2

CIRCULAR ECONOMY IN THE HOSPITALITY AND TOURISM SECTOR: THE CASE OF WASTE COOKING OIL

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ABSTRACT

The hospitality sector, one of the fastest-growing global industries, significantly contributes to economic development but is simultaneously responsible for substantial environmental impacts, particularly waste generation. Waste cooking oil (WCO) emerges as a critical environmental and economic issue within this industry, presenting challenges and opportunities. This chapter explores the transformative role of circular economy (CE) principles in hospitality through the reutilization of WCO, showcasing its conversion from an environmental burden into valuable industrial resources, such as biofuels, polymers, and industrial additives. It further examines regulatory frameworks, innovative recycling pathways, and sustainable business models that leverage WCO within regional hospitality contexts.

Keywords: Circular economy; waste generation; sustainable environment; sustainable business models; waste cooking oil; tourism and hospitality sector

INTRODUCTION

Industrial progress in the 20th century brought substantial economic and social benefits, but simultaneously created pressing environmental challenges, including resource depletion, pollution, and climate change (Geels et al., 2015). Among the industries significantly contributing to these environmental burdens, hospitality stands out due to its high resource consumption and waste generation (Jones & Wynn, 2019). Within this sector, WCO represents a critical yet often neglected waste stream. Recognizing the potential for resource recovery, recent scholarly and industrial interest has focused on integrating CE strategies into hospitality management, aiming to transform WCO into valuable products and reduce environmental impacts (Amicarelli et al., 2023).

This chapter discusses the theoretical and practical dimensions of the CE related to WCO in hospitality. It outlines current regulatory contexts, explores innovative recycling technologies, and examines case studies demonstrating sustainable business models leveraging WCO as a strategic resource.

CE IN HOSPITALITY: A PARADIGM SHIFT

CE strategies emphasize resource recovery, waste reduction, and sustainability through systematic reuse and recycling. Despite initial adoption in manufacturing and agriculture, these principles remain underutilized in hospitality due to fragmented supply chains, seasonal demands, and stakeholder diversity (Jones & Wynn, 2019). However, given the industry's scale and waste generation profile, embedding circular strategies can significantly enhance sustainability outcomes.

The hospitality and tourism sector ranks among the most prominent global industries, fueling substantial economic growth and employment opportunities in developed and developing regions. This industry encompasses various activities from accommodations and food services to transportation, entertainment, and leisure, ultimately catering to a diverse and ever-expanding customer base. Despite its economic significance, it is also widely recognized for its negative externalities, including environmental degradation, resource overconsumption, and disruptions to local communities and cultures. These impacts have prompted calls for sustainable development within the sector, as underscored by scholars (Boley, 2011) who highlight the urgency of addressing ecological and social challenges. Nevertheless, achieving sustainability in such a multifaceted domain remains an intricate task (Jones & Wynn, 2019), whose research underscores the persistent struggles in integrating environmental responsibility into business models and day-to-day operations.

Recent scholarly work indicates that formal research on the CE in hospitality and tourism began gaining traction around 2018. However, a few earlier studies did emerge periodically (Bux et al., 2025). Before this period, farm-to-fork perspectives and sustainability considerations within hospitality's food and service segments saw rising interest between 2017 and 2018. Such attention has frequently revolved around waste management, reflecting a consistent theme in the literature from 2013 through 2021. This demonstrates the centrality of waste reduction and recycling to CE approaches, particularly in industries that deal heavily with consumable resources.

Despite the growing recognition of sustainability's importance, embedding CE principles into tourism and hospitality remains an ongoing challenge for academics, policymakers, and industry practitioners. While CE strategies have seen broader adoption in agriculture, manufacturing, and construction (Pattanaro & Gente, 2017), the acceptance within tourism has been more limited, often hindered by split supply chains, seasonal fluctuations in demand, and the diverse array of stakeholders involved. Consequently, scholars have increasingly focused on understanding how circular models might be adapted to the unique characteristics of tourism destinations and hospitality services.

Literature exploring CE within tourism frequently examines farm-to-fork strategies (Dolnicar et al., 2020), sustainable waste management programs (de Grosbois & Fennell, 2021), and eco-innovations tailored to hospitality operations (Kim & Hall, 2019). Scholars have recommended that increased government intervention, green procurement, and energy-saving initiatives highlight the vital role that policymakers and local authorities play in guiding sustainable transformations (Zhang et al., 2018). Scheepens et al. (2016) examined sustainable water recreation in Friesland (Netherlands), identifying strategic pathways toward reduced environmental footprints. However, the study also revealed that insufficient customer recognition of eco-friendly efforts can reduce market competitiveness, underscoring the importance of consumer education and stakeholder collaboration in supporting sustainable business models. In many tourism businesses, circular practices, such as reusing cooking oil from waste, are being adopted. However, customer value recognition remains uncertain. One of the most significant risks of these initiatives is their invisibility, as eco-innovations are often invisible to customers. A lack of transparency in communication can lead to customers undervaluing sustainability initiatives, lowering their impact on brand loyalty and willingness to pay. In addition, some people may question greenwashing's authenticity due to skepticism. Therefore, it is essential to develop communication strategies that are transparent, credible, and contextually relevant for circular business models to be seen and appreciated.

When it comes to hospitality-specific contexts, academic inquiries remain comparatively scarce. The alignment of CE principles with hospitality operations can accelerate business growth while fostering a more sustainable experience for patrons and communities (Zaki & Farrag, 2024). However, beyond isolated studies estimating the financial and environmental benefits of waste reduction and recycling in hotels, the literature still lacks robust frameworks tailored explicitly for hospitality. Nevertheless, scholars widely concur that monitoring water and waste management and energy consumption is fundamental to a comprehensive sustainability strategy (Jones & Wynn, 2019). Effective data capture, processing, and reporting systems are essential if businesses aim to make informed decisions, track improvements, and communicate progress to stakeholders.

Restaurants serve as a particularly fertile ground for exploring circular practices (Bux et al., 2025). A considerable portion of research focuses on farm-to-fork initiatives, emphasizing short supply chains, local sourcing, and the responsible use of natural resources. For instance, nutrient recycling, composting, and biodiesel production derived from cooking oil to energy recovery from organic waste (Carmona-Cabello et al., 2018, 2019; Paciarotti & Torregiani, 2018; Scozzafava et al., 2017; Velazquez Abad et al., 2015). By engaging in these practices, restaurants can reduce operational costs, enhance environmental performance, and even generate new revenue streams.

The evolution of food waste management toward circular strategies further testifies to the sector's growing environmental consciousness. Research indicates that integrating CE principles, such as reusing and recycling surplus food, can lead to cost savings, the creation of value-added products, and broader environmental benefits (Haque et al., 2023; Kumar et al., 2022; Lopes de Sousa Jabbour et al., 2021). In addition, restaurant operators are increasingly turning to consumer-oriented approaches like sustainable menu design, local procurement, and sharing economy platforms to divert edible surplus from landfills. Equally important are shifts in consumer choice architecture, wherein diners receive clear information about their selections' environmental and social implications. Such as labeling menus with carbon footprint data or using descriptive language that highlights ethical sourcing can nudge customers toward climate-friendly dining habits (Bacon & Krpan, 2018).

These studies underscore a gradual yet undeniable momentum in the hospitality and tourism sector toward integrating CE strategies. From government policies that incentivize resource-efficient practices to innovations in waste management and educational campaigns targeting consumer awareness, a multifaceted approach is essential for driving meaningful change. As CE research develops, future inquiries may offer deeper insights into holistic

methods for reshaping the industry, transforming its impacts on local communities, and ensuring its alignment with broader global sustainability targets. Due to low environmental awareness and infrastructure constraints, it can be difficult for customers to recognize circular practices in less-developed tourism economies, especially in the Global South. Despite efforts such as reusing WCO, aligning with CE goals, tourists often overlook or undervalue these efforts, significantly when economic affordability trumps environmental concerns. A lack of resources may also prevent local businesses from communicating these initiatives, putting them at risk of misinterpretations or failures. Therefore, to increase value recognition in such contexts, communication strategies that are culturally grounded, capacity-building for sustainable innovations, and policy support are needed.

WCO REUTILIZATION STRATEGIES

In the European Union, WCO management is governed by several regulations, notably Directive 2008/98/EC, which defines WCO as non-hazardous but environmentally problematic waste (Commission Decision 2014/955/EU) (Van Caneghem et al., 2019). Each member state has considerable autonomy in designing its collection and recycling systems, creating diverse logistical landscapes. For instance, in Italy, Legislative Decree 152/2006 mandates the participation of operators in specific consortia (e.g., CONOE), which organize the collection, transportation, and recycling of WCO (Lopresto et al., 2024). This structured approach is critical to preventing environmental contamination and promoting resource efficiency.

WCO is generated primarily through repeated frying processes in food services. Its disposal poses significant environmental risks, particularly aquatic contamination and ecosystem damage. Therefore, effective reutilization is economically and environmentally strategic. With the introduction of increasingly hard regulations governing the use of toxic substances in industrial processes, research efforts are turning toward bio-based components as safer and more sustainable alternatives. Such components have gained particular importance in the plastics industry, where they function as additives, most notably in the role of plasticizers (Jia et al., 2018). By incorporating these additives, manufacturers can adjust polymer properties such as flexibility, toughness, and processability, ultimately broadening the range of applications for various plastic products (Bocqué et al., 2015). Plasticizers are essentially low-molecular-weight organic molecules added to polymer formulations to serve as lubricants among polymer chains. Plasticizers lower the polymer's

glass transition temperature by reducing intermolecular forces, enhancing its flexibility and ductility. One common industrial example is polyvinyl chloride (PVC), a resin widely employed in food packaging, medical devices, and building materials, which is, by nature, hard and brittle at room temperature. By incorporating suitable plasticizers, PVC can be transformed into a more flexible, user-friendly material (Rahman & Brazel, 2004).

However, conventional plasticizers, particularly phthalates such as dioctyl phthalate (DOP), have attracted considerable scrutiny due to their toxicity and potential to migrate out of polymer matrices. In Europe, for instance, DOP faces REACH restrictions (Annex XVII) that limit its use in toys, food packaging, and medical instruments (Cheng et al., 2020). A significant concern is that these phthalates can leach into their surroundings, especially in contact with fatty foods, solvents, or biological fluids, posing health and environmental risks (Zygoura et al., 2007).

Against this backdrop, the search for safer, bio-based plasticizers has led researchers to explore WCO as a non-toxic, biodegradable, and readily available feedstock for additive manufacturing. By chemically modifying WCO, scientists can create renewable plasticizers that provide comparable or even superior performance to traditional fossil-derived additives, aligning with the global imperative to reduce hazardous chemicals' use and tackle plastic waste more sustainably.

A compelling example is the work of Liu et al. (2020), who developed an acetylated-fatty-acid methyl ester-trimellitic acid ester (AC-FAME-TAE) from WCO. When used as a plasticizer in PVC formulations, this renewable additive endows the plastic with mechanical and thermal properties that closely match those obtained using phthalate-based plasticizers, while exhibiting significantly reduced toxicity and lower environmental impact. This breakthrough underscores WCO's potential as an adequate substitute for hazardous petrochemical additives, offering a safer, cleaner pathway to plastic production.

By harnessing WCO in plastic formulations, manufacturers may meet tightening regulations, enhance product safety, minimize toxic waste, and promote CE principles. Future research is expected to focus on scaling up these technologies, refining cost-efficiency, and optimizing formulations so that WCO-derived additives can seamlessly integrate into existing industrial processes, reinforcing their broad commercial viability and environmental benefits.

SUSTAINABLE BUSINESS MODELS AND APPLICATIONS

Therefore, WCO presents itself as a promising waste source on the creation of "second-life products." Leaving aside its primary use as a renewable source

for biodiesel production, WCO can be chemically modified and used as bio-based plasticizers (Landi et al., 2022; Zheng et al., 2018), polymeric materials (Kim & Hall, 2019), bio-lubricants (Mannu et al., 2019, 2020), detergents and soaps (Mannu et al., 2020; Panadare & Rathod, 2016), cosmetics (Escobar Lanzuela et al., 2015), bio-solvents for pollutants (Mannu et al., 2019), and binder additive for aged bitumen (Asli et al., 2012).

The growing emphasis on CE principles and sustainable development spurred by societal, regulatory, and environmental concerns presents a timely opportunity for collaborative partnerships between agri-food operations, local communities, and artisan businesses (Borrero & Yousafzai, 2024). In particular, WCO has emerged as a promising feedstock that bridges environmental responsibility and economic benefit. When collected and processed correctly, WCO can be transformed into a diverse range of bio-based products such as biodiesel, plastic additives, and polyurethane precursors, offering a pathway to resource efficiency and value creation (Bardella et al., 2024).

These opportunities arise most notably through the synergy of agri-food material recovery and the participation of local communities and craft enterprises. Agri-food material recovery can strengthen local supply chains, where producers, restaurants, and households cooperatively gather WCO. Craft enterprises such as small-scale biodiesel producers, artisanal cosmetics makers, and construction material innovators benefit from a consistent, cost-effective supply of renewable raw materials. Meanwhile, local communities gain from reduced environmental pollution and increased green jobs, thereby cultivating pride in eco-friendly initiatives.

CE FRAMEWORK FOR WCO IN THE TOURISM SECTOR

The tourism sector generates significant volumes of WCO, mainly through food preparation activities in hotels, restaurants, and resorts. Often regarded as a pollutant, WCO poses environmental hazards if improperly managed, such as water contamination and increased greenhouse gas emissions. However, applying CE principles can transform this waste into valuable resources, contributing to sustainability, resource efficiency, and local economic development. For this, we developed a framework through a conceptual blend of available literature on CE applications in the tourism sector and WCO management. We adopted the narrative review methodology of peer-reviewed (Sukhera, 2022) studies that allows us to identify key actors, stages, and challenges involved in the WCO management lifecycle within the tourism sector. After carefully reading the relevant studies, we integrated the conceptual

connections around the CE and WCO. This framework (Fig. 2.1) outlines a circular approach for managing WCO within tourism settings, consisting of seven interconnected components: generation, collection, logistics, re-utilization, business models, policy, and outcomes.

- The first stage begins with WCO generation during routine cooking in hospitality establishments. Tourism businesses, particularly those with in-house food services, are primary producers of WCO. At this stage, the goal is to recognize WCO not as waste but as a potentially valuable input for other industrial processes.

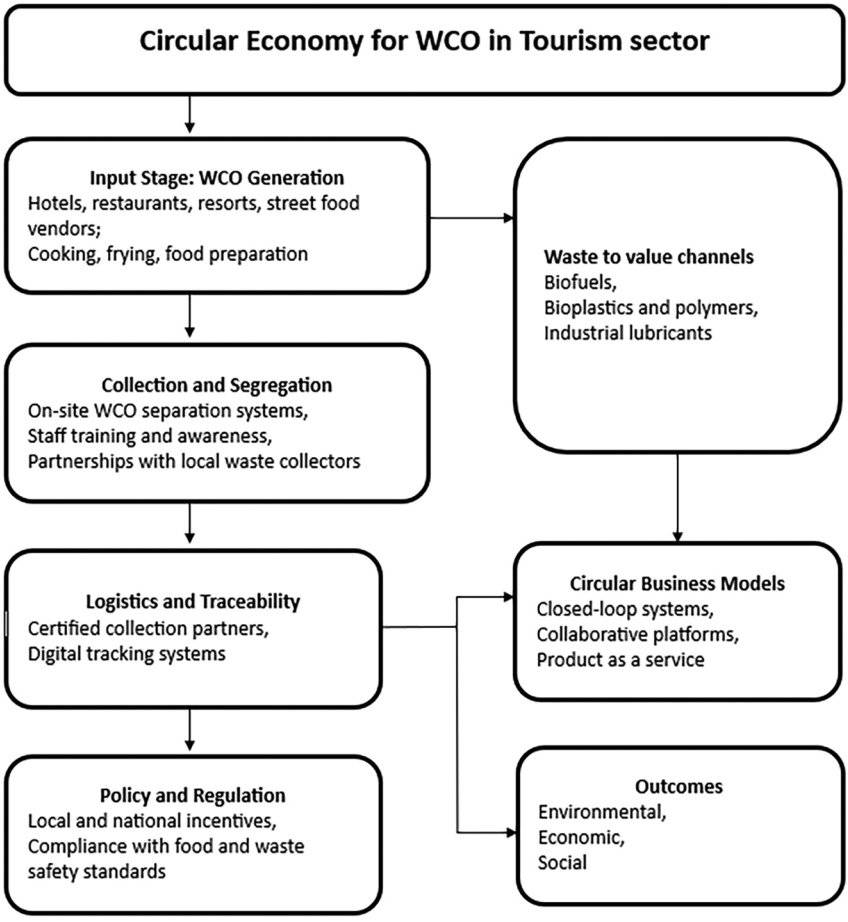

Fig. 2.1. Circular Economy Framework for Waste Cooking Oil (WCO) in the Tourism Sector.
Source: Authors' elaboration.

- Next, collection and segregation are critical. To prevent contamination, WCO must be separated from other waste streams and stored appropriately. Hospitality staff should be trained to handle WCO responsibly, and partnerships should be established with certified collectors. On-site storage systems and periodic pickups by registered handlers ensure safety and efficiency.
- Following collection, the logistics and traceability component emphasizes the importance of transparent and secure transportation. Implementing digital tracking systems can enhance trust and ensure compliance with local regulations. For example, blockchain-based solutions could trace the flow of WCO from source to final product, supporting both sustainability claims and regulatory requirements.
- The center of the framework suggests different value channels for the reutilization of WCO. WCO can be processed into multiple high-value products, such as biofuels, especially biodiesel, for hotel transportation fleets or local energy needs. Bioplastics and polymers are suitable for packaging, utensils, or hotel supplies. Industrial lubricants are used in building maintenance and equipment. The viability of these applications depends on local infrastructure, technology availability, and demand for sustainable alternatives. Innovative circular business models must be adopted to support these practices. For example, closed-loop systems allow hotels to reuse biodiesel from their WCO. Collaborative platforms enable regional tourism clusters to pool shared collection and processing resources. Alternatively, service-based models offer integrated solutions where external providers handle waste and supply bio-based products in return. Policy and regulatory frameworks play a vital enabling role. Government incentives, such as tax reductions or sustainability certifications, can motivate businesses to participate. Clear WCO handling and recycling regulations are essential to ensure health, safety, and environmental protection.
- Finally, this framework's outcomes span multiple domains. Environmentally, it reduces landfill waste and emissions. Economically, it creates new revenue streams, supports green entrepreneurship, and may reduce operational costs. Socially, it fosters job creation in waste management and promotes community participation in sustainable tourism.

This CE framework for the WCO reuse aspect presents a practical and scalable model for integrating sustainability into tourism operations, aligning with global goals for climate action and responsible consumption.

CONCLUSION

Integrating WCO re-consumption into regional economies requires strategic business models involving multiple stakeholders. The Interconnected Nord-Est Innovation Ecosystem (iNEST) project exemplifies integration, linking local communities, craft enterprises, and hospitality businesses. This collaboration encourages innovation in WCO collection and processing, transforming it into marketable products that support regional tourism economies. Living labs established within this project demonstrate practical implementation, where regenerated oils are reintroduced into local economies as sustainable consumer products (e.g., artisanal goods, bio-based plastics). These initiatives illustrate how CE principles can strengthen regional identities, enhance environmental stewardship, and promote inclusive economic development.

By establishing a CE network, municipalities can coordinate logistical support, organize educational campaigns, and provide incentives for participation, while small businesses innovate ways to commercialize WCO-based products. This approach decreases waste disposal costs and stimulates local economies by fostering business innovation. The context of Venice, Verona, and Trento exemplifies how WCO-based partnerships might operate in practice. In Venice, the tourism and hospitality industries generate substantial WCO volumes, making it feasible for local associations to create effective collection points and potentially for small-scale cosmetics producers to market "Venetian-made" products derived from recycled oil. There is also a clear possibility of testing WCO-based biodiesel as a cleaner energy source for the city's water buses or delivery boats, thus reducing emissions in a fragile lagoon environment (Choi et al., 2024).

In the Verona and Vicenza areas, famed for their gastronomic traditions and vineyards, local agritourism, restaurants, and wine producers could collaborate in collecting and processing WCO. These efforts might support the experimentation of WCO-based polyols in eco-friendly foams, insulating panels, or adhesives by local craft enterprises and building-material innovators. The city's emphasis on cultural and culinary heritage and a well-established tourism sector could showcase how heritage can be harmonized with sustainability and innovation (Morea et al., 2022).

With its notable focus on mountain tourism and environmentally conscious visitors, Trento offers yet another compelling case of a region primed for bio-based research and circular initiatives. The local cooperative structure, including mountain huts, hotels, and breweries, could systematically collect WCO and direct it to urban processing facilities managed by a dedicated consortium.

Small-scale chemical laboratories or start-ups backed by Trento's academic network could transform this feedstock into specialized applications such as super-hydrophobic coatings or eco-friendly polyurethane insulation suited to alpine climates. These processes could be integrated into public demonstrations or outreach programs, reinforcing ecological awareness among visitors and residents.

Implementing efficient WCO recovery systems in these regions can yield a double dividend by reducing the environmental impact of used oil disposal and creating economic opportunities across waste management, transportation, and bio-based manufacturing. Local businesses benefit by lowering disposal fees and opening revenue streams from newly developed green products. Policy support is crucial in this regard, since tax incentives, grants, and subsidies are valuable tools for helping small- and medium-sized enterprises adopt WCO-based processes. Equally important is community engagement, which ensures a steady supply of WCO and maintains public enthusiasm through transparent communication about environmental gains. WCO-based initiatives can unify public, private, and communal interests in pursuing ecological and economic resilience. Research in this area is rapidly evolving, and further progress will likely hinge on continued policy support and the widespread recognition that sustainable manufacturing and circular practices are as integral to local economies as they are to the more significant global push for more responsible resource usage.

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