



Review article

Circular economy and sustainable development in the tourism sector – An overview of the truly-effective strategies and related benefits

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ABSTRACT

Circular Economy (CE) is considered a possible solution to mitigate the environmental externalities of the tourism industry, with a view to more sustainable tourism by reducing environmental, social, and economic burdens in an integrated holistic approach. Moreover, the role of CE in tourism is highlighted by the possibility of achieving all sustainable development goals (SDGs) directly and indirectly using the links that connect SDG 12 with the others.

From this point of view, this literature review was aimed at discussing the key strategies of CE applied to the tourism industry, focussing on the widespread problems of single-use plastic, excess food, and water consumption. The environmental and socio-economic benefits deriving from the application of the CE principles to waste management will be shown, by contributing to meeting all the SDGs. Many strategies have been proposed to make tourism circular and sustainable, and research revealed that those are mainly based on the concepts of reduce, reuse, recycle, and recover.

This article confirmed the importance of – and the need for - research on CE in the tourism sector; further, by contributing to expanding research in this content area, it can stimulate the development and application of solutions that make the industry more efficient and resilient. This study was also conceived to raise the awareness of tourism stakeholders on the importance of CE to mitigate the negative externalities of the sector.

1. Introduction

Tourism is a multibillion-dollar global industry that is acknowledged worldwide to favour job placement, to increase financial business assets, to support a healthy natural and built environment both on the local and global scale, and to promote cultural heritage [1,2].

Tourism is one of the most developed sectors worldwide, with international tourist arrivals having increased from 25 to 100 million over the course of the past sixty years. Such a growth is expected to continue up to 1.8 billion arrivals by 2030, with consequential environmental impacts, against the undeniable socio-economic and cultural benefits [3]. The World Travel and Tourism Council has predicted that, by 2026, the tourism industry will reach a value of USD 10,986.5 billion, which is expected to represent 10.8 % of the global gross domestic product (GDP) [2]. Previously published studies have described tourism as the industry that can provide

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financial assistance to countries and an attractive landscape and can also contribute to building a positive image of the country [2]. From an environmental perspective, tourism is proven, however, to be a highly water- and energy-demanding, and waste-and-wastewater generating sector, as well as one of the largest contributors to global greenhouse gas (GHG) emissions [4–6]. Tourism-derived GHG emissions are estimated to represent approximately 8 % of the global value and, alarmingly, are expected to triple by 2050 [7,8]. Additionally, in Europe, water consumption is about 300 L/day per tourist, which is twice the consumption of an average European citizen [9]. According to Pablo-Romero et al. [10], the link between tourism activities and GHG emissions should be attributed to the energy intensity of the sector, coming from transport, commercial activities, and auxiliary services. This article's authors encountered difficulties in finding data on the energy increase due to tourist activities on the global dimension, as data available in the literature are mainly related to the regional scale: in Italy, by way of example, according to statistics from the Italian Institute for Environmental Protection and Research (ISPRA), in 2022 the tourism sector contributed around 4 % of the national electricity consumption [11]. As regards waste-related issues, tourism has a significant impact on waste generation, since tourists generate twice as much waste as residents [12]. Estimates from the United Nations Environment Programme (UNEP) say that 35 Mt solid waste is generated each year solely by tourists [13]. Regarding wastewater, UNEP reported that, in the Mediterranean basin, tourism contributes to water pollution by around 7 %, by generating up to 180 L of wastewater per tourist every day [14]. About this point, to get the problem right, it is worth noting that the Mediterranean basin is, by far, the largest global tourism destination that, as a single area, tends to attract almost one-third of the world's international tourists. Its popularity is growing exponentially, so much so that it is predicted that the number of tourists will increase to 381–415 million by 2030 [15], with an average of three-quarters of Mediterranean tourism being concentrated in France, Spain, Italy, and Greece. All of those figures result in amplifying the magnitude of the aforementioned environmental problems of tourism, thereby emphasising the need for combined short- and long-term strategies. The latter can be designed and implemented by company managers, guided, supported, and incentivised by decision- and policy-makers, to reduce the environmental burdens of their tourism facilities and services. Doing so will make it possible to contribute to cutting global emissions by at least 55 % by 2030, according to the EU Green Deal, and to take part in the green tourism transition [16]. The latter falls within the broader objective of developing a more sustainable and responsible ecosystem, which is a process that involves all multi-level governance actors, including industry, destinations, authorities, and tourists. Under this perspective, authors like Khizar et al. [2] and Rasoolimanesh et al. [17] have highlighted the predominant role that tourism has in the process of achieving sustainable development goals (SDGs). This implies, however, to fully consider its current and likely-future economic, social, and environmental impacts, whilst addressing the needs of visitors for a quality touristic experience, and of the hosting local communities, for being positively involved in tourism-service design and implementation, up to the point that they see tourism as an economic, social and cultural growth driver [18]. Such puts emphasis upon the need for a sustainable tourism that allows for preserving the environmental, landscape and cultural heritage, whilst promoting products from local handicrafts and industries, including that of food and wine.

Circular Economy (CE) is for sure one of the strategies that can be implemented to make tourism sustainable, as it can have multiple key roles for enhancing both quality and sustainability of the tourism sector. It is based on the 10R strategies [19,20], which the authors have dedicated a whole section to, in the following of the text. At the same time, CE allows for both economic growth and the wellbeing of local communities, by favouring job placement and more inclusive local value chains, with the result of creating a virtuous circle between businesses and territories [21,22]. As highlighted by the European Parliament [23], the CE transition has the potential to be largely beneficial from an environmental, economic, and social perspective. Keeping products in the loop as long as possible, thus preserving their characterising value in use, may have the effect of saving 7.9 billion euros per year in the entire European economy, whilst boosting the European GDP by 0.8 % and generating two million new jobs. Furthermore, utilising secondary raw materials could lead to energy reductions from 20 % to 90 %, as well as massive water savings [23]. In light of this, CE is increasingly seen as the valid way out of the disastrous effects caused by the COVID-19 situation on the tourism sector and, overall, on the global socio-politic and economic context [24]. In the tourism industry, CE is also considered as a possible solution for the long-term implementation of SDGs, pursuing the most suitable trade-offs between the environmental, economic, and sociocultural dimensions of sustainability [25]. Although the origin of the CE model dates back to the early seventies [26], it is just in recent times that it has attracted attention worldwide from governments, organisations, businesses, and academia as a solution to the environmental challenges caused by the linear economic model [27,28]. Several attempts have been made to describe CE, with all of them converging on a resource-oriented perspective, that highlights the need for durable, reusable, and easily repairable commodities, and for closed material loops, thereby contributing to sustainable development in multiple ways [5,29]. The increase in popularity of this model should be attributed to the works of the Ellen MacArthur Foundation [5], which focus on the three main principles of waste and pollution elimination, material circulation, and nature regeneration [30].

Municipal waste accounts for 27 % of total waste generated in the EU and, if not managed properly, can lead to significant negative impacts on both human health and the environment [31]. It was chosen by the authors as this article's focus because, as evidenced above, it is largely affected by the tourism industry. The challenges of waste management intensify, in fact, as the result of rapid urbanisation, as well as of the growing number of tourists and average stays, especially during the high season [32,33]. Waste management can be, however, substantially improved through CE-principles application [34], thus generating environmental and socioeconomic gains that are cascaded to the tourism industry making it more sustainable. Even before than that, the European Commission recognised the greatest environmental benefits that could be delivered by waste generation prevention strategies [35]. Those could be implemented by increasing the lifespan of consumer goods and ensuring strong support for product reuse and would contribute to halving by 2030 the quantity of municipal waste that is not recycled or prepared for reuse.

So, this study was set to explore waste management, with a special focus on plastic, food, and water waste, considering that:

- plastic waste is identified as the most significant pollutant amongst the solid waste types [36];
- food waste, despite its social implications, has negative environmental consequences such as GHG emissions, land use change, biodiversity loss, and increased water scarcity [37];
- wastewater is a growing global concern because, if not properly treated, can lead to polluting soils and water bodies [38].

In this context, this study was conceived with the multiple aims of:

- exploring the direct and indirect links between tourism and SDGs in the context of a sustainable CE;
- reviewing the CE-principle-based 10R-framework, to extrapolate those strategies that can be truly effective in making improvements in the tourism industry, with special regard to the plastic-, food-, and water-waste streams;
- highlighting the resulting environmental and socio-economic benefits, and the achievable SDGs; and
- overall, contributing to filling existing gaps in such an important field of research, thereby contributing to its expansion.

According to the authors, the added value of this manuscript stays in the comprehensive review of the relevant up-to-date issues of CE implementations in the tourism industry for its enhanced sustainability, by focussing upon its most representative waste streams.

Such was done by the authors structuring (Fig. 1) and developing this review article to make it an effective and reader-friendly tool for knowledge dissemination and advancement. To the authors' knowledge, this has not been done before, which puts emphasis on the novelty of this article and the contribution it will make to the specialised literature upon publication.

Finally, the authors believe that the article may raise the awareness of tourism managers, policymakers, sector stakeholders, and decision-makers awareness on the importance of CE to mitigate the negative externalities of the sector, whilst enabling environmental, social, and economic benefits.

2. Tourism and SDGs: the role of circular economy

CE is closely tied to the 2030 Agenda, which is a collection of 17 SDGs provided by the United Nations Member States, to protect people and the planet, whilst guaranteeing prosperity and progress [39,40]. Ortiz-de-Montellano et al. [41] and, even earlier, Stevens and Kanie [42], have presented SDG implementation as the opportunity to contribute to transforming, in a permanent manner, the nature of development, and to turning environmental and social sustainability into a key feature for any economic activity definition.

Tourism was documented in the literature to play a precise function in achieving “decent work and economic growth” (SDG 8), “responsible consumption and production” (SDG 12), and “life below water” (SDG 14) [2,22]: such an important interaction occurs, in particular, through targets n. 8.9, 12.b, and 14.7. Target 8.9 was conceived to devise and implement, by 2030, measures to promote sustainable tourism, thereby creating new job positions, and promoting local territories, cultures, and commodities. In addition to this, target 12.b remarks the need for developing and implementing tools to monitor sustainable development impacts for green tourism, and target 14.7 identifies tourism as one of the tools that, by 2030, can sustainably contribute to increasing the economic benefits to Small Island developing States and least developed countries [39].

In this context, CE is increasingly proven in the literature to play multiple key roles in the global implementation of SDGs, as it promotes resource and energy conservation, waste prevention, and pollutant emission reduction and, at the same time, contributes to preserving resource availability, human health, and ecosystem quality. The link between SDGs and CE has been widely explored in the literature, given its relevance in the global process of ecological transition, and will continue to be so in the future [43]. Results achieved thus far tend to question the way CE promotes economic growth, whilst protecting the environment and society [41]. Scholars agree on the n. 12 to be the SDG which CE is primarily connected with [40,41], though authors like Rosato et al. [44] claim that given the lack of sufficient studies, future research is desirable to explore and generate new knowledge on the links between SDGs and tourism.

Under this perspective, consistently with the aim and scope of this article, from an in-depth analysis of the 17 SDGs, this section was conceived to explore their interconnections with the tourism industry, in the CE context. Doing so allowed this article's authors to

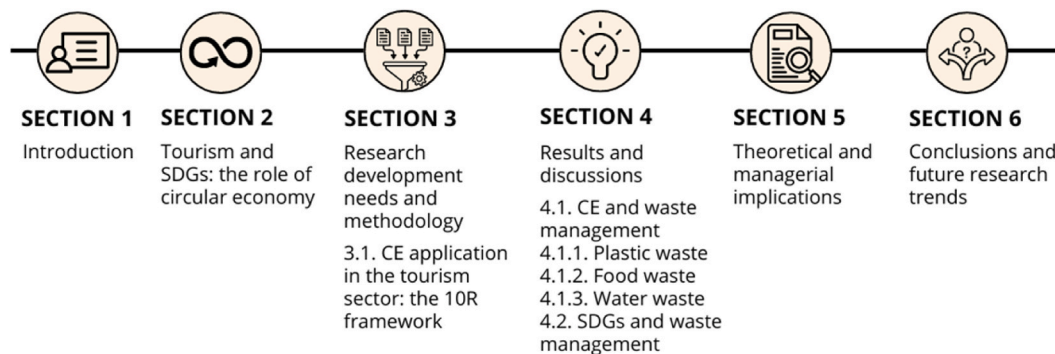


Fig. 1. Structure of the article.

demonstrate that from SDG 12, which expresses the principles of a sustainable CE, it is possible to achieve directly and indirectly all other SDGs in the tourism sector. SDG 12 can be regarded as directly interacting with SDG 8 and SDG 14 (as shown by the red lines in Fig. 2), as it specifically calls for massive waste prevention, recycling rate increase, and material consumption reduction, which is all about goals being achievable through a shift to sustainable CE business models [45]. Under this perspective, assessment methodologies and tools, like the Life Cycle Impact Assessment (LCA), are increasingly needed to explore the relevant economic and environmental aspects of circularity and sustainability implementations in the tourism sector [46]. Doing so will turn into encouraging the promotion of sustainable economic development and job creation in tourism (SDG 8) and the ecological and physical protection of oceans and their resources, for sustainable tourism development (SDG 14).

Achieving SDG 12 in the tourism sector, which means complying with the CE principles and features, could lead, however, to directly achieving other SDGs (light blue lines in Fig. 2), namely:

- SDG 7, by using clean energy sources like those produced from biomass residues and food waste through small-scale anaerobic digestion plants [47];
- SDG 11, with infrastructures supporting sustainable transports, which guarantee access to sustainable and circular mobility in tourist destinations [48];
- SDG 13, by assessing and mitigating the climate change impact of tourism [49];
- SDG 6 as, in the context of sustainable water management, wastewater can be treated through constructed wetlands and reused for irrigation purposes in agri-tourism facilities [50–52];
- SDG 9, with the implementation of investments in infrastructure improvement and the promotion of innovations in the tourism sector [53];
- SDG 15, by adopting measures to reduce the pressure on the environment, and to respect the earth's carrying capacity [46]; and, finally
- SDG 17, by creating tourism networks and partnerships between the actors of the sector, supporting the sustainable tourism destination [54].

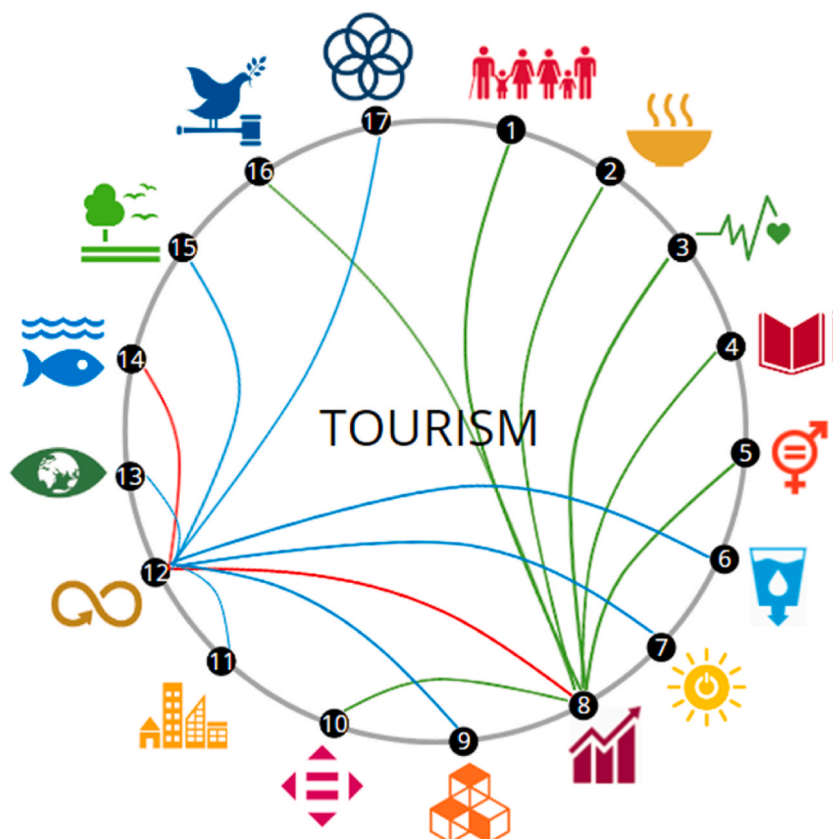


Fig. 2. SDGs interaction with CE in the tourism sector.

Note: The red lines directly connect SDG 12 with SDGs 8 and 14. The blue lines directly connect SDG 12 with SDGs 6, 7, 9, 11, 13, 15, and 17. Then, the green lines indirectly connect SDG 12 by SDG 8 with SDGs 1, 2, 3, 4, 5, 10, and 16.

Source: personal elaboration by the authors.

Moreover, considering the aforementioned SDG interconnections, by promoting new decent job positions and economic growth, SDG 8 has the potential to help to indirectly achieve other SDGs (as the green connections present in Fig. 2). This can be done, by contributing to reducing poverty (SDG 1) and fighting against hunger (SDG 2), allowing for equal gender opportunities (SDG 5), and providing a quality education that is accessible for all (SDG 4) [46,55]. In this way, circular tourism will guarantee inclusivity and equality, by contributing to tolerance and multicultural understanding (SDG 16) [56]. Furthermore, from SDG 8, sustainable economic development will lead to reducing income inequalities among countries (SDG 10) [57], and to promoting people's life satisfaction and physical and psychological well-being (SDG 3) [58].

According to Rodríguez et al. [12] and Boluk and Rasoolimanesh [59], it can be concluded that sustainable tourism directly and indirectly interacts with all SDGs, and so can play multiple active roles in the fight against climate change, resource overexploitation prevention, and global environmental pollution. Finally, in line with previously published literature studies like Scrucca et al. [60] and Raman et al. [61], findings from the analysis carried out by the authors in this section confirmed the central predominant role that SDG 12 plays in achieving all other SDGs. This reads as implementing CE paths being proven as the key strategy for a holistically sustainable resilient and future-proof transition of the tourism industry. It is, however, important that, to be successful, any change made in that direction duly considers the business context, external trends, desired market positioning, target customers, core capabilities, strengths, and weaknesses of any organisation involved.

3. Research development needs and methodology

The objective of this work was not to perform a systematic literature review (SLR), which entails rigorous requirements with a scientifically based, transparent, and reproducible methodology [62]. That was, instead, to provide a comprehensive review of the literature driving circularity through waste management, with a quantitative and qualitative, smart, and reader-friendly approach. To the authors' knowledge, this is the first time that a review like this is published, that condenses such tourism-relevant issues to favour their analysis, understanding, and dissemination. According to the authors, this can be read as a sign of its novelty and of the valuable contribution that it could make upon publication, in terms of complementing the existing body of previously-published work. To perform this review, the authors followed the research scheme proposed by Ingrao et al. [37] and, accordingly, paid a lot of attention to evaluating the sources to ensure the information's value and relevance, using criteria such as accuracy, objectivity, and relevance.

To attain to its proposed goals, and to fill the existing gaps, the literature review which this article is based upon was split into two steps: the first was focussed upon previously-published reviews to highlight the difference over the here-presented one, whereas the second was conceived for reviewing and building upon the most effective strategies for sustainable CE implementations in the tourism sector.

For development of both review steps, the authors selected "sustainable development", "circular economy", "tourism" and "waste", to be the keywords that best represented the research content area explored in this study, consistently with its aim and scope. Those were searched by the authors in the fields of article title, abstracts and keywords within Scopus, as the latter is globally recognised to be one of the most comprehensive databases of peer-reviewed literature, storing the broadest range of published articles [52]. By limiting the bibliographical search to publications in scientific journals and to the English language use, a total of twenty-six articles was found, that was distributed as follows: eighteen were original research, and eight were reviews. To create a relevant review sample that enabled meeting each step's aim, the authors performed a screening of the articles found, based upon their objectives and findings. Doing so made it possible for the authors to extrapolate the reviews of Rodríguez et al. [12], González-Sánchez et al. [63], Herrera-Franco et al. [35], Fadeeva and Van Berkel [64], and Margeta [65] that, so, were considered for this first review step development. Those reviews' authors have, overall, explored the way applying the CE principles to waste management can help turn tourism into a green version, that minimises negative impacts and promotes environmental conservation, cultural preservation, and social responsibility. In particular, Rodríguez et al. [12] analysed the correlations between CE and tourism and highlighted the importance of doing elevated research in implementing CE actions in agriculture to develop rural tourism; using renewable energy for a sustainable circular-based tourism economy; and finding the most feasible and effective ways to achieve all 17 SDGs. Finally, they recognised waste generation to be a very important aspect to consider within the touristic production value chain.

González-Sánchez et al. [63] performed a bibliometric analysis to explore the nexus between CE and tourism and concluded that mobility and waste management are the main topics to be addressed. In addition to this, five main clusters emerged from their analysis, that are innovation and eco-efficiency, management of sustainable tourism models, achievement of the SDGs, circular mobility, and circular waste management. With special regard to this one, González-Sánchez et al. [63] highlighted that the CE promotes responsible waste management in tourist destinations, though the majority of their review sample articles have mainly focussed upon actions for sustainable solid waste management. Conversely, Herrera-Franco et al. [35] conducted a SLR on waste management in coastal areas to valorise solid waste by adopting different sustainable strategies, such as the reduction in consumption, reuse, separation at source, recycling, differentiated collection, composting, and energy recovery through incineration, which together reduce the amount of waste.

In a previous study, Fadeeva and Van Berkel [64] discussed how to tackle marine plastic pollution through CE and the importance of technological and policy innovations, along with research and monitoring actions to mitigate and prevent it. Margeta [65] examined the challenge of managing wastewater on islands, which can be up to 10 times higher in the summer due to tourism, proposing the CE as a sustainable management system.

The review reported in this article differs from those previously published because, for the first time and in the form described above, it investigates which practical actions have been adopted thus far for accomplishing the R-strategies of the CE framework in the field of plastic-, food-, and water-waste management to achieve SDGs in the tourism sector. This is the core research need that the

authors wish to meet through this review article of theirs. To that end, the authors reviewed the objectives and findings of the aforementioned eighteen original-research articles, to extrapolate those reporting strategic actions taken for CE implementations in the tourism sector. The authors then analysed those actions against the CE framework to understand which of the 10R-strategies had been accomplished, and which of the 17 SDGs had been achieved.

In doing so, the authors paid a lot of attention upon highlighting the climate change adaptation or mitigation strategies that had been investigated in those reviewed articles.

Overall, the way this review article was conceived and developed made it possible for the authors to address potential weaknesses by carefully evaluating and critically summarising the information, going beyond simple literature descriptions to develop a clear and comprehensive picture of the most relevant issues related to CE, SDGs, and waste management.

3.1. CE application in the tourism industry: the 10R framework

This subsection was dedicated to describing the 10R framework, which is a framework of strategies that put in place the key CE features of enhancing product manufacturing efficiency, sharing products to make their use intensive, and slowing and closing the resource loops [66]. The 10Rs, depicted in Fig. 3, are aimed at favouring the process of transitioning from a linear to a circular economy both with regard the technological and biological cycles, and were assigned three differently coloured faces, based upon how close that strategy, or that category of strategies, is to the circular approach, in the sense that it more or less fully expresses its features.

Those strategies can be classified under the following three strategy categories:

- R0-R2 (with the dark green smiling face), which are characterised by smarter product manufacture and use, and so most fully express the CE concept;
- R3-R7 (green smiling face), which promote extending the lifespan of products and their parts;
- R8 and R9 (light green face), are based on material recycling and energy recovery of post-use products, which can also be considered part of linear economy business models [19,20].

Those strategies could also be classified based upon their capacity to generate an adaptation to or a mitigation of climate change. According to Simpson et al. [67], mitigation measures involve “technological, economic and social changes and substitutions that lead to emission reductions”, whilst adaptation solutions imply “an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities”. Both adaptation and mitigation policies are equally important and urgent to address climate change and other related environmental challenges like water scarcity and abiotic element availability [37,68]. In spite of this, based upon their definitions, mitigation measures are aimed at long-term solutions, whilst adaptation strategies seek short-term solutions [69]. To that end, the more mitigation strategies are implemented now, the fewer adaptation measures are needed to be adopted in the future, since actions are made upstream. Summing up, in Fig. 3, the dark

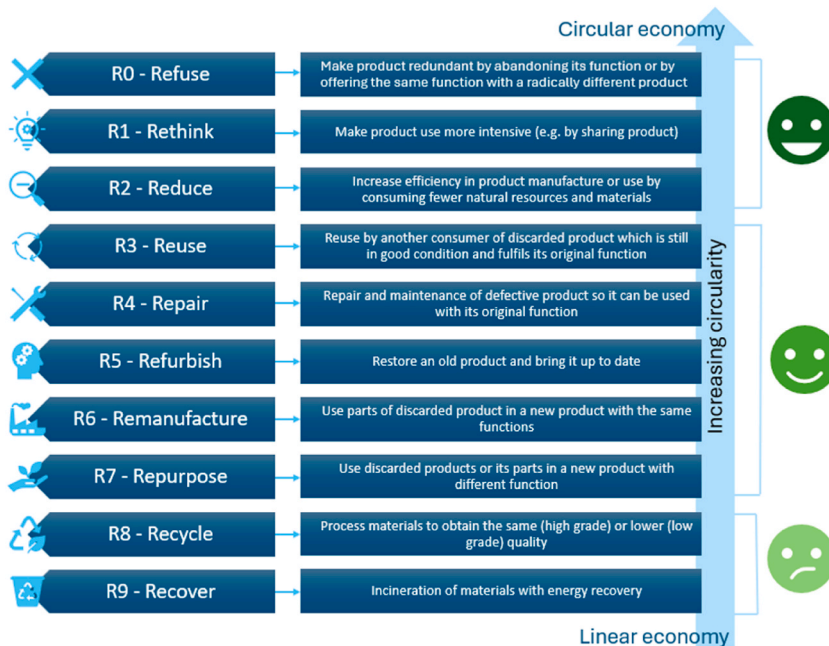


Fig. 3. Framework of the 10R of circular economy. Source: Adapted from Kirchherr et al. [19] and Potting et al. [20].

green smiling face represents the best CE strategies, which allows for mitigation actions, whilst the light green face is nearer to linear rather than circular model and represents an adaptation measure, and the green smiling face is in the middle between mitigation and adaptation actions.

Starting from the 10R framework, as explained above, the authors searched the literature for strategies relating to each R and waste considered, to show whether they are effective in achieving the sustainability objectives.

4. Results and discussions

In this section, from the review of the second-step sample, the present study collected CE practices and solutions on plastic, food, and water waste from previously-published studies. By doing so, the key CE-based R10 strategies applied to the tourism industry have been discussed, and the environmental and socio-economic benefits have been highlighted. Then, the SDGs achievable through waste management have been identified.

4.1. CE and waste management

Despite the limited studies and empirical research on CE in the tourism sector [24], different authors have identified which CE strategies can best adapt to the tourism sector to achieve sustainable development [5]. This section was conceived to offer an overview of the 10R strategies that can be implemented for the greening of the tourism industry by operating on the management of plastic, food, and water waste. As detailed in the methodology section, the articles were examined to determine the qualitative and quantitative evidence of the economic, social, and environmental benefits or drawbacks of implementing 10R strategies in the tourism sector, highlighting how sustainability in waste management can be achieved through CE applications.

4.1.1. Plastic waste

Thanks to its versatility and low price, plastic has become ubiquitous in daily life and production, especially in the tourism industry [70]. However, the increase in plastic waste production is one of the main negative externalities related to this sector [71] since among the different solid wastes generated, plastic-related wastes are considered the most pollutants [36]. This material contains, indeed, economic and environmental downsides, that mainly derive from fossil-fuel-derived plastics contributing to GHG emissions during the extraction, production, and processing stages [72]. Moreover, every year, millions of tons of post-use plastics end up in landfills where they are burned or leaked into the environment [73]. Despite those environmental problems, plastics have a series of benefits, mainly related to product containment and protection, that make them one of the most widespread packaging materials that are present in daily life. This is why, according to this article's authors, it is practically impossible to imagine a plastic-free world, but medium- and large-scale improvement strategies can be made to make this industry more sustainable. From this point of view, according to the EU Action Plan on the Circular Economy, the CE model establishes a more sustainable production and consumption system in which, by closing the loops, plastic is kept longer in production cycles and can be used repeatedly, thus reducing waste, marine litter, and GHG emissions [74]. Given this, plastic is currently the only material particularly addressed in the framework of the EU's circular economy strategy.

Based upon the 10R framework, the CE principles focussing on plastics can be described with the following strategies, according to Ellen MacArthur Foundation [73] and other literature studies like de Oliveira et al. [71], and Septiariva et al. [75]:

- *Reduce*: with the elimination of all problematic and unnecessary plastic items,
- *Rethink*: by continuous innovation that leads to increasingly performant and sustainable materials,
- *Reuse*: with the creation of the circulation of all plastic items,
- *Recycle*: by turning waste into zero-burden resources from which to extract the materials they are made out of, thereby obtaining secondary materials that, then, can be processed into value-added commodities,
- *Recover*: by processing plastic waste into energy through incineration and pyrolysis.

Concerning recycle- and reduce-related strategies, the specialised literature is rich in studies proving the benefits of CE principles application to produce new added-value commodities. By way of example, Ingrao and Wojnarowska [76] documented that whether recycled polyethylene terephthalate (PET) is utilised in 50 % weight for manufacturing of new PET bottles for water packaging, a 20% reduction of the overall environmental damage could be obtained.

As a result of the *rethink and reuse* strategy, in tourism facilities, some of the solutions to mitigate plastic waste concern the changing from the plastic cover of slippers to recycled paper, from plastic key cards to wooden or digitalised keys, and from single-use items to refillable dispensers, for example, for body cleansers [77].

The economic and environmental benefits of transitioning to a circular economy model in plastic management in tourism can be demonstrated by delving into data-driven insights. The hotel industry produces annually 150 million tons of single-use plastics [78]. Moreover, plastic waste produced in the Mediterranean Sea increased by up to 40 % in the summer months [79], and it is due to the intensity of tourism, whose seasonality makes destinations vulnerable [80].

Through CE implementation, Sujai and Juwana [81] highlighted that the XYZ Bandun Hotel in Indonesia was able to save their shopping expenditure costs of up to \$ 54 per day by replacing single-use packaging with refillable ones. In addition to economic benefits, at Accor hotels worldwide, the reduction of 300 tons of single-use plastic prevented roughly 980 tons of CO₂ emissions from being released into the environment [82].

4.1.2. Food waste

In the tourism industry, gastronomy is an indispensable attraction for tourists as more and more people use culinary criteria to choose a desired destination to discover local culture [83]. However, food waste nowadays is a global substantial problem that exists due to several factors in the food supply chain, from production to consumption [84]. Statistically, a third of the food produced globally (which is around 1.3 billion tons per year) is becoming lost or wasted annually, and it is equivalent to the quantity of food required to feed 870 million people [85]. Furthermore, food waste has hidden negative consequences for the environment, which include GHG emissions, land use change, biodiversity loss, and increased water scarcity [37]. When food decomposes in landfills, it releases methane (CH₄), that is a GHG having a 25-time higher capacity of trapping heat in the atmosphere than carbon dioxide (CO₂), with an 87 % contribution to global warming that is nearly equal to that of global road transport emissions [86,87]. As a result of this, finding a way to process and consume foods responsibly and reduce food waste is the most urgently needed measure for the protection of biodiversity, climate, ecosystem quality, and human health. In this context, the CE model can create economic, environmental, and social capital rather than merely reducing harm [88].

Based on the 10R framework and according to the study by the Ellen MacArthur Foundation, and by Närvänen et al. [89], there are several CE strategies that tourism facilities can implement; those can be traced to the following:

- *Reduce*: with the reduction of food waste by providing food onsite, avoiding food overpreparation, and reprocessing food that is left unserved and is still safe for humans, or by donating that food to people in need through charities,
- *Recycle*: by turning food waste into compost, or into bio-based materials,
- *Recover*: with the generation of energy from leftovers,
- *Reuse*: by using food waste as a resource for animal feed.

Concerning reduce-related strategy, zero-kilometre foods can help to reduce waste for several reasons. For instance, short transportation distances allow tourism industries to order quantities of food based on actual demands, thereby reducing the risk of overstocking and resulting in food spoilage and, at the same time, achieving fresh and seasonal products [90]. Whereas agri-tourism can produce and supply their food to their customers with a farm-to-fork approach [91]. This will not only support the local economy and community engagement but will also contribute to the broader movement toward responsible and sustainable tourism that reduces food waste generation. It is also important to educate and engage visitors and workers about more conscious consumption because knowledge and awareness of CE strategies could encourage to pursuit of sustainable behaviour and practices [92].

In their article, Juvan et al. [13] documented waste from tourism and hospitality to be globally composed as follows: 37%–72 % organic waste, 6%–40 % paper and cardboard, 5%–15 % plastic, and 3%–14 % glass. Therefore, the organic food waste that is inevitably produced (such as vegetable scraps, fruit peels, coffee grounds, and eggshells) could be reused by recycling strategy by creating a sustainable loop to produce compost which can be applied as a natural amendment that, by providing nutrients, improves soil fertility and structure, increases water retention, and promotes plant development [90,93]. Furthermore, it is also possible to

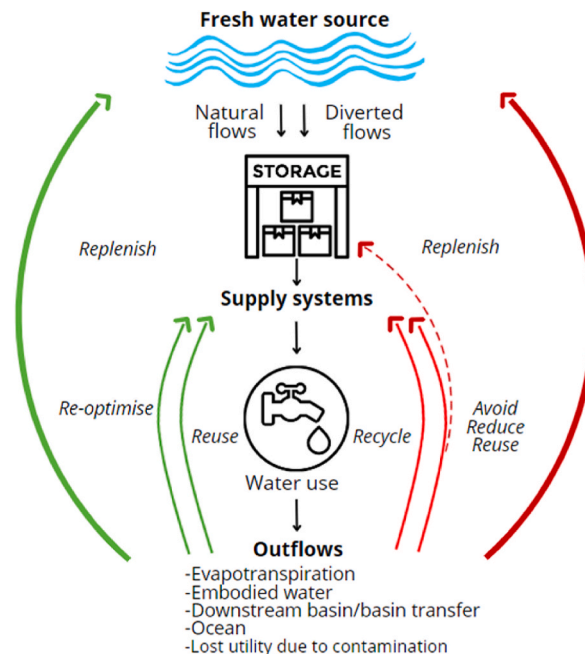


Fig. 4. Water and circular economy.

Source: Adapted from Ellen MacArthur Foundation [99].

generate biogas from food waste by using anaerobic digestion [94]. This recover strategy provides a dynamic and environmentally beneficial option that matches perfectly with the principles of a sustainable CE, as it serves as a renewable energy source and creates digestate with the same application purposes and benefits of compost [93,94].

As highlighted in the study by Camilleri [90], CE applications contributed both to reducing food waste and to increasing revenues, by implementing a food waste prevention campaign, that allowed organic waste to decrease by an average of 16 % in two hotels in Lisbon, and by 39 % in three hotels in Tenerife over five months. Furthermore, selling surplus food from a sharing economy perspective leads to an increase in revenue of about 2–6%. Otherwise, donating surplus food leads to saving around 7000 dollars a month in waste transportation costs.

4.1.3. Water waste

Water is a precious and indispensable resource for all creatures living on this planet called Earth [37]. However, currently, wastewater or water pollution is one of the alarming concerns worldwide [38]. The tourism industry is facing an increasing crisis due to the lack of water management measures, causing shortages, waste, and pollution of water resources, leading to environmental pollution, and disrupting the harmony of ecosystems [37,95]. Following the report of the European Environmental Agency [96], tourists can contribute up to 9 % of water use annually in the EU, whilst in 2021, the Travel and Tourism sector was responsible for around 134 billion m³ of freshwater withdrawals globally [97].

The most common reason for water consumption in tourism facilities can be considered as coming mainly from daily laundry operations, leisure activities, cleaning rooms, shower & bath, and food preparation [98]. The circular approach is the most suitable model, to manage water systems for long-term sustainability and minimising waste. From a system perspective according to the Ellen MacArthur Foundation [99], the Butterfly System Diagram (Fig. 4) can be used to study the Circular Water Economy. The left side of the diagram shows the natural state of water circulation without any human-caused activity, whereas the right side shows the human-managed system in which human activities have disrupted the inherent circulation of water flows. This happens when humans: i) consume fresh water at a rate that exceeds its natural replenishment capacity; ii) increase wastewater through inefficient irrigation and distribution techniques; iii) pollute water sources, thereby reducing their usability for other purposes [99].

Therefore, to minimise those consequences, with the suggestion of the Ellen MacArthur Foundation [99], Margeta [65], and Coelho et al. [100], instead of wasting water and discharging polluted wastewater into the environment, tourism facilities can apply CE for improved water management, through the following strategies:

- *Reduce*: through continuous innovation and optimisation of allocation and management of water resources, also improving the efficiency of the water distribution network, it will be possible to reduce unnecessary water consumption and water leaks.
- *Recover and Reuse*: by reclaiming water, for example by harvesting rainwater from rooftops for gardening irrigation,
- *Recycle and Reuse*: with systems for wastewater recycling, such as recycled grey water for flushing toilets which will allow water savings.

Water leaks, together with evaporative losses, are, in fact, a significant problem that requires attention in the hospitality sector, as they contribute an average 20 % of water consumption [98]. To put reduction strategy in place, businesses also need to train employees, provide guidelines on water conservation measures, and encourage them to promptly report leaks or water-related problems. Additionally, it is important to educate and encourage customers to participate in water conservation practices, like reusing towels and bed linens, and checking and turning off faucets when not in use [4]. Opportunities to recover water for reuse within the facility can be explored, such as collecting rainwater for use in landscaping, watering ornamental plants or other non-potable applications, as also recommended by Nyakundi et al. [101] and Ingrao et al. [37]. Another example regards nutrient recovery from wastewater for agricultural purposes, as it allows for reducing chemical fertiliser applications, and related environmental impacts [102].

Furthermore, it is important to implement initiatives that allow for avoiding using drinking water when it is not needed. By way of example, those include treating and recycling grey water into water useable for activities, such as toilet flushing, heating/cooling systems, and garden watering which do not require pure drinking water [103]. Furthermore, given that 10–20 % of energy consumption in hotels is for heating the water used for hygiene services, responsible consumption of that water may result in significant heating-energy savings and obviously in water savings [98].

Since 2016, the Accor group has been operating with a policy designed to support the transition to CE, by managing and reducing water consumption in its hotels which, overall, allowed them to reduce water consumption by 6.1 % and GHG emissions by 8.3 % [40]. Whereas, in Birmingham, the ETAP Hotel installed a rainwater harvesting system which helps to save up to 780 m³ of drinking water annually, equivalent to 5–10 % of consumption [9]. Moreover, Coelho et al. [100] estimated that treated wastewater reuse can make it possible for hotel facility managers to save 20 % of water consumption.

4.2. SDGs and waste management

If carried out to comply with the principles and features of a sustainable CE, waste management can effectively support multiple SDG achievements, thus contributing to sustainable development pathways in the urban and rural context with a holistic integrated approach [104,105].

For this research development, from the review of the articles of Fuldauer et al. [106], Ghafari [107], Herrera-Franco et al. [35], and Voukkali et al. [33], combined with an in-depth analysis of the 2030 Agenda, the authors identified in Table 1 the SDGs that are mostly connected with a sustainable and circular waste management (SCWM), both directly and indirectly. It is highlighted that all the

SDGs explicitly mention or implicitly guarantee SCWM systems, by allowing for environmental, social, and economic advantages.

Finally, [Table 2](#) shows a summary of the CE-based strategies that are most effective in addressing the challenges coming from the management of the three tourism-representative waste streams considered in this article. Such was complemented by the authors with an indication of the environmental and socioeconomic benefits resulting from those strategies' application and of the achievable SDGs.

Overall, from the review of the specialised literature and results shown in [Table 2](#), the study interestingly documented that the most common strategies used in the tourism industry to reduce the environmental pressure from the management of plastic, food, and water waste are *Reduce*, *Reuse*, *Recycle*, and *Recover*. Specifically, for adaptation measures, the most widely adopted waste management strategies are both *Recycle* and *Recover*. Whilst for mitigation measures, the most frequently employed strategy is *Reduce*, and only for plastic waste, the *Rethink* strategy is also employed. To the authors' opinion, this recalls the concepts of material selection and eco-design and, downstream, a vision of a global economy in which plastics never become a waste, thus contributing to the shift to a new circular-based plastics economy. From the review conducted, there is evidence that the most adopted CE strategies fall within the adaptation approach, namely recycle and recover. Those are aimed at providing short-term solutions that are close related to the concept of a linear economy and minimise harmful consequences to the environment and the health of human beings. So, it seems that just four of the 10 R-strategies are pursued for waste management improvement in the tourism sector, with a combined adaptation/mitigation approach. This highlights the need for long-term and mitigation solutions, that are more related to the R0-R2 strategy approach. Moreover, although adaptation solutions are more widespread, various environmental and economic benefits have emerged from the application of CE strategies, mainly related to the reduction of environmental negative externalities, resource over-exploitation prevention, and economic advantages. From these findings, it emerged that in the tourism sector, when it comes to sustainability, the social one is the least examined.

Concerning SDGs, through the CE, all the SDGs could be reached in the tourism industry. Furthermore, it is shown that sustainable and circular waste management could directly and explicitly, and indirectly and implicitly reach all the SDGs, allowing the sustainable transformation of this sector.

5. Theoretical and managerial implications

From a theoretical perspective, this literature review contributed to the existing body of knowledge, by exploring the CE strategies that are mostly feasible for application in the tourism industry with special regard to the management of plastic waste, food waste, and wastewater. Further, this research highlighted the pillar role of SDG 12 which allows to reach directly and indirectly all the other 16 SDGs, to guarantee a sustainable development of the sector. From the review of the key contributions published to-date in the literature, this article allowed to understand that CE research in the tourism sector is relatively new and has been gaining increasing attention worldwide. This is mainly because tourism is one of the main economic activities carried out by the mankind but, if not designed and managed in a sustainable and responsible manner, it can produce serious economic imbalances, severe social disruption and enormous environmental and cultural damage.

In addition to this, to the article enabled identifying that the most investigated R-strategies are *Reduce*, *Reuse*, *Recycle*, and *Recover*, and that more mitigation-related strategies need to be designed, developed and promoted. From the review, the authors also found that the CE strategies and initiatives that seem to be effective from a social, environmental, and economic point of view on touristic management, such as the mitigation of GHG emissions, waste reduction, increase in revenue whilst reducing costs. These results are relevant in the literature to guide analysis and future research developments, highlighting which areas and topics are most investigated

Table 1

Direct and indirect connections of SDGs with sustainable circular waste management.

| Sustainable and circular waste management | SDGs | Description |
|---|------|---|
| Explicitly and directly mentioned | 6 | By wastewater treatment and recycling |
| | 11 | Improving the life quality of a city, by integrating and increasing sustainable waste management |
| | 12 | By reducing waste generation by adopting CE strategies through prevention, reduction, recycling, and reuse |
| | 14 | Reducing marine pollution caused by uncontrolled plastic waste disposal. |
| Implicitly and indirectly achievable | 1 | Eradicating poverty providing waste management job opportunities |
| | 2 | Ending hunger and ensure access to food with food waste prevention |
| | 3 | Promoting well-being avoiding air, water, and soil pollution and contamination |
| | 4 | Ensuring quality education for waste management skills |
| | 5 | Guaranteeing gender equality and preventing discrimination in all stages of waste management |
| | 7 | With waste as a resource for energy production |
| | 8 | Promoting sustainable and inclusive economic growth with the technological upgrading and innovation in waste management |
| | 9 | Developing sustainable and resilient waste management infrastructure |
| | 10 | Reducing inequalities by addressing social and environmental issues of waste management |
| | 13 | Promoting waste management systems to tackling climate change |
| | 15 | Reducing pollution caused by uncontrolled waste disposal to preserve the ecosystem |
| | 16 | With a waste management system which ensures responsive, inclusive, participatory, and representative decision-making at all levels |
| | 17 | Encouraging the collaboration of every sector and country to successfully achieve the sustainable waste management |

Table 2

Summary of CE strategies applied to the tourism industry concerning plastic, food, and water waste, benefits of CE implementation, and achievable SDGs.

| 10R framework | Plastic waste | Food waste | Wastewater |
|-----------------------------|---|--|---|
| R0: Refuse | | | |
| R1: Rethink | 😊 | | |
| R2: Reduce | 😊 | 😊 | 😊 |
| R3: Reuse | 😊 | 😊 | 😊 |
| R4: Repair | | | |
| R5: Refurbish | | | |
| R6: Remanufacture | | | |
| R7: Repurpose | | | |
| R8: Recycle | 😬 | 😬 | 😬 |
| R9: Recover | 😬 | 😬 | 😬 |
| Benefits from CE strategies | Reduction of GHG emissions and economic costs | Food waste reduction and revenue increase | Reduction of water and energy consumption, and of GHG emissions from their production |
| Achievable SDGs | 1, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17 | 1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, 15, 16, 17 | 1, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 15, 16, 17 |

and where gaps and unexplored aspects may be found.

From a managerial perspective, this article offered valuable insights, as it overviewed for the practices that embracing CE principles and can be followed to make tourism greener. Managers can use this research's findings to help their companies transition to a new, circular, and sustainable business approach, thereby increasing their competitiveness through the adoption of sustainable practices.

Overall, the authors believe that this article can allow tourism industry managers, and other stakeholders, to better understand the advantages of applying CE principles to meet the 17 SDGs of the Agenda 2030, by providing them with comprehensive circular information on the relevant environmental, social, and economic sustainability issues. In doing so, from the review of the 10R framework, the work described here can assist managers and entrepreneurs in applying the CE strategies that are most valid for the greening of the tourism sector, unlocking its potential, educating them to the added value of the environmental impact mitigation approach.

The findings of this research can be beneficial for local tourism managers, policymakers, key sector stakeholders, and decision-makers in determining where to allocate resources and taking appropriate and timely actions to mitigate the effects of their activities. Consequently, this research will support stakeholders and tourism firms in developing sustainable and circular practices and strategies.

6. Conclusions and future research trends

The tourism sector, as one of the most developed industries in the world, on the one hand, allows for social, economic, environmental, and cultural benefits, on the other hand, causes, amongst others, GHG emissions, waste management difficulties, and high resource consumption. CE is considered as a possible solution to mitigate those externalities, whilst achieving all the 17 SDGs and therefore guaranteeing sustainable development in tourism. It is known that the application of CE is becoming increasingly popular around the world, promoting self-reliance, resource optimisation, sustainability, and environmental-friendly development.

The contribution of this study is twofold. Firstly, SDG 12, which is the one relating to the CE, shows the possibility of interacting and connecting directly and indirectly with all the other SDGs, guaranteeing sustainable and circular development of this sector. Secondly, this study captures the key CE strategies and initiatives currently arising in the tourism sector around plastic waste, food waste, and wastewater to mitigate the environmental impacts deriving from this sector whilst guaranteeing socio-economic and environmental advantages. This research revealed that, within the 10R framework, the strategies applied in this sector are mainly based on the concepts of Reduce, Reuse, Recycle, and Recover. Moreover, the economic and environmental benefits, deriving from the application of those strategies to the tourism industry, are related to the reduction of GHG emissions, waste, and economic costs, the increase in revenue, the sustainable resource management.

The limitations of this study concern the topics discussed, which do not represent all the impacts that the sector generates, although plastic, food, and water issues are considered amongst the most impactful externalities. Therefore, these strategies could be considered as a starting point from which to start the transition towards circular tourism. Findings from this literature review form the essential theoretical basis for future practical applications from the authors' side in such an interesting and up-to-date research content area, with the main aim of measuring the environmental, social, and economic benefits of CE applications in the tourism sector. In addition to this, the need emerged for more in-depth studies exploring other Rs of the 10R framework to this sector from the theoretical point of

view and by translating the knowledge into practice, showing the benefits (or disadvantages) of implementing mitigation rather than adaptation measures, which have already been widely discussed in the literature. Thus, this study could be valuable for academics to guide future research to explore these aspects.

Finally, the authors believe that findings from this study of theirs will assist tourism managers and other stakeholders in making appropriate improvements, practices, and strategies to increase the sustainability, circularity, and attractiveness of this entire industry.

CRedit authorship contribution statement

Rossana Strippoli: Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Conceptualization. **Teodoro Gallucci:** Writing – review & editing, Validation, Supervision. **Carlo Ingrao:** Writing – review & editing, Writing – original draft, Validation, Supervision, Investigation, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Prof. Carlo Ingrao reports a relationship with Elsevier Ltd that includes: board membership. He is, in fact, currently serving as an associate editor of Heliyon Environment. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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