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Towards Circular Sustainable Cities: Thoughts and Recommendations for Qatar

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ABSTRACT: Despite the ambitious national visions, Qatar is facing many challenges regarding the notion of sustainability. In this context, a considerable emphasis has been placed on the notion of Circular Economy (CE) to address suitability issues. Despite such an emphasis, the actual implementation of CE notions is still facing several obstacles present in, but not limited to, the Qatari context, such as heavy reliance on landfilling, water scarcity, and a heavy reliance on the oil and gas sectors. Our contention is that CE is an important factor in the sustainability equation and works towards meeting Qatar's vision of becoming an environmentally sustainable country. by using a qualitative approach, predominantly adopting case study, document and content analysis, this paper explores the notion of CE and its implementation in light of the Qatar National Vision 2030. the challenges facing CE implementation, such as resources, qualified personnel, access to technology, and coordination between different areas of the economy, should be of prime importance for policymakers in Qatar. in order to ensure a sustainable circular city model in Qatar, the challenges related to CE implementation must be addressed accordingly. To this end, the paper suggests several policy recommendations, including the provision of adequate resources and personnel, the use of clean technology to improve the environmental quality of economic activities, in addition to the provision of adequate support and funding for the development of sustainable economic practices. These solutions will help to ensure sustainable economic development based on the concept of CE.

Keywords: Circular economy; Sustainable cities; Qatar; The Qatari National Vision 2030

1. Introduction

With the beginning of the current millennium, global attention has been paid to the new concept and development model called "circular economy", as an alternative to the linear industrial development model currently prevailing in most developing countries. The traditional linear economic model is based on extracting resources to manufacture products and then disposing of waste without recovery [1]. The disposal processes are normally carried out by throwing waste using polluting and unsustainable methods such as burning, dumping, and backfilling, which have negative impacts on the environment. In contrast to these unsustainable practices, the notion of CE clearly emphasizes the need for optimal and efficient use of the available natural resources in order to extend the life of these resources for the longest possible period [2]. This efficient and rational use of resources through the principles of the CE would maximize the benefits arising from the process of economic development for current and future generations [3]. The application of the CE principles and practices would also reduce environmental damage associated with industrialization and economic development, such as increased greenhouse gases and climate change. Hence, the CE is seen as a new economic model capable of creating added value from waste, and making economic operations more efficient and sustainable by extending the life cycle of products. This process is done by reusing or recycling the waste with the help of modern technology. This, in turn, helps to eliminate the drawbacks of current linear production and consumption methods and leads to more sustainable and environmentally friendly societies [4].

Due to its emphasis on resource conservation and waste reduction, the CE has emerged as a promising paradigm for sustainable cities. By minimising waste, cutting pollution, and promoting material reuse, recycling, and regeneration,

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the CE seeks to advance the sustainable use of resources. This concept aims to develop a closed-loop system where resources are kept in use for as long as possible while waste is kept to a minimum. The idea has grown as a viable response to the environmental issues that many nations are currently facing [1]. In this context, the CE has been introduced as an alternative to the traditional linear economy. The adoption of a CE has several benefits, including environmental, economic, and social. However, the implementation of a CE faces several challenges, including a lack of awareness, a complex value chain, and investment requirements [2]. Despite these challenges, the adoption of a CE is essential to ensure the long-term sustainability of the economy and environment.

In the context of the State of Qatar, several environmental and development challenges emerge that make adopting a CE model an urgent necessity. Qatar is one of the countries in the world with the highest waste generation rate per capita, with a heavy reliance on landfill technologies in waste management, which constitutes an increasing environmental and economic burden. The country also faces a scarcity of natural water resources, making it heavily dependent on energy-intensive desalination. In addition, the Qatari economic sector remains dependent on oil and gas resources, which weakens the economy's flexibility in the face of global transformations towards a green economy. In addition to these challenges, there are cultural and institutional aspects, including limited community awareness of the concepts of reuse and recycling, and weak coordination between sectors concerned with environmental and development affairs. Accordingly, studying ways to implement the CE in the Qatari context requires a deep understanding of these challenges and proposing policy solutions that are consistent with the country's economic, social, and cultural specificity.

To this end, the State of Qatar has made significant progress towards the adoption of a CE. For instance, the European Union has developed a comprehensive CE package that includes policies and regulations aimed at promoting the CE [5,6]. China has also developed a CE policy, which aims to reduce waste and promote sustainable production and consumption [7]. In Qatar, the government has launched a National Vision 2030, which includes a CE as a core pillar. Consequently, many companies and government agencies have embraced the CE and are redesigning products and services to be more sustainable. This paper examines the relationship between the CE and sustainable cities by exploring the ways in which the CE can contribute to achieving sustainable development goals. The paper also discusses the challenges of implementing the CE and provides potential solutions to overcome these challenges. The underlying assumption is that the CE plays a direct role in achieving the goals of sustainable cities, especially the goals related to the sustainability of energy resources, environmental preservation, climate change, and sustainable societies. Particular attention is devoted to investigating the implementation of the CE in Qatar. With the current vision of a CE in Qatar, the focus is on promoting the transition towards a more sustainable and efficient economy by maximizing the utilization of available resources and minimizing waste generated. Investments in green infrastructure, clean technology, and the promotion of innovation and environmental awareness are among the most important foundations of the CE in Qatar. The initial findings of the paper demonstrate that the CE can contribute to sustainable cities by promoting economic growth, reducing environmental impact, and increasing social inclusivity.

2. Literature Review

The literature has witnessed a significant increase in addressing the global shift towards CE models, with a focus on reducing resource use, limiting waste generation, and minimizing environmental damage. However, research related to the CE in the Gulf region, especially in Qatar, is still relatively limited, but it is witnessing gradual growth. For example, some studies point to the structural challenges facing Qatar in its transition towards a CE, such as limited local recycling capacities and high per capita waste generation. Similarly, other studies analyze sustainable waste management initiatives in some Gulf countries, including the United Arab Emirates and the Kingdom of Saudi Arabia. This branch of studies highlights the role of government policies and diversification of industrial sectors in enabling CE practices. The results of these studies are highly relevant to the reality of the CE in the State of Qatar, which has committed, through its National Vision 2030, to diversifying its economy and achieving environmental sustainability. Recent studies highlight the need for cooperation between different sectors and the importance of investing in clean technologies as essential factors for enabling the CE in the economies of the Gulf countries. Despite the disparity in the level of progress between the GCC countries and the Gulf Cooperation, the challenges are shared, most notably the issues of water, dependence on fossil fuels, and the fragmentation of policies. These challenges create a vital area for adopting CE models by integrating regional visions to move towards CE.

2.1. Circular Economy and Sustainable Cities

Sustainable development is a concept that has gained significant attention in recent years as a way to balance economic growth with social and environmental considerations. As such, sustainable development has become a global priority, with the United Nations setting 17 Sustainable Development Goals (SDGs) to be achieved by 2030 (see Figure 1). To reach these goals, many governments and private businesses around the globe have devised different strategies and searched for new means to arrive at the SDGs end. In other words, many countries and governments, in light of the environmental crises, rushed to search for an alternative model to the linear economy model. The aim is to preserve human health and living beings, in addition to sustainably achieving economic development by relying on environmentally friendly renewable energy sources. Governments also aimed, through their search for this alternative model, to reduce waste and dispose of it safely.

Figure 1. The United Nations set 17 Sustainable Development Goals (SDGs). Note: Source: [8].

In this context, the notion of circularity and CE has appeared as a plausible means that can lead to achieving the SDGs. In other words, the CE has been introduced as a model that can contribute to sustainable cities by reducing waste and promoting the efficient use of resources. In that sense, the CE is a relatively recent concept that focuses primarily on achieving sustainable cities by effectively employing resources and reducing waste and pollution. The CE is characterized by its dependence on the circulation of goods, services, and resources in closed circles, where resources are reused and waste is recycled in a way that preserves natural resources and reduces environmental pollution.

2.2. Conceptualizing Circular Economy

Attempts to define the concept of the CE have received a lot of attention, both by academics and practitioners, as it is a practical way to implement the concept of sustainability. In general, it can be noted that the term CE carries different meanings according to those who analyse and study it. Hence, there is no agreed-upon definition of the CE, but there are many definitions, so that some of them focus on the engineering and technical aspects while others focus on the legal dimensions. Additionally, a third category of definitions that focus on the social, economic, and environmental dimensions can be identified in the literature. Without entering into the theoretical debate over the definition of CE, this concept can simply be considered as an economic system based, in essence, on the idea of reusing and recycling resources in the various stages of production, distribution, and consumption. This system can work at the micro level, such as individuals and companies. It can also be applied at the macro level, *i.e.*, at the level of regions and countries. The main objective of applying this system is to achieve sustainable development and social justice for current and future generations.

The CE model is based on the 3Rs: reduce, reuse, and recycle (see Figure 2). The aim is to keep materials in use for as long as possible and to minimize waste by designing out waste and pollution, keeping products and materials in use, and regenerating natural systems. The. The first principle, reduce, involves minimizing the use of resources by designing products that are durable, energy-efficient, and resource-efficient. This principle also encourages the use of renewable energy and the reduction of greenhouse gas emissions. The second principle, reuse, involves keeping products

and materials in use for as long as possible by repairing, refurbishing, or reusing them. This principle also involves sharing resources, such as tools, vehicles, and housing, to reduce the need for individual ownership and consumption.

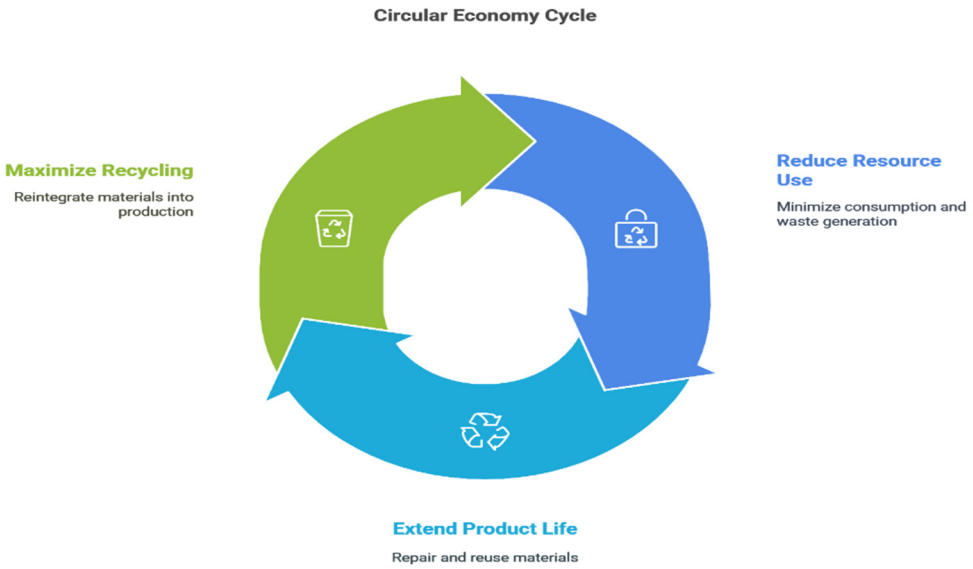

Figure 2. The 3Rs of circular economy. Note: Source: authors' elaboration.

The third principle, recycle, involves extracting maximum value from products and materials by recycling them back into the production process, thereby reducing waste and pollution. In that sense, the CE is a regenerative economic system that aims to minimize waste and maximize resource efficiency. It is based on the principle of closed loops, where resources are kept in use for as long as possible and waste is eliminated by designing products and services that can be reused, repaired, or recycled.

In contrast to the traditional linear economy, which is based on the take-make-dispose model, the CE is focused on creating value from resources and reducing environmental impact. By doing so, circular economic practices can contribute to sustainable cities by reducing greenhouse gas emissions, promoting energy efficiency, and reducing the use of resources [9,10]. As such, the CE can be perceived as a system of production and consumption that seeks to eliminate waste by ensuring that products and materials are used as efficiently as possible [10,11].

Following on from the above discussion, CE can be perceived as a system that optimises the entire material cycle, from raw materials to finished materials, components, products, outdated items, and finally, disposal. It is related to resources, the environment, and the economy (see Figure 3).

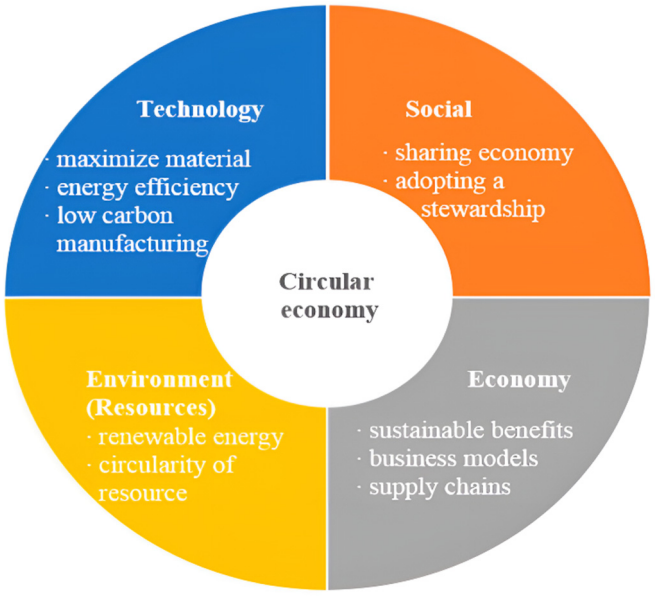

Figure 3. The conceptualisation of circular economy. Note: Source [12].

As the figure indicates, the notion of CE encompasses four main aspects: social, economic, environmental and technological. On the social level, the societal acceptance of the circular economy is a basic factor in the success of applying this concept in various sectors and reaching the idea of a sharing economy. From an economic perspective, the concept of the circular economy focuses on building economic models based on the idea of sustainability by using available resources in a way that achieves sustainable benefits for society as a whole through the business models that are adopted and during the different stages of supply chains in the local economy. With regards to the environment and the use of natural resources, the concept of the circular economy emphasizes the necessity of using renewable and environmentally friendly resources to reduce the environmental impact of economic activities. It also focuses on the necessity of re-employing and using waste in a way that achieves the greatest possible economic efficiency in the process of using natural resources. The circular economy also views technology as a catalyst that can reduce the negative environmental impacts of economic activities by employing modern technological applications to reduce carbon emissions and greenhouse gases that directly cause global warming and climate change.

2.3. Circular Economy: A Balance

Following the above discussion, it can be noted that CE has numerous benefits at different environmental, economic, and social levels. One of the key environmental benefits of the CE is reducing waste and pollution (see Figure 4).

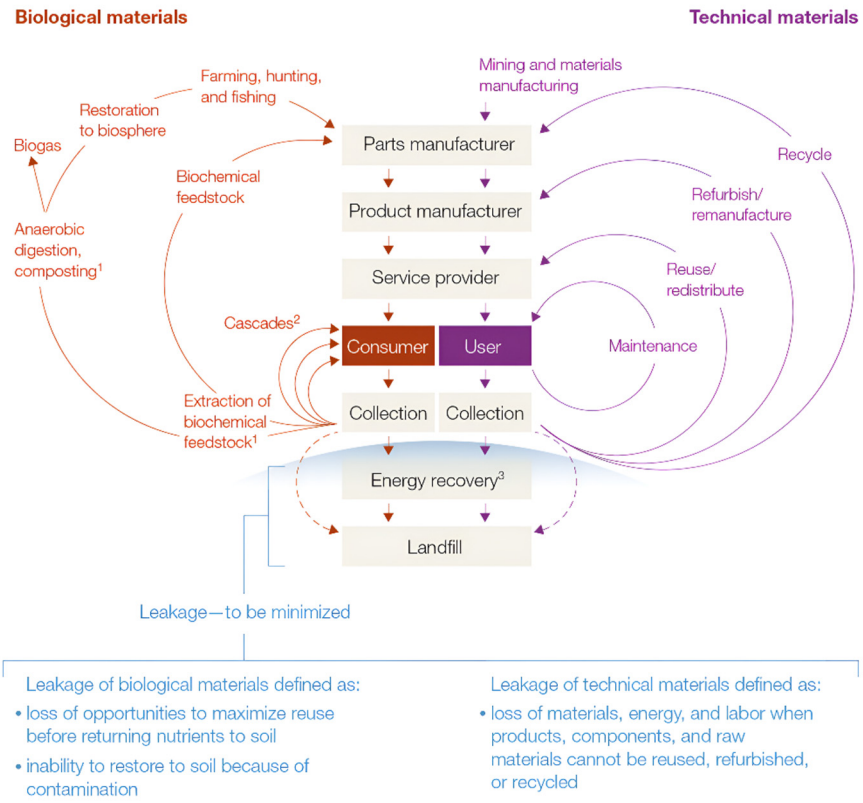

Figure 4. The benefits of the circular economy. Note: Source [1]. [1] Can take both postharvest and postconsumer waste as an input. [2] Diversifying reuse across value streams—eg, cotton clothing reused as secondhand clothing, as fiber fill for upholstery, and as insulatation for construction. [3] Can reduce opportunities for reuse of materials. For example, excess capacity of incinerators could set up competition between their operators and recyclers for end-of-use materials.

By keeping products and materials in use, waste is minimized, and the need for new materials is reduced. This helps to reduce the strain on natural resources, leading to lower greenhouse gas emissions and reduced energy consumption [13]. The CE also has significant economic benefits. By reducing waste, businesses can save on raw material costs, reduce waste disposal costs, and generate new revenue streams through recycling and upcycling. The CE also has social benefits, such as job creation, as new businesses and industries emerge [14]. By combining these factors, the CE is closely linked to sustainable cities as it promotes economic growth, reduces environmental impact, and increases social inclusivity [10,15]. On the one hand, CE can contribute to sustainable cities by promoting resource efficiency and reducing waste. Additionally, it can create new economic opportunities and promote social inclusion.

The CE model aims to create a closed-loop system, where resources are kept in use for as long as possible, reducing the need for raw materials and minimizing waste. This reduces environmental impact by reducing the extraction of natural resources and the generation of waste [16]. In addition, circular economic practices may also promote economic growth by creating new opportunities for businesses, innovation, and entrepreneurship [17]. In turn, this can lead to job creation and economic growth, contributing to sustainable cities [18]. With regards to social inclusivity, the CE can contribute to this aspect by promoting a more equitable distribution of resources as circularity reduces the risk of resource depletion and promotes a more equitable distribution of resources [19].

Following the above discussion, it can be noted that CE and sustainable cities are closely related concepts. The CE model promotes resource efficiency, waste reduction, and the recovery and reuse of materials [16]. These objectives align with the principles of sustainable cities, which seek to promote economic growth while ensuring social and environmental sustainability. Integrating the CE model into sustainable cities' strategies can bring several benefits. For example, it can reduce the use of resources, promote local production, create jobs, and reduce waste generation. The CE model can also contribute to the achievement of the United Nations Sustainable Development Goals (SDGs), particularly those related to responsible consumption and production, climate action, and sustainable cities and communities [20,21].

Despite such benefits, implementing the CE model in the context of sustainable cities can be challenging [18]. Some of the major challenges facing the successful implementation of CE include, but are not limited to, insufficient awareness, inadequate infrastructure, high costs, and cultural attitudes. Given the novelty of the CE concept, there is a need to raise awareness among policymakers, businesses, and the public about the benefits of circular economic practices. Additionally, the existing infrastructure may not be designed to support the CE. For instance, waste management systems may not be optimized for recycling and composting, making it difficult to recover and reuse materials [16,22]. Added to this, implementing the CE model can be expensive, particularly in developing countries, as it requires significant investment in new technologies, infrastructure, and regulations. The absence of such investments can be a significant barrier to adopting the notion of circularity and CE. With regards to cultural attitudes, it can be noted that public behaviour towards waste disposal and consumption patterns can also be a challenge. In case the existing practices and behaviours are not supportive of the adoption of CE, there will be a need to change the uncooperative attitudes of people towards waste and encourage them to embrace the CE model.

By reviewing the previous literature, it becomes clear that the principles of the CE, such as resource efficiency, waste reduction, and circular production systems, constitute a conceptual foundation for supporting the development of sustainable urban systems. However, the extent to which these concepts can be applied in the Qatari context still requires further study. This research builds on the global and regional literature related to the CE, exploring the unique implementation pathways, institutional challenges, and socio-economic dynamics that affect Qatar's efforts to integrate the CE into its national sustainable development agenda. The paper focuses on how CE practices can effectively contribute to Qatar's transition towards the concept of sustainable cities, which is in line with the goals of the Qatar National Vision 2030. While the global literature on the CE offers diverse models, ranging from industrial synergies in Europe to digital circular systems in Asia, many of these frameworks were developed within socio-economic contexts that differ significantly from the reality of Qatar. The Qatari economy's dependence on hydrocarbon exports poses a fundamental challenge, as circular models based on resource scarcity and industrial reuse may not be directly applicable without policy and market reforms. Furthermore, Qatar's extreme water scarcity and reliance on energy-intensive desalination systems open up opportunities for a CE that focuses less on physical recycling and more on improving energy and water efficiency. The high per capita waste generation rate resulting from consumption patterns and a multicultural expatriate population complicates waste reduction efforts common in the OECD literature. These cultural and structural factors require a local interpretation of CE principles that integrates between national development goals, urban planning requirements, and cultural consumption patterns. This paper seeks to assess the applicability of CE models in the unique Qatari context and to identify the elements that call for contextual adaptation or policy innovation. Thus, the previous literature is used not only as a theoretical foundation but also as a basis for comparing the general framework and assessing the possibility of adapting CE practices to suit the economic, environmental, and policy circumstances specific to the State of Qatar.

3. Data and Methods

This paper relies on qualitative content analysis to understand how the principles of the CE are applied within the framework of sustainable development in the State of Qatar. This approach was chosen due to the exploratory nature of

the study, which aims to analyse the political discourse, institutional arrangements, and structural challenges associated with the CE in the Qatari context, rather than measuring them quantitatively. The analysis was based on a deliberate selection of a range of primary and secondary documents, including government reports and policy documents such as the Qatar National Vision 2030, the Second National Development Strategy 2018–2022, and the National Environment and Climate Change Strategy 2021, along with a number of documents related to environmental planning and policies. The paper also analysed institutional publications issued by specific entities such as the Qatar General Electricity and Water Corporation (KAHRAMAA), the Ministry of Municipality and Environment, and the Planning and Statistics Authority. The paper relied on secondary data sources, including peer-reviewed articles from academic journals and literature published by international organizations such as the United Nations, the United Nations Environment Programme, and the World Bank. Additionally, the paper reviewed statistical data related to environmental performance, energy consumption, waste management, and water consumption in the State of Qatar.

A thematic content analysis was used to extract and categorize the main themes. The data emerged, guided by the fundamental principles of the CE, such as reducing waste, increasing resource efficiency, recycling, and designing renewable systems, as well as their relationship to urban sustainability in Qatar. The analysis steps included the following:

First, document selection and review: documents were selected based on their relevance to the application of the CE, environmental sustainability, and urban policies in Qatar.

Second, coding: textual data were systematically coded to identify recurring patterns and political narratives, such as institutional coordination, regulatory gaps, infrastructure challenges, and technology adoption.

Third, synthetic analysis: the extracted themes were analysed within the context of Qatar's challenges and opportunities, with a focus on how the CE is formulated, prioritized, and implemented in national political discourse.

This qualitative approach is suitable for understanding the complexity and subtle dynamics of policy environments, particularly in the context of emerging concepts such as the CE in Qatar. This approach also provides a comprehensive understanding of institutional intentions, policy statements, and social and environmental considerations that cannot be expressed through quantitative methods alone. Through the analysis of policy and institutional texts, this paper provides insights into how to interpret and apply the CE.

4. Circular Economy and Sustainable Development in Qatar

4.1. Circular Economy and Sustainable Development in Qatar: A Contextualisation

The aforementioned theoretical discussion has indicated that the concept of the CE has emerged as a potential solution to reach SDGs and to address the environmental and climate change challenges [23]. Qatar, as a country with a high per capita waste generation and significant dependence on non-renewable resources, is a prime candidate for the adoption of CE principles. Qatar is a small country with a population of approximately 2.8 million people. The country has a high per capita income and is one of the largest producers of oil and gas in the world. However, its dependence on non-renewable resources has significant environmental consequences, including high levels of greenhouse gas emissions, water scarcity, and waste generation. According to the Qatar National Vision 2030, the country aims to develop a sustainable and diversified economy, and the CE presents an opportunity to achieve this goal [24].

4.2. Circular Economy and Sustainable Development in Qatar: Importance and Main Drivers

As such, CE is important for Qatar for several reasons. On the one hand, the successful adoption of CE will help diversify the economy [25]. Qatar's economy has traditionally been heavily reliant on the oil and gas sector. By transitioning towards a CE model, Qatar can diversify its economy and reduce its reliance on finite resources. This, in turn, will help to ensure long-term economic stability and sustainability [26]. Circular economic practices will also help increase resource efficiency. By adopting CE principles, Qatar can reduce its resource consumption, increase efficiency, and minimize waste, which will help to conserve natural resources for future generations. Environmental considerations and the achievement of sustainability can be regarded as other reasons why Qatar should adopt CE. Qatar has a harsh climate and fragile ecosystem, and its rapid development has put pressure on the environment. By transitioning towards a CE model, Qatar can reduce its environmental impact, promote sustainability, and protect the environment. Added to this, the transition towards a CE model requires innovation and new business models, which can drive competitiveness and create new opportunities for entrepreneurs and businesses. This can help to stimulate economic growth and create jobs in new industries [27]. Furthermore, adopting CE practices can help Qatar enhance its international reputation as a leader in sustainability and fulfil its international commitments of promoting sustainable development and reducing greenhouse gas emissions. Hence, CE is important for Qatar as it can help promote economic diversification, resource

efficiency, environmental sustainability, innovation, and competitiveness, while also enhancing its international reputation as a sustainable and responsible country.

There are several drivers of CE and sustainable development in Qatar. These key drivers include the National Vision 2030, economic growth and innovation policies, international agreements, public awareness and environmental concerns. Qatar's Vision 2030 aims to promote sustainable development by diversifying the economy, investing in infrastructure, and protecting the environment [26]. This vision has created a framework for promoting CE and sustainable development practices in the country. With regard to economic growth and innovation, it can be stated that Qatar's economy has grown rapidly in recent years, creating opportunities for investment in renewable energy, sustainable industries, and CE practices [25,27]. In addition, the state of Qatar is investing in research and development to promote innovation in sustainable technologies and CE practices. This includes investments in renewable energy, waste management, and sustainable transportation [28]. At the international level, Qatar has signed several international agreements related to sustainable development, including the Paris Agreement and the Sustainable Development Goals [23]. These agreements have created a global framework for promoting sustainable practices and reducing environmental impact. Environmental concerns were among the key driving forces behind signing such agreements. Qatar's harsh climate and limited natural resources have led to increased awareness of the importance of environmental sustainability. This has led to a greater focus on reducing waste and promoting CE practices [29]. Such efforts by the Qatari Government has resulted in an increasing awareness among the public and industry about the importance of CE and sustainable development. This has led to greater demand for sustainable products and services, and increased investment in sustainable industries. These factors are fostering a suitable atmosphere in Qatar for the advancement of sustainable development and the CE. By utilising these forces, Qatar can build a more sustainable future for future generations.

4.3. Circular Economy and Sustainable Development in Qatar: Policy and Regulatory Actions

At the level of policy and regulatory frameworks, recent studies indicate that the availability of these frameworks helps in the effective implementation of the CE in the Arabian Gulf region. In the Qatari case, the main national frameworks, such as the Qatar National Vision 2030 and the National Environment and Climate Change Strategy, explicitly stipulate the importance of environmental sustainability, resource efficiency, and economic diversification. Hence, the State of Qatar meets many of the prerequisites for implementing CE principles. Regarding official backing, the Qatari government has demonstrated a significant commitment to advancing CE and sustainable development principles. Qatar's Vision 2030 and the National Development Strategy both include targets for reducing waste, promoting resource efficiency, and increasing environmental sustainability. Additionally, Qatar has a strong and stable economy with significant financial resources, which can be leveraged to support CE practices. This provides opportunities for investment in sustainable industries, renewable energy, and waste management infrastructure [29]. In terms of its geographic location, Qatar is strategically located between Asia, Europe, and Africa, which provides opportunities for regional cooperation and the development of circular supply chains [7,30]. Qatar also has a skilled and educated workforce, which can be trained in CE practices to support the transition towards more sustainable production and consumption patterns [26]. With regards to infrastructure, Qatar has invested heavily in infrastructure, including transportation, water and wastewater treatment, and waste management [28]. This provides a foundation for the development of CE practices. In addition, there is increasing awareness among the public and industry about the importance of CE and sustainable development. This creates a favourable environment for the adoption of CE practices. Although there are still issues to be resolved, like water scarcity and a lack of adequate recycling infrastructure, Qatar satisfies many of the criteria for implementing the CE. Qatar can build a more sustainable future by utilising these assets and tackling the problems.

Although the aforementioned strategies set general goals in line with the principles of the CE, the literature indicates that implementation mechanisms are still not fully developed. For example, some studies point to the fragmentation of regulatory frameworks and weak coordination between government agencies as two major obstacles to adopting the CE model in the State of Qatar. Therefore, the absence of binding regulations on waste sorting, mandatory recycling, or the principle of extended producer responsibility reveals a clear gap between declared ambitions and actual implementation. Compared to the more advanced CE frameworks in the United Arab Emirates or the Kingdom of Saudi Arabia, where laws have been implemented, there is a Mandatory green building and the establishment of industrial zones compatible with the principles of the CE. The regulatory system in Qatar still relies heavily on voluntary incentives and is characterized by sectoral fragmentation. These findings underscore the urgent

need to critically assess how the policy environment in Qatar supports or hinders the effective and local implementation of CE concepts.

4.4. Circular Economy and Sustainable Development in Qatar: Key Initiatives and Challenges

Over the past years, Qatar has taken major steps in adopting the notion of circularity and CE. The efforts in this regard have focused primarily on waste and water management in addition to renewables and green buildings (see Figure 5).

Figure 5. Qatar's Circular Economy Initiatives. Note: Source authors' 'elaboration'.

Qatar generates a significant amount of waste, with an estimated 7 million tons produced annually (see Figure 6). The majority of this waste is sent to landfill sites, which have negative environmental consequences [31]. Qatar's waste management system is currently focused on landfilling, with around 90% of waste ending up in landfills. This approach to waste management is unsustainable, and it is not in line with the principles of a CE. However, the CE offers an alternative approach to waste management, where waste is seen as a resource rather than a problem. Recycling and waste-to-energy technologies can be used to extract value from waste and reduce its environmental impact. For example, the Qatar Integrated Waste Management Facility (IWMS) is a state-of-the-art waste-to-energy plant that converts waste into energy and produces 30 megawatts of electricity, enough to power 20,000 homes. In this context, one of the main opportunities for a CE in Qatar is the potential to create a new market for waste materials. Qatar generates a significant amount of waste, and much of it ends up in landfills. However, this waste can be a valuable resource if it is properly managed. For example, organic waste can be converted into compost or biogas, and construction waste can be recycled and reused in new projects. By creating a market for waste materials, Qatar can reduce the amount of waste sent to landfills and create new business opportunities.

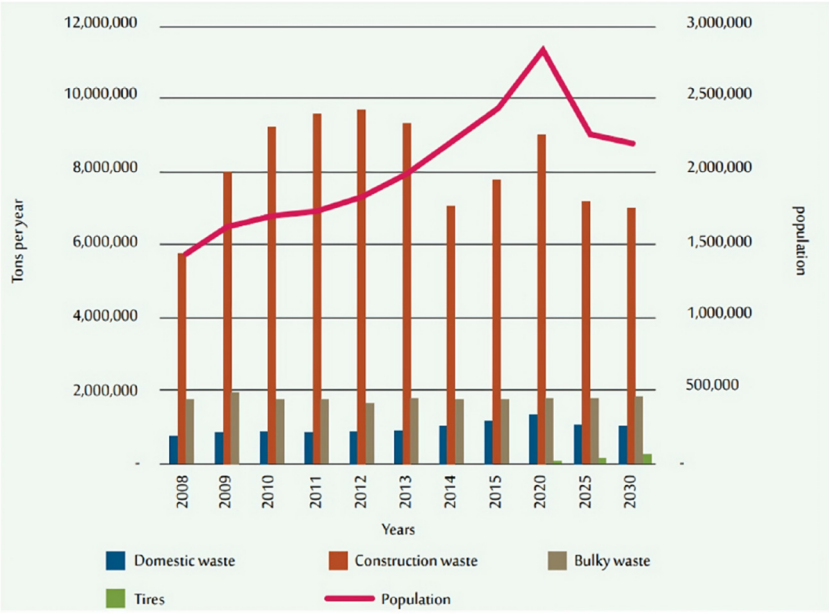

Figure 6. The waste production from 2008–2030. Note: Source [32].

With regards to water management, it can be noted that water scarcity is a significant issue in Qatar, with the country relying heavily on desalination to meet its water needs. According to the planning and statistics authority, the water use in Qatar has increased in the period between 2015 and 2019 (see Figure 7).

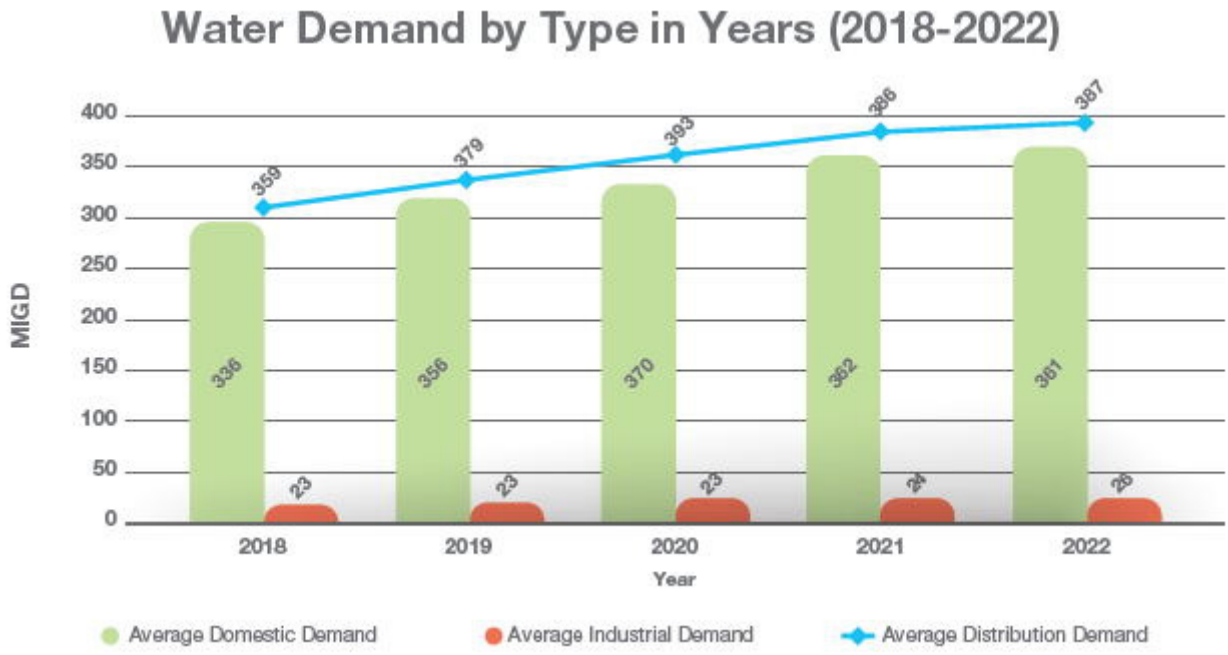

Figure 7. Total water Demand by type Note: Source [33].

Agriculture is one of the main economic sectors when it comes to water demand and consumption. Accordingly, the State of Qatar is now looking to increase the efficiency of water use in agriculture and reduce lost and unmeasured water by renewing water networks. The notion of circularity can help a great deal in this endeavour [34]. Added to this, desalination is an energy-intensive process that contributes to greenhouse gas emissions. The CE offers opportunities to reduce water consumption and promote water reuse. For example, the Qatar General Electricity and Water Corporation (KAHRAMAA) has launched a pilot project to treat and reuse wastewater for irrigation purposes. This project has the potential to reduce water consumption and promote sustainable agriculture in Qatar [28].

Regarding renewable energy, Qatar is a significant producer of oil and gas, but the country has recognized the need to diversify its energy mix and promote renewable energy. Qatar's reliance on fossil fuels for energy generation is a significant contributor to greenhouse gas emissions, which contribute to climate change [23] (see Figure 8). Therefore, the adoption of a CE is essential to ensure the long-term sustainability of Qatar's economy. The CE offers opportunities to promote renewable energy generation and reduce greenhouse gas emissions. For example, solar energy can be used to power desalination plants, reducing the carbon footprint of water production [23,35]. The Qatar National Vision 2030 includes a target to generate 20% of the country's electricity from renewable sources by 2030, which demonstrates the country's commitment to promoting sustainable energy [28].

Green buildings are another initiative adopted by the Qatari Government in an attempt to achieve CE by reducing greenhouse gas emissions. Buildings are a significant contributor to energy consumption and greenhouse gas emissions. The CE offers opportunities to reduce the environmental impact of buildings through sustainable design and construction practices. For example, buildings can be designed to be energy-efficient and use renewable energy sources. The Qatar Green Building Council (QGBC) is a non-profit organization that promotes sustainable building practices in Qatar. The QGBC has developed the Qatar Sustainability Assessment System (QSAS), a rating system that evaluates the sustainability of buildings based on various criteria. As such, another opportunity for a CE in Qatar is the potential to reduce the country's carbon footprint. Qatar is one of the largest per capita emitters of greenhouse gases in the world, and reducing emissions is a critical part of the country's sustainable development goals. A CE can help reduce emissions by reducing the need for materials, promoting energy-efficient production methods, and reducing waste.

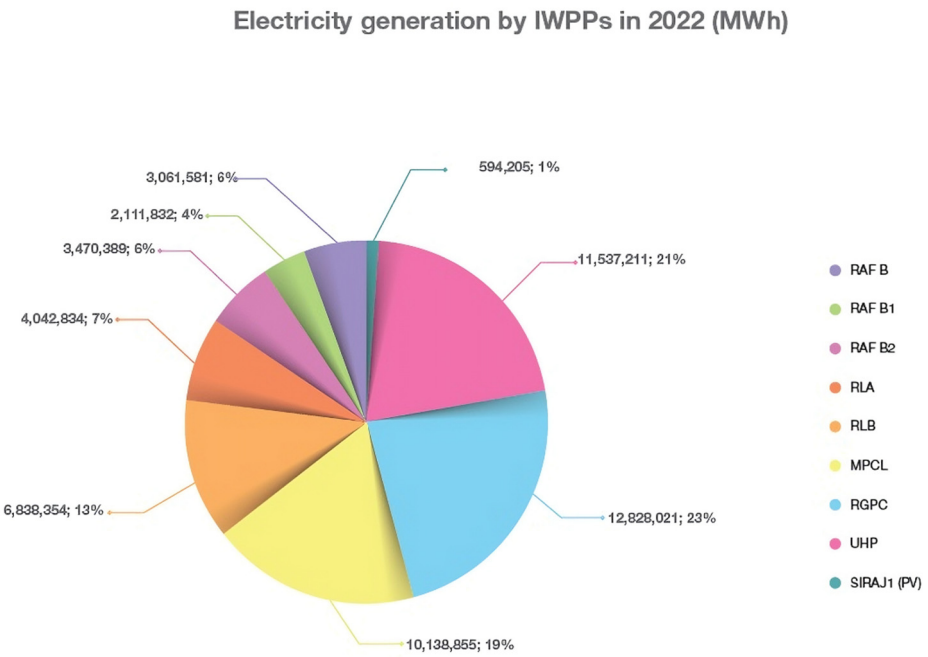

Figure 8. Qatar's electricity generation in 2022. Note: Source [33].

For environmental sustainability and waste reduction in Qatar, the principles of CE and sustainable development are both crucial. However, there are a number of issues that must be resolved to implement these ideas properly [24]. One of the major challenges that are facing the State of Qatar is facing in this respect is water scarcity. Qatar is a water-scarce country with limited access to freshwater resources. The lack of water resources can make it difficult to implement sustainable practices, such as water recycling and reuse [28]. Additionally, the limited infrastructure in terms of recycling and waste management facilities represents another challenge for Qatar. The existing infrastructure needs to be upgraded and expanded to support the CE and sustainable development initiatives. Furthermore, Qatar is heavily reliant on fossil fuels, which are a major contributor to climate change [23]. The country needs to transition towards renewable energy sources and smart energy systems in order to reduce its carbon footprint [36]. The successful implementation of CE is also faced with the current lifestyle and the unsustainable practices in the Qatari society. It can be noted that there is a lack of awareness among the public about the importance of CE and sustainable development. Cultural practices in Qatar may not align with sustainable development goals. For example, the tradition of using disposable plates and cups at social events can contribute to waste generation. Changing longstanding cultural practices can be a challenge. Thusly, education and awareness-raising campaigns are needed to promote the concepts of circularity and encourage sustainable practices. From an economic perspective, the economic dependence of the Qatari economy on oil and gas exports makes it challenging to transition to a CE. New economic models and incentives may be needed to support the transition. To this end, and given the limited research and development efforts in the area of CE and sustainable development in Qatar, the Qatari Government may need to increase investment in research and development in order to develop innovative solutions for the challenges facing the country. Promoting sustainable development and CE practises in Qatar will require a concerted effort from the government, industry, and public to meet these difficulties [24].

5. Conclusions and Recommendations

The concept of the CE represents a transformational path towards sustainability by promoting a closed circular system in which resources are reused, recycled and renewed. Despite the rapid economic progress in the State of Qatar, it faces pressing environmental challenges, including high resource consumption, increasing waste and over-reliance on fossil fuels. This paper addresses the prospects and challenges of implementing the CE in the State of Qatar and demonstrates its potential to support the achievement of sustainable development goals and the Qatar National Vision 2030. In that sense, CE is a concept that focuses on creating a closed-loop system where resources are used, recycled, and reused. The aim of a CE is to reduce waste and create a sustainable future. Qatar is one of the wealthiest countries in the world, with a growing economy and a high standard of living. However, like many other countries, Qatar is facing environmental challenges due to its growing population, industrialization, and urbanization. In this paper, we explore

the CE concept in Qatar and its challenges and opportunities. The discussion has indicated that the CE model has the potential to contribute to sustainable development in Qatar by promoting resource efficiency, waste reduction, and the recovery and reuse of materials. As such, a CE could be a vital component of Qatar's sustainable development goals. Qatar has recognized the need to diversify its economy and reduce its reliance on fossil fuels, and a CE could be an essential part of achieving this goal. By creating a new market for waste materials, Qatar can reduce the amount of waste sent to landfills and create new business opportunities. Additionally, a CE can help reduce Qatar's carbon footprint and promote sustainable development. However, there are also challenges to implementing a CE in Qatar, including the lack of infrastructure and regulatory frameworks to support circular practices. Qatar, like many countries, faces environmental challenges that require a sustainable solution. With its booming economy and growing population, Qatar needs to adopt a CE to ensure long-term sustainability. To translate the principles of the CE into practical practices, it is necessary to address the main challenges highlighted by the study, which include limited access to advanced recycling technologies, a shortage of qualified personnel, resource constraints and weak coordination between different economic sectors. The following recommendations aim to bridge these gaps through practical strategies appropriate to the Qatari context (Responding to comments one and two, a prelude to concrete and practical recommendations).

5.1. A Collaborative Approach to Achieve Circular Economy and Sustainable Development

Overcoming the challenges of CE and sustainable development in Qatar will require a collaborative effort between government, industry, and the public [37]. One potential solution to address the challenges is water conservation. Implementing water conservation measures such as rainwater harvesting, greywater reuse, and efficient irrigation systems can reduce water consumption and promote sustainable development [28]. Added to this, increasing investment in recycling infrastructure and offering updated training programmes for waste management personnel would also help address the aforementioned challenges. The government and private sector can invest in upgrading and expanding the recycling infrastructure in Qatar [29]. This includes increasing the number of recycling facilities and collection systems. Economic diversification provides a useful strategy to achieve CE. In this regard, diversifying the economy away from oil and gas and promoting sustainable industries can create new opportunities for CE practices. Furthermore, the government and private sector can promote awareness-raising campaigns to educate the public about the importance of CE and sustainable development. This includes promoting sustainable practices such as waste reduction and recycling.

In this context, effective cooperation between the government, the private sector, and civil society represents one of the main axes for advancing the CE in the State of Qatar. The country can benefit from successful models in the context of the Gulf Cooperation Council countries, such as the smart model for sustainability in the United Arab Emirates or environmental partnerships in the Kingdom of Saudi Arabia to establish joint projects in the fields of recycling, sustainable packaging, and environmental industrial cities. These partnerships can be preserved by providing government guarantees, joint investment in innovation incubators, and simplifying regulatory procedures for pilot projects.

5.2. Developing the Policy and Regulatory Frameworks

Developing the policy and regulatory frameworks is a key to the success of CE and sustainable development transition efforts [36,37]. In that sense, developing policies and regulations that incentivize CE practices and sustainable development can encourage the adoption of sustainable practices in the private sector and government organizations. Furthermore, encouraging innovation and research in sustainable development and CE can lead to the development of new technologies and solutions to the challenges facing Qatar. Such efforts can be sustained via collaboration and partnerships. Such collaborations and partnerships between governments, industry, and the public can lead to the development of sustainable solutions that benefit all stakeholders. Hence, overcoming the challenges of CE and sustainable development in Qatar will require a sustained effort from all stakeholders. By working together and implementing innovative solutions, Qatar can achieve a more sustainable and CE [38].

By focusing on the role of the Qatari government in adopting CE practices, it can be noted that the government in Qatar plays a critical role in addressing the challenges of CE and sustainable development [37]. Some of these key roles and responsibilities of the Qatari government include creating a supportive policy environment. The government has created policies, laws, and regulations that incentivize and support CE and sustainable development practices. This includes establishing targets, standards, and regulations for waste reduction, recycling, and the use of renewable energy. The Qatari government has also worked on developing and implementing sustainable development strategies that promote CE practices and reduce waste. This includes promoting sustainable industries, creating green jobs, and investing in renewable energy.

In this regard, developing stimulating regulatory and legislative frameworks is necessary to create an appropriate environment for implementing the CE. To achieve this goal, the Qatari government should adopt a set of steps, foremost among which is establishing laws for Extended Producer Responsibility (EPR), as well as establishing green government procurement policies within financial contracts. The Qatari government should also establish tax incentives and provide financial support to companies that adopt circular practices, such as reusing materials or integrating renewable energy. The paper also recommends the need to develop a national roadmap for the CE that sets measurable goals and establishes periodic evaluations to ensure follow-up and strategic integration with broader environmental goals.

5.3. Developing Infrastructure

Investing in infrastructure can be another important role for governments to play in adopting CE initiatives. In this context, the government can invest in the infrastructure needed to support CE and sustainable development initiatives. This includes investing in recycling facilities, collection systems, and waste management infrastructure. Such efforts can be complemented by providing financial support to key stakeholders. The government can provide financial support for CE and sustainable development initiatives. This includes providing grants, subsidies, and other forms of financial assistance to support the transition to a CE. The private sector and concerned industries can work with government organizations to help face the challenges posed by adopting the notion of CE. In this respect, encouraging public-private partnerships is paramount. The government can encourage public-private partnerships to promote CE and sustainable development initiatives. This includes working with industry and other stakeholders to develop innovative solutions to the challenges facing Qatar. The government can also raise awareness about the importance of CE and sustainable development among the public, industry, and other stakeholders. This includes developing public education campaigns and working with the media to promote sustainable practices. As such, the government has a critical role to play in promoting CE and sustainable development in Qatar. By creating a supportive policy environment, investing in infrastructure, and raising awareness, the government can help to create a more sustainable future for Qatar.

From this standpoint, providing sufficient financial and human resources is a crucial element for the successful implementation of the CE model. Priority areas include investing in advanced recycling technologies for plastics, construction waste, and electronic waste. Priority investment areas also include developing national waste sorting and collection systems supported by digital tracking technologies. In addition, vocational training programs in waste management and sustainable engineering can be developed that are aligned with the needs of the labor market in the State of Qatar. Institutions such as the Qatar Development Bank and the Ministry of Municipality can cooperate with universities and the private sector to develop financing tools and training curricula.

In terms of enhancing public participation and behavior change, public awareness campaigns are essential to changing the culture of the CE. National media, including television, social media platforms, and educational curricula, can be used to spread awareness of behaviors such as reducing consumption, sorting waste, and reusing. Community programs can also be implemented, such as product repair workshops or recycling competitions in schools, to encourage local participation. It can be noted that achieving this requires the effective application of the CE from an integrated governance perspective. Governance can consider establishing a national council for the CE that includes representatives from relevant ministries in the fields of environment, economy, education, and representatives from the private sector, academics, and civil society organizations. This council can coordinate policies, monitor the implementation process, and facilitate knowledge exchange. Enhancing investment in research and development through national grants enables the creation of local solutions that are compatible with Qatar's desert and resource-consuming environment.

Successful implementation of these recommendations will not only contribute to addressing current environmental challenges but will also strengthen Qatar's position as a regional leader in innovation in the CE, supporting the diversification of the Qatari economy and protecting the environment. Implementing these recommendations will also help achieve the goals of the Qatar National Vision 2030. Through sustained collaboration between various stakeholders, strategic investment, and policy innovation, Qatar can transition from a resource-dependent economic model to a more circular, sustainable, and resilient future.

Author Contributions

A.B. led the analysis of the case study, authored the results and conclusion sections, and developed the policy recommendations. S.B. was responsible for developing the literature review and research methodology. Both authors jointly contributed to the research design and the development of the theoretical framework. All authors reviewed and approved the final manuscript.

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