

## Circular Economy in tourism: Challenges and opportunities for a sustainable future

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**Abstract:** The aim of this research is to identify structural gaps in consumption patterns and sustainable practices between developed and emerging countries through a comparative and systematic analysis of circular economy (CE) implementation in the tourism sector. Tourism, as one of the world's largest industries, faces the significant challenge of balancing growth with environmental sustainability. The (PRISMA®) protocol was used, which resulted in the selection of 52 relevant articles. The findings reveal that most of the literature focuses on developed countries, where ecotourism, resource conservation and circular economy business models prevail. The transition towards a circular economy in tourism requires stakeholder collaboration, although barriers persist such as high investment costs, regulatory obstacles and resistance to change. Nevertheless, significant opportunities for sustainable innovation in the sector are identified.

**Keywords:** Barriers; Circular economy; Sustainable development; PRISMA review; tourism industry.

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**Cite:** Pacheco, M. E. T.; Mayorga, L. V. L.; Parra-Orobio, B. A.; Mejia-Parada, C.; Alvarez, J.; Saavedra-Pasaje, C. & Soto-Paz, J. (2026). Economía Circular en el turismo: Desafíos y oportunidades para un futuro sostenible. *Pasos. Revista de Turismo y Patrimonio Cultural*, 24(2), 391-411. <https://doi.org/10.25145/j.pasos.2026.24.026>.

## Economía Circular en el turismo: Desafíos y oportunidades para un futuro sostenible

**Resumen:** El objetivo del presente trabajo consistió en identificar las brechas estructurales en patrones de consumo y prácticas sostenibles entre países desarrollados y emergentes mediante un análisis comparativo y sistemático de la economía circular (EC) en el sector turístico. El turismo como una de las industrias más grandes del mundo, enfrenta el desafío de equilibrar el desarrollo con la protección ambiental. Utilizando el protocolo (PRISMA®) se seleccionaron 52 artículos relevantes. Los hallazgos revelan que la mayoría de la literatura se centra en países desarrollados, donde prevalecen el ecoturismo, el ahorro de recursos y los modelos de negocio de economía circular. La transición hacia un turismo circular requiere la colaboración de los interesados, aunque persisten barreras como altos costos de inversión, obstáculos regulatorios y resistencia al cambio. No obstante, se identifican oportunidades significativas para la innovación sostenible en el sector.

**Palabras clave:** Barreras; Economía circular; Desarrollo sostenible; Revisión PRISMA; Industria del turismo.

### Acronyms

CE	Circular Economy	IQR	Interquartile Range
CHSB	Cornell Hotel Sustainability Benchmarking Index	LAC	Latin America and the Caribbean
CSPS	Circular Smart Production System	LCA	Life Cycle Assessment
DC	Developed Countries	LoRaWAN SDGs	Low Power Wide Area Network Sustainable Development Goals
DEA	Data Envelopment Analysis	SEM	Structured Equation Modelling
DWHR	Domestic Wastewater Heat Recovery system	TTDI	Travel & Tourism Development Index
GDP	Gross Domestic Product		
GHGs	Greenhouse Gases		
HWMI	Hotel Water Measurement Initiative		
IoT	Internet of Things		

## 1. Introduction

Tourism, a key sector of the global economy, faces the challenge of balancing growth with environmental sustainability. According to the World Travel & Tourism Council (WTTC, 2024), tourism is estimated to contribute US\$11.1 billion to global GDP and support nearly 348 million jobs by 2024. However, this rapid growth has raised concerns about its environmental impact, particularly in emerging economies (WTTC, 2024).

Traditional tourism is showing its limitations in terms of unsustainable resource consumption. An average tourist uses 350 liters of water per day, compared to 150 liters for a local resident, which accelerates the depletion of water resources and threatens the long-term viability of the sector (Kirchherr et al., 2018). Therefore, this dependence on natural resources constitutes a threat to their degradation and scarcity (Pan et al., 2018). In addition, the greenhouse gas emissions associated with tourism are significant. In 2016, the sector emitted 7.23 billion tons of CO<sub>2</sub>, accounting for 23% of total anthropogenic emissions (Wang & Wu, 2022). Passenger transport is responsible for 64% of the sector's emissions, with a projected increase of 21% by 2030 (Organización Mundial del Turismo, 2020). The global carbon footprint of tourism increased from 3.9 to 4.5 GtCO<sub>2</sub>eq between 2009 and 2013, accounting for nearly 8% of global greenhouse gas emissions (Lenzen et al. 2018). Therefore, tourism waste management poses significant challenges, including minimizing wastewater pollution, air degradation, and biodiversity loss (Gazta, 2018; Khan et al., 2020).

The circular economy (CE) is emerging as an alternative paradigm that offers promising solutions for tourism sustainability (Sun et al., 2023). This model seeks to promote a paradigm shift from linear economies by reincorporating valuable by-products into production chains (Costa et al., 2022; Kirchherr et al., 2017). While there are many benefits to the application of CE in the tourism industry, challenges need to be addressed for successful implementation. One of the main challenges is the integration of

networks and collaboration along the entire value chain (Mauss et al., 2023). This involves the adoption of new waste recovery and valorization technologies and the participation of stakeholders, including suppliers, tour guides, transport companies and tourists (Sigala, 2008). Effective collaboration among these stakeholders is fundamental to the success of CE strategies, as it allows for optimizing the use of resources and minimizing environmental impacts at all stages of the tourism process (Rodríguez et al., 2020).

Despite these challenges, CE models (such as collaborative models, closed-loop systems, and products as services) have the potential to improve the sustainability of tourism (Pamfilie et al., 2018). In this regard, Gössling et al. (2005) highlight the importance of developing business models based on the eco-efficiency of products or services. Similarly, Xu et al. (2022) point out the need for the greening of the tourism industry, which involves constraints and the coordinated development of models between the elements of a closed-loop tourism system. Other initiatives in the framework of closed systems or coordinated models include energy generation through anaerobic digestion systems, the use of biofertilizers, the recycling of materials, and the modification of buildings to make them bioclimatic (Abdou et al., 2020; Sakai et al., 2017).

On the other hand, achieving sustainability in tourism requires a holistic approach that includes the economic dimension, requiring its financial feasibility (Bux & Amicarelli, 2023); the social dimension, promoting equal opportunities and empowering local communities (Denu et al., 2023); and the environmental dimension, conserving resources, reducing pollution, optimizing water and energy consumption, and implementing responsible waste management (Halkos & Aslanidis, 2023; Khanam et al., 2023). The participation of suppliers, tourists, and local communities plays a critical role in the sustainable development of tourism (Xu et al., 2022). This interconnection between the tourism sector, the application of circular economy principles, and the participation of different stakeholders in the value chain is essential for achieving the Sustainable Development Goals (SDGs) (Li & Hunter, 2015). Various literature reviews have been developed on sustainability, tourism, and CE. Rosato et al., (2021) conducted a bibliometric analysis from 2015 to 2019 to determine the relationship between the SDGs and tourism. They emphasize that tourism companies can improve their competitive advantage by adopting sustainable practices, taking advantage of the positive externalities of transitioning to more sustainable business models. Rodríguez et al. (2020) conducted a critical literature review on the contribution of CE to the tourism sector, identifying gaps in the transition to circular models or the lack of knowledge generated on tourists and CE. Also, a bibliometric review of the relationship between digital technologies and circular tourism should be developed, highlighting its impact on CE and, consequently, on social aspects. Most of the literature reviews developed are bibliometric or critical, and there are few or no systematic reviews that reduce subjectivity, especially when we want to define research trends and knowledge gaps (Oviedo-Ocaña et al., 2022; Soto-Paz et al., 2017, 2023). In addition, the reviews focus mainly on developed countries of the European Union and, to a lesser extent, on emerging countries (Gabor et al., 2023).

To contribute to the knowledge of CE management in the tourism industry, this study aims to i) analyze data from the Cornell Hotel Sustainability Benchmarking Index (CHSB) of 2023 and identify trends in energy performance, water and carbon emissions in different types of hotels in developed and emerging countries; ii) identify global trends in CE research for hotel sustainability using the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) methodology, complemented with bibliometric tools using the specialized tool Bibliometrix®. To the authors' knowledge, this methodological articulation has not been developed in the scientific field to define trends and knowledge gaps in the tourism industry and CE. In addition, studies comparing CE between developed and emerging countries for this type of industry are scarce. This study could describe significant contributions to the field of hotel sustainability and future trends in CE research. The findings provide a valuable reference for identifying current research gaps and directions for research development that will guide industry practices and assist policy makers in developing effective strategies to promote CE adoption.

This research advances the understanding of CE in the tourism sector, revealing significant differences in eco-efficiency between advanced and emerging economies. Our findings reveal differentiated patterns of carbon and water footprints based on facility type and region, and show that successful adoption of circular models depends on the integration of regulatory frameworks, financial support, use of advanced technologies, and willingness to engage all stakeholders, including communities.

## 2. Methodology

### 2.1. Data Collection

A systematic review was conducted using the PRISMA methodology. This methodology is used in various fields of research and facilitates the analysis of data from databases. PRISMA was complemented with the bibliometric tool Bibliometrix® to identify research trends and perspectives in the field of CE in the tourism industry for both developing and emerging countries. This tool has been used in reviews on circular economy and solid waste management (Soto-Paz et al., 2017, 2023). The databases used were Web of Science® and SCOPUS®, which are considered the most comprehensive in the scientific field (Chadegani et al., 2013). However, they were supplemented with information from other databases such as Dimensions.ai® and Scielo®. The keywords used in this study were “circular economy,” “tourism,” “business models,” “sustainability,” “waste,” “emerging countries,” and “developed countries,” and the Science direct® thesauri were used to determine the feasibility of using these terms. The search equation was TITLE-ABS-KEY (circular AND economy AND tourism AND industry) AND (“developing countries” or “emerging countries”) and TITLE-ABS-KEY (circular AND economy AND tourism AND industry) AND “developed countries”.

### 2.2. Data Selection and Screening Criteria

The records collected from the databases were compiled into a CSV file. The following inclusion criteria were applied: i) presence of search terms in at least one of the main fields (title, keywords or abstract); ii) Only scientific articles were considered for inclusion, not reviews in the field, because they can introduce potential duplication of results in the metadata.; iii) Only works written in English were considered because it is an international language and the most widely accepted in the databases consulted.; and iv) limitation of the year of publication between January 2014 and March 2024 to define research trends and knowledge gaps. These criteria were based on previous research, such as that conducted by Soto-Paz et al. (2023). In addition, the snowballing technique was used to verify and find papers that were not found with the search equations. As a result, 52 articles were selected for analysis. Figure 1 illustrates the selection process of papers according to the PRISMA® methodology. In addition, we used the consolidated database of Ricaurte & Jagarajan (2021) for a comparative analysis of environmental resource consumption between developed and emerging countries. For this purpose, geographic maps showing the average water, carbon and energy consumption per square meter were created, using blue for developed countries and red for emerging countries, and box plots were constructed to analyze the information. This allowed patterns and differences to be identified, providing critical information for understanding and addressing global environmental challenges.

### 2.3. Data organization, structure and analysis

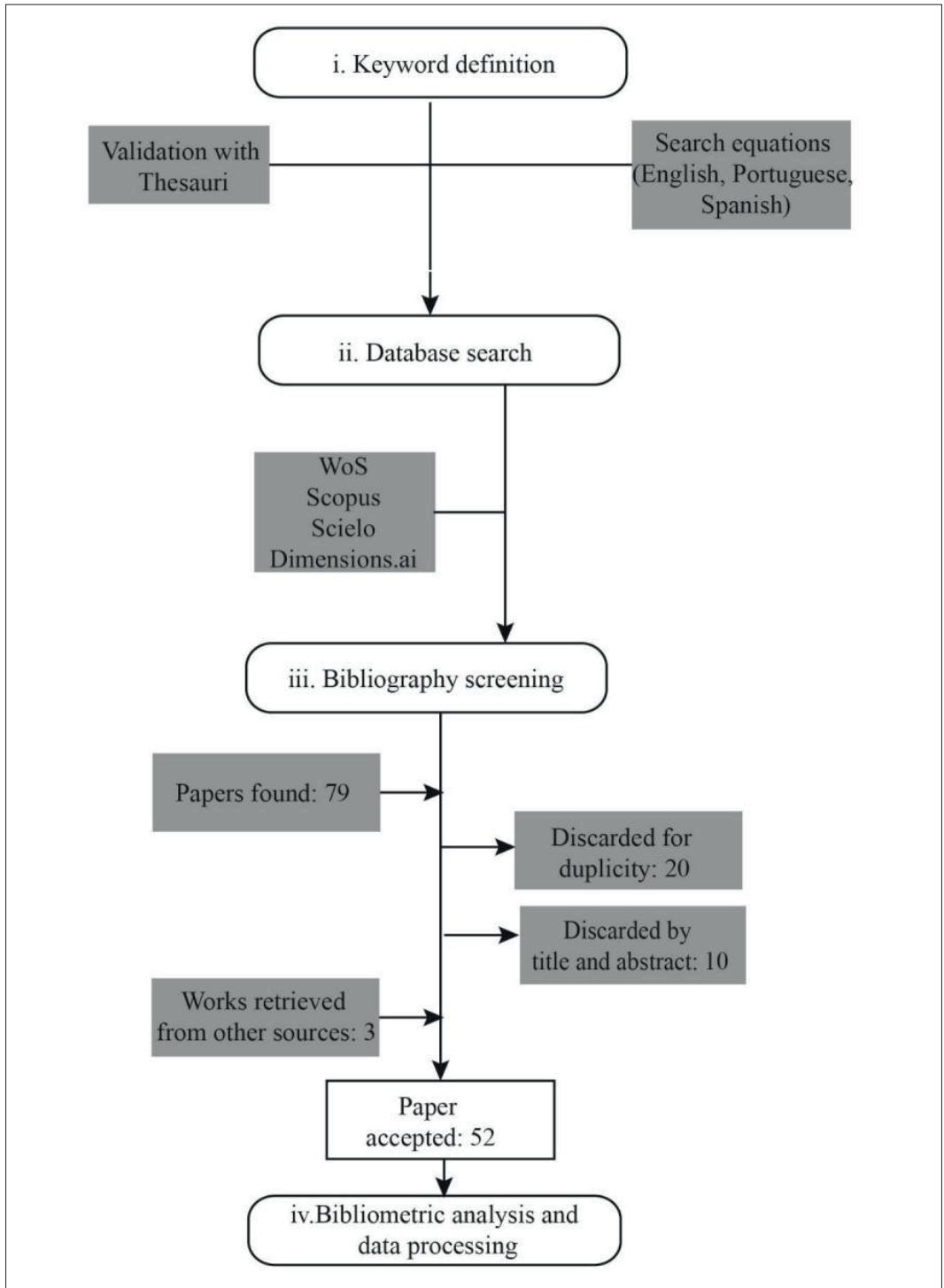
The refined database was organized in Excel®, where information on authors, year of publication, research objectives, business model, and type of tourism industry were collected. The information was complemented with estimated carbon and water footprint data from the Hotel Water Measurement Initiative (HWMI). This made it possible to establish a solid database to analyze the information systematically. In addition, the interquartile range (IQR) was used to identify outliers and the dispersion of variables.

The resulting database was organized in Excel® to collect information on authors, year of publication, research objectives, business model, and tourism industry type. The information was complemented with estimated carbon and water footprint data from the Hotel Water Measurement Initiative (HWMI). This provided a robust database for systematic analysis of the information. In addition, the interquartile range (IQR) was used to identify outliers and the dispersion of variables.

### 2.4. Data processing using bibliometric tools.

The information in the database was analyzed using the free package de R Bibliometrix®, which is widely used in literature reviews and bibliometrics. Bibliometrix® is a computer tool that uses the R programming language to perform bibliometric analysis using matrices. It has been used to identify scientific production and its distribution over time, to generate thematic maps, and to analyze research trends. These thematic maps are divided into four quadrants, allowing the exploration of driving, basic, emerging, or declining topics, as well as highly specialized or niche topics.

Figure 1: Selection process from 2014 to 2024 with PRISMA® methodology.



### 3. Results and discussion

#### 3.1. Worldwide overview of tourism

The recovery of global tourism is evident in the Travel & Tourism Development Index (TTDI) 2024, with an increase of 0.7% and improvements in 71 out of 119 economies since 2019 (World Economic Forum, 2024). However, this accelerated growth has raised concerns about its environmental impact, making sustainability an imperative for the hotel industry (Kuo et al., 2022). As shown in Figure 2, the CHSB indicates that carbon and water footprints vary by specific asset type, location type, and star rating.

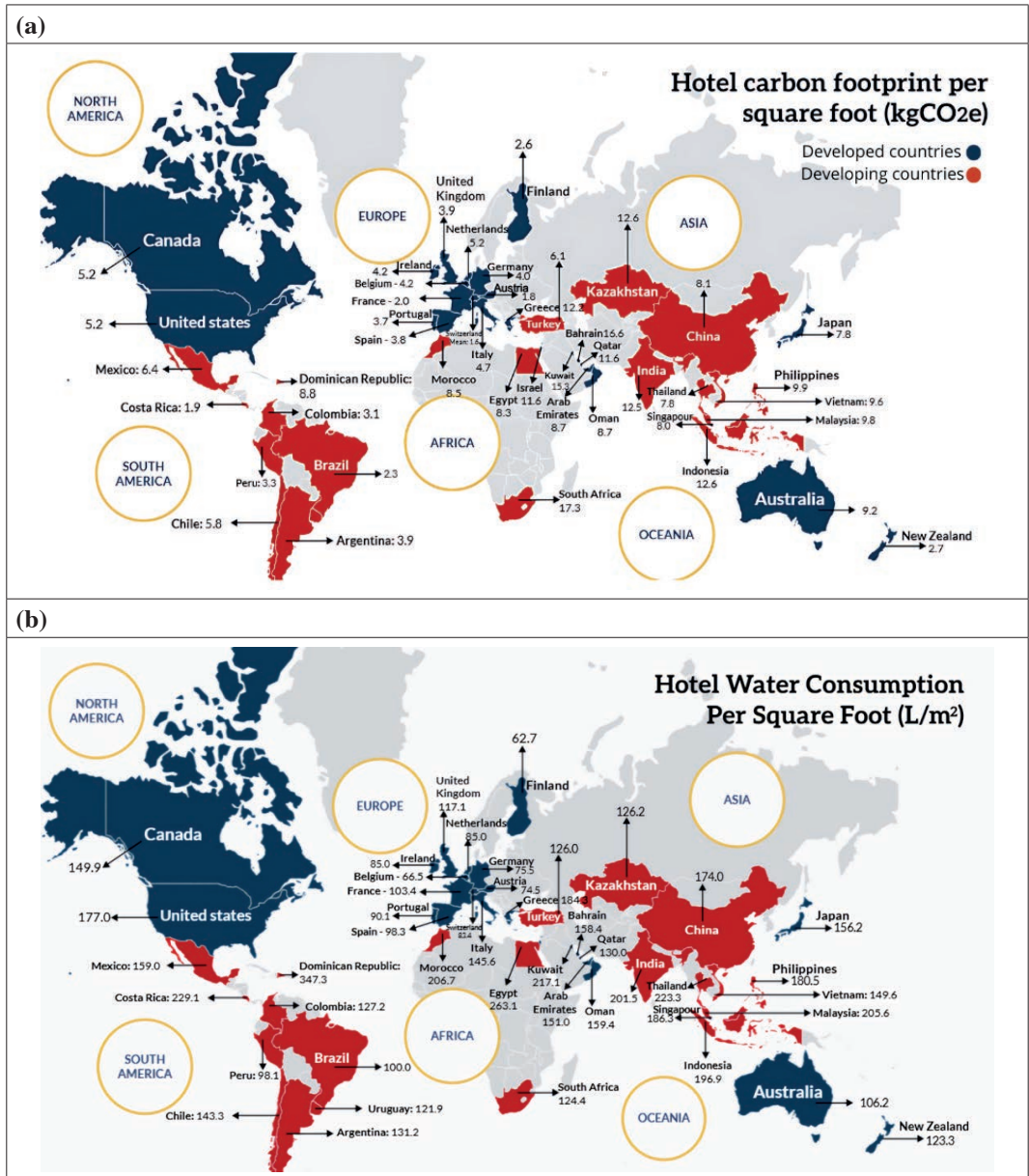
In developed countries, the carbon footprint (Figure 2a) ranges from 2.6 to 9.2 KgCO<sub>2</sub>eq, with higher values in Australia (9.2 KgCO<sub>2</sub>eq), Japan (7.8 KgCO<sub>2</sub>eq), USA (5.2 KgCO<sub>2</sub>eq) and Canada (5.2 KgCO<sub>2</sub>eq) compared to European countries (i.e. 2 to 4.7 KgCO<sub>2</sub>eq). The differences can be attributed to stricter regulatory frameworks in Europe for the implementation of sustainable practices, including the reduction of energy consumption and the adoption of CE principles in waste management (Camilleri, 2021). Therefore, regardless of the type of country, the ecological footprint of the tourism industry is recognized as a critical issue that requires prioritized attention (Ghosh et al., 2022). Gabor et al. (2023) confirm this trend in their study of 30 countries, including members and non-members of the European Union, using structural equation modeling (SEM). Their results show a causal relationship between tourism development and the increase in CO<sub>2</sub> emissions, highlighting the need for a paradigm shift towards innovative and sustainable strategies, especially in developing countries. Liu et al. (2022) extend this perspective by analyzing 70 developed and developing countries, confirming the direct correlation between tourism growth and the increase in CO<sub>2</sub> emissions. The authors propose the implementation of decarbonization strategies, the use of renewable energy for air conditioning, and the transition to carbon-neutral transportation as effective mitigation measures. Similarly, Santana et al. (2019) suggested that rainwater or graywater reuse practices for secondary uses should be used to minimize the water footprint of the hotel industry. The implementation of innovative waste management strategies, such as those of the European Union's URBANWASTE project in high-traffic tourist destinations, demonstrates the effectiveness of integrated approaches to mitigate the environmental impacts of urban tourism. These initiatives, which range from waste tracking, food donations, refillable water bottles, and composting of biowaste to energy recovery, reduce carbon footprints and optimize economic resources (Camilleri, 2021; Obersteiner et al., 2021).

In emerging economies, the carbon footprint of the tourism industry differs from that of developed countries. In Latin America and the Caribbean (LAC), the carbon footprint ranges from 2.3 to 8.8 kgCO<sub>2</sub>eq, in some cases higher than in developed countries, especially in Caribbean countries with higher GDP. In Africa, it ranges from 8.3 to 17.3 kg CO<sub>2</sub>eq, while in Asia it varies from 6.1 to 13 kg CO<sub>2</sub>eq. This disparity is related to nascent management practices in resource and service optimization, including electrical energy use (e.g., lighting, air conditioning, electronics), transportation (e.g., logistics and procurement), and solid waste management (Goffi et al., 2019; Guo et al., 2023; Hosseini et al., 2021).

The hotel industry in emerging markets faces management challenges in integrating CE practices. Despite some programs to reduce greenhouse gas emissions, the regulatory framework is often limited. The lack of educational programs, customer awareness, strict public policies, and government incentives for environmental practices and clean energy have a significant impact on carbon footprint (Alonso-Almeida et al., 2017). Further research is needed to improve stakeholder relations, understand their needs, and analyze the economic benefits of industrial symbiosis within the CE framework.

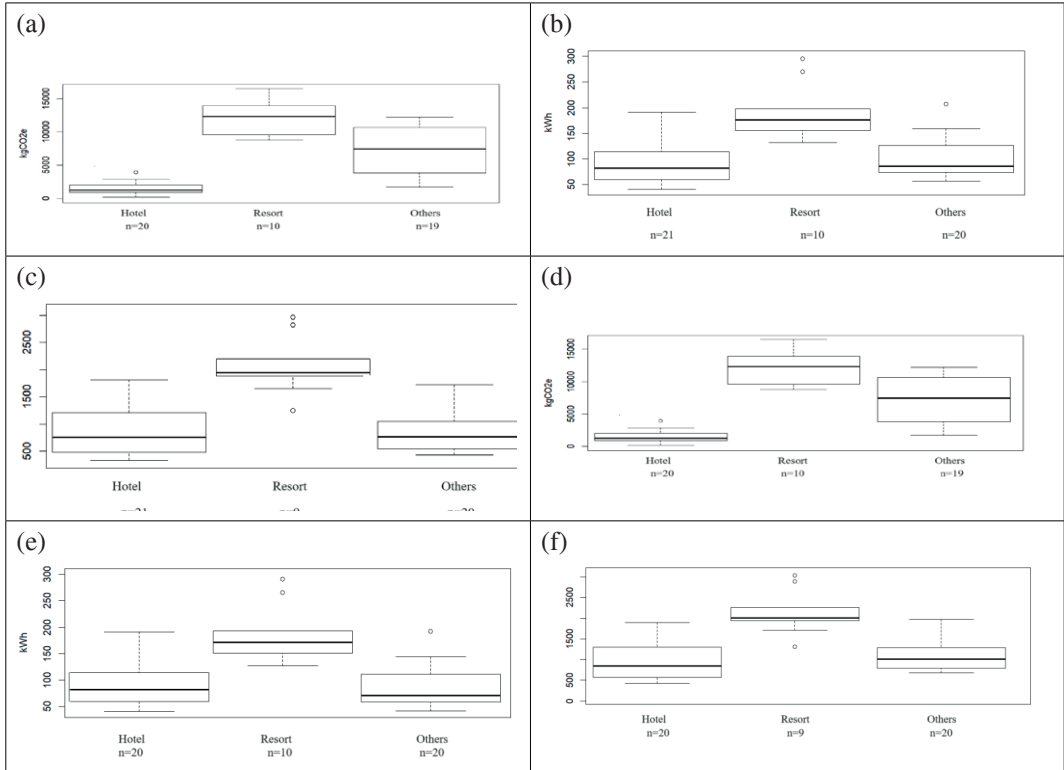
In Asian countries such as China, India and Indonesia, the water footprint ranges from 126 to 206 L/m<sup>2</sup>, as well as in LAC (100-347.3 L/m<sup>2</sup>) and Africa (124.4-217.1 L/m<sup>2</sup>). This indicates minimal water reuse and highlights the need for research to address this issue. Figure 3 differentiates carbon and water footprints according to whether they are hotels, resorts or other facilities. A comparative analysis of carbon, energy, and water consumption data per square foot reveals significant differences between these facilities and the type of country (i.e., developed or emerging). For carbon, developing countries have a higher average consumption of 8.0 kWh compared to 6.4 kWh in developed countries, reflecting a greater environmental impact. On the other hand, energy consumption in developed countries averages 21.2 kWh, slightly higher than in developing countries at 19.1 kWh, indicating more intensive energy use in developed countries, albeit with less variability. For water consumption, developing countries have an average of 182.6 L/m<sup>2</sup>, higher than developed countries with 123.2 L/m<sup>2</sup>, suggesting less efficient management of water resources. These patterns highlight the need to improve resource management efficiency and implement sustainable practices in developing countries to reduce water and carbon consumption. Meanwhile, developed countries should continue to optimize energy use.

Figure 2: (a) Carbon footprint in the hotel industry. (b) Water footprint in the hotel industry.



Source: Adapted from Greenview Hospitality Pte Ltd., (2023)

**Figure 3: (a). Footprint per square foot for developed countries, (b). Energy consumption for developed countries, (c). Water consumption for developed countries, (d). Footprint per square foot for emerging countries, (e). Energy consumption for emerging countries, (f). Water consumption for emerging countries.**

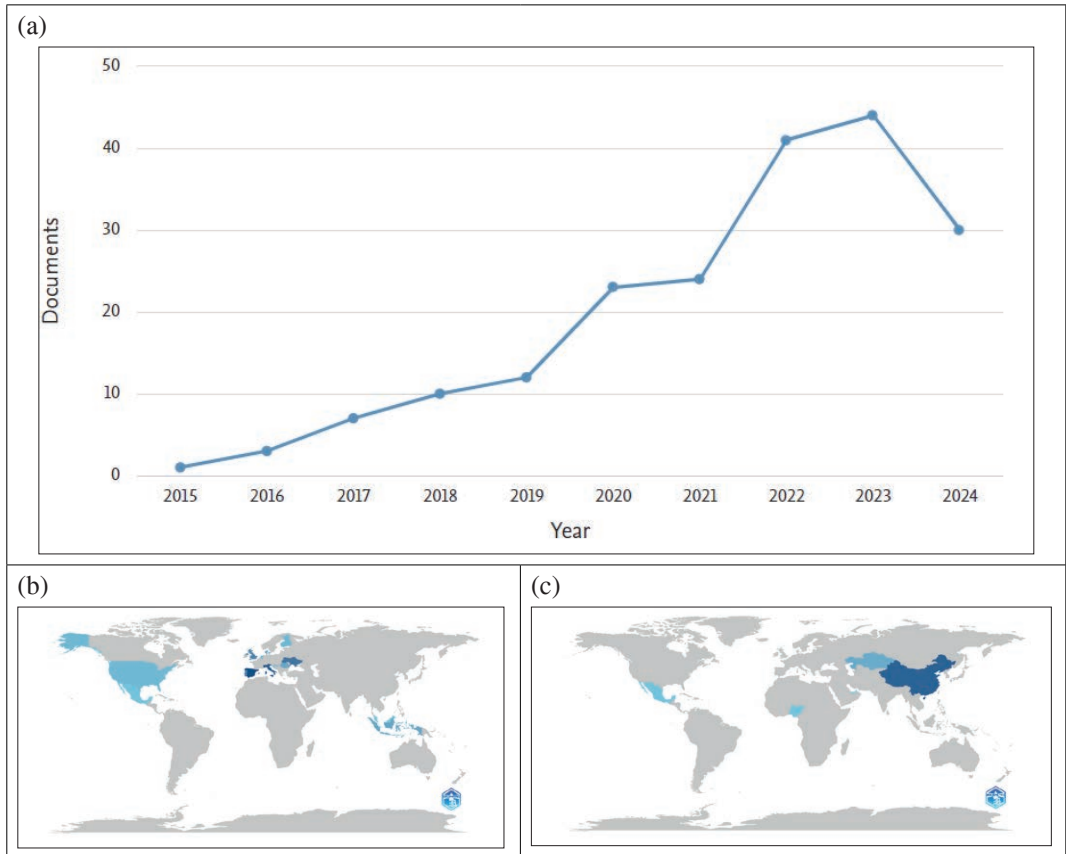


### 3.2. Global Intellectual Productivity Scenario: Developed and emerging countries

Figure 4a shows an increase in intellectual production between the decade 2018-2024, with a total of 52 papers on the topic of CE and tourism. The growth rate is 12.25%, with an average of 2.5 papers published per year. The increase in intellectual production is related to the impact of policies to implement CE in different countries, which aim to improve the management of solid waste through its valorization and reduce environmental impacts. In addition, at the organizational level, it is perceived that proper waste management, and the promotion of sustainable practices could generate a competitive advantage in attracting tourists. It is also noted that there is a gap. In the databases consulted and during the research period, the latter represented only 14% of world production in this context.

Figure 4b shows the geographical distribution of intellectual production in developed countries. Countries such as Spain, Italy and Portugal are the leading exponents in Europe, while in the Americas the United States is the most important intellectual producer. Research in these countries is focused on developing business models that include replacing conventionally sourced materials with materials from waste that are transformed into valuable products, energy generation, energy conservation, including bioclimatic aspects, and minimizing the water footprint. Figure 5c shows the geographic distribution of emerging markets. In this context, Asian countries such as China and Kazakhstan have made the most significant progress in research, with similar results reported in Mexico and Chile in Latin America and the Caribbean. These countries have developed policies to implement CE. On the African continent, Nigeria is making progress towards sustainable tourism, but its research is still at an early stage. The results show a wide gap between developed and emerging countries in the implementation of CE in the tourism industry.

**Figure 4: (a). Intellectual production between 2018 and 2024.**  
**(b). Intellectual productivity in developed countries.**  
**(c). Intellectual productivity in emerging countries.**



The implementation of CE models presents considerably different challenges and opportunities in peripheral economies, such as in Africa, where sustainable tourism is threatened by the exclusion of rural communities. The alienation of land for tourism projects displaces farmers and destroys their livelihoods. Without viable alternatives, these populations are marginalized, creating social conflict and affecting the sustainability of the sector. For this reason, community participation is essential to make tourism work for all stakeholders in the chain (Segrelles, 2009). This structural problem shows that CE models need to integrate territorial justice considerations and involve communities in these tourism development processes.

In Zanzibar, an archipelago with a large influx of tourists in Africa, the Greenest Zanzibar campaign is actively promoting sustainability in tourist hotels, promoting local purchasing, reducing food waste, and training staff in best practices to reduce the 1.8 kg of waste per guest per day (Ally et al., 2024). This initiative represents a circular model adapted to the specific characteristics of a tourism-dependent island economy, and demonstrates how targeted strategies can have a significant impact on reducing the sector’s environmental footprint.

CE in tourism extends beyond economic and environmental benefits and acts as a catalyst for social change. In Indonesia, the transformation of a limestone quarry into a tourist attraction generated microcredit for single mothers, new jobs, community enterprises, and sustainable resource management (Fitrianto et al., 2024). At the same time, women’s participation in circular rural tourism in the Himalayan region of West Bengal has strengthened cultural preservation through ethnic lodges, preservation of

handicrafts, and direct marketing of local products (Singh & Das, 2025). These cases demonstrate how CE can re-qualify communities previously dependent on extractive activities, preserve cultural heritage, and distribute economic benefits equitably.

### 3.3. Financial considerations

The transition to CE faces financial challenges that can be addressed through specific strategies. Experiences with wood-plastic composites (WPCs) show how companies of different sizes can mitigate the initial costs of implementing circular practices by recovering waste and generating multiple sources of income from the same previously discarded or underutilized material stream (Ranta et al., 2018). For example, in the hotel sector, textiles such as used sheets and towels can be repurposed into functional products—such as reusable bags or cleaning cloth—extending their useful life and reducing the operational costs associated with their disposal. Effective financing mechanisms include green credits, government subsidies for circular conversion, and public-private partnerships that spread infrastructure costs and opportunities, especially for small businesses that are more disadvantaged by the costs of adapting to the CE transition.

### 3.4. Policies

Effective policy frameworks play a crucial role in the transition to circular tourism practices. Analysis of international success stories reveals actionable patterns in different contexts.

The circular economy policy implemented in Krabi integrates public-private partnerships through strategic regional declarations, multi-level collaborative networks, and government leadership, and facilitates the transition to sustainable practices through regulatory frameworks that encourage green behaviors among tourism stakeholders (Pongsakornrungrsilp & Pongsakornrungrsilp, 2023). This Thai model demonstrates how regulatory structures can encourage multi-stakeholder participation in high ecological value coral reef tourism destinations.

Taiwan has consolidated integrated circular policies that combine robust regulatory frameworks, mandatory social participation, and digital technologies and artificial intelligence to optimize urban waste management and position itself as an effective model for CE in densely populated environments (Kurniawan et al., 2022). Its approach emphasizes the use of emerging technologies to incorporate products from recycling.

The Spanish CE strategy, exemplified by Andalusia, sets progressively achievable targets applicable to sectors with a high degree of circularity and implements fiscal policies that penalize the excessive use of resources and promote environmentally friendly products (Forastero, 2023). The tourism sector, of course, has a high impact on the consumption of natural resources and should be included in this path towards a green economy.

In this sense, the European Commission's Circular Economy Action Plan underlines the need to adapt regulatory frameworks to strategic sectors with high potential for circularity, establish restrictions on single-use products, increase the content of recycled materials (Communication from the Commission to the European Parliament, the Council, n.d.). This legislation has been especially effective in regulating single-use plastics, which if focused on the tourism sector, would transform operations in all-inclusive hotels where resource-intensive consumption is traditionally observed.

International experience shows that the most effective policy frameworks for CE in tourism share fundamental characteristics: i) establishment of measurable objectives with specific deadlines; ii) clearly defined financing mechanisms and fiscal incentives; iii) multilevel governance that integrates national and local authorities; iv) transparent monitoring and evaluation systems; and v) platforms for knowledge transfer among tourism stakeholders.

### 3.5. Worldwide research trends

Figure 5a shows the keyword co-occurrence map in the tourism industry. This map identifies three macro-clusters based on the frequency of words appearing at least five times in each analyzed article: i) CE and sustainability (red cluster), mainly adopted in the hotel industry and aligned with SDG compliance, proposing strategies to inform policy formulation; ii) tourism management (blue cluster), examining waste flows within supply chains and their potential to generate competitive advantages in the tourism industry; and iii) sustainability practices (green cluster), addressing ecotourism, eco-design, stakeholder roles, and environmental impacts. It is important to emphasize that the sustainability approach is still in its infancy in emerging economies, which offers significant research opportunities.

**Figure 5: (a) Keywords co-occurrence network. (b) Thematic map.**

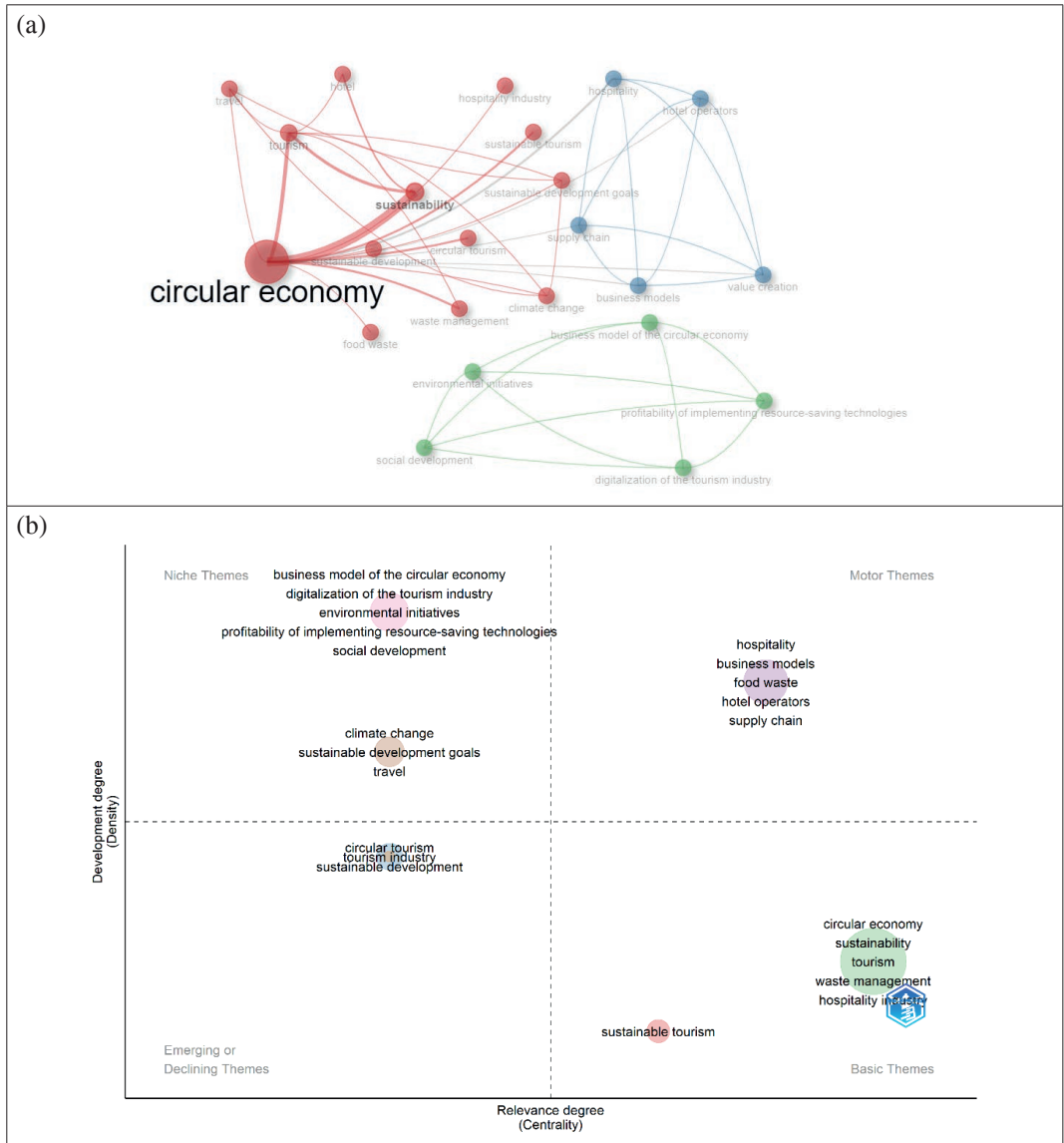


Figure 5b shows the thematic map identified by Bibliometrix®. In the lower right quadrant (i.e., Basic Themes), keywords such as sustainable tourism, hospitality, waste management, and CE were found, indicating their importance as basic themes that are relevant but need further consolidation in terms of research. In contrast, in the upper right quadrant (i.e., Motor Themes), keywords such as business models, supply chains, and food waste were found. This shows that these are relevant topics that have been addressed with the aim of closing cycles by valuing different types of waste, such as food waste to obtain renewable energy, producing products that can be used in gardens, or other products. It should be noted that this type of work requires more in-depth research due to its location on the thematic map. In the upper left quadrant (i.e., Niche Themes), keywords such as EC-oriented business models, environmental initiatives, cost-effectiveness of implementing resource-saving technologies, and social

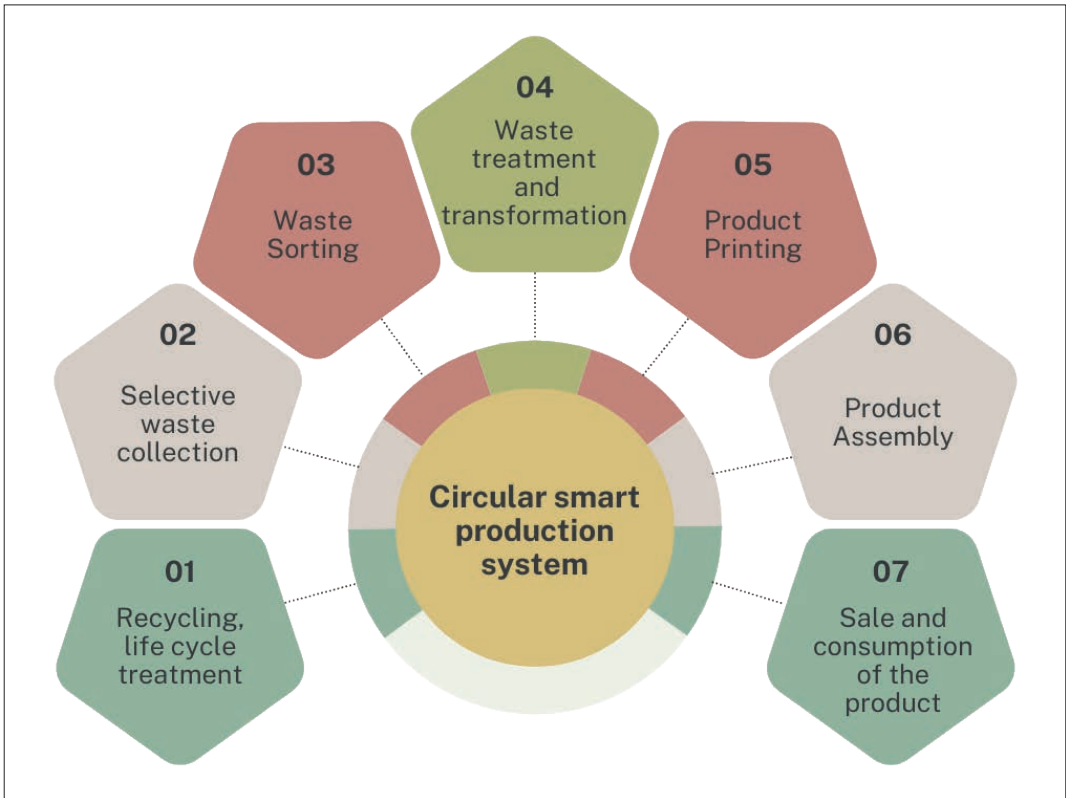
development have been identified. These themes are developed in different researches considering aspects of environmental, social, technical, political and cultural dimensions in the tourism industry and require further research. Finally, in the lower left quadrant (i.e. emerging or declining themes) it showed the words circular tourism and sustainable development, which seek to propose industrial ecosystems based on industrial ecology to use and valorize different types of waste. Due to the location of the words in this quadrant close to the starting point of the thematic map (i.e., intercept of centrality and relevance), these are emerging topics where research is still in its infancy, highlighting research opportunities in both developed and emerging countries.

### 3.6. CE and sustainability

Sustainable tourism is an application of the idea of sustainable development in the field of tourism (Xu et al., 2022). A recent study by Iller & Torres-Delgado (2023) analyzes the integration of sustainable tourism indicators and stakeholder cooperation to achieve SDGs 8, 9, and 12 of the 2030 Agenda and proposes a monitoring system for national sustainability policies. Other studies show the link between the development of sustainable practices in the tourism sector and the well-being of local communities sector (Boluk et al., 2019; Galli et al., 2018; Rosato et al., 2021). Another emerging approach is the transition to low-impact transportation infrastructure, for example, developing countries such as China and Morocco are investing in high-speed rail networks to reduce dependence on air travel (Peeters et al., 2019). This is related to the business paradigm of the 21st century, where the convergence between business models and the SDGs has become a concurrent imperative. The Circularity Gap Report 2024 has revealed a worrying trend: the global circularity rate has decreased from 9.1% to 7.2% in 2023 2023 (Circle Economy Foundation, 2019). This highlights the need for comprehensive strategies in implementing circular solutions.

Therefore, the transition to circular frameworks requires a strong commitment from top management to integrate CE principles throughout the value chain. This approach encompasses strategies from product eco-design, with a focus on extending product life and implementing technology cycles, to effectively closing the material loop (Bocken et al., 2016; Lüdeke-Freund & Dembek, 2017). Despite the significant challenges, a circular economy model offers a unique value proposition with tangible benefits. These benefits include reducing inputs, optimizing resource use, generating new revenue streams through recycling, and enhancing corporate reputation. It is crucial to recognize that contemporary consumer behavior is increasingly inclined to favor companies that implement actions that have a positive impact on sustainability and communities (Bocken et al., 2016). In this regard, Breuer et al. (2018) propose a conceptual framework based on four fundamental pillars for the implementation of circular business models: i) a holistic approach that balances environmental, social, and economic aspects; ii) value creation for multiple stakeholders; iii) systems thinking that considers the complex interrelationships of the business environment; and iv) the alignment and involvement of diverse stakeholders in the transformation process. In parallel, another important breakthrough model is the Circular Smart Production System (CSPS) management model, which presents an innovative approach with seven circular phases for the reuse of inorganic solid waste: product life cycle, separate collection, sorting, treatment, 3D printing, assembly, and sale. This approach, as shown in Figure 6, integrates reverse logistics and advanced technologies to promote circularity (Nascimento et al., 2019).

At the forefront of these business strategies, a recent study Czekala et al., (2023) an advanced waste management model as LoRaWAN (Low Power Wide Area Network) that integrates artificial intelligence and digitization technologies, with an emphasis on integrated Internet of Things (IoT) sensors that record information over long distances and its minimal energy consumption. This approach enables monitoring and optimization of the entire waste cycle, using parameters such as waste generation rate, collection efficiency, sensor accuracy and recyclability to simulate scenarios in a network-based environment. This approach not only increases the likelihood of timely recycling, but also contributes significantly to the goals of circularity and sustainability in waste management (Seyyedi et al. 2024). Finally, the transition to circular models requires a deep organizational commitment that infuses circularity into the mission, vision, values, goals, business strategies, and budget. This transformation requires significant investments in economic, human and technological resources, as well as systemic collaboration between all actors in the value chain. However, this approach promises to significantly improve global circularity indicators and deliver long-term environmental, economic and social benefits.

**Figure 6: Circular Smart Production System**

**Source:** Adapted from Nascimento et al. (2019)

E-ecotourism is emerging as an innovative paradigm that integrates sustainability policies, tourism competitiveness, and advanced technologies to optimize the management of ecotourism destinations. This approach incorporates the implementation of artificial intelligence and big data analytics in the management of protected natural areas, such as national parks, which is crucial to effectively respond to the demands of the current tourism market (Schwab, 2017). In order to achieve sustainable destination development, it is essential to track the environmental footprint of tourists using big data technologies to enable more informed and responsible management of natural resources (Eddyono et al., 2021). This convergence of technology and ecotourism promises to enhance both the visitor experience and the conservation of the environment, marking a significant advancement in the sustainability of the tourism industry.

In developing countries, public policies and green governance are essential to promote sustainable ecotourism (Manzanares Garmendia, 2020). In addition, investments in infrastructure and the promotion of authentic experiences that integrate nature and local culture can attract foreign investment. These policies aim to overcome structural constraints, promote sustainable practices, and stimulate economic growth while preserving the natural and cultural heritage of these emerging economies (Shang et al., 2023).

### 3.7. Sustainable Practices, Barriers, and Recommendations

The tourism industry is a complex ecosystem of interconnected actors, and requires accurate indicators to assess its sustainability. The European Tourism Indicator System, implemented in more than 100 destinations with 43 core indicators, and the SDGs provide a reference framework (De Marchi et al., 2022). The integration of emerging technologies, such as IoT, blockchain, and artificial intelligence,

enables real-time monitoring of critical environmental variables, facilitating a more accurate and timely assessment of tourism sustainability. Table 1 presents some sustainable practices applicable to the tourism sector.

**Table 1: Practices with potential application in the tourism industry**

Category	Specific Practices	Description
Energy	100 % Solar energy operation	Use of solar power for all operations
	Solar energy systems	Installation of solar panels for On-site of energy-consumption
	LED Lighting	Reduction of energy consumption through LED technology
Water	Rainwater harvesting for irrigation and cleaning	Use of rainwater to reduce potable water demand
	Automatic drinking water taps	Encourage refilling water in reusable bottles
	Guests sensitizing to reuse towels and sheets	Sensitizing guests to forgo daily towel and sheet changes
	Biological treatment of wastewater within facilities	Reuse treated water for cleaning of common areas.
	Composting of organic waste in hotels	Use of organic waste as garden fertilizer
Carbon Footprint	Offsetting climate footprint with reforestation projects	Reforestation initiatives to offset CO <sub>2</sub> emissions
	Reducing food waste	Charitable donations of unused food
	Purchase of local products	Support for local communities that organically produce their products
	Reverse logistics of organic matter	Transformation into ecological compost delivered to allied suppliers
	Electric vehicle alternatives	Promoting sustainable mobility using electric vehicles
Products	Use of biodegradable, phosphate-free cleaning products	Cleaning products that do not pollute water and soil
Waste	Paper, cardboard and plastic recycling	Separation and recycling of materials to reduce waste
	Phasing out of single-use plastics	Reduction of plastic waste by eliminating the use of plastics or opting for bioplastics
	Collaboration with local associations for waste management	Partnerships to improve waste management and promote sustainable practices
Others	Environmental awareness	Training for collaborators and communities on the use of resources

**Source:** Adapted from (Baxter, 2021; Borysova et al., 2022; Costa et al., 2022; Golfinoopoulos et al., 2022).

First and foremost, it depends on the willingness of stakeholders to prioritize training, capacity building and education (Fraguas & Lerena, 2024). The key lies in the commitment of each stakeholder and the development of well-structured sustainable strategies. One effective approach is tiered savings, where companies allocate a portion of additional revenue, especially during peak seasons, to funds dedicated to sustainable initiatives. In Latin America, regulations such as the one implemented in Cancun, Mexico, where tourists are charged a per-night fee specifically for environmental sanitation (REPORTUR, 2021). This approach is complemented by a range of initiatives, including the use of clean energy, support for local markets, the phasing out of plastics, the use of innovative technologies, a preference for recycled products, and training and development programs for local communities. The synergy between these individual and collective actions contributes significantly to reducing the carbon footprint of the tourism sector.

**Table 2:** Barriers and recommendations for the implementation of the Circular Economy in tourism

Actor	Main barriers	Specific recommendations	References
<b>Government policy makers</b>	Regulatory challenges	Define a regulatory framework that establishes direct fiscal incentives to promote voluntary measures in tourism companies that implement clean and circular technologies	(Chenavaz & Dimitrov, 2024)
	Policy challenges with a community approach	Community integration in government sustainable tourism programs requires CE training; their decisive participation, not only consultative. By valuing traditional knowledge and initiatives such as "Green Jobs", communities can develop specialized services and sustainable productive projects, generating tangible benefits while preserving their cultural heritage and traditions.	(Yanes et al., 2019)
	Cultural resistance	Establish a strategic plan that integrates different guilds of the sector (hotels, guides, communities, universities, among others), through training programs that develop technical skills and environmental awareness, transforming entrenched paradigms towards sustainable consumption models based on CE principles.	(Chaher et al., 2025)
	Regional inequality in technical capabilities	Promote regulations that require measuring circularity indicators (efficient use of resources, investment in renewables, social participation, among others) and establish continuous feedback mechanisms to evaluate, adjust and demonstrate the effectiveness of sustainable transition strategies.	(Arias et al., 2023)
<b>Tourism companies Micro, Small and Medium Enterprises (MSMEs)</b>	High upfront costs	The adoption of progressive savings models that channel percentages of seasonal income to sustainable projects, creating an institutional infrastructure that facilitates guest awareness through strategic signage, encouraging their voluntary participation in practices such as towel reuse, water conservation, food waste.	(Fernández-Xicotencatl et al., 2023; Liu et al., 2025)
	Immediate financial return and technology adoption	The implementation of CE in hotel establishments through efficient technologies (IoT sensors) and 4R practices generates return on investment by optimizing water and energy resources, reducing operating costs through rechargeable systems, minimizing food waste and recycling wastewater for multiple uses.	(Pomianowski et al., 2020; Strippoli et al., 2024)
	Limited access to certifications	The adoption of environmental certifications in lodging establishments provides multidimensional benefits: it optimizes energy and water consumption, improves waste management, strengthens brand positioning and generates competitive advantages, simultaneously facilitating access to responsible markets and compliance with emerging regulatory standards.	(Dias et al., 2024; Velaoras et al., 2025)
	Low participation in financial efforts and training	Strengthen training as a link between local actors and the private sector, where it stimulates, through subsidies and financial incentives, the adoption of circular practices, especially in MSMEs, promoting continuity through technical support and consultancy.	(Garrido-Prada et al., 2021)
<b>Local communities</b>	Restricted participation in tourism governance	Promote capacity building programs with local communities, in Nicaragua supported micro-enterprises in supply chains with small grants, business training and reorientation of local businesses to respond to real tourism demand in protected areas..	(Yu-Fai Leung et al., 2019)

In the current context of sustainable tourism, CE presents itself as a promising solution, although its implementation faces complex challenges. This model is characterized by a regenerative and interconnected system that seeks to reinvent the way we use and reuse resources, helping to transform the tourism industry towards more sustainable and efficient practices (MacArthur, 2013). This approach requires concrete changes to reduce carbon footprints, optimize energy, manage water efficiently, and

reduce food waste (Rodríguez et al., 2020). The majority of CE model initiatives are concentrated in developed countries and are based on the use of technology. For example, studies show that a Domestic Wastewater Heat Recovery (DWHR) system in hotels significantly reduces energy and water consumption, achieving efficient configurations of up to 27.3% and 24.0%, with a payback period of 5 years and significant savings in CO<sub>2</sub> emissions (Pomianowski et al., 2020; Sayegh et al., 2021). Another recent study in hotels in the Nordic countries supports the feasibility of transcritical CO<sub>2</sub> heat pump systems, showing a 60% reduction in energy consumption compared to conventional methods. Reddy et al. (2024), found savings of up to 1.8 GWh/year and 600 MWh/year (Smitt et al., 2021). Extending this potential to hotels in India, a developing country, this system is presented as a clean and energy efficient alternative with a payback period of less than two years.

Some of the technical barriers to EC uptake include the lack of availability of resource efficient technologies such as water and energy, thereby reducing carbon footprint, and the lack of technical support and training to raise awareness and provide information on the economic, fiscal and especially environmental benefits (Rizos et al., 2015). Similarly, according to Kirchherr et al. (2018), the main obstacles include: i) cultural barriers, where resistance to change and lack of environmental awareness among customers and organizations slow down the adoption of circular practices; ii) market barriers, where the high upfront costs of investing in circular technologies are a major challenge, especially for small and medium-sized tourism enterprises; iii) regulatory challenges, where there are gaps and a lack of encouragement to adopt a CE model; and iv) technological limitations, where it is difficult to access high quality products made from recycled materials. These barriers indicate that a transition to circular tourism requires cross-sectoral cooperation of all stakeholders under a regulatory policy framework aligned with CE principles.

Table 2 below summarizes the main barriers faced by some stakeholders in the tourism sector when implementing CE practices and offers specific recommendations based on scientific evidence to overcome them. These proposals seek to facilitate the adoption of circular models through differentiated strategies for policy makers, tourism businesses and local communities, taking into account their particular contexts and capacities.

#### 4. Conclusions

The tourism industry is under increasing pressure to adopt sustainable practices due to its significant environmental impacts. The transition to a circular economy model is essential to mitigate these impacts and ensure the long-term viability of the sector.

This research offers a significant contribution to the understanding of the EC in the tourism sector through a systematic comparative analysis between developed and emerging countries. Geographical mapping of consumption patterns reveals important structural divergences: emerging countries have higher carbon footprints (8.0 kWh vs. 6.4 kWh), water consumption (182.6 L/m<sup>2</sup> vs. 123.2 L/m<sup>2</sup>) and higher energy intensity (21.2 kWh vs. 19.1 kWh). These divergences reflect not only differences in technological infrastructure, but also in strict regulatory frameworks, strategic plans to reduce the impacts associated with the excessive use of natural resources and the need to reduce the use of natural resources in energy production. There is a notable disparity in circular economy research, with a predominant focus on developed countries. This inequality limits the understanding of how to implement circular practices in the context of emerging countries, where tourism is booming and can benefit from these strategies, not only for economic, but also socio-cultural and environmental benefits. In addition, the need for effective policies is identified, underlining the importance of a sound regulatory framework to support the implementation of the circular economy in tourism. Policies should encourage collaboration among different stakeholders in the sector and provide incentives for the adoption of sustainable practices. Innovation and technology are also crucial, as the integration of emerging technologies can facilitate the transition to the circular economy, optimizing the use of resources, improving waste management and monitoring the environmental impact of tourism activities and improving business indicators. Finally, this study identifies key areas for future research, especially in the context of emerging countries. It points to the need for further research on waste management practices, further development of specific indicators of tourism circularity and longitudinal evaluation of the impact of differentiated strategies according to economic context, as well as the role of education and awareness in the adoption of CE.

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*Recibido:* 20/08/2024  
*Reenviado:* 04/05/2025  
*Aceptado:* 05/05/2025  
*Sometido a evaluación por pares anónimos*