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Measuring the Level of Circularity in a Ho.Re.Ca. Organization According to UNI/TS 11820:2024

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Abstract

Assessing the level of circularity in the Hotel, Restaurant and Catering (HoReCa) sector is a significant challenge due to the lack of standardized quantification methods and the absence of structured environmental and material accounting systems, features that are typical of a sector largely composed of micro-enterprises. The technical standard UNI/TS 11820:2024 has developed a set of 71 indicators for the circular economy, structured across six domains (material resources and components; energy and water; waste and emissions; logistics; products and services; and human resources, assets, policies, and sustainability), allowing the assessment of circularity levels in a replicable and comparable manner. The present research measures circularity in a table-service restaurant micro-enterprise, which has voluntarily adopted circular economy practices since its foundation. The purpose is to test the applicability of UNI/TS 11820:2024 in the HoReCa context, improve knowledge about this technical standard, and highlight its strengths and weaknesses from the managerial, methodological and public authorities' perspective. The overall organization's circularity score achieved is 31.88%, with performance ranging from 14.40% for "material resources and components" to 56.25% for "human resources, assets and policies". Although UNI/TS 11820:2024 aims at bridging theoretical and practical gaps towards a harmonized set of measurement tools, sector-specific indicators for the foodservice context remain underrepresented, and public authorities and universities should promote both basic and advanced education in the field of circular economy measurement to support wider adoption.

Keywords: circular economy; HoReCa sector; measurement; sustainability; food and beverage

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1. Introduction

Although the Hotel, Restaurant and Catering (HoReCa) sector in Italy plays a pivotal role in GDP generation and employment, representing a key driver of tourism in a country deeply rooted in food culture, its environmental impacts are substantial and warrant careful attention [1]. In particular, the sector is associated with significant CO_2 emissions [2], considerable waste generation and pervasive food waste, all of which highlight the need for more sustainable and efficient operational practices [3]. The adoption of circular economy good practices can significantly enhance the sustainability of the HoReCa

sector [4,5]. However, prior to implementing such practices, it is essential to assess the current level of circularity in order to establish a clear baseline. This enables a comprehensive understanding of existing conditions and supports informed decision-making regarding which organizational and operational aspects should be improved to reduce environmental impacts of a such important Italian sector. According to the most recent data published by FIPE Confcommercio (Federazione Italiana Pubblici Esercizi) [6,7], as of December 2025, there were 324,436 active enterprises in the Italian foodservice sector, comprising 124,917 bars, 194,899 restaurants and mobile catering operations, and 3984 banqueting and collective catering companies. In terms of employment, the sector recorded approximately 1.3 million workers in 2025, growing by 1.7% compared to 2024, with over one million dependent employees surpassing pre-pandemic levels by more than 100,000 units. In 2025, the added value of restaurant services was estimated at 59.3 billion euros, growing by 0.5% compared to the previous year. At the European level, the HoReCa sector accounts for 6.4% of total employment in Italy, one of the highest shares among EU Member States and significantly above the EU-27 average of 4.7%.

Beyond its economic weight, the HoReCa sector carries considerable environmental and social significance [8]. Although the sector itself does not represent a primary direct source of greenhouse gas emissions, its environmental impact is predominantly indirect, arising from its position within the agri-food supply chain [9]. According to ISPRA and European scientific assessments [10,11], the food system as a whole accounts for approximately 20–30% of global greenhouse gas (GHG) emissions, with the HoReCa sector contributing through downstream demand and operational activities. These impacts are mainly associated with energy consumption in professional kitchens and refrigeration systems, water use in food preparation and service, and upstream pressures embedded in food production, processing, and logistics. Consequently, the HoReCa sector can be considered a critical "hotspot" within the food supply chain, amplifying environmental burdens rather than functioning as an isolated emission source. In addition, the inefficient use of food, water and energy resources in the HoReCa sector generates a strong environmental burden, with raw and ancillary materials, water and electricity jointly representing approximately 25% of total annual restaurant costs, i.e., a loss equivalent to around 5% of total annual revenues [12]. These figures underscore how the sector's operational model is predominantly linear: goods are purchased, stored, processed, served and consumed with little or no integration of circular solutions [13]. From a social perspective, the sector also plays a critical role in shaping community well-being, employment inclusion, and the preservation of Italian food culture [13,14]. Italy has the largest hospitality sector in Europe by number of establishments, with the fourth highest density of HoReCa businesses relative to population. The scale amplifies both the sector's positive social contributions and its aggregate environmental footprint.

Given this dual relevance, a growing body of scientific literature has investigated the application of circular economy (CE) principles to the HoReCa and broader hospitality sector. The circular economy, which aims to extend the life cycle of products and minimize waste through resource reuse, recycling and regenerative design [15,16], has gained prominence as a structural response to the environmental burdens of the food industry. Research confirms that CE practices in hospitality settings can be adopted at both the organizational and customer levels, and their implementation has been associated with promoting sustainable food production and consumption while encouraging broader sustainable behaviors [17]. Several studies have demonstrated tangible benefits of CE adoption. Companies integrating sustainability into their operations have been shown to benefit not only from reputational gains and enhanced consumer loyalty but also from cost reductions through renewable energy use and more efficient resource management [18,19].

Nevertheless, the literature specifically dedicated to the HoReCa sector and its supply chain remains relatively scarce, confirming the need for further empirical research on circular strategies and their economic and environmental implications in foodservice contexts. In the HoReCa sector, the circular economy imperative is closely tied to the ability to effectively serve high-value market segments, improve resilience to future crises, and meet increasing sustainability standards across energy, water and material resources. Yet despite these opportunities, to date the sector demonstrates limited engagement with the circular economy and limited awareness of its potential to reduce greenhouse gas emissions, boost resource productivity and reduce costs [20].

A key challenge that emerges from both academic and policy debates is the absence of a standardized, replicable and sector-agnostic methodology for quantifying circularity performance across organizations [21]. Without such a framework, it is impossible to benchmark progress, compare performance across enterprises, or formulate evidence-based sustainability strategies. In response to this gap, the Italian standard UNI/TS 11820, "Measurement of Circularity—Methods and Indicators for the Measurement of Circular Processes in Organisations," was first published in November 2022 [22] and defines a set of circularity indicators applicable at the meso- and micro-levels, designed to assess, through a rating system, the level of circularity of an organization or group of organizations. Since its introduction, UNI/TS 11820 has served as the national reference tool for measuring and evaluating organizational circularity, providing a standardized method based on specific indicators to monitor progress over time and identify potential areas for improvement. The standard was developed within the framework of the "Advanced Policy Instruments for Circular Economy" project, promoted by the Italian Ministry of Environment and Energy Security in collaboration with the Ministry of Enterprises and Made in Italy, ENEA, ISPRA and the OECD. Indicators are grouped into seven categories: material resources and components; energy and water resources; waste and emissions; logistics; products, and services; and human resources, assets, policies, and sustainability. The 2024 revision of the standard has introduced greater adaptability to different application contexts, including modifications to the indicator set and the methodology for calculating the overall circularity level. The update also increases alignment with international ESG standards and integrates feedback accumulated from two years of real-world implementation, consolidating UNI/TS 11820:2024 as the most comprehensive and operationally grounded tool currently available for the measurement of organizational circularity in Italy [23]. Although this newly revised methodology has so far seen limited application in academic literature due to its recent introduction [24,25], it holds significant potential for both researchers and practitioners aiming to assess circular economy performance. The concept of circular economy itself lacks a single, universally accepted definition, with as many as 114 identified in the literature, alongside a wide range of measurement approaches [26]. In this context, the UNI/TS framework offers a valuable opportunity to harmonize these diverse methodologies, enabling more consistent and comparable assessments of circularity across sectors and over time.

Against this background, the present study proposes the first systematic application of UNI/TS 11820:2024 to the Italian HoReCa sector. By collecting quantitative, qualitative and semi-quantitative data across the standard's seven indicator domains, this research aims to produce a complete circularity assessment for a representative HoReCa organization, generating results that are simultaneously actionable for business decision-making on sustainability investments and informative for policymakers engaged in designing regulatory and incentive frameworks for the sector's transition toward a more circular and sustainable model. From a theoretical and methodological standpoint, the study contributes to the growing body of literature on circular economy measurement by providing empirical

evidence on the applicability, strengths, and limitations of UNI/TS 11820:2024 in a sector-specific context. Compared to alternative circularity assessment frameworks proposed in the agri-food and hospitality literature [27–31], UNI/TS 11820:2024 offers a distinct advantage in terms of replicability and cross-sector comparability. The present application extends the empirical base of the standard, previously tested in manufacturing [32] and waste management [24] contexts, to the foodservice domain, thereby broadening its scope and informing future methodological refinements.

2. Data and Methods

2.1. Case Study Scenario

BeyondFood S.r.l. is a micro-enterprise operating in the Italian HoReCa sector, specifically within the Ateco classification 56.10.11 (restaurants with table service). The company is located in Sciacca (Agrigento Province) and was established in 2024. Despite its recent foundation, the firm represents a relevant and representative case for the sector, both in economic and organizational terms. Indeed, BeyondFood reports values that are broadly consistent with the structural averages of small-sized foodservice businesses in Italy, such as an annual turnover of approximately €400,000 and employment of 10 workers.

The relevance of this case study lies not only in its representativeness but also in its strategic positioning. Since its inception, BeyondFood S.r.l. has explicitly adopted sustainability and circular economy principles as a source of competitive advantage in a market characterized by a high level of fragmentation and the presence of well-established competitors. In particular, the company has implemented a set of operational practices aligned with circular economy and ESG principles (Table 1).

Table 1. Circular economy good practices adopted by BeyondFood s.r.l.

N.	Practice	Description	Circular Economy Relevance
1	Renewable electricity sourcing	Procurement of electricity derived 100% from a mix of renewable energy sources	Reduces carbon footprint and reliance on fossil fuels
2	Photovoltaic systems	Use of small-scale photovoltaic panels for external lighting	On-site renewable energy generation
3	Full electrification of equipment	Exclusive use of electric machinery (ovens, fryers, and induction hobs) instead of gas-powered systems	Improves energy efficiency and reduces emissions
4	Food waste reuse system	Internal system to reuse production waste as secondary raw materials in other preparations	Enhances material circularity and minimizes food waste
5	Biodegradable and recycled materials	Use of biodegradable materials derived from recycled resources for service and packaging	Reduces waste generation and promotes sustainable materials
6	Eco-friendly cleaning products	Adoption of refillable and biodegradable detergents and cleaning agents	Reduces chemical pollution and packaging waste
7	Digitalization of processes	Use of digital tools for menus, customer communication, and employee management	Reduces paper use and improves organizational efficiency

From an environmental perspective, the company sources electricity entirely from a mix of renewable energy sources and complements this supply with small-scale photovoltaic systems dedicated to external lighting. Furthermore, all production and service equipment (such as ovens, fryers, and induction hobs) are fully electric, representing a deliberate shift away from conventional gas-based systems typically used in the sector.

In terms of resource efficiency and waste management, BeyondFood has developed an internal system aimed at reusing production waste as secondary raw materials in other food preparations, thereby reducing food waste and improving material circularity. Additionally, the company exclusively adopts biodegradable materials derived from recycled resources for packaging and service operations and employs refillable, environmentally friendly cleaning products.

From a social and organizational standpoint, the firm leverages digital processes to enhance internal and external communication, including the dematerialization of menus, customer engagement tools, and employee management systems (e.g., shifts, leave requests, and internal communications).

Overall, BeyondFood S.r.l. constitutes a meaningful case for analyzing the application of circular economy measurement frameworks, such as UNI/TS 11820:2024, within the Italian HoReCa sector.

2.2. Data Collection

To support the application of circular economy assessment within the BeyondFood S.r.l. case study, a structured primary data collection process was implemented. Given the objective of quantifying circularity performance through the UNI/TS 11820:2024 framework, a systematic and semi-structured interview methodology was adopted, focusing on the analysis of key operational inputs, outputs, and internal processes. This approach was essential to collect the information required for the computation of the circularity indicators and for the contextual interpretation of sustainability practices within the HoReCa environment. As Figure 1 illustrates, the data collection was defined within a consistent analytical perimeter covering the main dimensions of the company's value chain, including material inputs (food and non-food resources), energy consumption, water use, waste generation, logistical flows, service delivery processes, and organizational and human resource management practices. This structured framework ensured coherence across heterogeneous categories and enabled a comprehensive assessment of circularity-related performances.

The interview protocol was specifically designed to capture the variables required for the calculation of UNI/TS 11820 indicators. A total of five semi-structured interviews were conducted, each lasting approximately 60–90 min, with the company's chief executive officer, the head of operations, and selected kitchen and service staff. The interview guide was organized according to the six indicator domains of UNI/TS 11820:2024, with each session addressing the specific quantitative, qualitative, and semi-quantitative variables required for indicator computation. Qualitative and semi-quantitative responses were coded using predefined scoring criteria as specified in the standard (0 = not implemented; 0.5 = partially implemented; 1 = fully implemented), and each coded response was subsequently verified against available documentary evidence to ensure consistency. Multiple guided interviews were conducted with the company's management and operational staff through on-site sessions at the BeyondFood facility in Sciacca. To strengthen data reliability, the information collected was triangulated through cross-checking with internal documentation, operational records, and sustainability-related reports, complemented by follow-up clarification interviews where necessary. Additional validation was conducted through on-site inspections and informal discussions with operational personnel involved in kitchen activities,

logistics, and service management. After completion of data acquisition, a preliminary estimation of circularity indicators was developed and subsequently reviewed with the company's management to ensure consistency and accuracy. The robustness of the dataset is supported by the use of verifiable operational data rather than estimations or proxy variables, ensuring a high level of reliability for the application of the circular economy assessment model.

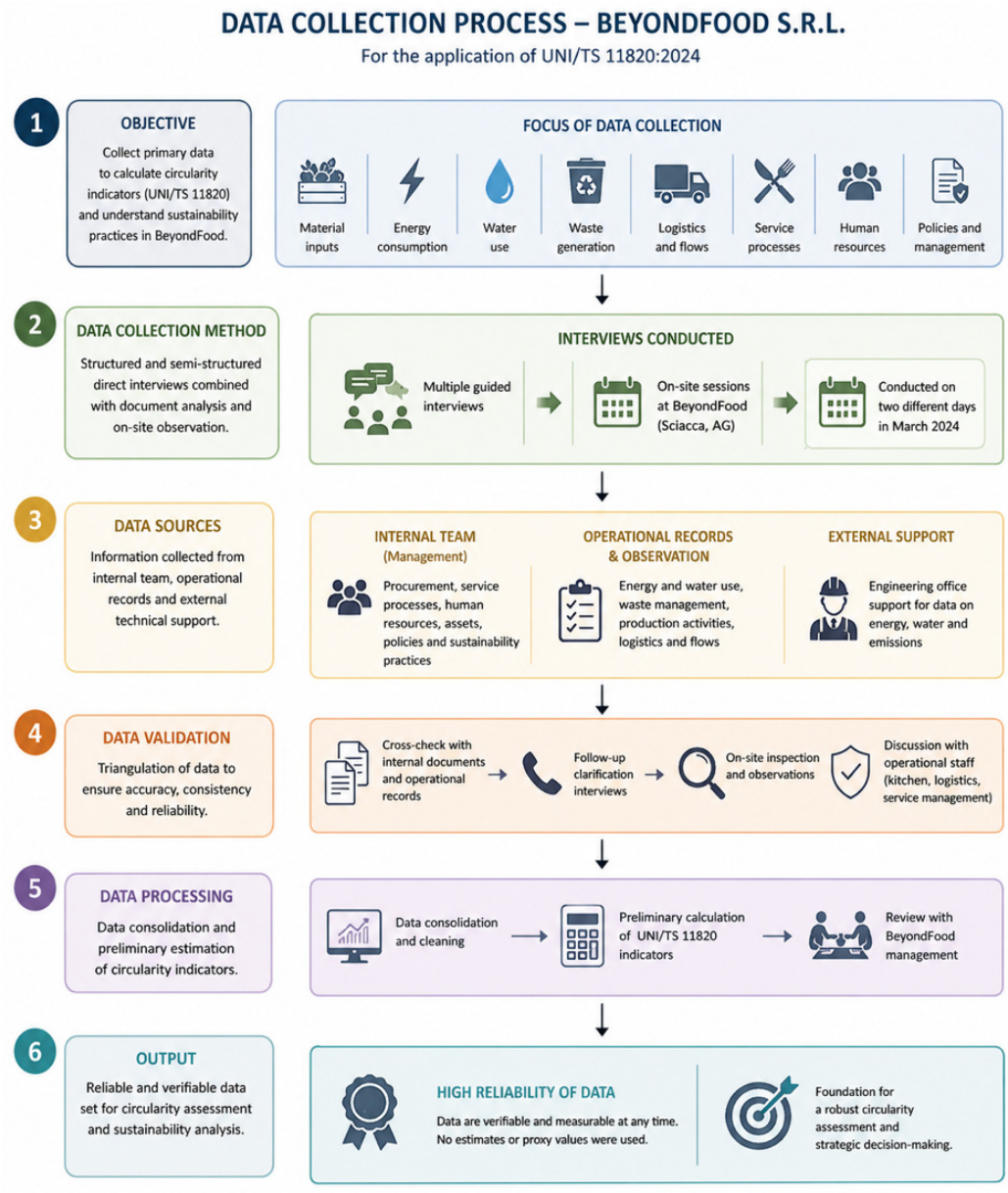

Figure 1. Data collection process implemented to obtain the data for UNI/TS 11820 indicators computation.

2.3. UNI/TS 11820:2024 Framework

UNI/TS 11820:2024 introduces a comprehensive framework composed of 71 key performance indicators designed to assess the circularity level of an individual organization or groups of organizations [23]. These indicators are structured into six main domains: material resources and components; energy and water consumption; waste and emissions; logistics; products and services; and human resources, assets, policies, and sustainability. The framework provides an international reference for the circular economy, including its foundational principles and implementation guidelines. As reported in Table 2, the

standard differentiates among core indicators (Ic), which are mandatory, specific indicators (Is), for which at least 50% compliance is required, and rewarding indicators (Ir), which are optional but contribute positively to the final circularity score.

Table 2. Number of indicators per category and typology according to UNI/TS 11820:2024.

Category	Core Indicators (Ic)	Specific Indicators (Is)	Rewarding Indicators (Ir)	Total
Material resources and components	3	3	-	6
Energy and water resources	-	3	-	3
Waste and emissions	2	1	-	3
Logistics	-	3	-	3
Products and services	-	11	1	12
Human resources, assets, policies and sustainability	2	5	1	8

The methodology also incorporates cut-off thresholds that allow the exclusion of indicators with negligible influence on the overall assessment, following predefined and transparent criteria. Compared to the 2022 version of the standard [22], which required the completion of all Pc indicators and at least 50% of all Ps indicators, the 2024 revision introduces greater flexibility in indicator selection. Nevertheless, it maintains a minimum requirement whereby at least 50% of indicators must be fulfilled within each of the six categories. In addition, any unfulfilled Ps indicators are assigned a value of zero in the final computation. The aggregation of indicators is performed through a linear weighted function (LWF), producing a final circularity score ranging from 0 to 100 (Equation (1)), representing the degree of circularity achieved at the time of assessment. Overall, the standard is intended for application at both the micro-level (e.g., individual enterprises or public entities) and meso-level (e.g., networks or consortia of organizations), enabling comparative and scalable circularity assessments.

$$LC = \frac{\sum I_c + \sum I_s + 50\% \sum I_r}{nI_c + nI_s} \quad (1)$$

where the numerator is composed by the sum of both the core and specific indicators calculated and the half value of rewarding indicators. The denominator represents the number of the core and specific indicators applied to the organization.

Regarding indicators on material resources and components (Table 3), four metrics are excluded from the analysis, as some are not applicable while others are not mandatory under the applicable regulation. As shown in Table 4, three out of five energy and water indicators are considered in the report, since not all organizations utilize thermal energy systems. Table 5 indicates that half of the total indicators are selected for the study: two belong to the core set, while the remaining one is specific. One additional core indicator is excluded due to its non-applicability, and its redefinition is not required. Out of six logistics indicators, the study includes three specific metrics tailored to the characteristics of the company under analysis (Table 6). This selection is justified either by their limited relevance based on quantitative results or by their incompatibility with the logistics processes implemented by the company. Table 7 presents twelve product-related indicators, corresponding to nearly 50% of the total subset, as the study prioritizes those most representative of the relevant market. The data revealed no significant relevance for the business under consideration, while inclusion of the full fraction would have produced

a value between 0 and 1, significantly influencing the analysis. Moreover, some indicators were not applicable. Finally, Table 8 reports indicators related to human resources, assets, policy, and sustainability. Within this category, all core indicators are selected, along with 50% of the specific indicators and one reward-related metric, in order to conduct the analysis.

Table 3. Indicators on material resources and components from UNI/TS 11820:2024. Source: authors' elaboration.

Material Resources and Components				
N.	**Type**	**Measure**	**Numerator Definition**	**Denominator Definition**
2	Ps	Quantitative	Inbound raw materials and secondary res. from local suppliers	Total inbound raw material and secondary resources
3	Ps	Quantitative	Inbound material res. equipped with tracking systems	Total inbound material res. equipped with tracking systems
4	Pc	Quantitative	Inbound by products and(or) secondary res.	Total inbound material res.
7	Pc	Quantitative	Renewable of recycled res. for packaging	Total packaging used
9	Ps	Quantitative	Total restricted or authorized substances	Total inbound material res.
10	Pc	Quantitative	(Inbound resources − residues produced)	Total residues produced

Table 4. Indicators on energy and water resources from UNI/TS 11820:2024. Source: authors' elaboration.

Energy and Water Resources				
N.	**Type**	**Measure**	**Numerator Definition**	**Denominator Definition**
11	Ps	Quantitative	Self-produced electricity from ren. res. or recovery	Total electricity consumed
13	Ps	Quantitative	Purchased electricity from ren. res.	Total electricity purchased
15	Ps	Quantitative	Inbound water from reuse and recycling	Total water need

Table 5. Indicators on waste and emissions from UNI/TS 11820:2024. Source: authors' elaboration.

Waste and Emissions				
N.	**Type**	**Measure**	**Numerator Definition**	**Denominator Definition**
16	Pc	Quantitative	Urban and(or) special waste sent to landfills	Total urban and(or) special waste generated
17	Pc	Quantitative	Municipal and(or) special waste collected separately	Total urban and(or) special waste generated
19	Ps	Qualitative	Has the organization carried out the assessment of its carbon footprint according to UNI EN ISO 1064 in year n and/or n − 1 and/or n − 2?	

Table 6. Indicators on logistics from UNI/TS 11820:2024. Source: authors' elaboration.

Logistics				
N.	**Type**	**Measure**	**Numerator Definition**	**Denominator Definition**
22	Ps	Quantitative	Waste treated at local valorization plants	Total waste treated at valorization plants (local or not)
25	Ps	Quantitative	Actual load capacity used by vehicles (round trip)	Total capacity of the vehicles
26	Ps	Quantitative	Number of employees adhering to sustainable mobility	Total employees

Table 7. Indicators on products and/or services from UNI/TS 11820:2024. Source: authors' elaboration.

Products and/or Services				
N.	**Type**	**Measure**	**Numerator Definition**	**Denominator Definition**
29	Pr	Quantitative	Outbound resources with a tracking system	Total outbound resources
40	Ps	Quantitative	Quantity of products generated	Quantity of resources employed
41	Ps	Quantitative	Value of products and services from local suppliers	Total value of products and services
43	Ps	Qualitative	Has the organization made investments in the circular design of its products and/or services in years n and/or n − 1 and/or n − 2?	
44	Ps	Qualitative	Has the organization made investments in the circular design of its processes in years n and/or n − 1 and/or n − 2?	
45	Ps	Qualitative	Has the organization made investments in the circular design of its assets in years n and/or n − 1 and/or n − 2?	
46	Ps	Quantitative	Investment in R&D linked to the circular economy	Total investment in R&D
49	Ps	Quantitative	Inbound water resources from industrial symbiosis	Total inbound water resources
50	Ps	Quantitative	Outbound water res. valorized with industrial symbiosis	Total outbound water resources
51	Ps	Quantitative	Inbound energy resources from industrial symbiosis	Total energy water resources
52	Ps	Quantitative	Outbound energy res. valorized with industrial symbiosis	Total outbound energy resources

Table 8. Indicators on human resources, assets, policy and sustainability from UNI/TS 11820:2024. Source: authors' elaboration.

Human Resources, Assets, Policy and Sustainability				
N.	**Type**	**Measure**	**Numerator Definition**	**Denominator Definition**
56	Ps	Qualitative	Has the organization already carried out staff training on the circular economy in the current year and in the two years before?	
57	Pc	Semi-quantitative	Which is the average energy performance index of buildings for civil use of the organization? Class A = 100%; Class B–C = 50%; Class D–F = 25%; Class G = 0%.	
59	Pc	Semi-quantitative	Has the organization developed and implemented a circular economy strategy?	
60	Ps	Qualitative	Does the organization carry out external communication of its sustainability and circularity performance (through sustainability reports, non-financial statements, etc.)?	
67	Ps	Qualitative	Has the organization planned to carry out internal staff information and training activities on the circular economy?	

Table 8. *Cont.*

Human Resources, Assets, Policy and Sustainability				
N.	**Type**	**Measure**	**Numerator Definition**	**Denominator Definition**
68	Ps	Qualitative	Has the organization carried out external training and information plans on the circular economy aimed at stakeholders?	
69	Pr	Qualitative	Does the organization have an energy efficiency plan?	
71	Ps	Qualitative	Does the organization adopt an Environmental Management system?	

3. Results and Discussion

The level of circularity of the HoReCa organization for the year 2025 is evaluated at 31.88% through the application of the complete set of indicators (Table 9) using the final formulation (Equation (1)) defined in UNI/TS 11820:2024. It should be emphasized that UNI 11820 does not establish a minimum threshold for circularity; instead, it enables benchmarking against the maximum achievable level. For contextual reference, the only available prior applications of UNI/TS 11820 in other sectors report scores broadly in the range of 20–45% for organizations at an early or intermediate stage of circular transition [5,24,32]. Within this frame of reference, the score of 31.88% achieved by BeyondFood S.r.l. can be interpreted as indicative of a moderate level of circularity, consistent with an organization that has deliberately adopted sustainability practices but has not yet fully systematized its circular economy approach. This result should therefore be read not as a failure to meet a normative threshold but as a meaningful baseline from which targeted improvements can be planned and monitored over time.

The overall result highlights the organization's proactive orientation toward environmental sustainability, suggesting a positive trajectory toward the adoption of circular and sustainable practices in future activities. As Figure 2 reports, the use of this assessment framework improves decision-support capabilities by identifying areas with significant potential for improvement. Specifically, the circularity scores for each indicator group are as follows:

(a) 15.40% for material resources and components (Table 3);
(b) 36.00% for energy and water resources (Table 4);
(c) 41.33% for waste and emissions (Table 5);
(d) 33.00% for logistics (Table 6);
(e) 35.14% for products and/or services (Table 7);
(f) 56.25% for human resources, assets, policy, and sustainability (Table 8).

Table 9 reports the numerical values associated with each individual indicator, including the relevant unit of measurement (kg, kWh, euro, m^3, or 0–1 for qualitative variables) and category classification.

The indicators resulting in Table 9 are computed in accordance with the definitions presented from Tables 3–8 connected to each different class of indicators through the identification number (N.). With respect to semi-quantitative (e.g., 57 and 59) and qualitative (19,43–45,56,60,67–69,71) indicators, the questionnaire is implemented to the chief executive officer assessed in the cross-verification mechanism outlined in Section 2.2.

In the case of quantitative indicators, the data collection procedure (Figure 1) is carried out in order to assess the numerator and denominator composing the indicator.

The assessment of circular economy performance within organizations carries relevant theoretical implications, particularly in relation to resource depletion, environmental impact, economic efficiency, and social equity. From a managerial standpoint, understanding internal organizational processes is essential to identify critical challenges and define effective strategies to support sustainability transitions. Bridging theoretical frameworks from

the literature with operational decision-making can strengthen the practical implementation of UNI/TS 11820:2024.

Table 9. Indicator results and descriptions according to UNI/TS 11820:2024. Source: authors' elaboration.

Indicator Category	Type	N.	Unit	Value
Material resources and components (a)	Is	2	kg	0.41
	Is	3	kg	0.07
	Ic	4	kg	nd
	Ic	7	kg	0.11
	Is	9	kg	0
	Ic	10	kg	0.18
Energy and water resources (b)	Is	11	kWh	0.08
	Is	13	0,1	1
	Is	15	m^3	0
Waste and emissions (c)	Ic	16	kg	0.38
	Ic	17	kg	0.86
	Is	19	0,1	0
Logistics (d)	Is	22	0,1	nd
	Is	25	0,1	0.65
	Is	26	n	0
Products and/or services (e)	Ir	29	kg	nd
	Is	33	0,1	0.78
	Is	40	kg	0.47
	Is	41	euro	0
	Is	43	0,1	1
	Is	44	0,1	0
	Is	45	0,1	0.09
	Is	46	euro	nd
	Is	49	kg	0.12
	Is	50	kg	nd
	Is	51	kWh	nd
	Is	52	kWh	0.244
Human resources, assets, policy and sustainability (f)	Is	56	0,1	1
	Ic	57	alternative	0.5
	Ic	59	alternative	0
	Is	60	0,1	0
	Is	67	0,1	1
	Is	68	0,1	1
	Ir	69	0,1	1
	Is	71	0,1	0

Within the category "material resources and components" the indicators have scored the lowest (15.40%) despite the 41% achieved by inbound raw materials and secondary resources sourced from local suppliers. This suggests the need for alternative supply channels of local suppliers to reduce transportation impacts and improve supply chain sustainability, as well as inbound material resources equipped with tracking systems [5]. Moreover, it is also crucial to increase the level of recycled resources for packaging, despite the nature of the sustainability of bio-based packaging often being doubtful. Moresi (2026) [33] argues that the potential advantages of compostability are presently constrained by shortcomings in industrial infrastructure, emphasizing that effectively transitioning to bioplastics depends on both progress in material development and wider structural upgrades to waste management systems.

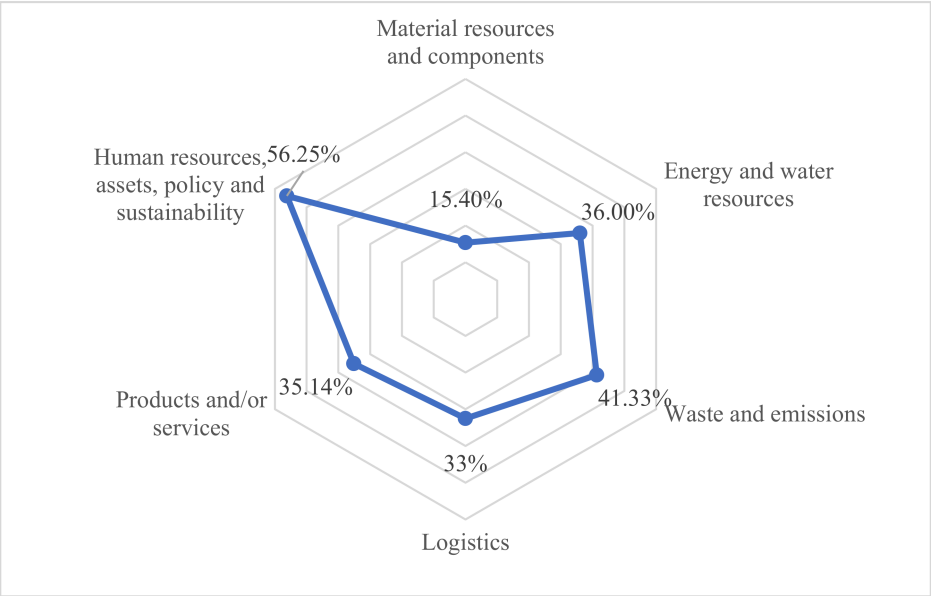

Figure 2. Radar chart on circularity scores for each indicator group.

The category "products and/or services" obtains a score of 35.14%, which may be improved by outbound resources with a tracking system and investing in R&D linked to the circular economy. The adoption of enhanced eco-design strategies could facilitate the integration of circular design principles into product development with a focus on recyclability while simultaneously reducing resource consumption and waste generation throughout the product life cycle. However, organizations should pay attention to eco-design within the food industry, as it is often linked to upcycled food products, and people's acceptance of these products is affected by psychological factors [34].

For "energy and water resources", the level of circularity is 36%, which appears to be easily increasable by installing photovoltaic panels on the facility rooftop while implementing some good practices for water efficiency [35]. Although 100% of electricity purchased derives from a mix of renewable resources, 0% in inbound water from reuse and recycling significantly reduces the overall category circularity score.

Regarding "waste and emissions", the score (41.33%) seems to indicate a commitment towards consumer sensibilization and internal good practices on separated collection of wastes. End-of-life alternatives for the management of leftover food play a crucial role in improving the circularity score of waste management of the HoReCa organization, as demonstrated through a life cycle assessment study [36].

However, circularity practices in logistics (33%) remain limited, indicating the potential for development through initiatives such as local waste valorization, solutions to increase the number of employees adhering to sustainable mobility and other network and urban infrastructural initiatives. However, shortcomings in infrastructure, inconsistent regulatory frameworks, and low levels of public participation still slow down advancement. Longo et al. [37] underscore the importance of coordinated approaches that link environmental, institutional, and social aspects in order to promote more circular, resilient, and inclusive urban systems.

The category "human resources, assets, policy, and sustainability" is the best among the ones observed, achieving a circularity score of 56.25%. This demonstrates relatively advanced circular practices and the commitment of the organization towards external training and information plans on the circular economy aimed at stakeholder and internal staff information and training activities on the circular economy. Finally, the organization develops an energy efficiency plan each year. Still, further improvements could be achieved

by strengthening collaboration with suppliers, customers, and policy stakeholders, as well as by enhancing employee training and external communication regarding circular products and services.

From a policy perspective, this study contributes to the ongoing validation of UNI/TS 11820:2024, a recent framework designed to measure organizational circularity. Macro-level studies on sustainability need to be complemented by research like the present study, which focuses on micro-level agri-food organizations in order to better understand the underlying drivers of aggregated outcomes.

For instance, Tudor et al. [38] found no significant overall differences in sustainability performance associated with measures at the macro-level of circularity over the analyzed period, highlighting the need to align circularity goals with targeted actions and for sector-specific guidance for the agri-food chain to support effective monitoring and policymaking at the EU level. Such a multilevel approach can better inform targeted policies and strategies, ultimately supporting more effective and context-specific transitions toward sustainability in the agri-food sector. UNI/TS 11820 may additionally support policymakers in the decision-making process linked to circular economy good practice to incentivize from a fiscal point of view within the food sector.

Such a circularity measurement framework might also help conscious consumers to drive their purchase choices. The HoReCa market is highly competitive, and brands labeled as "eco-friendly" are generally viewed as higher in quality and more attractive. Most people show a preference for brands that include environmentally oriented elements on their packaging. These results suggest that incorporating sustainability-related messaging into packaging can provide brand owners with a competitive edge in the food industry [39]. However, the food sector is huge and heterogenous, presenting strong differences along supply chains and across markets. Specifically, Öztürk Birim & Kazancoglu [40] find that food-related characteristics continue to be the most important factors in predicting customer satisfaction, followed by service quality and the dining environment. Although environmentally friendly practices were found to be statistically significant, they had the least influence, suggesting that customers pay relatively little attention to sustainability initiatives compared to aspects directly related to food. Furthermore, Mocan et al. [41] shows a clear gap between people's stated commitment to sustainability and their real-world actions within the HoReCa sector. Key barriers identified were sensitivity to price, doubts about the credibility of environmental marketing claims, and limited access to straightforward information on companies' sustainability practices. Although people generally endorse sustainable initiatives in theory, they often find it difficult to reflect these values in their purchasing behavior.

From a methodological point of view, the findings of this study are consistent with those reported in the literature [5,24,32], confirming that the UNI/TS 11820:2022 standard constitutes a robust instrument for evaluating circularity at the micro-organizational level across different sectors. Nevertheless, in line with prior research, notable challenges arise in its practical implementation, particularly in settings where structured and reliable systems for material tracking and accounting are not in place. Some circular economy measurement approaches, strictly based on the agri-food sector and using a set of sector-specific indicators, may fit particularly well in the HoReCa [27] compared to a more general technical standard sector and dimension agnostic. For example, the circularity level provided by internal good practices carried out by BeyondFood s.r.l. may only be gauged by specific indicators related to the HeReCa sector.

Conversely, the updated version of the standard, UNI/TS 11820:2024, introduces significant improvements, including the threshold system, which enhances the usability and applicability of the framework, even for organizations with lower levels of data man-

agement maturity. This development appears to reduce previously identified operational barriers and supports a broader adoption of the standard. Although the newly developed version aims to balance completeness and operational simplicity, certain relevant dimensions, like internal good practices adopted in production, remain underrepresented, thereby indicating opportunities for further refinement in future iterations related to the HoReCa sector of the framework. However, the higher the number of indicators and the more sector-specific they are, the greater is the complexity in aggregating the indicator in obtaining a single and representative circularity score that is mathematically effective. This is a very common issue, leading to the aggregation method facing several crucial limitations (e.g., different measurement units, compensation and importance weight attribution) when dealing with metrics that are different in nature and with trade-off problems caused by conflicting/interacting objectives [42].

To this regard the final formulation of UNI/TS 11820 (Equation (1)) could be modified, taking into consideration aspects of Multi-Criteria Decision Approaches (MCDA) [43].

4. Conclusions

This study has applied the UNI/TS 11820:2024 standard for the first time to an organization operating in the Italian HoReCa sector, producing a comprehensive circularity assessment of BeyondFood S.r.l., a table-service micro-enterprise located in Sicily. The overall circularity score achieved is 31.88%, a result that, while not reaching advanced levels, attests to the organization's proactive orientation towards environmental sustainability and outlines a positive trajectory towards the progressive adoption of circular practices.

The disaggregated analysis by indicator category reveals an articulated picture consistent with the structural specificities of the sector. The category "human resources, assets, policies and sustainability" achieved the highest score (56.25%), reflecting a strong organizational commitment to staff training, energy efficiency planning, and external communication on circularity. At the opposite end, "material resources and components" recorded the lowest score (15.40%), highlighting structural weaknesses related to inbound material traceability, limited integration of secondary resources, and insufficient use of recycled packaging. These findings are consistent with the existing literature [5,24,32], which identifies material flow management and resource traceability as the primary areas for improvement for organizations approaching circularity measurement for the first time.

The intermediate categories, energy and water (36.00%), products and services (35.14%), logistics (33.00%), and waste and emissions (41.33%), indicate areas with relatively accessible improvement potential. Regarding energy, the installation of photovoltaic panels on the facility rooftop and the adoption of water efficiency practices represent high benefit-to-cost interventions. On the logistics side, local waste valorization and incentivizing sustainable commuting for employees constitute strategic levers for significantly increasing the score. For products and services, implementing outbound resource tracking systems and investing in circular economy research and development can further strengthen overall performance. Specifically, future revisions of the framework could consider incorporating indicators that capture food waste valorization rates, the share of locally sourced ingredients, and the adoption of plant-based or low-impact menu compositions, dimensions that are central to the environmental performance of foodservice operations but currently fall outside the standard's measurement scope. Such additions would improve the sensitivity of the framework to sector-specific circular practices and strengthen its relevance for the HoReCa context. By extending the empirical basis of UNI/TS 11820 to a previously untested sector and surfacing these refinement opportunities, this study makes a concrete contribution to the ongoing development of standardized circular economy measurement tools.

From a methodological standpoint, this study contributes to the empirical validation of the UNI/TS 11820:2024 standard in its updated version, which introduces relevant innovations compared to the 2022 edition: greater flexibility in indicator selection, the introduction of exclusion thresholds for indicators with negligible influence, and closer alignment with international ESG frameworks. These improvements broaden the usability of the tool for organizations with lower data management maturity, lowering the operational barriers that had constrained earlier applications. However, some areas of potential refinement remain: in particular, internal production good practices, while forming an integral part of the organization's circular model, are still underrepresented in the indicator set, suggesting the opportunity to develop sector-specific indicators dedicated to the HoReCa context in future revisions of the standard.

From a policy perspective, the findings of this study provide operational guidance for public decision-makers engaged in designing regulatory and incentive instruments to support the circular transition of the HoReCa sector. The availability of a standardized and replicable method for measuring and comparing circularity is a fundamental prerequisite for monitoring progress, setting sectoral targets, and designing targeted interventions, such as tax credits for resource efficiency investments, incentives for sustainability certification, and continuous training programs on circular practices. It is also advisable to promote systemic interventions that foster both basic and advanced education in circular economy in order to equip organizations with the skills needed to effectively implement measurement standards such as UNI/TS 11820:2024.

In conclusion, the case of BeyondFood S.r.l. demonstrates that even micro-enterprises in the HoReCa sector can successfully embark on a path of organizational circularity measurement and improvement. The combination of sustainability-oriented operational practices and a structured, standardized measurement framework generate value both for internal decision-making and for the external communication of sustainability performance. The scalability of the proposed approach suggests its applicability to broader contexts, paving the way for future comparative research on larger samples of Italian and European HoReCa enterprises, with the aim of building robust sectoral benchmarks and practical tools to support the transition towards a genuinely circular foodservice model. It should nonetheless be acknowledged that the single-case design of this study carries inherent limitations with respect to external validity and the generalizability of findings. The results are specific to BeyondFood S.r.l. and reflect the characteristics of a sustainability-oriented micro-enterprise in the Sicilian HoReCa market. Future research should address this limitation by applying the UNI/TS 11820:2024 framework to a broader and more heterogeneous sample of HoReCa organizations, including different firm sizes, geographic contexts, and levels of circular economy maturity. Comparative multi-case studies would enable the construction of sectoral benchmarks and allow for a more robust assessment of how contextual and organizational factors shape circularity performance across the Italian and European foodservice industry.

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