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Unlocking sustainability: Exploring the benefits and challenges of implementing circular economy principles in the Maldives

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Abstract

While circular economy offers a promising solution for issues in sustainability, this area remains unexplored in the context of Maldives. Hence, this paper explores the circular economy's complex environment, looking at its benefits, challenges, and implications for sustainable development. A concurrent mixed method design was used in the study, involving the simultaneous collection of quantitative and qualitative data, separate analysis, and integration during the interpretation phase. A total of 203 participants took part in the online survey and 17 participants took part in the interview. The quantitative data was analyzed by using descriptive statistical analysis and thematic analysis was used to analyze the qualitative data. As per the quantitative findings, the biggest challenges were identified as poor accountability of government organizations (3.97) and lack of infrastructure (3.97). Qualitative findings showed benefits such as reduced waste generation, enhanced resilience and sustainability, resource conservation, climate mitigation, and economic diversification. However, there are challenges to be overcome at both the micro and macroeconomic levels that were identified from this research. The findings of the research provide insight into circular economy benefits and challenges in Maldives, that could lead the government to draft effective policies and regulations. Moreover, the study's findings contribute to the extant literature on the benefits and challenges of transitioning to a circular economy from a linear economy.

Keywords: Circular economy, Maldives, Sustainable development, Sustainable growth

1. Introduction

The Maldives currently follow a "take, make, waste" linear economic model. This type of production results in inefficient waste disposal, which causes environmental harm and poor health conditions [1]. Hence, Maldives face everyday challenges in managing over a thousand tonnes of solid garbage. This is brought on by inadequate institutional capacity for sustainable management, a lack of public awareness, and an inadequate infrastructure for waste management [1]. Despite these challenges, the nation is geared to find a more effective and sustainable

means of solid waste management systems. This is evident from the 3R (Recycle, Reduce, and Reuse) strategy which is the foundation of the National Solid Waste Management (SWM) policy developed by the Ministry of Environment of Maldives, which intends to facilitate and encourage waste resource earnings and use the revenues for waste management in islands [2]. Thus, this demonstrates that the government of Maldives is in the process of shifting to a circular economic model to ensure the long-term viability of waste management for economic growth. The circular economy has been shown to have potential as a model that reduces reliance on natural resources and boosts prosperity. Globally, business executives and governments are moving beyond the "take, make, waste" paradigm of growth in order to strategically transition to a long-term-focused strategy. A circular economy not only offers immediate financial advantages to people and companies, but it also presents a big chance to address major global issues like land degradation, biodiversity loss, and climate change [3]. Although the circular economy presents a promising solution to issues by emphasizing resource efficiency, waste reduction, and environmental conservation, this area remains unexplored in the context of Maldives. In particular, the benefits and challenges of this model in terms of addressing the unique challenges faced by the nation to promote economic growth. Hence, it is crucial to learn how useful this model is to the Maldives, being an archipelago of over a thousand islands, facing unique challenges due to its geographic location, limited natural resources, and vulnerability to climate change. Therefore, this paper explores the circular economy's complex environment, looking at its benefits, challenges, and implications for sustainable development.

2. Literature review

Concept	Critical analysis of the concept
Definition of Circular Economy	Scholars agree that Circular Economy represents a shift from a linear (take-make-dispose) economy to a closed-loop system focused on waste minimization and resource efficiency [4],[5],[6],[7]. Some definitions emphasize economic resilience and sustainability [6], [8], [9] while others emphasize eco-industrial development [10]. However, most definitions are generic and lack context-specific applications. In addition, from the literature reviewed, it was found that circular economy definitions were mainly derived from developed economies, making its applicability to resource-scarce, import-dependent island nations like the Maldives unclear.
Benefits of Circular Economy	The following benefits were identified from the literature reviewed; • Environmental benefits: research highlights waste reduction, carbon emission mitigation, and conservation of natural resources [6], [8], [11], [12], [13] [14], [15], [16]. However, these studies focus on developed economies with established recycling industries and fail to address the infrastructural limitations in Small Island Development States (SIDS). • Economic benefits: Circular economy implementation enhances job creation with the emergence of new markets. In addition, it is cost-saving compared to other industries [6], [11], [17], [18], [19]. However, many of these benefits assume the existence of large-scale manufacturing industries. The literature does not account for import-dependent SIDS economies where local resource circulation is difficult. • Sustainability and resilience: circular economy enhances long-term economic resilience by reducing reliance on raw materials [7], [20], [21], [22]. However, there is limited research on how a circular economy can create close material loops in economically vulnerable SIDS.
Challenges	The following challenges were identified from the literature reviewed; • Economic challenges: research identifies high investment costs, lack of incentives, and financial risks as challenges to circular economy

Concept	Critical analysis of the concept
	implementation [6], [11], [13], [23-26]. However, these challenges assume functioning markets and financial support services, which small economies like the Maldives do not have. In addition, lack of access to international funds is an overlooked challenge, which is relevant to the Maldivian context. • Organizational constraints: organizations struggle with lack of expertise, resistance to change, and inadequate training [20], [22]. While these studies highlight the skill shortages, they fail to explore how small economies can upskill their workforce. • Legislative and policy barriers: poor policy alignment, lack of regulations and taxation are challenges identified in circular economy adoption [10], [25], [26], [27]. However, there is less discussion on how island nations can develop policies suited to their limited economic scale and with few industries. • Lack of awareness: low consumer trust in recycled products and lack of awareness is found to be another challenge in the literature reviewed [11], [28] [29]. However, the circular economic adoption and awareness of SIDS remains understudied.

From the above literature analysis, it was found that most of the circular economy benefits were studied in developed and industrialized economies, while research on island economies is lacking. Additionally, there is a limited exploration of studies tailored to economies highly reliant on imports such as the Maldives. Moreover, in terms of challenges, most studies focus on policy and financial constraints in industrialized economies and overlook the structural and economic realities of SIDS. These studies overlook the unique challenges SIDS faces such as the dependency on imports, lack of local production, and infrastructural shortage.

Hence, this study fills a critical research gap by exploring how circular economy principles can be applied in SIDS such as in the Maldives, with economic constraints, geographic limitations, and climate vulnerabilities, that are not addressed in existing literature. By addressing these gaps, the study provides insight to the policy makers and organizations on the benefits and challenges of transitioning to a circular economy, aiding them to make better decisions in the future. Moreover, this research lays the foundation for future studies on the benefits and challenges of adopting a circular economy in resource-constrained SIDS, such as the Maldives.

3. Research method

A concurrent mixed method design was used in the study, involving the simultaneous collection of quantitative and qualitative data, separate analysis, and integration during the interpretation phase. The target population of the study was representatives from government institutions, businesses, and non-governmental organizations. Hence, purposive sampling was used to select the most relevant participants, which consisted of two groups. Namely, the senior management team and lower-level administrators. The total sample size of these groups was 203 (N=203), which was chosen by using the Cochran formula to get an ideal sample from the target population of 425. For the qualitative data, purposive sampling was adopted to select 17 participants. The participants were chosen based on the criteria that they have worked in the field for more than five years.

The quantitative data was analyzed by using SPSS (version 23) and ATLAS.ti 7 was used to analyze the qualitative data. The data gathered from the various participants were analyzed by using descriptive statistics for quantitative data and thematic analysis for qualitative data. The data was compared to find similarities and differences among the participants to inform the findings of the study thereby to achieve the outlined objective of the study. Cronbach's Alpha analysis was used to verify the internal consistency of the questionnaire. The result of the categories was between 0.8 and 0.9 (see Table 1), proving that the items in specific categories are internally consistent with each other.

Table 1. Cronbach's Alpha value for each category on the questionnaire

Categories	Cronbach's Alpha
Challenges - citizen behavior	0.898
Challenges - regulatory	0.977
Challenges - financial	0.866
Challenges - human resource	0.957
Challenges - infrastructure	0.96

Table 2. Profiles of respondents

Name	Designation	Industry
A	Director General	Tourism
B	Director General	Manufacturing
C	Director General	Manufacturing
D	Manager	Construction and transport
E	Manager	Construction and transport
F	Manager	Construction and housing
G	Manager	Power and energy
H	Manager	Power and energy
I	Managing Director	Recycling
J	Manager	Construction and housing
K	Director	Public service
L	Assistant Director	Public service
M	Project Manager	Waste management
N	Director	Waste management
O	Assistant Manager	Waste management
P	Senior Program Office	Environment and sustainability
Q	Project Consultant	Environment and sustainability

4. Results and discussion

4.1. Results

First, the qualitative results are presented, followed by the quantitative results.

4.1.1. Qualitative findings

The benefits identified from the interviews can be broadly classified into resource conservation, reduction in waste management, climate change mitigation, economic diversification, and enhanced resilience and sustainability.

4.1.1.1. Resource conservation

The majority of participants highlighted how adopting circular economy principles in the Maldives can significantly contribute to the conservation of important resources like energy, water, and wood. Through the

promotion of recycling, reusing, and remanufacturing, the country can reduce its dependence on finite resources and minimize environmental degradation associated with their extraction and disposal. In particular, the Maldives, a nation with few resources and climate vulnerability can benefit from this. One such example was given by a participant, who emphasized the importance of wood conservation.

"There is a demand for waste like wood, after cutting a tree, instead of throwing it away as waste, it can be given to an artist who needs to create a product out of wood. In this way we can conserve natural resources through recycling" (Participant O)

4.1.1.2. Reduce waste generation

Participants mentioned that adopting circular economy principles can significantly reduce waste generation across various sectors in the Maldives. Hence, they emphasized designing products for longevity and facilitating efficient recycling and composting systems. Such practices can minimize the volume of waste sent to landfills or incinerators, thereby mitigating environmental pollution and conserving landfill space. Thus, they suggested that the current waste management system could be improved by adopting proper waste disposal methods without resorting to landfills. A participant from the tourism industry gave a good example of such a practice:

"As you know, the tourism sector produces the largest amount of food waste. However, this food waste is efficiently composted into fertilizers to minimize the volume of waste sent to landfills. This is a practice in almost all resorts. In addition, according to regulations, all the resorts should have machines such as bottle crushers, incinerators, and compactors. All of this helps them to effectively manage the waste." (Participant A)

Similarly, it was highlighted that from an economic perspective, waste management can decrease resource consumption and generate revenue from reused items. While environmentally, it can result in a cleaner environment, as noted by one participant:

"At the end of the day, if we can manage the waste in an effective manner, then it will be the best thing you can do for your environment." (Participant N)

4.1.1.3. Climate change mitigation

Moreover, according to participants, industries such as the tourism industry could enhance waste management while promoting the blue economy. Similarly, the fishing industry would benefit from reduced wastage and the preservation of the ocean environment.

In addition, the majority of the participants highlighted how the circular economy practices can play a vital role in mitigating the adverse effects of climate change in the Maldives. By reducing greenhouse gas emissions associated with waste management, the country can contribute to the global efforts to limit global warming and adapt to climate-related challenges such as sea-level rise and extreme weather events. One participant emphasized the importance of circular economy practices in helping Maldives mitigate climate change:

"We always hear about climate change and its effect on the sea level rising in Maldives. I strongly believe that circular economy practices can help us to overcome these climate change issues we are facing." (Participant I)

4.1.1.4. Economic diversification

All the participants agreed that transitioning to a circular economy model can foster economic diversification and innovation in the Maldives. By promoting sustainable business models and renewable practices, the country can create new revenue streams, enhance competitiveness amongst businesses, and stimulate job creation in sectors such as renewable energy, waste management, and green technologies. One participant shared an example of how waste can generate revenue for their organization:

"We always say that the waste is like gold for us, something we can generate revenue from. When we visit Thilafushi we can see mountains and mountains of these gold. If we sell the things that are reusable, we can generate revenue." (Participant N)

4.1.1.5. Resiliency and sustainability

Similarly, being a country which is heavily dependent on imports, circular economy practices are believed to foster the creation of products and industries. It can expand the economy of the country and give more opportunities for businesses to flourish. This in return can create a resilient and sustainable economy within the country. Participants emphasized the potential for the emergence of new industries, such as the recycling and waste management sectors which could assist in reducing the import value and related taxes.

"We import everything from outside, but with circular economy principles, we will be able to circle the resources within a closed loop. This, I believe will foster production within the country." (Participant Q)

Moreover, adopting circular economy practices can enhance the resilience and sustainability of the Maldivian economy and society. By promoting closed-loop systems and sustainable consumption patterns, the country can build a more resilient infrastructure, reduce its vulnerability to external shocks, and improve the overall well-being and quality of life of its citizens.

The benefit of the circular economy to industries such as tourism, fisheries, and waste management are also deliberated upon by participants, emphasizing the potential for economic growth and sustainability in the Maldives from these sectors. Sustainable tourism is one such example that was highlighted by participants.

"Especially in a country like Maldives, natural beauty is important. We are selling this beauty. We are living from this. So, we can make this income sustainable by knowing that our environment is delicate and by respecting and protecting our environment through these recycling and reusing concepts." (Participant C)

Moreover, the challenges identified from the interviews can be broadly classified into lack of human resources, lack of policies and regulations, lack of awareness and education, limited infrastructure and financial constraints, and lastly dependency on imports.

4.1.1.6. Lack of human resources

The lack of employees who have expertise in managing such operations is also identified as a challenge by participants in the interview. Though few machineries are available in the organization, one participant stated that no one is trained to use it.

"We have incineration machines, but we do not have people to operate them, I mean locals. But we are in the process of commencing the operations with technical help from expatriates." (Participant N)

4.1.1.7. Lack of policies and regulations

The majority of the participants noted that government policies and regulations partially support circular economy initiatives. In fact, it was highlighted that policies pertaining to recycling were missing in Maldives. Similarly, it was brought to light that waste management policies and procedures, including those applicable to sustainable practices and renewable energy, were not enforced.

"We don't have such policies in the Maldives. Only recently there was a law about the protection of the environment. Under this law, there is a clause about single-use plastic. However, we are not ready for these things, there are a lot of challenges. Since we are invested heavily in the industries it's really difficult to make the changes as per the policies." (Participant B)

The lack of accountability for regulatory compliance from state-owned enterprises, the private sector, and the government authorities was also raised by the participants. According to them, even though certain regulations exist, challenges lie in aligning them with industry practices and local island infrastructure. Similarly, participants also emphasized the absence of policies and regulations in collaborating with the private sector for sustainability practices.

"Another challenge is lack of industries and lack of empowerment in the private sector for sustainability development. We need the private sector to be involved, there should be collaboration between the government and private sector. However, there are no policies or regulations facilitating this." (Participant P)

4.1.1.8. Lack of awareness and education

All the participants agreed that there was a lack of awareness and understanding among stakeholders, including policymakers, businesses, and the general public, about the concept and benefits of circular economy practices. One participant mentioned a prevalent issue that concerns consumers.

"The most challenging thing is to change consumer behavior. All humans want things to be really convenient. Since plastic is really light and it's very convenient, we don't want to get away from this. A lot of environmentalists are working against this but still, the plastic industry is expanding." (Participant B)

This challenge highlights the public's ignorance of environmental problems and the immoral actions of companies that prioritize profit over environmental obligations.

4.1.1.9. Limited infrastructure and financial constraints

As per the majority of participants, one of the primary challenges facing the adoption of circular economy practices in the Maldives was the lack of adequate infrastructure for waste management, recycling, and remanufacturing. This is further exacerbated by spatial limitations. The Maldives, being highly dispersed, requires infrastructure on every island, posing a significant challenge that concerns everyone. The scattered nature of the islands and the absence of centralized facilities pose significant logistical and operational challenges in establishing efficient circular economy systems.

"Also, if we look at the raw materials, metals are a raw material that can be found in large quantities in our waste, and this is something that can be recycled. But there is no metal recycling industry in Maldives, so that is an issue. Neither we have the machinery nor the land to carry out the operation." (Participant Q)

Furthermore, Maldives faces economic constraints, including limited financial resources and funding opportunities, which can hinder the adoption of circular economy practices. Implementing sustainable technologies, upgrading infrastructure, and incentivizing circular business models require substantial investments that may be difficult to mobilize without external support and cooperation.

"At the investment scene, it's not that practical. For us, at the moment it's more sustainable to probably go into finding a way, without investing in the first thing you see and putting a lot of money in and then realizing it's not the solution. We don't have the population to justify that investment either, we don't have the services to justify that investment, we don't have the production capacity to justify that." (Participant I)

4.1.1.10. Dependency on imports

Maldives heavily relies on imports for goods and materials due to limited domestic production capabilities. This dependency presents a challenge in transitioning to a circular economy, as it requires substantial changes in supply chain management, product design, and consumption patterns to promote local production, reuse, and recycling.

"We import everything, from food to clothes to anything else you see on the market. We do not make anything in the country except tuna cans. In such an economy, we cannot easily implement circular economy practices. We have to build industries, we have to come up with business models, we need finance, we need capital to do so. This will be a huge challenge for a country like Maldives where 99.9% of everything is imported." (Participant I)

4.1.2. Quantitative findings

Table 3. The demographic analysis of the participants of the survey

Items		Frequency	Percentage
Gender	Male	135	66.5%
	Female	68	33.5%
Type of organisation	Government	172	84.7%

Items		Frequency	Percentage
	Private	31	15.3%
Years of experience	0-5 years	44	21.6%
	6-10 years	85	41.9%
	11-15 years	55	27.2%
	Over 16 years	19	9.3%
Highest level of qualification	Certificate	1	0.5%
	O-Level	4	1.9%
	A-Level	14	6.89%
	Diploma	41	20.2%
	Degree	77	37.9%
	Masters	65	32.2%
	PhD	1	0.5%
Level of position in the organization	Administrative/Operational level	67	33%
	Middle management level	100	49.3%
	Senior management level	36	17.7%

Analysis of the demographic data shows that out of the 203 respondents who completed the questionnaire, 135 (66.5%) were males and 68 (33.5%) were females. Out of the 203 respondents, 172 (84.7%) worked in the government sector while 31 (15.3%) of them worked in the private sector. Additionally, of the 203 respondents, 100 (49.3%) held middle management positions, 67 (33%) held administrative/operational positions and 36 (17.7%) held senior management positions.

Table 4. Challenges – Citizen behavior

Items	VL	L	M	H	VH	Mean	Standard Deviation	Interpretation
Citizen's preference to buy disposable products	1	13	36	103	50	3.93	.850	High
Citizen's misperception of recycled or reused products	1	13	47	103	39	3.82	.833	High
Citizen's lack of awareness in the environment	1	18	35	99	50	3.88	.899	High

Note: N-203, VL=Very Low, L=Low, M=Moderate, H=High, VH=Very High.

The items in this category were interpreted by using the scoring range of Likert scale. As per the interpretation, all the mean scores fall within 3.41 and 6.20, meaning that all the challenges are rated as high by the respondents. The highest mean score (3.93) was for citizen's preference to buy disposable items. In contrast, the lowest mean (3.82) was for citizen's misperception of recycled or reused products indicating the importance of educating citizens on circular economy and altering their mindset.

Table 5. Challenges – Regulatory

Items	VL	L	M	H	VH	Mean	Standard Deviation	Interpretation
Lack of law enforcement of government agencies	1	17	29	102	54	3.94	.888	High
Poor accountability of government agencies	1	18	25	101	58	3.97	.901	High
Lack of effective collaboration mechanism between organizations	1	17	36	99	50	3.89	.891	High

Items	VL	L	M	H	VH	Mean	Standard Deviation	Interpretation
Limited funding for the establishment of CE model/practices	1	16	30	107	49	3.92	.864	High
Lack of regulation, standards, and laws aimed at achieving CE	1	16	33	102	51	3.92	.878	High
Mismatch between current legislation and legislation aimed at achieving CE	1	19	33	100	50	3.88	.904	High
Lack of defined national goals to move toward CE	1	19	29	108	46	3.88	.882	High
Lack of educational campaigns for CE	1	14	39	102	47	3.89	.857	High

Note. N-203, VL=Very Low, L=Low, M=Moderate, H=High, VH=Very High.

The items in this category were interpreted by using the scoring range of the Likert scale. As per the interpretation, all the mean scores fall within 3.41-6.20 meaning that all the challenges are rated as high by the respondents. The highest mean score (3.97) was for poor accountability of the government, indicating that respondents have less faith in the government's capacity to fulfill its obligations to the circular economy. In contrast, the lowest mean (3.88) was for the mismatch between legislation and lack of national goals towards circular economy, highlighting the need to align national goals with legislation to attain circular economy-related goals.

Table 6. Challenges – Financial

Items	**VL**	**L**	**M**	**H**	**VH**	**Mean**	**Standard Deviation**	**Interpretation**
Large costs of investments associated with the implementation of CE	1	18	31	105	48	3.89	.883	High
Ambiguity related to business model viability	1	37	48	78	39	3.58	1.01	High
Financial risks associated with implementation of CE	1	14	36	105	47	3.90	.850	High

Note. N-203, VL=Very Low, L=Low, M=Moderate, H=High, VH=Very High.

The items in this category were interpreted by using the scoring range of Likert scale. As per the interpretation, all the mean scores fall within 3.41-6.20 meaning that all the challenges are rated as high by the respondents. The highest mean score (3.90) was for financial risks associated with circular economy, which represents the risks related to return-on-investment risks of circular economy. On the other hand, business model ambiguity had the lowest mean (3.80), emphasizing the necessity of incorporating creative business models for circular economy adoption.

Table 7. Challenges – Human resources

Items	VL	L	M	H	VH	Mean	Standard Deviation	Interpretation
Limited environmental awareness of the directors and decision-makers in relevant authorities	1	16	32	106	48	3.91	.865	High
Lack of expertise or skills at an operational level	1	11	36	106	49	3.94	.824	High
Lack of training and education programs	1	11	33	111	47	3.95	.810	High

Note. N-203, VL=Very Low, L=Low, M=Moderate, H=High, VH=Very High.

The items in this category were interpreted by using the scoring range of the Likert scale. As per the interpretation, all the mean scores fall within 3.41-6.20 meaning that all the challenges are rated as high by the respondents. The highest mean score (3.95) was for lack of training and education programs, indicating the importance of developing human resources in a circular economy. On the contrary, the lack of environmental awareness of directors had the lowest mean (3.91), emphasizing the necessity of having circular economy advocators and champions on the management level.

Table 8. Challenges – Infrastructure

Items	VL	L	M	H	VH	Mean	Standard Deviation	Interpretation
Lack of infrastructural support in relevant organizations	1	11	29	114	48	3.97	.802	High
Lack of existence of appropriate technology to support CE	1	13	29	112	48	3.95	.825	High

Note. N-203, VL=Very Low, L=Low, M=Moderate, H=High, VH=Very High.

The items in this category were interpreted by using the scoring range of the Likert scale. As per the interpretation, all the mean scores fall within 3.41 and 6.20, meaning that all the challenges are rated as high by the respondents. The highest mean score (3.95) was for the lack of existence of technology to support the circular economy, emphasizing the importance of investing in appropriate technology for the implementation of the circular economy.

4.2. Discussion

The study focuses on identifying the benefits and challenges for a small island state like Maldives to transition from a linear economy to a circular economy. The main benefits of transitioning to a circular economy identified from this research are resource conservation, reduction in waste management, climate change mitigation, economic diversification, and resilience and sustainability.

One significant benefit identified from the qualitative findings of the study is resource conservation. Maldives, being a country with limited resources stands to gain a great deal from resource conservation, which can lower waste production in Maldives. This benefit could also help the country to mitigate the climate change issue which is a critical concern for the nation. At present, the country is accumulating waste in the landfill area of Thilafushi, which is soon to be incinerated. Nevertheless, shifting to a circular economy can help the Maldives to mitigate its climate change issue, resulting in a cleaner environment. Similar benefits were also identified in literature reviewed, where environmental and conservation benefits were widely mentioned as advantages of transitioning to a circular economy. The greatest benefit according to scholars was a decrease in hazardous gasses and toxic wastes [6],[13],[14],[15].

Diversification of the economy through circular economy practices was another benefit identified from this study as participants believed it can lead to the creation of new markets and new business models. Through this diversification, new markets such as recycling industries and renewable energy can be created as per the interviewed participants. This will open up job opportunities, which will enhance the economy of the country. This finding strengthens earlier findings of similar studies where scholars have highlighted the emergence of markets and an increase in job opportunities [6], [7], [11], [13], [17], [22].

Likewise, the enhancement of resilience and sustainability was also a benefit of the circular economy as per the interviewed participants. As evident from qualitative findings, almost everything is being imported into the country which leaves the country vulnerable and dependent on other countries. However, the creation of a closed-looped system through circular economy practices, can enable the manufacture of sustainable products and hence improve the overall economy and well-being of the citizens. Similar findings were observed in other

studies where resilience and sustainability benefits were associated with the incorporation of circular economy models and technologies [6], [17].

In terms of the challenges of the circular economy, challenges were identified at both the micro-level and the macro level. The micro-level challenges were identified at the organizational level while the macro-level challenge highlighted the challenges faced at the national level.

The micro-level challenges that were identified were financial constraints, lack of human resources, and lack of infrastructure and technology. A mean score of 3.92 was observed for limited funding for the establishment of circular economy practices and models from the questionnaire, while high implementation expenses were noted with a mean score of 3.89. Additionally, a lack of environmental awareness among directors was noted with a mean score of 3.91, while a lack of expertise at the operational level was responsible for the highest mean score of 3.94. Similar findings were observed from the interview where participants highlighted the budget cuts and financial limitations on circular economy initiatives as major obstacles which were made worse by senior management's lack of emphasis on them. This is comparable to earlier literature that has highlighted the difficulties in financing, where organizations view capital investment as expensive because they feel it is too risky to make an investment [6], [11], [20], [26], [30]. This is further made difficult by the lack of understanding and hesitancy from the senior management as identified from the interview and strengthens previous findings from the literature [22], [24]. In addition, a mean score of 3.97 for the lack of infrastructural support and a mean score of 3.95 for the lack of existence of appropriate technology were identified from the questionnaire. These findings were corroborated by the findings of the interview, in which the participants mentioned that one significant challenge in implementing circular economy practices was the lack of infrastructure and technology. Comparable findings were observed in previous literature where lack of infrastructural support and lack of viable technology for circular economy practices were highlighted [20], [26], [28].

As for the macro level challenges, one new challenge that was identified from the study was the dependency on imports. The Maldives, a nation with only two primary industries, is highly dependent on imports for everything from construction materials to food items. The C.I.F value for the Maldives was 53,660,566 MVR in 2022, up 40.3% from 35.4% in 2021 [31]. This indicates a sharp increase in the value of imports into the country. Due to the high import value in the Maldives, the manufacturing industry faces significant challenges in implementing circular economy principles as circular economy practices necessitate the existence of manufacturing and recycling businesses, both of which are currently absent.

The aforementioned challenge is aggravated by the lack of enforcement by government agencies with a mean score of 3.94, poor accountability of government agencies with a mean score of 3.97 and lack of regulation, standards and laws aimed at achieving a circular economy with a mean score of 3.92, as identified by the questionnaire. This is also corroborated from the findings from the interview conducted where participants highlighted the lack of policies aimed at recycling, lack of accountability and lack of enforcement by organizations. These findings strongly support similar findings from previous studies that showed the lack of policies and legislations in implementing circular economy practices in other nations such as China, U.K and New Zealand [10],[23],[24],[27]. However, one factor that was new and interesting in this study was the challenge associated with the lack of collaboration between the public and the private sector. Maldives having a small economy, small and medium enterprises (SMEs) account for a significant portion of the GDP, 41.7%, according to 2021 statistics [32]. Participants therefore agreed that SMEs' involvement is essential to the adoption of circular economy principles and practices in the Maldives. Environmental toxicology, elevated temperature, climate change and sea level rising in the current era is directly linked with greenhouse gases release by fossil fuels burning [33].

In addition, lack of infrastructure support due to financial constraints was highlighted as a challenge for circular economy implementation in the Maldives. Limited funding opportunities and investments were noted as a challenge by the participants interviewed. The relatively small economy of the Maldives is mostly reliant on funding and foreign direct investments. However, the Maldives' population and production capability currently

do not support the need for such a transition, hence the country faces difficulties in obtaining funding and assistance from other countries. Therefore, this could be a challenge for island nations with small economies.

Moreover, the challenges associated with the lack of awareness and education were found to be very high in Maldives with a mean score of 3.93 for citizens' preference to buy recyclable products, a mean score of 3.89 for lack of educational awareness campaigns on the circular economy and a mean score of 3.91 for lack of awareness of decision makers on circular economy practices was identified through the findings of the questionnaire. This was also supported by the participants of the interview where they highlighted the preference of Maldivians to buy single-use-plastics (SUP) items even though the government tried to regulate the use of SUP nationwide and the lack of participation in sustainable practices by both the decision makers and the community members. Similar findings were found in other studies where the community perceptions towards recycled products and lack of participation in sustainable practices were highlighted as challenges [6], [11], [13], [23], [20], [22], [24], [28].

5. Conclusions

As a Small Island Developing State, the Maldives faces unique sustainability challenges due to its geographic isolation, limited resources, climate challenges and heavy reliance on imports. This study highlights the benefits of transitioning to a circular economy to enhance resource conservation, waste reduction, climate resilience and economic diversification. Nevertheless, financial constraints, inadequate infrastructure, regulatory gaps and dependency on imports poses significant barriers in the Maldives. Hence, addressing these challenges requires targeted policy interventions, investment in infrastructure development and stronger public-private partnerships. By fostering circular economy practices, the Maldives can enhance long-term environmental and economic resilience to become a role model for other island nations facings similar challenges.

5.1. Limitations

The study is limited by its reliance on self-reported data, which may introduce bias. In addition, the sample size, though representative, may not fully capture the diverse stakeholder perspective from related government institutions. Similarly, the lack of longitudinal data prevents an assessment of long term impacts of circular economy in the Maldives. Moreover, the study focuses on national-level challenges, overlooking potential variations across different islands.

5.2. Future research directions

Building on these limitations, future research should incorporate industry specific analyses to enhance applicability and depth of findings. Hence, future research can examine the policy frameworks and circular economy business models specifically in the tourism or fisheries industry. Additionally, longitudinal studies are needed to assess the long-term economic and environmental impacts of circular economy adoptions. Moreover, comparative studies with other SIDS could highlight best practices too.

Declaration of competing interest

The authors declare that they have no known financial or non-financial competing interests in any material discussed in this paper.

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Author contribution

The contribution to the paper is as follows: study conception, analysis, and interpretation: Aminath Shaznie, literature review, data collection, analysis, and interpretation, draft preparation: Aishath Sinaau, analysis and

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Ethical approval statement

Research ethics approval was obtained by the ethics committee of the Islamic University of the Maldives.

Informed consent

Informed consent for the publication of personal data in this article was obtained from the participant(s) as per the ethical committee guidelines of the Islamic University of the Maldives.

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