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How can organisations measure their level of circularity? A review of available tools

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ABSTRACT

Ensuring the success of organisations in their transition to a circular economy requires providing them with tools capable of measuring, monitoring and communicating their progress. That is, there is a need for tools that allow them to make a diagnosis of the current situation from which to establish objectives and goals in the short, medium and long term, while also enabling them to monitor the extent to which they are fulfilled. The aim of this study is thus to carry out a review of 10 tools specifically developed to measure the level of circularity of organisations and to perform an in-depth analysis of their general characteristics (ownership, launch date, interface, availability, language, application cases and training materials), required information (questions, categories and input data) and the results that can be obtained and the way in which they are communicated. This review shows that the number of circular assessment tools has increased in recent years, although there is a clear lack of harmonisation in terms of characteristics and content. It is concluded that these tools can be useful as a first starting point, but it is necessary to consider that when using them for decision-making, the results obtained in the same application could differ significantly depending on the tool applied.

1. Introduction

Sustainable development and the circular economy (CE) have been identified as one of the biggest challenges for the European Union (EU) in recent years. In this context, the European Commission recently adopted the *European Green Deal* (COM 640, 2019) as a reference framework to achieve the climate neutrality target by 2050, with the *New Circular Economy Action Plan* (COM 98, 2020) as one of its main pillars. This new CE framework (COM 98, 2020), built on the previous *CE Action Plan* (COM 614, 2015), aims to ensure the use of resources for longer periods of time while at the same time minimising the amount of waste generated. To do so, it includes measures to boost the design of sustainable products and the empowering of consumers, and focuses on resource intensive sectors with a high potential for circularity (electronics and Information Communications Technology (ICT), batteries and vehicles, packaging, plastics, textiles, construction and housing, and food).

From the perspective of organisations, the implementation of actions that promote the transition to a CE and their communication to the different stakeholders has started to become an objective and a priority. Evidence of this is provided by the numerous studies related to the implementation of the CE in organisations that have been conducted: Marino and Pariso (2021) analysed and evaluated the transition in 13 sectors with the highest SME performance in Europe; Koszewska and Bielecki (2020) analysed the situation of the furniture sector in Europe and proposed a number of different models to make the industry more circular; Radavičius et al. (2021) proposed solutions to make the solar industry more circular; Mazzoni (2020) analysed which types of eco-innovation could lead to the implementation of the CE in Italian industrial clusters, exploring the case study of the Prato textile industrial cluster, which has already introduced circular measures; Hanuláková et al. (2021) analysed the Slovakian textile and clothing industry to explain the principles of transition and the potential for change, amongst many others.

Therefore, organisations need approaches to assess their level of implementation of the CE. In fact, the EU communication *A New Industrial Strategy for Europe* (COM 102, 2020) established the need to obtain CE performance indicators for measuring the advance of organisations towards the CE. However, in the EU context, a set of *indicators had been established at the territorial level (Eurostat, 2021) but they have not yet been defined for organisations. Therefore, as demonstrated by Vinante et al. (2021), the organisational level requires

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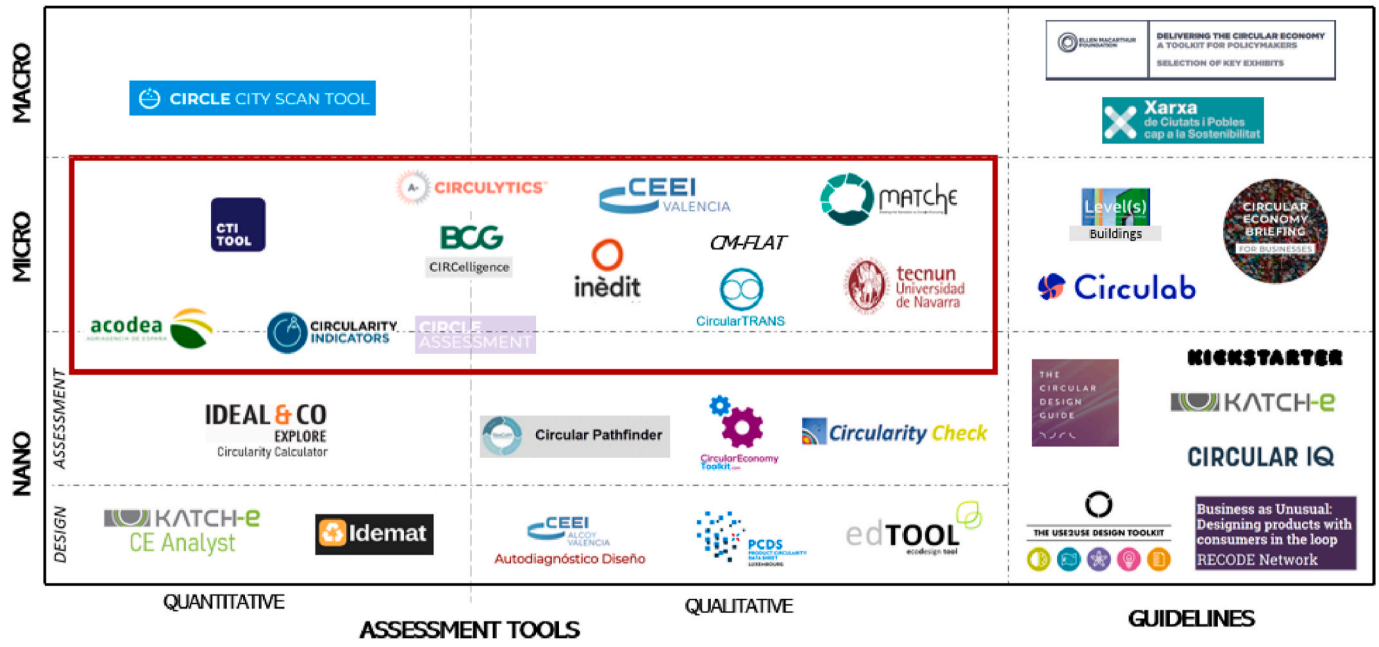


Fig. 1. Existing tools for the assessment of the circular economy in different areas.

specific attention. Organisations need their own CE indicators and also tools to assess the level of implementation of the CE that make it easier to calculate these indicators, thereby facilitating assessment and thus the transition towards the CE.

Numerous reviews focused on evaluating CE indicators/metrics can be found in the literature: Corona et al. (2019) and Elia et al. (2017) analysed different CE assessment indicators (such as Longevity indicator, Resource Potential Indicator or Sustainable Process Index) and CE assessment methods (such as Input Output Analysis, Material Flow Analysis or Life Cycle Assessment) at product level; de Oliveira et al. (2021) and De Pascale et al. (2021) analysed, respectively, 58 and 61 CE assessment indicators for products and organisations; Kristensen and Mosgaard (2020) analysed 30 CE assessment indicators for organisations; Moraga et al. (2019) analysed 30 CE assessment indicators for organisations and the Eurostat Indicators for the territorial level; Saidani et al. (2019) analysed 55 CE assessment indicators for organisations, eco-industrial parks and territorial level; and Vinante et al. (2021) analysed 365 CE metrics (i.e. measurable quantities for tracking and indicators) for organisations. Moreover, Franco et al. (2021) and Kravchenko et al. (2019) analysed, respectively, 58 and 250 CE indicators and their relationship with the implementation of circularity strategies in organisations. Apart from this, Sassanelli et al. (2019) analysed the current state of the art on CE assessment methods, and Lindgreen et al. (2020) and Parchomenko et al. (2019) analysed different elements (indicators, tools and methodologies) for organisations. All these studies reached a common conclusion: the lack of consensus when evaluating CE strategies due to the large number of metrics/indicators/methods that exist and the need for standardised procedures to achieve it.

Nevertheless, no review has yet been conducted on tools capable of measuring the level of circularity of organisations, despite the fact that if organisations want to evolve towards a CE, they need instruments that allow them to evaluate (in a simple way) and communicate (in a clear and unequivocal way) the results of their transition to a CE.

Regarding the evaluation of the level of circularity of systems, different assessment approaches have recently been developed. A review of these CE assessment approaches has been carried out using databases such as Scopus and Google Scholar and different online search engines to identify as many as possible. The approaches identified are reported in Fig. 1, where they are classified according to their objective into assessment tools (computer tools capable of measuring the level of circularity) or guidelines (approaches to identify potential opportunities to ensure progress towards CE business models in order to improve the competitiveness of organisations), and according to their level of applicability at the macro level (city/regional/national), meso level (eco-industrial park), micro level (organisational) and nano level (product), as suggested by Saidani et al. (2017).

Focusing on approaches that can be applied to evaluate the level of circularity of organisations (micro level), nine assessment tools were identified: one quantitative tool (CTI Tool, 2020), six qualitative tools (CEEI, 2020; CircularTRANS, 2020; Inedit, 2020; MATChE, 2021; CM-FLAT (Sacco et al., 2021); TECNUN, 2017) and two hybrid tools (CIRCelligence, 2020; Circulytics, 2020). In addition, guidelines were also identified, some of them applicable to any organisational sector (Economy, 2021; Circulab, 2021) and a specific guide for the building sector (Level(s), 2021). Moreover, two quantitative assessment tools applicable to both organisation and product were identified (ACODEA, 2018; MCI, 2017) and another one for which no information is available (Circle Assessment, 2017). On the other hand, several approaches have been found to be suitable to measure the level of circularity of products (nano level), differentiating among assessment tools focused on eco-design (two quantitative tools (Idemat, 2015; KATCHe, 2021) and three qualitative tools (CEEI, 2016; EdTool, 2016; PCDS, 2020)); assessment tools focused on evaluating the circularity of the product (one quantitative tool (Circularity Calculator, 2021) and three qualitative tools (CircularityCheck, 2018; Circular Economy toolkit (Evans and Bocken, 2014); Pathfinder, 2021); and guidelines (BAU, 2017; Circular design guide, 2021; Circular IQ, 2021; KATCHe, 2021; Kickstarter, 2021; Use2use, 2019). Apart from this, some approaches applicable to the city/regional/national (macro level) were identified, differentiating between tools (CITIES, 2021) and guidelines (EMF, 2015; Xarxa, 2018). As can be seen, there are many different approaches.

Hence, the aim of this paper is to analyse the existing tools that have been specifically developed to measure the level of circularity of organisations (highlighted inside the red rectangle in Fig. 1), in order to find common and differentiating patterns. To this end, three research questions are proposed: RQ1- What are the main characteristics of the existing tools capable of measuring the level of circularity of organisations? RQ2- Are the results from the different tools comparable with each other? RQ3- Which tool is the most complete and effective? To answer these questions, this paper is structured as follows: Section 2

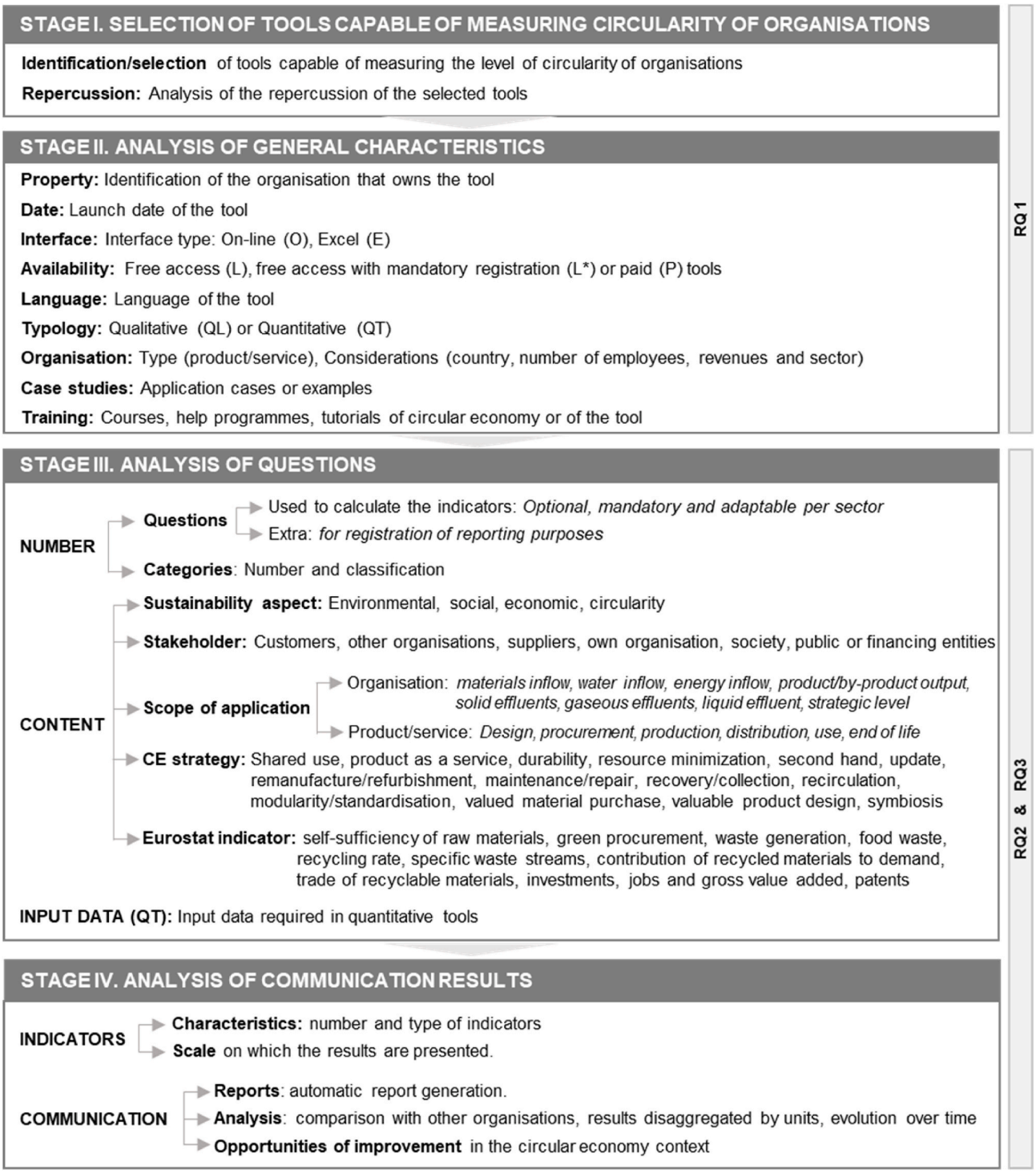


Fig. 2. Methodology for tools analysis.

describes the proposed four-step methodology, the application and results of which are reported in Section 3 and discussed in Section 4. The conclusions from the study are detailed in Section 5.

2. Methodology

In order to select and analyse the existing tools that have been developed specifically to measure the level of circularity of organisations, the four-step methodology shown in Fig. 2 and described below was proposed. Note that stages I and II were carried out with the aim of answering RQ1, while Stages III and IV were designed to answer RQ2 and RQ3.

In **Stage I (Review)**, a literature review was carried out to select the existing tools capable of measuring the level of circularity of organisations and to identify the repercussion/impact of the selected tools in research articles or reports. First, a search was carried out in databases such as Scopus and Google Scholar and in online search engines, by combining the keyword "circular economy" with "tool", "calculator", "diagnostic" and/or "assessment". The results obtained were then filtered to select only tools applicable to measuring the level of

Table 1
Circular Economy assessment tools applicable to organisations.

	Acodea. Tool for calculating the Material Circularity Indicator, following the methodology developed by the Ellen MacArthur Foundation. Developed by the Acodea Foundation with the support of the Spanish Ministry for Ecological Transition (ACODEA, 2018).
CEEI CONSELLERIA VALENCIANA CENTROS EUROPEOS DE EMPRESAS INNOVADORAS	**CEEI.** Tool coordinated by the European Centre for Innovative Enterprises of Valencia and the University of Valencia and funded by the Generalitat Valenciana and IVACE (CEEI, 2020).
BCG CIRCelligence	**CIRCelligence.** Tool implemented in a customisable web-based survey. Developed by Boston Consulting Group (CIRCelligence, 2020).
CIRCLE ASSESSMENT	**Circle assessment.** Tool developed by Circle economy (Circle Assessment, 2017).
	CircularTRANS. Tool developed by the Higher Polytechnic School of the University of Mondragon and with the collaboration of other organisations (among them, TECNUN) (CircularTRANS, 2020).
CIRCULYTICS	**Circulytics.** Tool implemented in the Qualtrics platform. Developed by the Ellen McArthur Foundation in collaboration with 13 Strategic Partners and member companies, and tested by over 30 companies during 2019 (Circulytics, 2020).
CM-FLAT	**CM-FLAT (Circularity and Maturity Firm-Level Assessment Tool).** Tool that is currently under development as a computer-supported instrument. Developed by the Fraunhofer Italia Research, Innovation Engineering Centre and the Faculty of Science and Technology, Free University of Bozen-Bolzano (Sacco et al., 2021).
CTI TOOL	**CTI Tool.** Tool developed by World Business Council for Sustainable Development and Circular-IQ (CTI Tool, 2020).
inèdit	**Inedit**. Tool developed by Inedit Innova (Inedit, 2020).
MATChE	**MATChE Readiness Assessment.** Tool developed by the Technical University of Denmark. (MATChE, 2021).
CIRCULARITY INDICATORS	**MCI (Material Circularity Indicator).** Tool that is part of a broader 'Circular Indicators Project' developed by the Ellen MacArthur Foundation and Granta Design (MCI, 2017).
tecnun Universidad de Navarra	**TECNUN.** Tool developed by the School of Engineering of the University of Navarra (Spain) (TECNUN, 2017).

circularity of organisations and to exclude tools only focused on product circularity and CE guidelines. Second, to identify the repercussion/impact, the name of each tool was used as a keyword in databases such as Scopus or Google Scholar. Then, the results obtained were filtered to choose those articles that cite, apply or analyse any of the selected tools.

In **Stage II (Analysis of general characteristics)**, for each tool identified in Stage I, the general characteristics were analysed at two levels. First, general aspects were identified: ownership, launch date, interface, availability, language, application cases and training materials. And second, specific aspects that could affect the level of circularity of an organisation were identified: the type of organisation to which the tool is addressed, the possibility of considering the activity index of the organisation and the type of tool (qualitative or quantitative).

In **Stage III (Analysis of questions/input data)**, for each tool identified in Stage I, the questions used to measure the level of circularity were identified, analysed and classified. First, all the questions included in each tool were classified into questions used to calculate the CE indicator/s, questions that are optional, mandatory or adaptable per sector, and extra questions used for registration or reporting purposes. Second, the questions were then classified into a common set of categories according to their content, taking into account the categories proposed by de Oliveira et al. (2021) and De Pascale et al. (2021), among others. The **Supplementary Material** includes a detailed list of criteria applied to classify the questions into the following categories: sustainability aspect, stakeholder, scope of application, CE strategy and Eurostat indicator. Lastly, for quantitative tools, the input data required to calculate the CE indicator/s was identified.

And finally, **Stage IV (Analysis of communication results)** included, for each tool identified in Stage I, an analysis of the characteristics of the CE indicator/s provided as a result (i.e. number and type) and their scale, and the communication of the results (how the results are reported, how the results are analysed and whether the tool offers opportunities for improvement in the CE context).

3. Results

3.1. Stage I: review

3.1.1. Identification/selection of tools capable of measuring the level of circularity of organisations

As a result of the research process described in the methodology, 12 CE assessment tools applicable to organisations were identified (see Table 1).

However, of the 12 tools identified, only 10 of them were available

Table 2
General characteristics of the analysed tools.

TOOL	Ownership[a]	Date	Interface[b]	Availability[c]	Language[d]	Typology[e]	O. Type[f]	Organisation[g]	Case studies	Training/Tutorial[h]
Acodea	G	2018	O	F	ES	QT	P	–	–	–
CEEI	G	2020	O	F*	ES,EN,CA	QL	P, S	–	–	–
CircularTRANS	U	2020	O	F*	ES,EU	QL	P, S	S	x	CE, T
Circulytics	P	2020	O[j]	F*	ES,EN,FR,PO,CH	QL, QT	P, S	C, E, R, S	x	CE, T
CM-FLAT	U	UD[i]	UD[i]	UD[i]	UD[i]	QL	P, S	E,S	x	UD[i]
CTI Tool	P	2020	O	F*,C	EN	QT	P, S	C, R, S	x	CE, T
Inedit	P	2020	O	F	ES	QL	P, S	S	x	T
MATChE	U	2021	O	F*	EN,DA	QL	P, S[l]	C, E, S	–	CE, T
MCI	P	2015	E	F	EN	QT	P	–	–	–
TECNUN	U	2017	O[k]	F	ES,EN	QL	P, S	C, E, S	–	CE

[a] Ownership: G (governmental institution), P (private company: organisations or non-profit foundations), U (university).
[b] Interface: E (Excel), O (online).
[c] Availability: F (Free), F* (Free, requires registration), C (Commercial).
[d] Language: CA (Catalan), CH (Chinese), DA (Danish), EN (English), ES (Spanish), EU (Basque), FR (French), PO (Portuguese).
[e] Typology: QL (qualitative), QT (quantitative).
[f] Organisation type: P (production), S (services).
[g] Organisation characteristics: C (country), E (employees), R (revenue), S (sector).
[h] Training/tutorial: C (courses), CE (circular economy), T (tool).
[i] *UD: Under development (Some characteristics are not identified because this tool is under development and this information is not yet available).*
[j] Implemented in the Qualtrics platform.
[k] Implemented in Google Forms.
[l] MATChE is designed for production organisations, although it can be applied to service organisations; at present the data obtained are not collected in the register.

Table 3
Question characteristics of the analysed tools.

TOOL	# Categories	# Total Questions	Questions used to calculate indicators				# Extra Questions
			# Questions	Mandatory	Adaptable per sector	Optional	
Acodea	1	7 [a]	7 [a]	100%			
CEEI*	5	25/74 [d]	25	100%			
CircularTRANS	8	153	153			100%	
Circulytics	12	69	23–51	45%	55%		18
CM-FLAT	2	45	24–41	59%		41%	4
CTI Tool	7	11 + 2 [b]+4 [c]	11 + 2 [b]+4 [c]			100%	
Inedit	1	16	6–16	33%	63%		
MATChE	8	39	30			100%	9
MCI	1	7 [a]	7 [a]	100%			
TECNUN	7	38	11–27	41%		59%	11

[a] Number of questions repeated for each product/component of the organisation.
[b] Number of questions repeated for each inflow of the organisation.
[c] Number of questions repeated for each outflow of the organisation.
[d] CEEI tool assesses the sustainability of organisations. For this analysis, only questions directly related to the field of CE were selected (25 questions out of a total of 74).

for analysis, as CIRCelligence is a private proprietary tool developed expressly for a specific client, and Circle assessment requires access via an online questionnaire, but no response was obtained after multiple attempts. On the other hand, regarding the Circulytics tool, the Qualtrics platform that supports it was not accessible for the analysis, but the documents EMF(2020a) and EMF(2020b) were used to carry out the review. With regard to CM-FLAT, the platform is under development, so the supplementary material of Sacco et al. (2021) was used for the review.

3.1.2. Repercussion of selected tools

Regarding the repercussion of these tools in the literature, the review showed that the impact is quite limited, mainly due to the recent development of the tools. On the one hand, only two studies are focused on describing CE tools: Sacco et al. (2021) described the basis of the CM-FLAT tool and Pigosso and McAloone (2021) described the basis of the MATChE tool and compared it with Circulytics. On the other hand, some articles cited the tools analysed: Vayona and Demetriou (2020) analysed the Circulytics tool with a focus on its social dimension (Theme 3. People and Competences); Maranesi and De Giovanni (2020) commented that the Italian company Itelyum had recently evaluated its circularity using the Circulytics tool, obtaining a level A score on a scale from E (worst) to A+ (best); Hofstetter et al. (2021) described the Circulytics and CTI Tool; Nordic Council of Ministers (2020) cited the Circulytics, CTI Tool and MCI tools; Navare et al. (2021) and Warren et al. (2020) cited the Circulytics tool; and Rocchi et al. (2021) adapted the indicator of the MCI tool to the biological cycle and applied it to the poultry sector. As can be seen, the tool with the greatest impact or repercussion is Circulytics followed by MCI and CTI Tool, while Acodea, CEEI, CircularTRANS, Inedit, and TECNUN are not cited, applied or analysed in any article/report.

Regarding the impact of these tools in organisations, the most used tools are Circulytics and CTI Tool (both have already attracted over 500 organisations), perhaps because they belong to globally known organisations. On the other hand, 45 companies are already participating in CircularTRANS, and Inedit has worked with multinational companies implementing the sustainability strategy or eco-innovation in each stage of the value chain. However, no information has been found on the rest of the tools.

3.2. Stage II: Analysis of general characteristics

Table 2 shows the general characteristics of the selected tools, analysed following the methodology detailed in Fig. 2. As can be seen, most of the tools are promoted by universities or private entities, with only two of them promoted by governmental initiatives. It is also noted that they have been launched in recent years (all of them since 2015, and 70% of them from 2020 onwards).

All of them are online tools, except MCI (in Excel format) and CM-FLAT, for which the interface is not yet developed. Moreover, practically all of them are free, although some require previous user registration (CEEI, CircularTRANS, Circulytics, CTI Tool and MATChE) and the CTI Tool is the only one that also has a commercial version (more complete). The predominant languages are English (67%) and Spanish (67%), although some tools offer more variety.

Moreover, it is observed that the only hybrid tool (including qualitative and quantitative questions) is Circulytics, while Acodea, CTI Tool and MCI are quantitative (they require quantitative input data from the organisation) and the others are qualitative (they require an answer to qualitative questions). All tools are applicable to production organisations and 80% also to service organisations. In addition, some tools consider characteristics of the organisation for their registration in the database, such as the country (40%), the number of employees (40%), the revenue (20%) and the sector (70%) of the organisation.

Finally, it is important to mention that 50% of tools offer case studies (as examples) and 50% offer training on the CE and its strategies and/or tutorials of the tool.

3.3. Analysis of questions

3.3.1. Number of questions and categories

The assessment of the circularity of an organisation through CE tools involves answering questions, which vary both in number and content depending on the tool. Table 3 shows the number of categories into which the questions are divided, and the total number of questions disaggregated into the questions used to calculate the CE indicators and extra questions (organisational questions for registration or reporting purposes). Moreover, questions used to calculate the indicators are disaggregated into mandatory questions (always have to be answered), optional questions (optional to answer because they present the option "Not applicable" to the organisation) and adaptable questions (only appearing occasionally, because they depend on the sector selected).

Table 3 shows that there is a big difference among the tools in terms of the number of questions, ranging from 16 questions (only 6 questions for certain sectors) in Inedit, to 153 questions in CircularTRANS. Moreover, Acodea, CTI Tool and MCI duplicate the same question for the different inflow/outflow used in the organisation, so the number of questions requested from the user by these tools can vary greatly.

Furthermore, in Table 3 (Extra Questions column) it can be seen that some tools (Circulytics, CM-FLAT, MATChE and TECNUN) include questions that are not used to calculate the CE indicators, but are used to register data about the organisation such as sector or size.

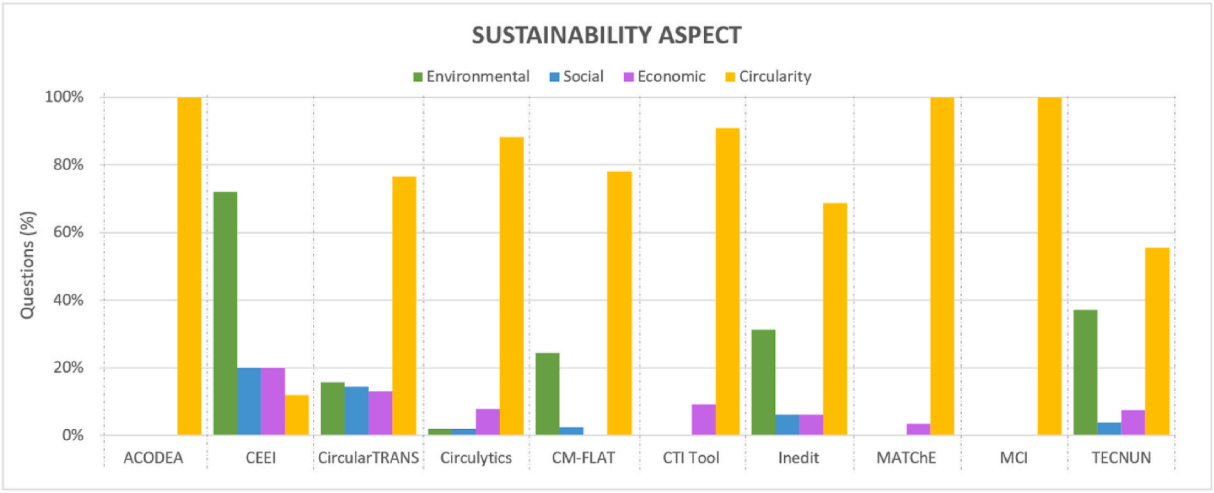


Fig. 3. Classification of questions according to the sustainability aspect, by each analysed tool.

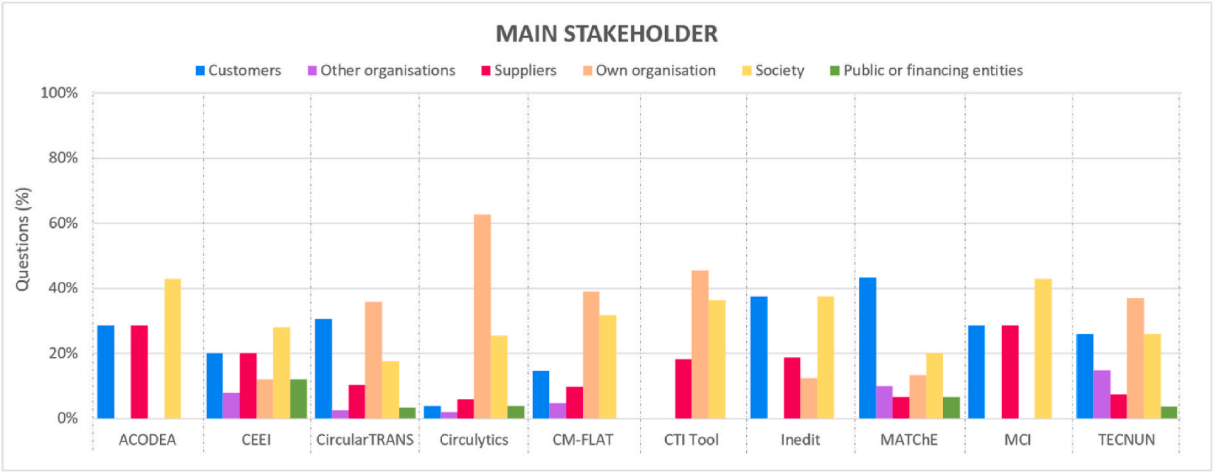


Fig. 4. Classification of questions according to the main stakeholder, by each analysed tool.

As Table 3 shows, 50% of the tools include optional questions, because they allow selection of the option "not applicable to the organisation" and therefore adapt to the user's preferences: CircularTRANS offers the option "Not applicable" in all the questions, CM-FLAT offers the option "Not applicable" in 41% of the questions, CTI Tool offers the option to select which indicators to include, MATChE offers the options "I don't know" and "Not relevant for my company" in all the questions and TECNUN offers the possibility of not considering some stages of the life cycle, which accounts for 59% of the questions.

Regarding the possibility of adapting the tool to the organisation under analysis, 20% of tools adapt the questions automatically according to the sector: Circulytics adjusts 55% of questions and Inedit varies 63% of questions. Acodea, MCI and CTI Tool vary the number of questions in relation to the number of inputs and outputs in the organisation. Therefore, CEEI is the only tool that cannot adapt the questions to the organisation under study.

Finally, it should be noted that there are also differences in terms of the number and nature of categories in which the questions of each tool were classified. CEEI classified the questions according to the stakeholders and the sustainability aspect; CircularTRANS classifies them according to the sustainability aspects, stakeholders and process; Circulytics performs the classification according to CE enablers or results; CM-FLAT does so according to maturity or circularity; CTI Tool bases it the CE strategy; MATChE uses the area of the organisation it affects; TECNUN carries out the classification according to the life cycle stage; and Acodea, Inedit and MCI only present a general category.

3.3.2. *Content analysis of questions*

Fig. 3 to Fig. 7 show the percentage of questions (relative value) for each tool related to the areas and aspects listed in the methodology: sustainability aspect in Fig. 3, main stakeholder in Fig. 4, scope of application in Fig. 5, CE strategies in Fig. 6 and Eurostat's CE indicators in Fig. 7.

As can be seen in Figs. 3, Figs. 4 and 5, all questions were linked to at least one of the sustainability aspects, the main stakeholder and to the organisation or product/service, respectively. However, as Fig. 7 and show, not all of them are related to the CE strategies or to the Eurostat CE indicators.

Regarding the **sustainability aspect** (Fig. 3), 70% of the tools have at least 75% of the questions directly related to circularity – in fact the Acodea and MCI tools focus exclusively on this aspect. Environmental questions are the next most considered, in 50% of the tools, representing between 15% (CircularTRANS) and 70% (CEEI) of all the questions, followed by economic aspects and, finally, social aspects, both below 20% of the ratio of questions in those tools that include them. The tools that include all the aspects are CEEI, CircularTRANS, Circulytics, Inedit and TECNUN, while CM-FLAT ignores the social aspect, CTI Tool and MATChE fail to take into account the environmental and social aspects,

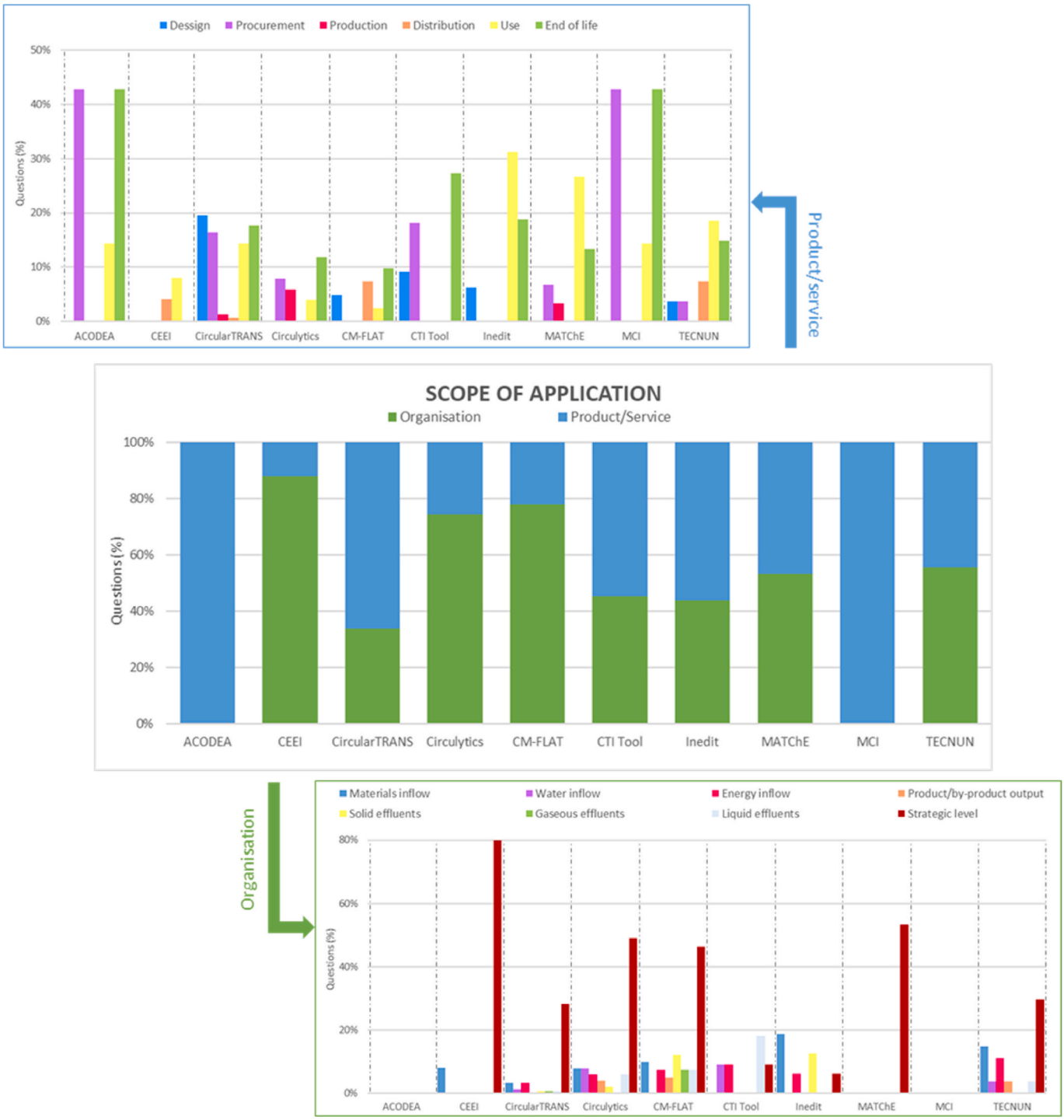


Fig. 5. Classification of questions according to the scope of application, by each analysed tool.

and Acodea and MCI do not consider the environmental, social and economic aspects. Note that circular aspects were thought to focus on the CE strategies and the alignment of the strategic plan with the CE. The environmental aspect questions are related to the measurement of the environmental impact and the implementation of strategies to reduce it. Regarding the social aspect, the questions focus on analysing the relationship between the organisation and the suppliers or customers and their values. Finally, regarding the economic aspect, most of the questions are related to investment in CE-related projects.

In terms of the **main stakeholder affected** (Fig. 4), it can be seen that all tools include questions related to society (in 50% of the tools at least 30% of the questions are linked to it and in the rest between 17% and 30% of the questions) because it benefits from the reduction in the environmental impact and the social and economic improvement associated with the CE. This is followed by the organisation itself, which is affected as a whole and specifically through employees, and is linked to more than 35% of the questions in 50% of the tools and between 12% and 13% in 30% of the tools. Customers are the next most linked stakeholders (60% of the tools include at least 25% of customer-related questions), as they are directly affected by the implementation of CE strategies. They are followed by suppliers, who are considered to be affected when the implementation of CE measures involving green

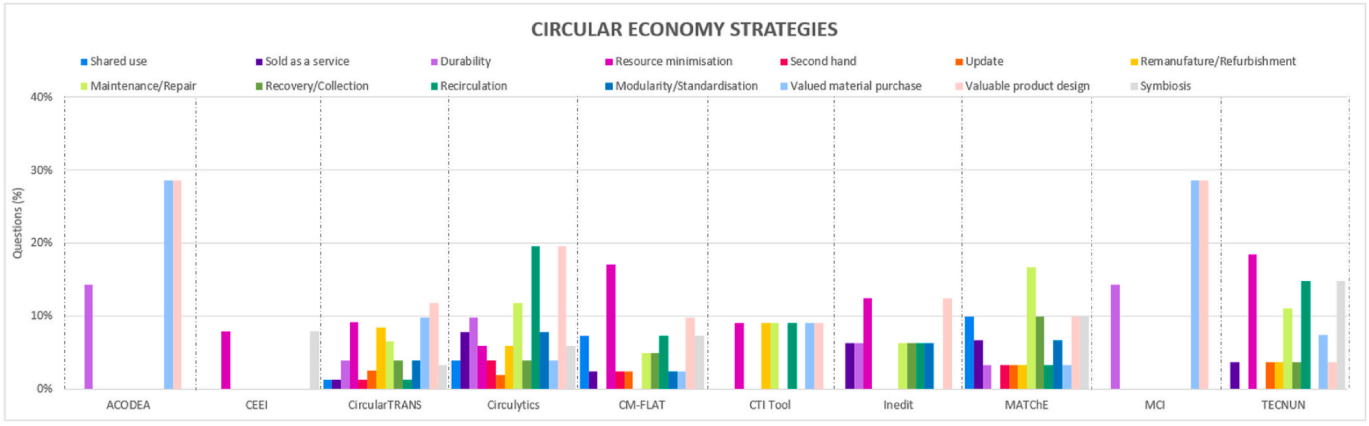
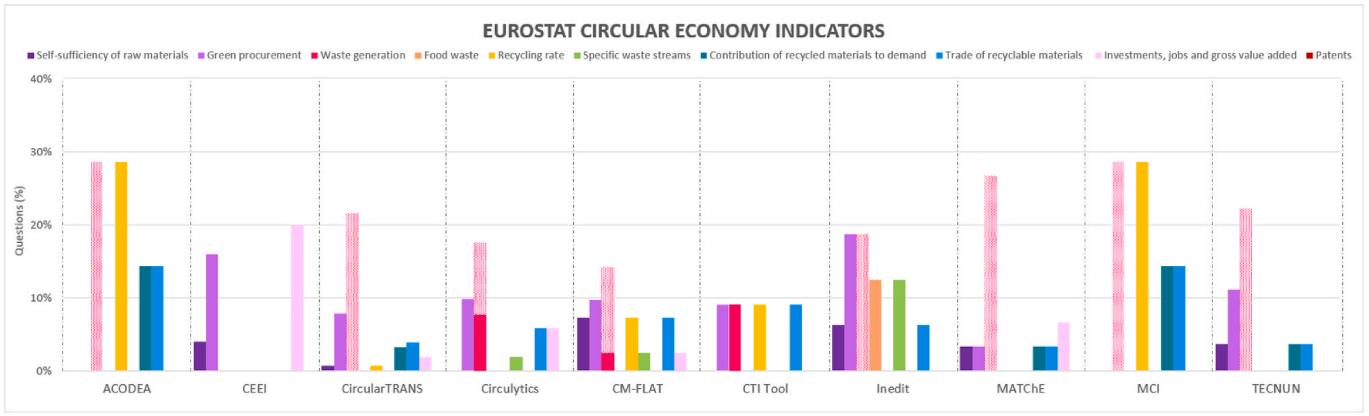


Fig. 6. Classification of the questions according to CE strategies, by each analysed tool.



*** The waste generation indicator is subdivided between questions that consider waste generation and those that contribute to the reduction of this indicator at territorial level (marked with a grid in the graph).*

Fig. 7. Classification of questions according to their contribution to Eurostat's CE indicators, by each analysed tool.

purchasing requirements must be satisfied by them, and are linked to 6%–28% of the questions in all tools. Finally, other organisations (companies affected by the industrial symbiosis, sharing resources and collaborating with other organisations) and, to a lesser extent, public or funding bodies responsible for establishing legislation and financing CE projects, with less than 15% of the questions in those tools that include them. In this respect, the tools are very different. While CEEI considers all stakeholders equally, Circulytics, CM-FLAT, CTI Tool and TECNUN place greater emphasis on the organisation itself and MATChE and Inedit focus on the consumers.

Regarding the **scope of application** of the questions, Fig. 5 shows that the questions are more linked to the product/service than to the organisation. The questions in the Acodea, CircularTRANS and MCI tools are mainly focused on the product/service (100%, 66% and 100%, respectively), while CEEI, Circulytics and CM-FLAT consider a greater number of questions related to the organisation in general (88%, 75% and 78%, respectively) and CTI Tool, Inedit and TECNUN consider both aspects almost equally.

Questions linked to the **product or service** were analysed in more detail to identify which stage of the life cycle was involved. It can be observed that the end of life is the most linked stage (80% of the tools have at least 10% of the questions linked to it), followed by procurement and use (40%–60% of the tools have at least 10% of the questions linked to it), design (30% of the tools have at least 5% of the questions linked to it), distribution (20% of the tools have at least 5% of the questions linked to it) and production (30% of the tools have less than 5% of the questions linked to it). Therefore, the stages most linked to the questions are those strongly related to CE strategies, in descending order: end-of-life stage (mainly related to recollection and recyclability), procurement of raw materials (mainly related to minimisation of consumption, recirculation of resources and procurement of recycled/reused materials), use (e.g. upgrade or reuse) and design (mainly related to durability and modularity). Moreover, clear differences between the tools were identified. Acodea and MCI focus on material procurement and end-of-life (around 40% of the questions for each stage); CEEI only includes distribution and use (around 4% and 8% of the questions, respectively); CircularTRANS and Circulytics consider all stages almost equally (around 15% and 8% of the questions, respectively) except production and distribution and design and distribution, respectively; in CM-FLAT more than 5% of its questions are linked to design, distribution and end-of-life and ignore material procurement and production; Inedit and MATChE are mainly linked to use and end-of-life (more than 25% of the questions), including design in Inedit and purchase and production in MATChE, and TECNUN considers all life cycle stages, except production, with more than 5% of questions linked to distribution, use and end-of-life.

Questions linked to the **organisation** were analysed in more detail to identify whether they were related to the strategic level or what inflow or outflow was involved. It was observed that 60% of the tools have at least 25% of the questions linked to the strategic level, followed by material inflows, energy inflows, liquid effluents, solid effluents and water inflow (with more than 5% of the questions linked to them in those tools that include them) and product/by-product output and gaseous effluents (with less than 5% of the questions linked to them in those tools that include them). On the other hand, clear differences were identified from one tool to another, the most complete being Circulytics, CM-FLAT and TECNUN.

Table 4
Quantitative data required by the quantitative tools.

Quantitative data		ACODEA	CTI Tool	Circulytics *	MCI
Inflow	Quantity	kg/€ [a]	kg/€ *	kg	kg/€ [a]
	Source	%	%	%	%
	Critical material		[b]	[c]	
Outflow	Quantity	kg/€ [a]	kg/€	kg	kg/€ [a]
	Recovery potential		%		
	Actual recovery	%	%	%	%
Energy	Quantity		kWh	kWh	
	Renewable		kWh	kWh	
Water	Inflow. Total		l /m^3	Ml	
	Inflow. Circular		l /m^3	Ml	
	Outflow. Total		l /m^3	Ml	
	Outflow. Circular		l /m^3	Ml	
	Water use		l /m^3		
Plant, Property and Equipment	Produced following CE			%	
	Allow recirculation			%	
Products	Designed with CE criteria			%	
	Recirculated			%	
	Number of reuses			%	
Finances	Revenue		€/$	USD	
	Revenue from services			%	

* Except in Circulytics, inflow and outflow data are requested by product/component.
[a] It is really the same, because it is the amount of product input and output.
[b] Identify what critical material is contained in the inflow.
[c] Identify whether the maximum concentration of the critical material is exceeded.

Regarding the linking of questions with the **circular economy strategies**, in Fig. 6 it can be observed that the strategies that are most linked to the questions are valuable product design, valued material purchase, resource minimisation, maintenance/repair, recirculation, durability and symbiosis (between 60% and 20% of tools have at least 10% of the questions related to them), followed by recovery/recollection, remanufacture/refurbishment, sold as a service, modularity/standardisation shared use and second hand (less than 10% of the questions in the tools that include them). On the other hand, Circulytics, MATChE, TECNUN, CM-FLAT, CircularTRANS and CTI Tool contain many questions related to the strategies, covering more than 70% of them. However, CEEI only mentions the minimisation of consumption and industrial symbiosis, and Acodea and MCI only consider durability, valued material purchase and valuable product design.

In terms of the contribution of the questions to the **Eurostat circular economy indicators** at territorial level, Fig. 7 shows that the indicator most linked to the questions is "waste generation". This is due to the fact that it aggregates those questions related to the waste production (indicated in solid colour in the graph) and the waste reduction (indicated by a grid in the graph) because many EC strategies, e.g. on recirculation or reuse, are associated with a decrease in waste generation. Thus, 60% of tools have at least 20% of the questions directly related to waste reduction and 20% of the questions have at least 5% of the questions related to waste generation. "Green procurement" is the next most considered due to the importance of acquiring valued products and selecting nearby suppliers (70% of tools have at least 7% of questions directly related to it). It is followed by the "Recycling rate" due to the importance of an optimal rate for a CE (40% of tools have at least 7% of questions directly related to it), the "Trade of recyclable raw material" – considering the design of the product to obtain a recyclable product – (50% of tools have at least 7% of questions directly related to it) and the "Contribution of recycled materials to demand", since it is one of the principles of the CE (2% of tools have at least 7% of questions directly related to it). Finally, "Investments, jobs and gross value added", "Self-sufficiency raw materials", "Specific waste streams" and "food waste" are related to the questions to a lesser extent and "Patents" is not linked to any of the questions analysed. On the other hand, it can be observed that Inedit, CM-FLAT, CTI Tool, Circulytics and TECNUN are the tools that consider a greater variety of Eurostat CE indicators.

Table 5
Type of result obtained by each analysed tool.

TOOL	#Indicators	Scale	Report	Improvement opportunities	Analysis of the results [a]
Acodea	1	0–100	–	–	–
CEEI	20	1–5	x	x	–
CircularTRANS	8	1–5	x	x	C
Circulytics	14	0-100/A-E	x	–	C, D, E
CM-FLAT	19	0–100	x	x	–
CTI Tool	9	0–100	x	x	C, E
Inedit	1	0–100	x	x	–
MATChE	9	1–5	x	x	C, D
MCI	1	0–100	–	–	–
TECNUN	7	1–7	x	x	C

[a] C (comparison with other organisations), D (disaggregated by units), E (evolution over time).

3.3.3. Input data required in quantitative tools

Although most questions require qualitative information to be answered, some tools (ACODEA, CTI Tool, Circulytics and MCI) need quantitative data for certain questions. As obtaining this information is usually more time-consuming, a deeper analysis was performed and the necessary quantitative data requested in each tool were reported in Table 4. As can be seen, the information requested varies both in type and in units.

3.4. Stage IV: Analysis of communication of results

3.4.1. Indicators

Table 5 shows the number of indicators that each tool calculates with its scale, the possibility of generating reports, the analysis of the results (comparison with other organisations, results disaggregated by units, evolution over time) and the provision of ideas for improvement opportunities for your EC. The number of indicators calculated in each tool differs, as can be seen by the fact that while Inedit includes only one global indicator, CEEI includes 20. On the other hand, the indicators

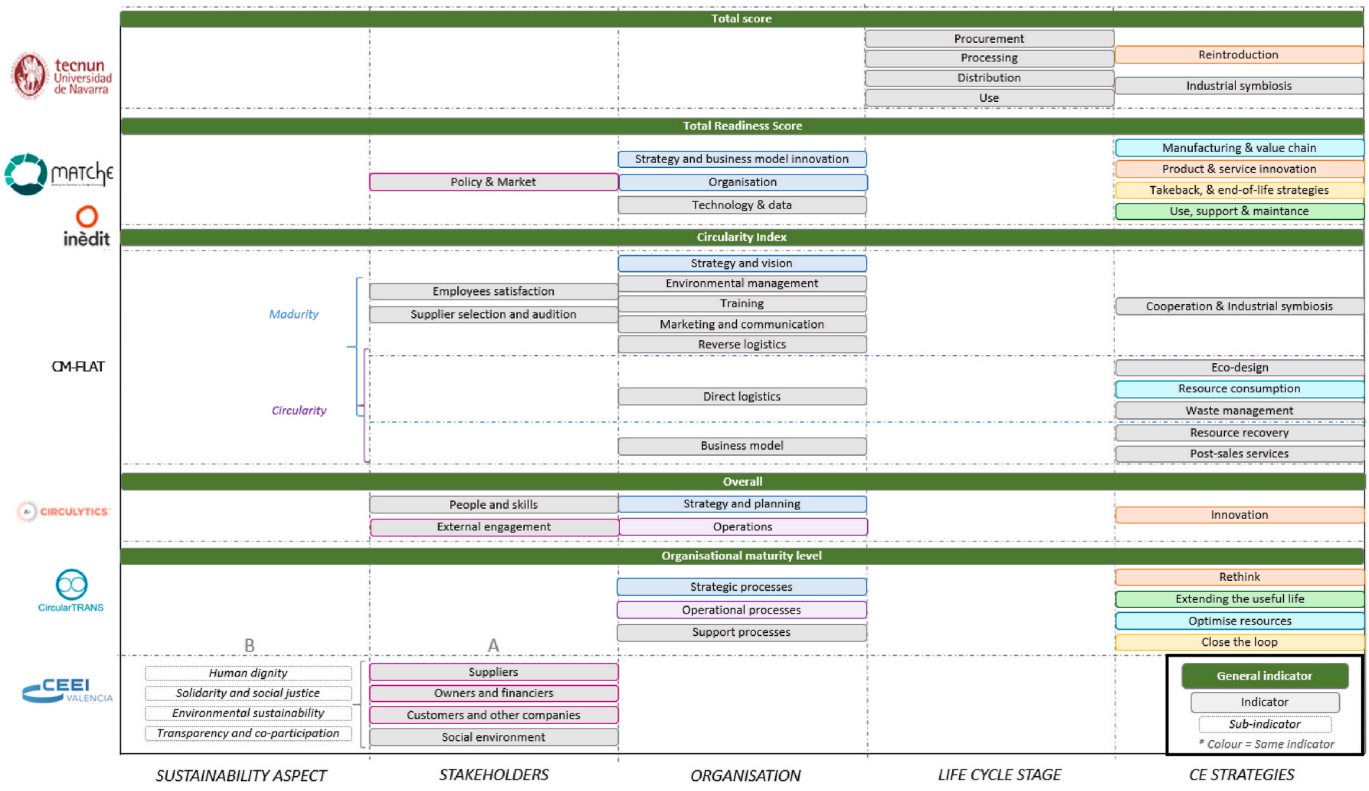


Fig. 8. Qualitative indicators provided by each analysed tools.

scale varies between 0 and 100 (60% of the tools), 1–5 (30% of the tools) and 1–7 (only in TECNUN), and the Circulytics has an alphabetical scale (A-E).

To analyse the indicators in more detail, Fig. 8 represents the qualitative indicators calculated by each tool broken down by areas, and Fig. 9 shows the number of quantitative indicators of each tool (first row) and the name, together with the formula used to obtain each of them.

As can be seen in Figs. 8 and 9, the indicators provided by the tools are different, so the results obtained in each tool are not comparable. Only the global indicators provided by the tools – except for CEEI, CM-FLAT and CTI Tool – can be compared. However, as each tool has a different scale (see Table 5), it would be necessary to convert all the indicators to a common scale in order to make a comprehensive comparison.

In addition, as Fig. 8 shows, the classification of the indicators is also different. CEEI uses indicators related to stakeholders and the sustainability aspect; the indicators in CircularTRANS are related to organisation and CE strategies; CM-FLAT uses indicators linked to maturity and circularity; those of MATChE deal with organisation and CE strategies; and the indicators of TECNUN are related to life cycle stages. Note that the CEEI tool uses the indicators proposed by the Economy for the Common Good (FEEBC, 2017) and positions the organisation on one of the four levels of Corporate sustainability proposed by the matrix of Dyllick and Muff (2016).

The way to obtain the indicators varies from one tool to another. As can be seen in Fig. 9, the formulas used to calculate the same indicator are not the same. Moreover, the method employed to obtain the global indicator is also different, and each tool uses different weights for each of its sub-indicators.

Finally, on comparing the indicators in Figs. 8 and 9 with the Eurostat CE indicators (which are shown in Fig. 7), it can be stated that the indicators provided by the tools do not correspond to those proposed by Eurostat, as they do not have similar names and do not use the same formulas.

3.4.2. Communication

Table 5 reveals that 80% of the tools, except Acodea and MCI, automatically generate reports with the results of the organisation's circularity assessment, which can be used to communicate and publicise the calculation.

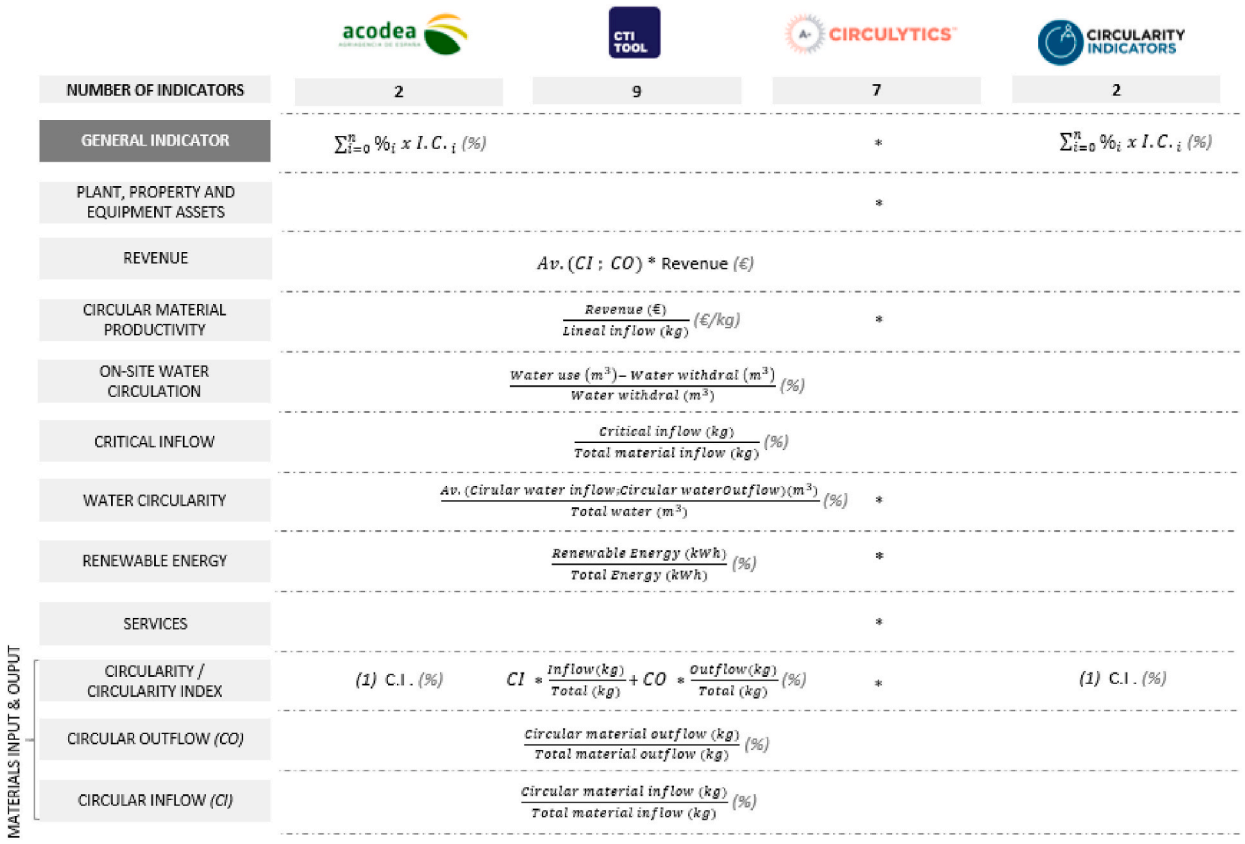
Additionally, some of the tools analyse the results in more detail. CircularTRANS, Circulytics, CTI Tool, MATChE and TECNUN compare the results obtained with similar organisations (same sector and/or size). Circulytics and MATChE allow the introduction of data disaggregated by units (e.g. business areas, organisational functions or departments), in order to observe differences between the organisation's units. Circulytics and CTI Tool (expected in its new version) allow analysis of the evolution over time of the level of implementation of CE in the organisation.

Finally, 70% of the tools offer the organisation certain ideas about improvement opportunities in the CE. This is very interesting, since after the previous analysis, they contribute to the progressive improvement for a better future. In this area, MATChE is very complete, since it allows the organisation to create a prioritisation actions map in the short, medium and long term.

4. Discussion

After reviewing and comparing existing tools for assessing the level of circularity of organisations, the research questions presented in the introduction can be answered.

Regarding RQ1, it was observed that currently there are tools capable of measuring the level of circularity of organisations. However, they have been launched in recent years (all since 2015 and most of them in the 2020s) and therefore their use is not yet widespread among organisations. The development of these tools has been boosted by the recent sustainable policies at the European level (COM 614, 2015; COM 640, 2019; COM 98, 2020) since many of their questions are related to the main aspects of these policies (waste reduction, renewable energy, repair or recycling). In addition, it is noted that most of the tools are



N/A: Calculation formula is Not Available
(1) Calculation process is explained in Pavlović et al. (2020).
Circular materials are those that increase their value as raw materials, follow the CE cycle (once used, they can be reused or returned to nature in the form of nutrients) and generate value over time.
Critical inflows are the elements of the linear inflow that are likely to become scarce in the relatively near future and are difficult to replace without hampering functionality. Several institutions have identified critical raw materials (e.g. the European Union lists 30 raw materials as critical (COM 474, 2020) and the USA lists 35 mineral commodities as critical (DOI, 2018)).

Fig. 9. Quantitative indicators provided by each analysed tool (COM 474, 2020, DOI, 2018).

available online for free, which makes them useful for creating sustainable awareness in organisations, their employees and society.

Regarding RQ2, it is observed that the results obtained are not comparable because there are clear differences among all the tools in different areas. The most striking difference is the type of tool (qualitative or quantitative), which implies that the results are complementary but not comparable because each typology focuses on different aspects. The most important differences are related to the number of questions and the adaptability of the tool to the case study under development, since the accuracy of the results depends on these two aspects. The number of questions means that the level of accuracy varies greatly due to the consideration of a number of different aspects and the fact that the tools are not always adapted to the case study. Regarding adaptability, some tools include optional questions (making the tool more customisable and adaptable to the organisation), while other tools are more rigid (sometimes leading to inaccurate results); furthermore, some tools are automatic (they adapt the questions autonomously according to the sector of the organisation) while in others it is the user who must select which questions to include and which not to include (which makes them more time-consuming, but also more precise and adaptable to the specific case). On the other hand, each tool includes different areas and aspects, and none of them include all the aspects and areas analysed (as occurs in Corona et al. (2019) and De Pascale et al. (2021) for indicators), which implies that it is not possible to obtain the same result. Moreover, each tool is more related to a different aspect of sustainability, most of them to environmental performance (as occurs in de Oliveira et al. (2021) for indicators, in Elia et al. (2017) for methodologies or in Vinante et al. (2021) for metrics). The most surprising difference is that each tool includes a different number of indicators, those included are not the same or they present the indicators on the same scale (as occurs in Vinante et al. (2021)), and not all the tools include a global or total CE indicator; this is due to the lack of standardisation in this field. Moreover, the way the indicators are calculated is different and the transparency (concrete and visible information on the basis of the tool) also differs greatly (the most transparent tool is the CTI Tool, which provides the necessary information and the formulas used to calculate the indicators; Acodea and MCI are also transparent, as they use a methodology presented in the literature (Pavlović et al., 2020). The Circulytics tool, however, does not provide any information on how the different indicators are obtained, which can cause confusion for the user and also makes it difficult to compare results). Finally, important differences have been observed in the reports generated (CircularTRANS being the most complete report).

The large differences in the tools analysed show the disparity in conceptions of what needs to be considered when assessing CE and the different understandings of the CE concept, which is in line with the results delivered by Corona et al. (2019), De Pascale et al. (2021) and Saidani et al. (2019), among others.

Regarding RQ3, in view of the results, it can be stated that the tool which includes the widest range of considerations is Circulytics, as it is the only hybrid tool (it considers both the quantitative and the qualitative parts); however, it is a tool that is not transparent and requires a

request for access. Regarding qualitative tools, the most extensive tool is CircularTRANS because it includes the largest number of questions and the report generated is the most detailed; however, this tool can be too time-consuming and despite including a large number of questions, may not consider the specificities of a particular organisation. Inedit is the ideal tool for having a first look at the level of circularity of the organisation, as it includes several aspects in a very small number of questions; however, it is not useful if the organisation wants to obtain the most accurate result possible. CM-FLAT, MATChE and TECNUN are the most well-balanced tools, as they do not have an excessive number of questions and take into account different scopes; however, they do not consider the specificities of a particular organisation. Finally, CEEI is the least desirable tool as it is a sustainability tool that does not focus on circularity and therefore does not include some of the most important aspects of the CE. On the other hand, regarding quantitative tools, the most complete is the CTI Tool; however, this tool should be extended by including some qualitative questions or complemented by a qualitative tool to take into account all the areas of circularity. So, despite the significant differences found, no one tool can be chosen as the most effective or optimal, since this depends to a large extent on the organisation under study. For example, MATChE could be useful for large multinational companies as it breaks the assessment down into units, whereas a small company does not need this breakdown, i.e. organisations may need different tools depending on their size, which is in line with Lindgreen et al. (2020). Circulytics is the most complete tool as it includes all types of questions, but if the organisation prioritises transparency, it will ignore this tool or the organisation may not even get access to it. CircularTRANS is the tool that includes the highest number of questions, but it is highly related to the product or service offered and to CE strategies and therefore it may not be useful for a service organisation. For these reasons, each organisation should select the tool that it considers most appropriate for its case (according its sector, size or main characteristics).

The review shows a large number of assessment tools that differ in numerous aspects, leading to a redundancy of tools that produces mismatches and results of low comparability, as well as promoting necessary debates in academia (Arbolino and De Simone, 2019). So, it can be concluded that although there has been an appreciable increase in interest on this topic on the part of researchers, practitioners and policymakers, there is a lack of standardisation, uniqueness and uniformity in the field of the CE, which is in line with the results reported by Elia et al. (2017) or Sassanelli et al. (2019) for CE methodologies, De Pascale et al. (2021) or Saidani et al. (2019) for CE indicators or Vinante et al. (2021) for CE metrics, among others. Research on indicators, metrics and methodologies to assess the implementation of CE is still under development, which allows freedom in the construction of evaluation tools, and this lack of harmonisation may result in low acceptance of CE assessment approaches by organisations (Lindgreen et al., 2020). So, it is important to develop a standardised tool which covers all the areas and themes described, includes the qualitative and quantitative parts of the evaluation, considers the specificities of the organisations, is easy to use and provides accurate and comprehensible results.

5. Conclusions

In this paper, a review and analysis of CE assessment tools for organisations has been carried out. 10 tools were identified and analysed in depth. It is concluded that these tools can be useful as a first starting point, but it is necessary to consider that when using them for decision-making, the results obtained in the same application could differ significantly. This study has the limitation of having included tools in Spanish or English, and that they are currently available online or for download, or even under development (in this case, related publications have been used).

Although this review provides a useful starting point, it has not addressed the applicability and utility of the tools reviewed, so the authors consider it necessary to continue this review by applying the tools to different case studies (organisations from different sectors) in order to compare the results obtained in more detail, to observe the convergence between offer and demand, and to observe other issues related to the application of the tools.

In addition, more research is needed to find a standardised methodology which will allow all organisations to obtain comparable CE indicators that will help them in their decision-making in the process towards a more sustainable organisation. In this way, it will become possible to design a tool that facilitates the work of organisations and promotes its calculation and communication.

CRediT authorship contribution statement

Karen Valls-Val: tools acquisition, Investigation, Methodology, Formal analysis, Writing – original draft, Writing – review & editing. **Valeria Ibáñez-Forés:** Conceptualization, Methodology, data acquisition, Supervision, Writing – review & editing. **María D. Bovea:** Funding acquisition, Project administration, Conceptualization, Methodology, Supervision, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jclepro.2022.131679.

References

ACODEA, 2018. Circularity Calculator for Organisations. Solidforest [WWW Document]. URL. https://acodea.solidforest.com/.
Arbolino, R., De Simone, L., 2019. Rethinking public and private policies in Europe with the support of a industrial sustainability index. Int. Environ. Agreements Polit. Law Econ. 19, 315–339. https://doi.org/10.1007/s10784-019-09438-7.
BAU, 2017. Business as Unusual: Designing Products with Consumers in the Loop RECODE Network. Cranfield University.
CEEI, 2016. Self-diagnosis Design for Companies. CEEI Alcoy [WWW Document]. URL. https://ceeialcoi.emprenemjunts.es/?op=65&tFM=70.
CEEI, 2020. Self-diagnosis Measuring Sustainability in Organisations. CEEI Valencia [WWW Document]. URL. https://ceeivalencia.emprenemjunts.es/?op=65&n=883.
CIRCelligence, 2020. Boston consulting group (BCG) [WWW Document]. URL. https://www.bcg.com/capabilities/social-impact-sustainability/circular-economy-circelligence.
Circle Assessment, 2017. Circle economy [WWW Document]. URL. https://www.circle-economy.com/digital/circle-assessment.
Circulab, 2021. Toolbox [WWW Document]. URL. https://circulab.com/toolbox-circular-economy/.
Circular design guide, 2021. Methods [WWW Document]. URL. https://www.circulardesignguide.com/methods.
Circular IQ, 2021. Product circularity improvement program [WWW Document]. URL. https://circular-iq.com/product-circularity-improvement-program.
Circularity Calculator, 2021. Ideal & CO explore [WWW Document]. URL. http://circularitycalculator.com/.
CircularityCheck, 2018. WeSustain enterprise sustainability & Ecopreneur [WWW Document]. URL. https://system.wesustain-esm.com/circularity-check/main.html/Login?portal=main.
CircularTRANS, 2020. Mondragón university [WWW Document]. URL. https://www.mondragon.edu/circulartrans/es/login.
Circulytics, 2020. Measuring circularity- ellen MacArthur foundation [WWW Document]. URL. https://www.ellenmacarthurfoundation.org/resources/apply/circulytics-measuring-circularity.
CITIES, 2021. Circle City Scan Tool. Circle-lab [WWW Document].

COM 102, 2020. A New Industrial Strategy for Europe. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. European Commission.
COM 474, 2020. Critical Raw Materials Resilience: Charting a Path towards Greater Security and Sustainability. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the regions.
COM 614, 2015. Closing the Loop - an EU Action Plan for the Circular Economy. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions.
COM 640, 2019. The European Green Deal. Communication from the Commission to the European Parliament. the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions.
COM 98, 2020. A New Circular Economy Action Plan for a Cleaner and More Competitive Europe. Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions.
Corona, B., Shen, L., Reike, D., Rosales Carreón, J., Worrell, E., 2019. Towards sustainable development through the circular economy—a review and critical assessment on current circularity metrics. Resour. Conserv. Recycl. 151, 104498 https://doi.org/10.1016/j.resconrec.2019.104498.
CTI Tool, 2020. WBSCD circular-IQ [WWW Document]. URL. https://ctitool.com/.
de Oliveira, C.T., Dantas, T.E.T., Soares, S.R., 2021. Nano and micro level circular economy indicators: assisting decision-makers in circularity assessments. Sustain. Prod. Consum. 26, 455–468. https://doi.org/10.1016/j.spc.2020.11.024.
De Pascale, A., Arbolino, R., Szopik-Depczyńska, K., Limosani, M., Ioppolo, G., 2021. A systematic review for measuring circular economy: the 61 indicators. J. Clean. Prod. 281 https://doi.org/10.1016/j.jclepro.2020.124942.
DOI, 2018. Draft list of critical minerals. Department Of the Interior. Fed. Regist 83, 7065–7068.
Dyllick, T., Muff, K., 2016. Clarifying the meaning of sustainable business: introducing a typology from business-as-usual to true business sustainability. Organ. Environ. 29, 156–174. https://doi.org/10.1177/1086026615575176.
Circle Economy, 2021. Circular Economy Briefing for Business.
EdTool, 2016. Sostenipra [WWW Document]. URL. http://edtool.sostenipra.cat/.
Elia, V., Gnoni, M.G., Tornese, F., 2017. Measuring circular economy strategies through index methods: a critical analysis. J. Clean. Prod. 142, 2741–2751. https://doi.org/10.1016/j.jclepro.2016.10.196.
EMF, 2015. Delivering the Circular Economy. A Toolkit for Policymakers. Selection of Key Exhibits. Ellen MacArthur Foundation.
EMF, 2020a. Indicator List. Ellen MacArthur Foundation, pp. 1–42.
EMF, 2020b. Method Introduction. Ellen MacArthur Foundation, pp. 1–20. Circulytics.
Eurostat, 2021. Circular Economy Indicators, Monitoring Framework. European Commission [WWW Document]. URL. https://ec.europa.eu/eurostat/web/circular-economy/indicators.
Evans, J.L., Bocken, N.M.P., 2014. A tool for manufacturers to find opportunity in the circular economy. KES Trans. Sustain. Des. Manuf. I 303–320. www.circulareconomytoolkit.org, 2011.
FEEBC, 2017. The Common Good Matrix. Federación Española de la Economía del Bien Común [WWW Document]. URL. https://economiadelbiencomun.org/la-matriz-del-bien-comun/.
Franco, N.G., Almeida, M.F.L., Calili, R.F., 2021. A strategic measurement framework to monitor and evaluate circularity performance in organizations from a transition perspective. Sustain. Prod. Consum. 27, 1165–1182. https://doi.org/10.1016/j.spc.2021.02.017.
Hanuláková, E., Daňo, F., Kukura, M., 2021. Transition of business companies to circular economy in Slovakia. Entrep. Sustain. Issues 9, 204–220. https://doi.org/10.9770/jesi.2021.9.1(12.
Hofstetter, J.S., De Marchi, V., Sarkis, J., Govindan, K., Klassen, R., Ometto, A.R., Spraul, K.S., Bocken, N., Ashton, W.S., Sharma, S., Jaeger-Erben, M., Jensen, C., Dewick, P., Schröder, P., Sinkovics, N., Ibrahim, S.E., Fiske, L., Goerzen, A., Vazquez-Brust, D., 2021. From sustainable global value chains to circular economy—different silos, different perspectives, but many opportunities to build bridges. Circ. Econ. Sustain. https://doi.org/10.1007/s43615-021-00015-2.
Idemat, 2015. Sustainability inspired materials selection app [WWW Document]. URL. http://idematapp.com/.
Inedit, 2020. Self-assess. Inedit Innova [WWW Document]. URL. https://circular.inedit innova.com/index/es.
KATCHe, 2021. Knowledge Platform. KATCHe Tools [WWW Document]. URL. https://www.katche.eu/knowledge-platform/.
Kickstarter, 2021. Una guía para reducir el impacto ambiental de tu producto [WWW Document]. URL. https://www.kickstarter.com/environment.
Koszewska, M., Bielecki, M., 2020. How to make furniture industry more circular? The role of component standardisation in ready-to-assemble furniture. Entrep. Sustain. Issues 7, 1688–1707. https://doi.org/10.9770/jesi.2020.7.3(17.
Kravchenko, M., Pigosso, D.C., McAloone, T.C., 2019. Towards the ex-ante sustainability screening of circular economy initiatives in manufacturing companies: consolidation of leading sustainability-related performance indicators. J. Clean. Prod. 241, 118318 https://doi.org/10.1016/j.jclepro.2019.118318.
Kristensen, H.S., Mosgaard, M.A., 2020. A review of micro level indicators for a circular economy – moving away from the three dimensions of sustainability? J. Clean. Prod. 243, 118531 https://doi.org/10.1016/j.jclepro.2019.118531.
Level(s), 2021. European Framework for Sustainable Buildings. European Commission [WWW Document]. URL. https://ec.europa.eu/environment/levels_en.
Lindgreen, E.R., Salomone, R., Reyes, T., 2020. A critical review of academic approaches, methods and tools to assess circular economy at the micro level. Sustain. Times 12, 4973. https://doi.org/10.3390/su12124973.
Maranesi, C., De Giovanni, P., 2020. Modern circular economy: corporate strategy, supply chain, and industrial symbiosis. Sustain. Times 12, 1–25. https://doi.org/10.3390/su12229383.
Marino, A., Pariso, P., 2021. The transition towards to the circular economy: European SMEs' trajectories. Entrep. Sustain. Issues 8, 431–455. https://doi.org/10.9770/jesi.2021.8.4(26.
MATChE, 2021. Making the Transition to Circular Economy. Technical University of Denmark [WWW Document]. URL. https://www.matche.dk/.
Mazzoni, F., 2020. Circular economy and eco-innovation in Italian industrial clusters. Best practices from Prato textile cluster. Insights into Reg. Dev 2, 661–676. https://doi.org/10.9770/ird.2020.2.3(4.
MCI, 2017. Material Circularity Indicator. Ellen MacArthur Foundation [WWW Document]. URL. https://www.ellenmacarthurfoundation.org/resources/apply/material-circularity-indicator.
Moraga, G., Huysveld, S., Mathieux, F., Blengini, G.A., Alaerts, L., Van Acker, K., de Meester, S., Dewulf, J., 2019. Circular economy indicators: what do they measure? Resour. Conserv. Recycl. 146, 452–461. https://doi.org/10.1016/j.resconrec.2019.03.045.
Navare, K., Muys, B., Vrancken, K.C., Acker, K. Van, 2021. Circular economy monitoring – how to make it apt for biological cycles. Resour. Conserv. Recycl. 170, 105563 https://doi.org/10.1016/j.resconrec.2021.105563.
Nordic Council of Ministers, 2020. Pre-study: Indicators on Circular Economy in the Nordic Countries.
Parchomenko, A., Nelen, D., Gillabel, J., Rechberger, H., 2019. Measuring the circular economy - a multiple correspondence analysis of 63 metrics. J. Clean. Prod. 210, 200–216. https://doi.org/10.1016/j.jclepro.2018.10.357.
Pathfinder, 2021. ResCoM. Ideal & CO explore [WWW Document]. URL. https://www.ideal-co.nl/pathfinder/.
Pavlović, A., Bošković, G., Jovičić, N., Nestić, S., Sliusar, N., Stanisavljević, N., 2020. Determination of circularity indicators - a case study of MB International Company. pdf. Recycl. Sustain. Dev. 13, 9–21.
PCDS, 2020. Product Circularity Data Sheet. Luxembourg [WWW Document]. URL. https://pcds.lu/.
Pigosso, D.C.A., McAloone, T.C., 2021. Making the transition to a circular economy within manufacturing companies: the development and implementation of a self-assessment readiness tool. Sustain. Prod. Consum. https://doi.org/10.1016/j.spc.2021.05.011.
Radavičius, T., van der Heide, A., Palitzsch, W., Rommens, T., Denafas, J., Tvaronavičienė, M., 2021. Circular solar industry supply chain through product technological design changes. Insights into Reg. Dev. 3, 10–30. https://doi.org/10.9770/ird.2021.3.3(1.
Rocchi, L., Paolotti, L., Cortina, C., Fagioli, F.F., Boggia, A., 2021. Measuring circularity: an application of modified Material Circularity Indicator to agricultural systems. Agric. Food Econ. 9, 1–13. https://doi.org/10.1186/s40100-021-00182-8.
Sacco, P., Vinante, C., Borgianni, Y., Orzes, G., 2021. Circular economy at the firm level: a new tool for assessing maturity and circularity. Sustainability 13, 5288. https://doi.org/10.3390/su13095288.
Saidani, M., Yannou, B., Leroy, Y., Cluzel, F., 2017. How to assess product performance in the circular economy? Proposed requirements for the design of a circularity measurement framework. Recycling 2. https://doi.org/10.3390/recycling2010006.
Saidani, M., Yannou, B., Leroy, Y., Cluzel, F., Kendall, A., 2019. A taxonomy of circular economy indicators. J. Clean. Prod. 207, 542–559. https://doi.org/10.1016/j.jclepro.2018.10.014.
Sassanelli, C., Rosa, P., Rocca, R., Terzi, S., 2019. Circular economy performance assessment methods: a systematic literature review. J. Clean. Prod. 229, 440–453. https://doi.org/10.1016/j.jclepro.2019.05.019.
TECNUN, 2017. Circular economy diagnostic questionnaire [WWW Document]. URL. https://economiacircular.wixsite.com/economiacircular/cuestionario.
Use2use, 2019. Design toolkit [WWW Document]. URL. https://www.use2use.se/?page_id=610.
Vayona, A., Demetriou, G., 2020. Towards an operating model for attribution in circular economy. Proc. - 16th Annu. Int. Conf. Distrib. Comput. Sens. Syst. DCOSS 490–495. https://doi.org/10.1109/DCOSS49796.2020.00082, 2020.
Vinante, C., Sacco, P., Orzes, G., Borgianni, Y., 2021. Circular economy metrics: literature review and company-level classification framework. J. Clean. Prod. 288, 125090 https://doi.org/10.1016/j.jclepro.2020.125090.
Warren, D.E., Scharding, T.K., Lewin, L.D., Pandya, U., 2020. Making sure corporate social innovations do social good. Rutgers Bus. Rev. 5, 166–184.
Xarxa, 2018. Economía Circular y Verde en el mundo local. XARXA de ciutats i pobles cap a la sostenibilitat.