of funding and resources. Overall, not having specific goals and outcomes.

He further added, 'Our ignorance and culture to pollute the environment by generating waste, lack of understanding and motivation about the benefits of recycling, reducing, and reusing waste/products are the most critical public participation barriers in this regard.'

Professor Dr. Mohammed Yusuf, an environmental researcher from Bangladesh, also echoed the challenges mentioned by Dr. Islam. He added that Bangladesh has the most potential to apply the circular economy model in solid wastage management than the liquid wastage treatment. Major steps, however, should come from the policymakers, he maintained. (Dr. Mohammed Yusuf, personal communication, November 28, 2020).

Engr. Mujahidul Islam, a young Bangladeshi now working in Turkey as an environment and water resource engineer recalled the experiences he gained in Bangladesh. He reckons the problems with factory owners and law enforcement agencies is that they play a vital role in this context. Some environmental officers compromise imposing laws at the expense of their personal gains. They accept bribes from factory owners and continue to pollute the environment. (Mujahidul Islam, personal communication, December 13, 2020).

In another interview with Engineer Sahadat Hossain, an environmental consultant from Bangladesh working with a World Bank project, he shared his experience with us. According to him, apart from the policymakers' efforts, stakeholders' role is crucial regarding implementing the circular economy model. Most of the producers do not pay heed to the law and environmental issues to recycle wastages. The mindset of many producers is not friendly to protect the environment. (Sahadat Hossain, personal communication, December 18, 2020).

Table 6 shows a summary of the various challenges to implement CE practices in Bangladesh.

Table 6. Challenges in implementing CE model in Bangladesh.

Barriers	Key Points
Technological barriers	• Lack of knowledge about new technologies • Lack of skills in operating new technologies • The unclear benefit of using technologies
Policy barriers	• Not having specific goals and outcomes • Lack of funding, and supporting resources • Lack of proper policy framework/guidelines • Lack of research-based knowledge, and user-friendly technology • Lack of organizational skills, and knowledge • Lack of implementing environmental laws
Public participation barriers	• Ignorance, and culture of polluting the environment • Lack of understanding about environmental issues like CE • Lack of motivation • Lack of financial facilities

Source: Interviews with the experts.

Most of the existing barriers mentioned in Table 6 are supported by Moktadir et al. (2018), Saha et al. (2021), Azizuddin et al. (2021), Ali et al. (2021), and Yadav et al. (2021). Among the authors, Saha et al. (2021), Moktadir et al. (2018), and Azizuddin et al. (2021) reiterated some of the barriers (Table 6) in the context of Bangladesh; such that Saha et al. (2021) blamed lack of proper management, technological, financial and human resource support. Aside from these, the author blamed the lack of consciousness among the consumers towards environment friendly products. Like Saha et al. (2021), Azizuddin et al. (2021) reiterated the lacking of consciousness among the public and technological support; further added the case of scarcity in logistic for implementing CE practices. Moreover, Moktadir et al. (2018) blamed knowledge lacking among the stakeholders, which is supposedly causing poor policy formation and implementation. Aside from the previously listed barriers, some of our particular barriers gained from interview include a lack of research-based information, and official's corruption.

In addition to the challenges mentioned above, the concept of circular justice was introduced by Julian Kirchherr (2021); as a fact of induced job loss due to transitioning towards CE practices. The author proposed a sustainable and equitable distribution of CE transition benefits all around the world; thus proposed sharing of technologies, and increased research more centered towards developing countries. However, as we saw in the findings section, a shift to CE would have a net positive impact on the economy, resulting in more job possibilities (Ovi (2014); Ovi and Mahmud (2019); Rahman et al. (2020); M. Uddin (2018)). However, if lacks behind due to technological barriers in compared to developed countries, it might cause job loss (Julian Kirchherr, 2021; Repp et al., 2021).

To tackle the barriers while implementing CE practices, Hartley et al. (2020) recommended some key policies. The authors proposed for stakeholder engagement by developing standard circular practice norms, increasing circular procurement, providing tax exemptions for factories that follow CE models, removing legal barriers to waste trading, promoting circular trading platforms, establishing an eco-industrial park, and making waste databases more accessible. Furthermore, to attain sustainable development. the collaboration of government and private initiatives is required to implement CE practices in Bangladesh (Azizuddin et al., 2021).

7. Conclusion

The circular economy model is one of the most prospective models that the world seeks for the future sustainable development. With innovation and modern technology, waste is regarded as a desired byproduct in many places in the world. People in many nations are turning waste into making homes, pants, cutlery, carpets, and many more.

In Bangladesh, the circular economy is partly followed in different sectors. Recycling is most commonly practiced in major industries in

Bangladesh. However, the model's overall execution is hampered by a lack of sufficient technological expertise and talent, a lack of public awareness, a lack of financial resources, ineffective policy, lack of research-based knowledge, and lack of implementation of the law, mostly due to corruption by officials. Bangladesh will benefit from the circular economy because it would prevent the country from over-exploitation of resources and pollution, resulting in overall sustainable growth. The government should encourage the practice of the circular economy in Bangladesh, and it should also implement the existing Environmental Law strictly.

Given the rarity of CE research in Bangladesh, we expect that this study can assist stakeholders in making productive and long-term decisions in production, consumption, and overall policymaking. Furthermore, in the future days, this topic will require more research, precisely identifying each of Bangladesh's sectors using empirical approaches based on the collection of primary or secondary data.

Although the research presents convincing results on CE in Bangladesh, some limitations can be highlighted, in order to lead advances in future studies on this topic. The limitations were related to the restricted sample size of interviews derived from the health crisis arising from COVID-19, and possible inconsistencies in secondary data, especially those from government databases. Despite these limitations, the authors took every attempt to make this study as consistent as possible and to provide high-quality, useable data.

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