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Research article

Sustainability reports as a tool for measuring and monitoring the transition towards the circular economy of organisations: Proposal of indicators and metrics

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ABSTRACT

Sustainability reports may play an important role as a supporting tool in the transition of organisations towards more circular economy models, since their content can help to measure, monitor and communicate the organisations' transition and to establish goals in the short/medium term. The aim of this study is to determine whether it is possible to calculate indicators capable of measuring the transition of organisations towards circularity from the information that they are currently communicating in their Corporate Sustainability Reports (CSRs), and what information would need to be incorporated in these reports to successfully carry out this procedure. To this end, by applying a three-step methodology, 34 indicators grouped into 10 categories were proposed to measure the level of circularity of organisations. This was completed with a detailed proposal of units/metrics to measure the indicators, based on those that organisations commonly use in their CSRs. For this purpose, information from 8 international programmes/frameworks that measure circularity at the territorial level was combined with circularity information that organisations are currently communicating in their CSRs. Finally, the proposed set of indicators and metrics were applied to a Spanish organisation dedicated to the forestry and paper sector with a CSR based on GRI-Standards. The results demonstrated that 25 of the 34 proposed indicators (74%) can be measured directly using the information included in the CSRs.

1. Introduction

The circular economy (CE) is based on keeping the value of products, materials and resources in the economy for as long as possible, and on reducing the generation of waste (COM 614, 2015). The current framework in Europe for the CE is established by the "*New Circular Economy Action Plan*" (COM 98, 2020) as the central axis of the "*The European Green Deal*" (COM 640, 2019). Focused on organisations, the "*Industrial Strategy for Europe*" (COM 102, 2020) addresses the challenges faced by organisations when it comes to advancing towards a digital and green transformation, including circularity. This new regulatory framework also stresses the importance of evaluating the progress being made by companies towards circularity by applying key performance indicators (KPIs). However, in the EU context, even though a set of standardised indicators had been established at the territorial level (Eurostat, 2021), they have not yet been defined for organisations.

The last decade has seen remarkable growth in the amount of literature focused on reviewing and classifying the variety of organisational-level CE indicators proposed both in the scientific literature and in public and private initiatives. Some of the most recent contributions include those by Calzolari et al. (2022), who reviewed not only industrial practice but also the academic literature to identify how the effect of adopting CE practices can be measured by means of indicators; De Oliveira et al. (2021), who analysed 61 publications and identified 58 heterogeneous circularity indicators, of which 20 were applicable to organisations; De Pascale et al. (2021), who analysed 137 articles, identified 61 circularity indices, 28 of them at the organisational level, and grouped them on the basis of the 3 R Core CE principles; Geronazzo

Acronyms: 11KI, Key Indicators from France; CE, Circular Economy; CHCEIS, Chinese Circular Economy Development Evaluation Indicator System; CSR, Corporate Sustainability Report; ECEI, Euskadi Circular Economy Indicator; FBAN, Framework and Baseline Assessment for monitoring the circular economy in the Netherlands; FPSMS, Fundamental Plan for Establishing a Sound Material-Cycle Society of Japan; GREP, German Resource Efficiency Programme; GRI, Global Report Initiative; KPI, Key Performance Indicator; SCES, Spanish Circular Economy Strategy.

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Franco et al. (2021), who analysed and identified 58 circularity indicators associated with 10 R-strategies; Kristensen and Mosgaard (2020), who analysed 31 publications and identified 30 different circularity indicators; Moraga et al. (2019), who analysed 14 papers and identified and classified 20 quantitative indicators; and finally, Saidani et al. (2019), who identified 20 sets of circularity indicators and developed an Excel-based tool to facilitate the selection of appropriate indicators according to the specific user's needs and requirements. Aside from these, Vinante et al. (2021) reviewed 130 studies and identified 365 different metrics related to the circular value chain framework, and Sassanelli et al. (2019) analysed the current state of the art of CE assessment methods.

These reviews highlight the wide and diverse spectrum of aspects considered under the CE umbrella and the lack of agreement on what should be measured. In addition, a common conclusion reached in the literature was that there is no international consensus on how to measure the level of circularity at the organisational level, and so a comprehensive CE assessment framework for organisations needs to be developed. Consequently, more research about indicators and metrics for evaluating the implementation of the CE is still required (Vinante et al., 2021; De Pascale et al., 2021; Simona Fortunati et al., 2020). The homogenisation of indicators is essential and involves the standardisation of the aspects to be evaluated, the proposed calculation methods and the assessment scales, in order to facilitate the comparison of circularity among organisations.

In parallel, Directive 2014/95/EU (European Commission, 2014) regulates the disclosure of the non-financial information of organisations, which can be carried out based on different organisational reporting frameworks such as the Social Responsibility Guide (ISO 26000, 2010), Environmental Management and Audit Systems (European Commission, 2009) or the Global Report Initiative (GRI, 2019), among others. These frameworks propose guidelines for selecting and measuring their indicators. However, although 80% of the 250 largest multinational enterprises publish Corporate Sustainability Reports (CSRs) using these standardised formats (KPMG, 2020), the information communicated in them continues to lack homogeneity (Adams and Frost, 2008; CNMV, 2018; Contreras-Pacheco and Claasen, 2017; Fonseca et al., 2014; Maia et al., 2021; Roca and Searcy, 2012).

Taking into account this context, the incorporation of standardised aspects related to circularity in the CSR is, today, a key aspect for organisations to gain business competitiveness and transparency, legitimacy and customers' trust (Hofmann, 2019). Therefore, more research is needed to identify the information related to the level of circularity that organisations are currently measuring and communicating in their CSRs, and the information they would need to incorporate in them to highlight CE aspects.

The framework proposed by the GRI (2019) represents the main scheme used by organisations to communicate information concerning their environmental and social performance (Hamad et al., 2020; Istudor and Suciu, 2020; Maia et al., 2021; Thijssens et al., 2016) and the only one that includes CE as an essential reporting requirement (Opferkuch et al., 2021). Tarquinio et al. (2018) identified Spain as one of the European countries that produce the highest quality reports. The content analysis of CSR belonging to Spanish organisations can therefore be considered an appropriate starting point to assess whether organisations are currently communicating information about their circularity.

Consequently, the purpose of this study is to determine whether it is possible to calculate indicators that allow a measurement of the advance of organisations towards circularity by using the information that they are already communicating in their CSRs. To fulfil this objective, a set of indicators adapted to the organisational context will be proposed, based on the revision of indicators proposed by different international frameworks to measure the progress of territories towards circularity. The metrics proposed for the calculation will be based on the information that Spanish organisations disclose in their CSRs. This study aims not only to facilitate the task of measuring circularity in organisations over time, but also to propose a method that encourages and makes it easier for them to publish such information in a more concise and useful way in their CSRs.

2. Background

From the perspective of organisations, the implementation of actions that promote the transition to more circular models and the communication of these actions to the various stakeholders have started to become a priority. However, although the CE should also be linked to rethinking how to create and deliver value while promoting organisational sustainability (Reichert and Mendes, 2014), the definition of the CE has often been limited to the optimisation of waste and material resource management activities. In this regard, Schroeder et al. (2019) and Rossi et al. (2020) claimed that the CE has the potential to contribute to other dimensions of sustainability beyond the environmental ones, even including several Sustainability Development Goals. In this line, it can be stated that there is a need to consider CE as an approach based on broader thinking, which addresses not only the challenges of resource efficiency but also business and management models, among other issues (Opferkuch et al., 2021).

Consequently, qualitative and quantitative tools capable of measuring and reporting the level of circularity of organisations have been developed in recent years. Valls-Val et al. (2022) reviewed and analysed these tools and showed that quantitative tools (ACODEA, 2018; Circulytics, 2020; CTI Tool, 2020; MCI, 2017) mainly focus on material and energy inflows and outflows, and that qualitative tools (CEEI, 2020; CircularTRANS, 2020; Circulytics, 2020; Inedit, 2020; MATChE, 2021; TECNUN, 2017) also include issues related to business management strategies and some social aspects, although they mainly remain focused on the environmental issues. Furthermore, it was observed that the indicators included in the tools were very diverse — in number, weight, scale and evaluation aspects — and therefore were not comparable, concluding that more research is needed in the field of circularity indicators for organisations. The recent growth of this type of tool highlights the interest in improving, measuring and communicating organisations' transition to circular behaviour.

In this line, sustainability reporting may play an important role as a supporting tool in the implementation of the CE model in industry (Dagiliene et al., 2020). Stewart and Niero (2018) stated that what companies disclose about the CE in their CSR provides relevant information about their business strategies and allows them to provide insights and trends on CE adoption. The CSR can even serve as an example of good practice for other organisations seeking to implement sustainable strategies (Istudor and Suciu, 2020). Statements made by Sihvonen and Partanen (2017) or Scarpellini et al. (2020) went a few steps further by highlighting the importance of reporting practices to redirect organisations towards more circular models, probably based on the assumption that sustainability reporting proves their level of proactivity up to the reporting period (González-Benito and González-Benito, 2006).

Despite the potential of sustainability reporting and the fact that both eco-design and life cycle engineering emerged in the late 1990s, the communication of these practices came later and still has many shortcomings that need to be improved (Deegan, 2017; Sihvonen and Partanen, 2017). Authors such as Dagiliene et al. (2020) or Fortunati et al. (2020) highlighted the need to improve communication in CSR in relation to CE issues, as this aspect is identified as scarce and commonly presented without using a selection of consistent data or narratives. Slacik and Greiling (2020), who focused their study on reporting made by electric utility companies, even expressed doubts about the coverage and quality of the aspects documented in the CSRs, due to the lack of transparency in the communication process. Opferkuch et al. (2021) compared different organisational approaches for CE disclosure in CSRs and concluded that companies were unsure about how to comprehensively communicate their CE practices and their assessment within the

CSR context. Among the factors responsible for this, they highlighted the lack of guidance for organisations and the inconsistent and highly heterogeneous CE-specific assessment frameworks that are available.

In a slightly different vein, Karaman et al. (2021) focused on analysing the connection between reporting and verifications of the reliability of the information communicated, and concluded that reports based on the GRI (2019) framework were more likely to obtain external assurance because of the better quality of the process and the guidance it offered. The GRI (2019) was also recognised by Opferkuch et al. (2021) as the only approach that truly considers CE issues without relegating them to the background. Additionally, Janik et al. (2020) and Chen et al. (2015), who studied GRI reports for identifying the environmental and CE practices in manufacturing and energy sectors, respectively, highlighted that it is worth acquiring information on CE issues from CSR, mainly based on GRI, as a resource for future studies on sustainability practices.

In this same line, although it remains scarce, over the last few years there has been an increase in the amount of research conducted with the aim of identifying, improving and providing descriptive overviews on the status of implementing CE strategies in organisations, by reviewing the content of their CSR based on the GRI standard (see Table 1). Many of these studies were published after 2018 and were mainly focused on European organisations.

Note that there are many other studies, not included in Table 1, focused on CSR content analysis from a sustainability perspective but without considering aspects of the CE. Some examples include Bjørn et al. (2017) , who identified the ecological limits/targets most considered in several CSRs worldwide; Meckenstock et al. (2016), who reviewed 142 CSRs from 12 industries to identify how sustainability evolves along the supply chain; or, in the same line, Comas Martí and Seifert (2013), who focused on examining CSRs to identify the business approaches related to the supply chain environmental strategies.

Based on information from Table 1, it can be stated that the existing studies focused on analysing aspects of the CE in CSRs are remarkably diverse in terms of their topic and scope. The number of CSRs reviewed in each study vary significantly and range from studies over a specific sector, which analyse one or two CSRs in depth, such as Bocken et al. (2020) or Khodaiji and Christopoulou (2020), to broader studies reviewing more than 50 CSRs from different industrial sectors, such as Janik et al. (2020) or Calzolari et al. (2022). The manufacturing, agri-food and energy sectors are those most widely analysed. Most of these studies use the "Sustainability Disclosure Database" (GRI Database, 2021) as a CSR source, since it has been identified as one of the most comprehensive.

It is also noticeable that the vast majority of the research reviewed is based on the content analysis technique, since the importance of CE concepts is usually valued by means of their frequency of appearance. For example, Calzolari et al. (2022) proposed two circularity multi-objective indicators built on an aggregation technique of the different sustainability aspects based on their relative frequency of appearance in the CSRs. However, the aggregation approaches have been widely questioned due to the requirement of normalisation and weighting techniques (Badinger and Reuter, 2015), which are commonly associated with high uncertainty and subjectivity (Brüggemann et al., 2006).

Content analysis is based on a coding process to review quantitative and qualitative information from a long text and compress it into a few content categories (Krippendorf, 2012). CSRs generally include qualitative statements and quantitative facts, in addition to graphics and figures (Bovea et al., 2021; Dagiliene et al., 2020). Despite this, most studies are mainly qualitative and exclusively based on narratives, leaving aside the identification of quantitative indicators (see Table 1). This clashes with the conclusions reached by Sihvonen and Partanen (2017), who indicated that reporting practices should include both qualitative and quantitative information. In this line, Ahi and Searcy (2015) highlighted the importance of a good definition of quantitative CE indicators and metrics to establish circular targets, since they play a critical role in measuring the progress towards circularity. They also discussed the difference between indicators and metrics. Based on their discussion, it is stated that "indicators" show the condition or existence of something and have a broader focus than "metrics", which are based on defining a standard of measurement, which in turn may be either qualitative or quantitative.

Focusing on KPIs specifically dedicated to measuring circularity in organisations, Rincón-Moreno et al. (2021) posited a series of CE indicators for Spanish organisations based on those proposed by Eurostat. Their results highlighted that indicators used for assessing CE at the territorial level (macro level) can be translated and adapted to the organisational context, where indicators are neither fully developed nor adopted (Saidani et al., 2019). However, a detailed understanding of how to select, adapt and measure those indicators is still lacking (Kristensen and Mosgaard, 2020). The lack of agreement on what needs to be measured and the standardised methods to do so are considered to be the main handicaps (Calzolari et al., 2022; Elia et al., 2017).

On the basis of the gaps that have been identified, the research questions that will be addressed in this study can be summarised as follows:

RQ1. What indicators can be used to measure the advance of organisations towards a CE?

RQ2. What aspects related to their circular behaviour are organisations communicating in their CSRs?

RQ3. How would it be possible to calculate circularity indicators with the information that organisations are currently communicating in their CSRs?

3. Materials and methods

The methodological procedure adopted in this study was based on three main stages and a case study shown in Fig. 1: (I) Selection and adaptation of indicators from CE programmes/frameworks; (II) Content analysis of CSRs to identify the information related to their CE issues; (III) Proposed set of indicators to measure the level of circularity of organisations and the definition of metrics for their calculation; and (IV) Case study.

Stage I. Selection and adaptation of indicators from CE frameworks. The aim was to identify circularity indicators that can be applied/adapted to measure the level of circularity in the organisational context. This were achieved by following the steps below:

- Selection of CE frameworks for monitoring the progress of the CE at the national and international levels. To select the frameworks to be reviewed, those referenced by the European Commission (2018) as being key for measuring CE at the territorial level were taken as a starting point. In addition, existing initiatives in the Spanish context were also included, since the case study was based on a Spanish organisation.
- Identification of the indicators that can be applied to measure the level of circularity of organisations. To do so, the CE indicators identified from the selected CE frameworks were examined to identify those adaptable or applicable to measure the level of circularity of organisations, either directly or by modifying their units/metrics or the area of application.
- Codification and classification of the indicators in a common category structure. As each programme groups its indicators based on its own structure, a set of common CE categories was proposed to classify the adaptable or applicable indicators homogeneously. These proposed categories considered the life cycle stages of a standard organisation and covered the essential aspects of the circular economy (*Design*, *Suppliers*, *Inputs*, *Production*, *Business*, *Outputs*, *Environmental Impact*, *Social*, *R&D in circularity* and *Communication*).

Table 1
Background.

Author	Geographical context	Financial years under study	CSR sample size	Database	Technique used for the review	Type of source		Topic			Activity sector							
						Organisation narratives	Indicators/ targets	Sustainability issues	CE strategies	Eco-design	Manufacturing	Cosmetic	Agri-food	Retailers	Services	Energy	ICT	Others
(Tiscini et al., 2022)	Italy	2014 & 2019	26	n/a	Content analysis	●		●	●			●						
Bocken et al., (2020)	Sweden	2018	1	Company's website	Content analysis	●			●				●					
Calzolari et al., (2021)	EU	2016–2018	37	Global Fortune 500 list	Content analysis and mapping approach	●			●		●		●		●	●		
Calzolari et al., (2022)	EU	2016–2019	50	Global Fortune 500 list	Content analysis and template technique		●	●	●									●
Chen et al., (2015)	Sweden, India & China	2010	37	Company's website	Content analysis	●				●	●							
Istudor and Suciu, (2020)	EU	2018	6	Company's website	Empirical content-based analysis	●			●					●				
Janik et al., (2020)	EU	2018–2020	61	Companies' websites, Corporate Register database & GRI's database	Qualitative content analysis	●	●	●	●							●		
Khodaiji and Christopoulou, (2020)	Greece	2018	2	Companies' websites	n/a	●		●							●			
Sihvonen and Partanen, (2017)	Global	2015	43	GRI's database & Companies' websites	Content analysis	●	●			●							●	
Maia et al., (2021)	Global	2017–2019	26	GRI's database	Compiling and evaluating on a case-by-case basis		●	●	●							●		
Stewart and Niero, (2018)	Global	2016	46	Corporate Register database	Content analysis and mapping approach	●		●	●		●		●					●

n/a = not available.

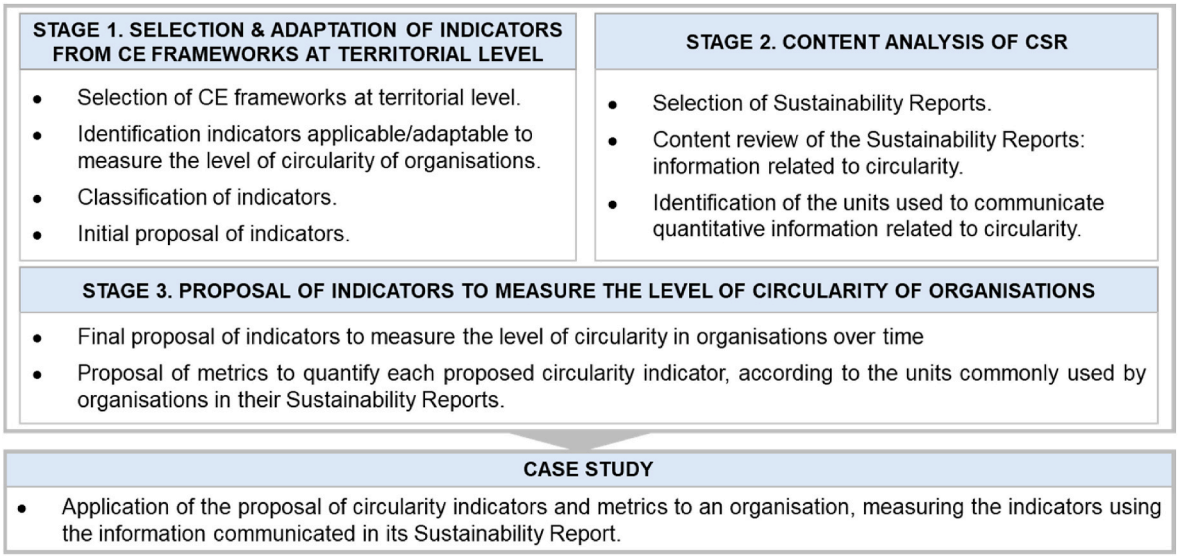

Fig. 1. Methodological approach.

- After eliminating duplicates and unifying nomenclature, an initial proposal of circularity indicators structured by categories was made.

Stage II. Content analysis of CSRs to identify the information related to their CE issues. To do so, the steps below were followed:

- Selection of the criteria for deciding on the sample of CSRs to be used (geographical, temporal, sector, etc.) depending on the aim of the study. The sample of CSRs included those belonging to Spanish organisations, drawn up in accordance with GRI-standards and published in 2020. To obtain the sample of CSRs, various public/private databases of CSRs could have been used (e.g., Corporate Register, 2021; Datamaran, 2021; GRI Database, 2021; United Nations Global Compact, 2021). The sample of CSRs selected was obtained from the "Sustainability Disclosure Database" (GRI Database, 2021), which is a large repository of CSRs containing around 65,000 reports published since 1999 up to the present.
- An exhaustive content analysis of the CSRs selected was performed to identify the information related to circularity included in them. During the information extraction phase, the CSRs were read in their entirety in order to identify both declarative information related to CE issues (qualitative information) and CE indicators reported through numerical or graphical data (quantitative information). The information extracted was codified and then organised using an Excel spreadsheet. Note that a keyword-based final check was carried out to ensure that all the relevant information was gathered from all the CSRs. The keywords were related not only to the CE indicators identified in Stage I, from those proposed by the European frameworks, but also to other CE strategies and good practices for improvement in the CE context.
- The information extracted (both qualitative and quantitative) was grouped according to the aspect of circularity to which it was related. Duplicates were then removed and the nomenclature was unified. Subsequently, it was classified according to the CE categories proposed in Stage I.
- Lastly, an assessment of the information was carried out to identify the units and metrics most commonly used to communicate qualitative and quantitative CE data. The specific physical magnitudes and generic units most commonly used to disclose each aspect of circularity were identified.

Stage III. Proposed set of indicators to measure the level of circularity of organisations and definition of the metrics for their calculation. This was achieved by following the steps below:

- A final set of indicators was proposed to measure the level of circularity in organisations, taking into account the initial proposal obtained in Stage I and additional information identified in Stage II.
- Subsequently, the metrics for quantifying each proposed circularity indicator were defined, according to the units commonly used by organisations in their CSRs. The most common metrics were selected for each indicator. Note that, for indicators that were communicated by organisations mainly through quantitative information, quantitative metrics were proposed. Analogously, for indicators communicated mainly through qualitative information, qualitative metrics were proposed.

Case Study, in which the proposed set of CE indicators and metrics were applied to a Spanish organisation. Indicators were measured using the information communicated in its CSR. The twofold aim of the case study was: (1) to assess whether it was possible to measure (qualitatively/quantitatively) the CE indicators proposed in Stage III with the information included in the company's CSR — that is to say, to test the proposal and methodology developed; and (2) to identify weak points and establish which recommendations or best reporting practices could be applied to ensure that CSRs communicate all the aspects considered relevant for measuring the circularity of the organisation.

4. Results

4.1. Stage I. Selection and adaptation of indicators from territorial level CE programmes to the organisational level

The selected frameworks, referenced by the European Commission (2018) as being key for measuring the CE at the national and international levels, to be reviewed were: Eurostat (Eurostat, 2021), GREP (BMUB, 2016), 11KI (SDES, 2021), FBAN (PBL, 2018), CHCEIS (NDCR, 2017) and FPSMS (Government of Japan, 2018). In addition, the ECEI (IHOBE, 2018) and the SCES (MITECO, 2020) were also included as Spanish initiatives, since Spanish organisations will be considered as a sample not only when assessing the CSRs (Stage II) but also in the case study (Stage IV).

After reviewing the 8 frameworks selected, 255 indicators related to CE issues were identified. These can be consulted in the Supplementary Material (Tables S1–S8). It should be noted that significant variations in the number of indicators proposed by each programme were identified,

which ranged from 10 (BMUB, 2016; SDES, 2021) to 20–40 (Eurostat, 2021; IHOBE, 2018; MITECO, 2020; PBL, 2018). The extreme case was FPSMS (Government of Japan, 2018), which proposed 120 indicators.

From the 255 indicators identified, 179 were selected as adaptable or directly applicable to measure the level of circularity of organisations. FPSMS (Government of Japan, 2018) was the programme with the highest percentage of indicators excluded in this stage (42%).

A set of 10 common CE categories were proposed to classify the 179 adaptable or applicable indicators homogeneously (*Design*, *Suppliers*, *Inputs*, *Production*, *Business*, *Outputs*, *Environmental Impact*, *Social*, *R&D in circularity* and *Communication*). After this classification, duplicates were eliminated and the nomenclature was unified until reaching the proposed set of 29 indicators given in Table 2. The indicators included in each programme and their classification in the proposed categories are presented in detail in the Supplementary Material (Table S9).

Fig. 2 shows the classification of the indicators identified as applicable/adaptable to the organisational context in each of the proposed categories. The results showed that, on the one hand, the Outputs category included the largest number of indicators (48%), followed by the Inputs category (35%). Most of the indicators in the Outputs category were related to waste generation and its management (97%). On the other hand, the categories of Suppliers, Business and

Table 2
Initial proposed set of indicators based on the eight programmes reviewed.

INITIAL PROPOSED SET OF INDICATORS		REVIEWED PROGRAMMES — no. of indicators directly related to the proposed indicator							
Category	**Indicator adapted to organisation**	**Eurostat**	**SCES, Spain**	**ECEI, Spain**	**GREP, Germany**	**11KI, France**	**FBAN, Netherlands**	**CHCEIS, China**	**FPSMS, Japan**
Design	Product design / Circular services	0%	0%	0%	0%	9%	0%	0%	3%
	Application of sustainability criteria for the product	4%	4%	5%	0%	9%	0%	0%	1%
Suppliers	Sustainable suppliers	0%	0%	0%	0%	0%	0%	0%	1%
Inputs	Total material consumption	0%	0%	15%	0%	18%	23%	6%	13%
	Consumption of new raw material (local / national / international)	0%	4%	0%	22%	9%	0%	0%	1%
	Consumption of secondary raw material (local / national / international)	20%	19%	5%	11%	9%	5%	0%	3%
	Consumption of reused material (internal)	8%	12%	10%	11%	0%	14%	6%	5%
	Consumption of reused material (external)	4%	8%	0%	22%	0%	9%	6%	4%
	Energy consumption	0%	0%	0%	0%	0%	0%	6%	0%
	Energy self-generation	0%	0%	0%	0%	0%	5%	0%	1%
	Renewable or non-renewable energy consumption (external)	0%	0%	0%	0%	0%	5%	0%	3%
	Use of heat or waste energy	0%	0%	0%	0%	0%	0%	0%	3%
	Total water consumption	0%	0%	0%	0%	0%	0%	6%	0%
	New virgin water consumption (external) or recirculated water	0%	0%	0%	0%	0%	5%	6%	0%
	Consumption of recirculated external water	0%	0%	0%	0%	0%	0%	6%	0%
Production	Investment in maintenance	0%	0%	0%	0%	9%	0%	0%	3%
	Management systems	0%	0%	0%	0%	0%	0%	0%	3%
Business	Circular business models (equipment and services)	0%	0%	0%	0%	9%	0%	0%	1%
Outputs	Total waste generation	12%	12%	5%	0%	0%	9%	0%	10%
	Waste generated that is recovered (externally) / or sent to landfill	44%	31%	50%	33%	9%	9%	31%	36%
	Total water discharge	0%	0%	0%	0%	0%	0%	6%	0%
	Discharged water, previously purified	0%	0%	0%	0%	0%	0%	6%	0%
	Raw discharged water	0%	0%	0%	0%	0%	0%	6%	0%
Environmental impact	GHG emissions	0%	4%	0%	0%	0%	9%	0%	3%
	Land use	0%	0%	0%	0%	0%	5%	6%	0%
Social	Social actions	4%	4%	5%	0%	9%	5%	0%	0%
R&D in circularity	Investment in research projects	0%	0%	0%	0%	9%	0%	0%	4%
	Patents related to circularity	4%	4%	5%	0%	0%	0%	0%	0%
Communication	Environmental reports published	0%	0%	0%	0%	0%	0%	0%	3%

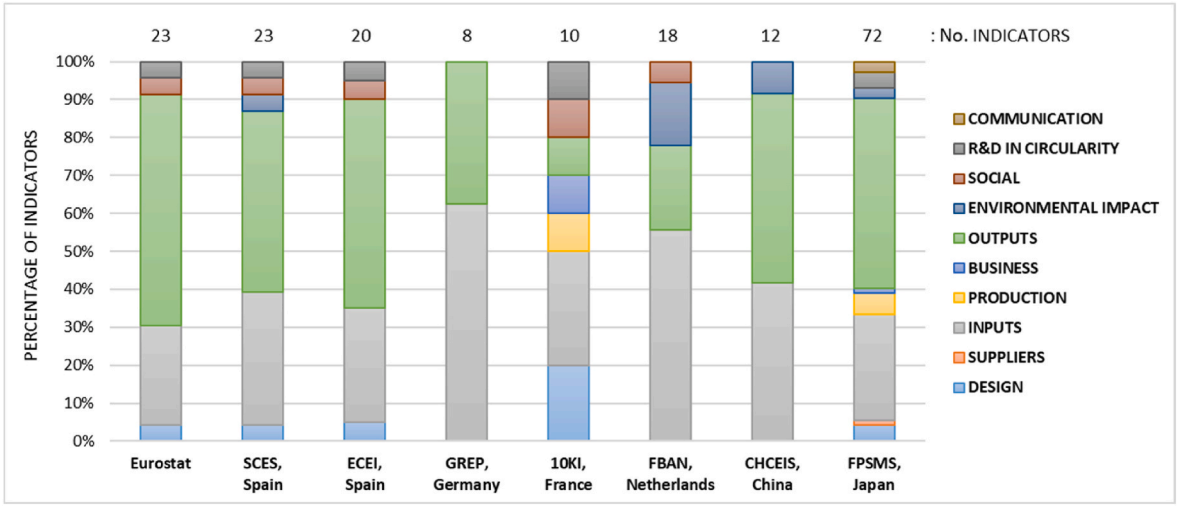

Fig. 2. Classification of indicators in the proposed categories.

Communication included only 1% of the indicators. This suggested that there are some aspects of circularity, such as those related to sustainable suppliers or the practices of sharing equipment, which are barely being considered in territorial programmes, but are necessary for analysing the organisational circularity context.

In analysing the diversity of indicators by programme, Fig. 2 shows that although the FPSMS programme (Government of Japan, 2018) included indicators for most of the proposed categories, it did not include any indicator for social aspects and almost 80% of the indicators were related to the *Inputs* or *Outputs* categories. The 11KI programme (SDES, 2021) was the most balanced, since it proposed at least 10% of the indicators in each category to which it contributes. However, it neglects to include the categories of *Suppliers*, *Environmental Impact* and *Communication*. Also noteworthy was the GREP programme (BMUB, 2016), which only proposed indicators related to the *Inputs* and *Outputs* categories, leaving aside aspects such as *Design* or *Research and Innovation*.

4.2. Stage II. Content analysis of CSR

To select the sample of CSRs to be analysed in this section, the following restrictions were applied in the GRI Database (GRI Database, 2021): Spain, 2020 and GRI-standard. A total of 29 CSRs were obtained: 11 belonging to productive sectors, such as automotive, construction and energy; and 18 belonging to services sectors, such as financial services and tourism.

After an exhaustive content analysis of the 29 CSRs selected, the qualitative and quantitative information related to circularity included in them was identified. As Fig. 3 shows, the information identified was mainly related to the categories *Inputs* (31%), *Production* (15%) and *Outputs* (14%). The most frequently reported circularity aspects identified were *Greenhouse Gas Emissions*, disclosed in more than 90% of the CSRs reviewed, followed by the *Total Energy Consumed*, reported by about 85% of them, and *Waste Generation (hazardous + non-hazardous)*, by 70%.

In addition, it is worth mentioning that there were up to 25 circularity aspects that were barely reported in 20% of the CSRs reviewed. These minority aspects were mainly related to circularity strategies, such as the incorporation of *Ecodesign strategies* or the implementation of *Reverse logistics* (reported in 7% of the reports reviewed), the *Employees dedicated to CE* (reported in 10%) and the *Use of collective facilities and equipment* (reported in only 3%).

Furthermore, the way in which each circularity aspect was communicated in each CSR (qualitatively or quantitatively) was also analysed and is presented in Fig. 3. On analysing the qualitative information in depth (the yellow bars in Fig. 3), it can be observed that the most communicated circularity aspects were *Environmental Management Systems — ISO 14001*, disclosed qualitatively by 69% of the reports, and *Digitalisation*, disclosed by 62% of the reports. Qualitative information about digitalisation was provided by communicating the development of business models 4.0 or detailing the digitalisation processes adopted by organisations. On analysing the quantitative information in depth (the green bars in Fig. 3), the units in which each circularity aspect was quantified were also identified. Specifically, both the physical magnitudes (such as mass, energy, volume, etc.) and the generic units (such as percentage, number, etc.) were identified.

Fig. 4 shows the physical magnitudes and the generic units used for each aspect of circularity. These units are shown grouped into the following six typologies: *Aggregated amount*, *Disaggregated amount (by type)*, *Previous year variation*, *Previous year variation (by type)*, *Costs* and *Others*.

As can be seen in Fig. 4, most of the aspects of circularity were communicated through an *Aggregated amount*. Specifically, the aggregated amounts "*mass*" and "*volume*" were the main units used to measure the *Total material consumption* and the *Water discharge* indicators, respectively. Information from previous years was provided in 55% of the circularity aspects communicated, which would facilitate measurement of the evolution of circularity in the organisation. Moreover, "*Costs*" were used in 22% of the circularity aspects communicated, including some that are not directly related to economic aspects, such as *Quality of effluent generated* or *Environmental regulation*.

Finally, note that companies used other specific units to communicate 33% of the aspects of circularity, which were classified within the typology "*Other*". Some examples of these specific units were:

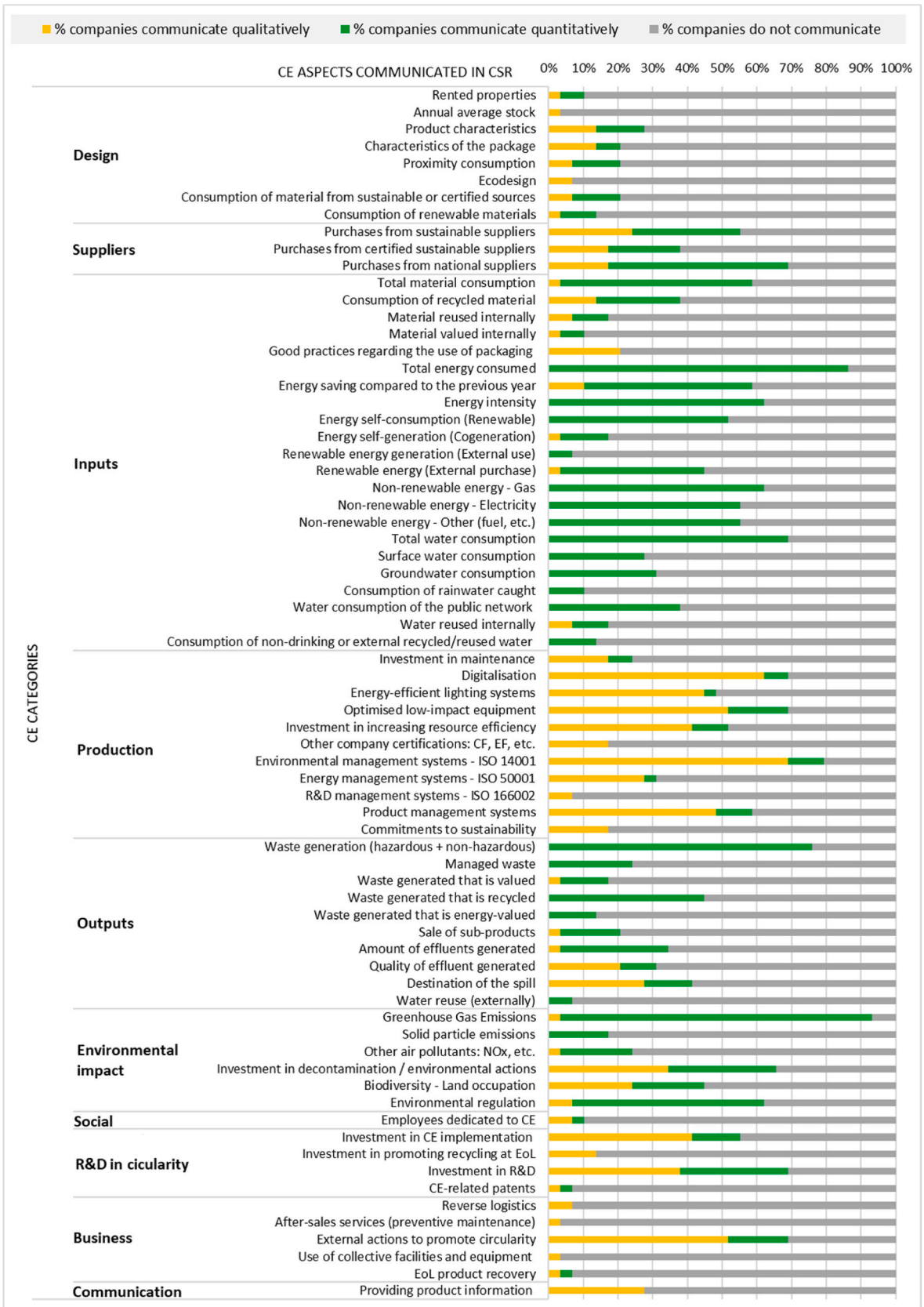

Fig. 3. Percentage of companies that communicate each aspect of circularity, differentiating between quantitative and qualitative information.

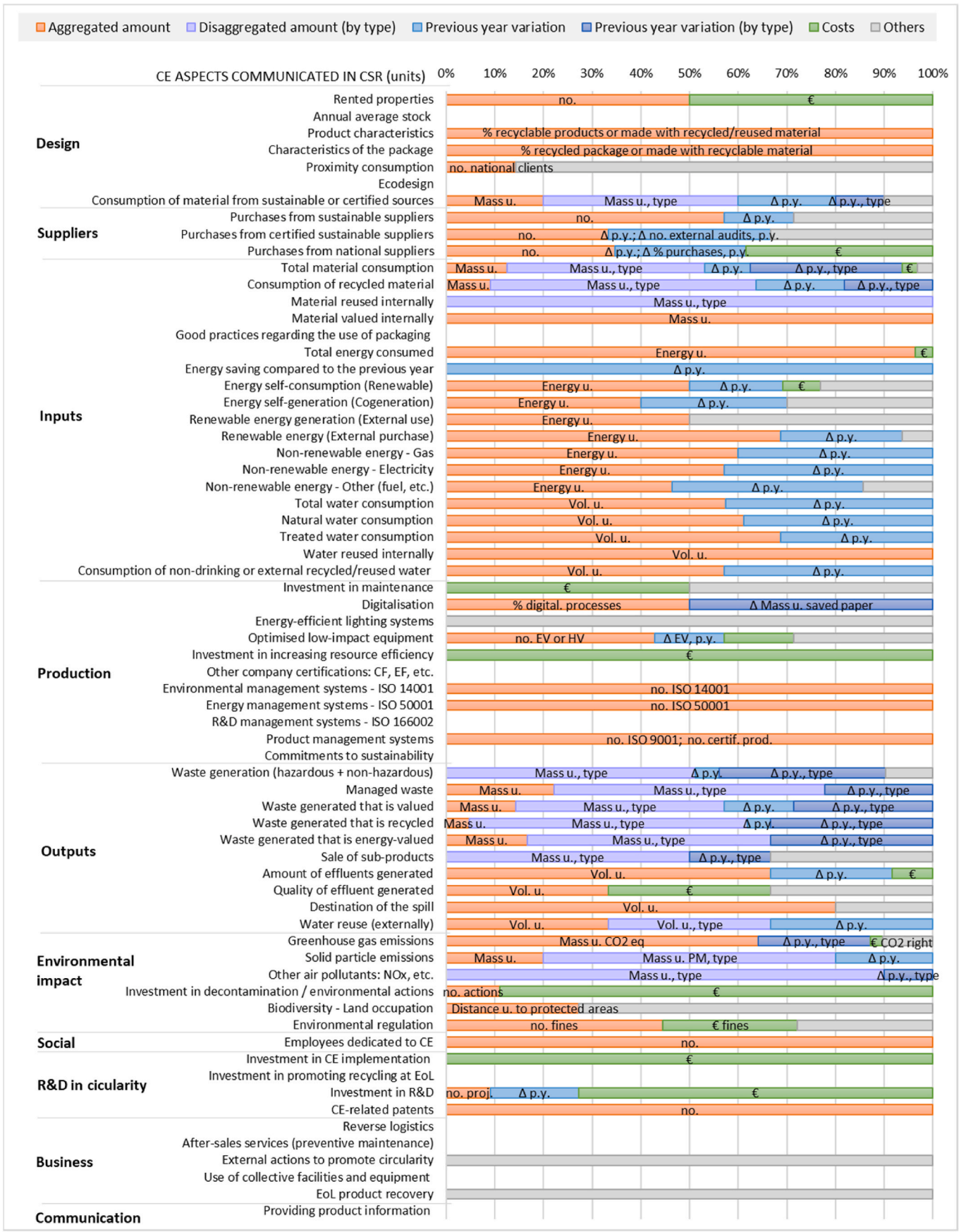

Fig. 4. Circularity aspects with their corresponding interpreted units. u = unit; p.y. = previous year; no. = number; EV = electric vehicles; HV = hybrid vehicles; no. certif. prod. = number of certified products; eq. = equivalent.; vol. = volume.

- For the circularity aspect *Proximity consumption*, communicated by 6 different quantitative units, 5 of them included in the *Other* category: the percentage of energy produced from local energy sources, the percentage of products distributed by each different type of transport used, the percentage of international clients having used the service for more than 5 years and, finally, the number of countries where the product is distributed or the number of markets where the product is present.
- For the circularity aspect *External actions for the promotion of circularity*, communicated in 14% of the CSRs: the number of electric vehicle charging points that they make available to their customers and the percentage of their stores that are eco-efficient.

Finally, it is important to highlight that some circularity aspects identified covered topics not considered in the initial proposed set of indicators from Stage I. These were related to good practices regarding the use of packaging, digitalisation, energy-efficient lighting systems, providing product information and optimised low-impact equipment, and investment in increasing resource efficiency. These aspects had to be integrated into the final set of indicators proposed to measure the level of circularity of organisations, since they were based on circularity strategies for improvement in the CE context, and were also currently communicated by organisations in their CSRs.

4.3. Stage III. Set of indicators proposed to measure the level of circularity of organisations

The aim of this section was twofold. On the one hand, the intention was to define the final set of indicators (and their metrics) proposed to measure the level of circularity of organisations based on the initial proposed set of indicators (Stage I) and the circularity aspects identified in Stage II. On the other hand, the objective was also to determine whether it is possible to calculate these indicators with the information currently communicated by organisations in their CSRs and identified in Stage II.

Regarding the first objective, as highlighted in Stage II, the following five indicators were incorporated into the initial proposal made in Stage I, because they were identified as currently communicated by organisations in their CSRs:

- *Good practices regarding the use and redesign of packaging*, included in the category *Inputs*.
- *Efficient equipment and machinery*, which is included in the category *Production* and based on the following circularity aspects:

Table 3
Proposed circularity indicators and metrics.

Category	Code	Proposed indicator		Metrics commonly used in CSR
Design	D01	Product design/Circular services	✓	- Does the organisation manufacture on demand?* - Has the organisation considered eco-design criteria during the design process?* - Does the organisation work with returnable packaging?* - Percentage of the product that is recyclable.* - Percentage of the package that is produced with recycled material.*
	D02	Application of sustainability criteria for the product	✓	- Is the raw material certified as a sustainable material?* - Is the product intended for the domestic market? - Percentage of eco-labelled products.*
Suppliers	S01	Sustainable suppliers	✓	- Are suppliers sustainable (origin, practices, etc.)?* - Are suppliers externally certified?*
Inputs	I01	Total material consumption	✓	- Mass unit, type - Percentage of change from the previous year
	I02	Origin of the raw material	✓	- Percentage of purchases made from national suppliers
	I03	Consumption of recycled material	✓	- Percentage of recycled material purchased, type*
	I04	Consumption of reused material (internal)	✓	- Percentage of material reused/valued internally, type*
	I05	Consumption of reused material (external)	✗	- Percentage of reused material (coming from outside), type*
	I06	Good practices regarding the use of packaging (*within the organisation)*	✓	- Does the organisation promote the removal of single-use plastics within itself?*
	I07	Energy consumption	✓	- Energy unit - Percentage of change from the previous year
	I08	Energy self-generation	✓	- Percentage of self-produced energy*
	I09	Renewable energy consumption (external)	✓	- Percentage of external renewable energy*
	I10	Use of residual energy	✗	- Percentage of change from standard consumption (energy saved)
	I11	Total water consumption	✓	- Volume unit - Percentage of change from the previous year
	I12	Recirculated water	✓	- Percentage of internally reused water*
	I13	Consumption of recirculated external water	✓	- Percentage of externally reused water*

(*continued on next page*)

Table 3 (*continued*)

Category	Code	Proposed indicator		Metrics commonly used in CSR
Production	P01	Investment in maintenance	✓	- Percentage of profit invested in maintenance*
	P02	Efficient equipment and machinery	✓	- Has the organisation implemented any digitalisation processes?* - Does the organisation use energy-efficient lighting systems?* - Has the organisation made any investments to increase resource efficiency?* - Percentage of fleet that are electric vehicles*
	P03	Management systems	✓	- Does the organisation have environmental management systems (ISO 14001)?* - Does the organisation have energy management systems (ISO 50001)?* - Does the organisation have product management systems?* - Does the organisation have environmental or climate change policies?*
Outputs	O01	Total waste generation (absolute value)	✓	- Mass unit, hazardous/non-hazardous wastes - Percentage of change from the previous year
	O02	Waste generated that is valued (externally)	✓	- Percentage of waste recovered, hazardous/non-hazardous waste*
	O03	Total water discharge (absolute value)	✓	- Volume unit - Percentage of change from the previous year
	O04	Quality of water discharge	✓	- Is the quality of water discharges within the required limits?
	O05	Amount of water discharged without purification	✗	- Volume unit
Environmental impact	EI01	Carbon footprint	✓	- Mass unit CO_2 eq. (Scope 1, 2 and 3) - Percentage of change from the previous year
	EI02	Environmental compensation actions	✓	- Percentage of profit invested in actions to improve the environment*
	EI03	Land use	✓	- Distance unit, from protected areas
	EI04	Environmental legislation	✓	- Does the organisation have any environmental sanctions or fines?
Social	SO01	Social actions	✓	- Does the organisation offer circularity/sustainability training to their workforce?*
R&D in circularity	R01	Investment in research projects	✓	- Percentage of profit invested in R&D*
	R02	Patents related to circularity	✓	- Does the organisation have patents related to circularity matters?*
Business	B01	Circular services offered	✓	- Does the organisation integrate reverse logistics?* - Does the organisation offer after-sales service (preventive maintenance)?* - Does the organisation offer charging points for electric vehicles?* - Does the organisation promote/offer the use of shared facilities or equipment?*
Communication	C01	Published environmental reports	✓	- Does the organisation make regular CSR communications?
	C02	Information about product sustainability characteristics	✓	- Does the organisation communicate sustainable characteristics in its labelling?*

* In the absence of information in the CSR, the following answers will be considered: 0% in the case of quantitative metrics or "no" in the case of questions/qualitative metrics. However, for metrics that are not marked with the symbol *, if there is an absence of information, it will be indicated that the report does not disclose enough information to provide an answer.

Digitalisation, *Energy-efficient lighting systems*, *Optimised low-impact equipment* and *Investment in increasing resource efficiency*.
- *Environmental compensation actions* added to the *Environmental impact* category and based on the circularity aspect *Investment in decontamination/environmental actions.*
- *Environmental legislation* added to the *Environmental impact* category and based on the circularity aspect *Environmental regulation.*
- *Information about product sustainability characteristics*, added to the *Communication* category and based on the circularity aspect *Providing product information.*

The final set of indicators proposed to measure the level of circularity of organisations is presented in Table 3. The proposal made includes 34 indicators (29 from Stage I and 5 from Stage II) and their respective metrics, grouped in the 10 circularity categories proposed in Stage I.

Related to the second objective, note that the proposed metrics were based on results from Stage II. Table 3 also indicates which circularity indicators can/cannot be measured directly with the information reported in the CSRs, by means of the following symbols:

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✓	The proposed indicator can be measured from data communicated through CSRs (Stage II).
✗	The proposed indicator cannot be measured from data communicated through CSRs (Stage II).

As can be observed in Table 3, only 3 of the 34 proposed circularity indicators (9%) cannot be measured through the information that organisations are communicating in their CSRs: 2 indicators from the *Inputs* category and 1 from *Outputs*.

4.4. Case study

The set of indicators proposed to measure the level of circularity in organisations was applied to a Spanish organisation in the forestry and paper products sector with a CSR based on GRI-Standards and published in 2020.

The results in Table 4 show that 25 of the 34 indicators of the proposal (74%) can be measured by means of the circularity information included in the CSR under study. The remaining indicators cannot be measured with the information disclosed. Specifically, two of the proposed indicators (6%) are not mentioned in the CSR under study, and seven (21%) are communicated by a different metric other than those proposed.

On the one hand, there were two indicators belonging to the *Outputs* (*Amount of water discharged without purification*) and *Inputs (Use of heat or waste energy)* categories, respectively, that were not mentioned in the report. This was consistent with the results observed in Stage III. On the other hand, upon analysing the seven indicators communicated with a

Table 4
Case study of the circularity indicators proposal.

Category	Code	Proposed indicator	Proposed metric		Circularity indicator in case study
Design	D01	Product design / Circular services	Does the organisation manufacture on demand?		Yes
			Has the organisation considered eco-design criteria during the design process?		**No**
			Does the organisation work with returnable packaging?		**No**
			Percentage of the product that is recyclable		100%
			Percentage of the package that is produced with recycled material		0%
	D02	Application of sustainability criteria for the product	Is the raw material certified as sustainable material?		Yes
			Is the product intended for the domestic market?		Yes
			Percentage of eco-labelled products		0%
Suppliers	S01	Sustainable suppliers	Are suppliers sustainable (origin, practices, etc.)?		Yes
			Are suppliers externally certified?		Yes
Inputs	I01	Total material consumption (absolute value)	Mass unit, type		Information doesn't fit proposed metric
			Percentage of change from the previous year		5.30%
	I02	Origin of the raw material	Percentage of purchases made from national suppliers		94.53%
	I03	Consumption of recycled material	Percentage of recycled material purchased, type		0%
	I04	Consumption of reused material (internal)	Percentage of material reused/recovered internally, type		10%
	I05	Consumption of reused material (external)	Percentage of reused material (coming from outside), type		0%
	I06	Good practices regarding the use of packaging	Does the organisation promote the removal of single-use plastics within itself?		**No**
	I07	Energy consumption (absolute value)	Energy unit		868,200 GJ
			Percentage of change from the previous year		-0.23%
	I08	Energy self-generation	Percentage of self-produced energy		100%
	I09	Renewable energy consumption (external)	Percentage of external renewable energy *		0%
	I10	Use of heat or waste energy	Energy saved (Percentage of change from standard consumption)		No information is available
	I11	Total water consumption (absolute value)	Volume unit		4,125,000 m^3
			Percentage of change from the previous year		+1.2%
	I12	Recirculated water	Percentage of internally reused water		Information doesn't fit proposed metric
	I13	Consumption of recirculated external water	Percentage of externally reused water		0%
Production	P01	Investment in maintenance	Percentage of profit invested in maintenance *		Information doesn't fit proposed metric
	P02	Efficient equipment and machinery	Has the organisation implemented any digitalisation processes?		**No**
			Does the organisation use energy-efficient lighting systems?		**No**
			Has the organisation made any investments to increase resource efficiency?		**No**
			Percentage of fleet that are electric vehicles *		0%
	P03	Management systems	Does the organisation have environmental management systems (ISO 14001)?		Yes
			Does the organisation have energy management systems (ISO 50001)?		Yes
			Does the organisation have product management systems?		Yes
			Does the organisation have environmental or climate change policies?		**No**
Outputs	O01	Total waste generation (absolute value)	Mass unit, hazardous/non-hazardous waste (hw/nhw)		Total: 76,297 t; 84 t hw; 76,213 t nhw
			Percentage of change from the previous year		+10%
	O02	Waste generated that is recovered (externally)	Percentage of waste recovered, hazardous/non-hazardous waste		42%
	O03	Total water discharge (absolute value)	Volume unit		Information doesn't fit proposed metric
			Percentage of change from the previous year		Information doesn't fit proposed metric
	O04	Quality of water discharge	Is the quality of water discharges within the required limits?		Yes
	O05	Amount of water discharged without purification	Volume unit		No information is available
Environmental impact	EI01	Carbon footprint	Mass unit CO_2 eq. (Scope 1, 2 and 3)		Information doesn't fit proposed metric
			Percentage of change from the previous year		Information doesn't fit proposed metric
	EI02	Environmental compensation actions	Percentage of profit invested in actions to improve the environment		Information doesn't fit proposed metric
	EI03	Land use	Distance unit, from protected areas		0 ha.
	EI04	Environmental legislation	Does the organisation have any environmental sanctions or fines?		**No**
Social	SO01	Social actions	Does the organisation offer circularity or sustainability training to their workforce?		Yes
R&D in circularity	R01	Investment in research projects	Percentage of profit invested in R&D		Information doesn't fit proposed metric
	R02	Patents related to circularity	Does the organisation have patents related to circularity matters?		**No**
Business	B01	Circular services offered	Does the organisation integrate reverse logistics?		**No**
			Does the organisation offer after-sales service (preventive maintenance actions)?		**No**
			Does the organisation offer charging points for electric vehicles?		**No**
			Does the organisation promote or offer the use of shared facilities and equipment?		**No**
Communication	C01	Published environmental reports	Does the organisation make regular CSR communications?		Yes
	C02	Information about product sustainability	Does the organisation communicate sustainable characteristics in its labelling?		Yes

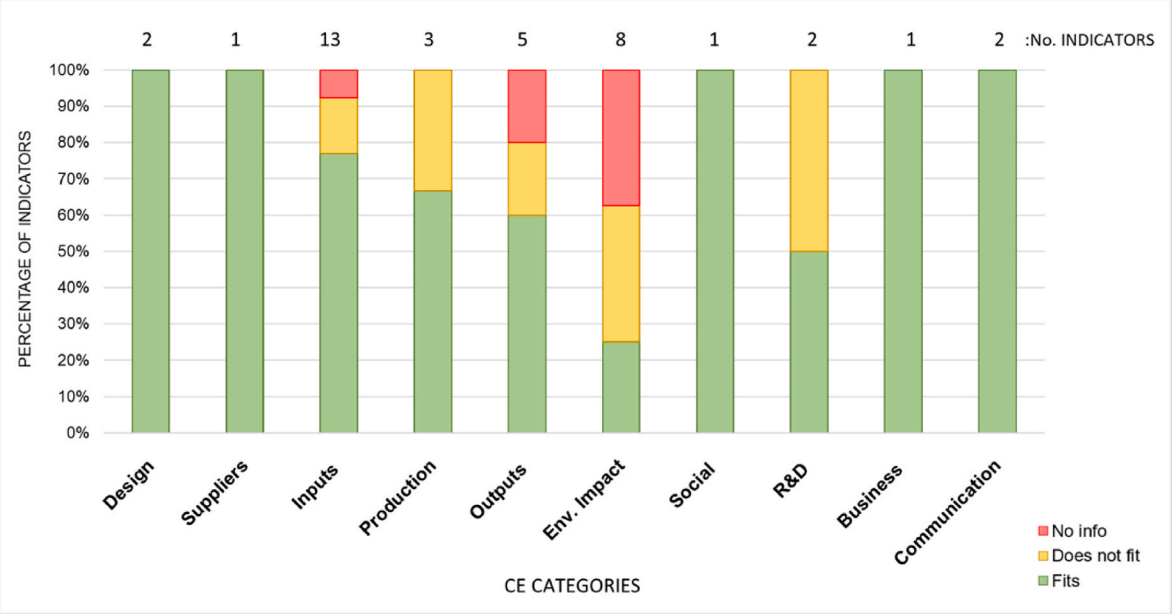

Fig. 5. Percentage of indicators that fit/do not fit/can't be measured with the proposed metrics.

The proposed metric fits the information included in its Sustainability Report.
The proposed metric does not fit the information included in its Sustainability Report.
No information is available in its CSR to quantify/qualify the proposed indicator.

metric other than that proposed, it was observed that two indicators belong to the *Environmental Impact* category (*Carbon footprint* and *Environmental compensation actions*), while another two were included in *Inputs* (*Total material consumption* and *Recirculated water*). The other three indicators belong to the following three categories, respectively: *Production*, *Outputs* and *R&D in circularity*.

Note that the organisation under study communicated its *Carbon footprint* indicator for scope 1 and 2 (within the *Environmental Impact* category). However, the proposed unit was the mass of CO_2 equivalent for scopes 1, 2 and 3. Although it is recommended to consider scope 3 when calculating the carbon footprint of organisations, companies today still frequently fail to take this into account.

Finally, based on the results, it can be said that the proposal can also serve as guidance to organisations, in order for them to easily identify

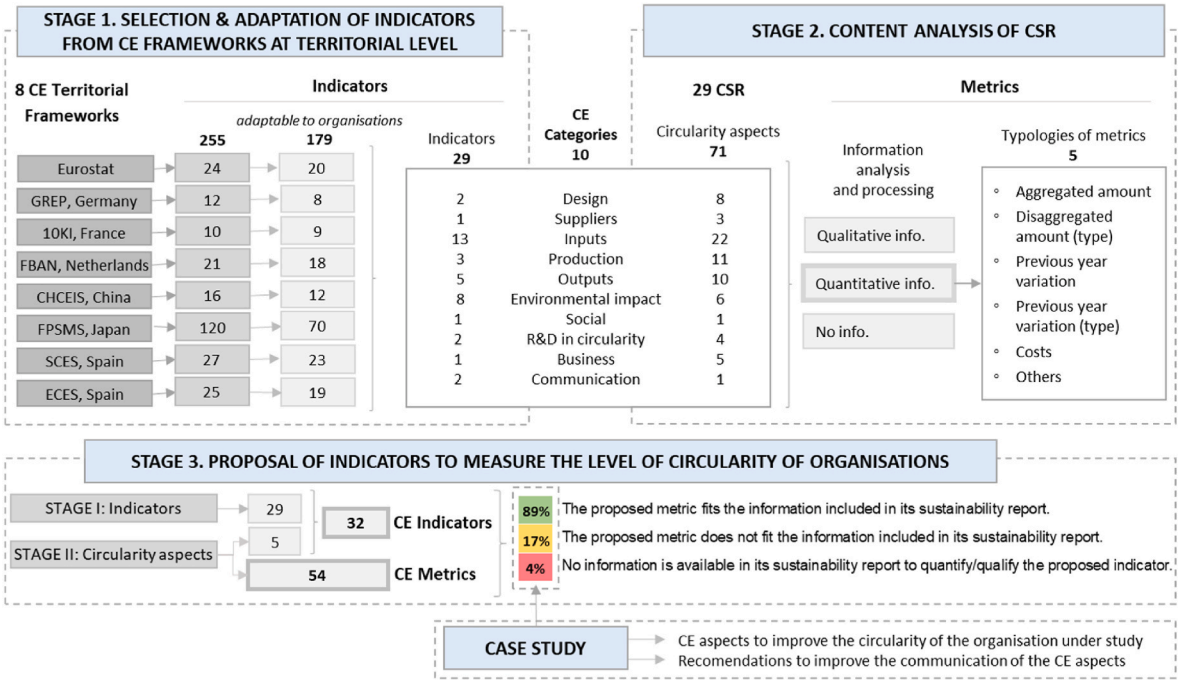

Fig. 6. Summary of the process and results carried out after applying the proposed methodology.

the company's weak points in relation to circularity. As an example, most of the indicators with a negative response for the company under study (marked in bold in Table 4) are CE strategies, such as offering circular services to customers. These services should be incorporated by the company and communicated in its CSR to demonstrate a real transition to a more circular business model.

To facilitate the analysis and visualisation of the results of the case study, Fig. 5 shows, for each of the 10 categories proposed, the percentage of proposed indicators that fit/do not fit the information included in its CSR. It also shows the percentage of indicators that cannot be calculated using the information included in the Sustainability Report. To make it easier to display the results, the following colour code was used:

In view of the results in Fig. 5, it can be stated that, in this case study, to ensure that the CSR analysed communicates all the aspects considered relevant for measuring the circularity of organisations, the following recommendations can be made: (1) include more information regarding *Environmental Impact*; (2) include Scope 3 when measuring the *Carbon footprint*; and, finally, (3) measure the percentage of the profit invested in both maintenance and environmental compensation actions.

5. Discussion

In this study, 34 indicators grouped into 10 categories were proposed to measure the level of circularity of organisations. The starting point was to review and adapt the indicators proposed in 8 programmes that measure circularity at the territorial level. From there, an initial set of 29 indicators was proposed, which was improved with another 5 CE indicators that organisations are currently communicating in their CSRs, and which were not reflected in the initial proposal. This was completed with the details of the units/metrics that organisations commonly use in their CSRs to communicate their non-financial results. Finally, a case study was conducted on a Spanish organisation to test the proposal and some recommendations were identified to ensure that all the CE aspects considered relevant for measuring its circularity were included in its CSR. Fig. 6 presents this process in detail.

Considering the set of 8 frameworks analysed in Stage I, it can be said that their approaches did not align with each other, in terms of the number of indicators, in the breakdown of CE categories established or in the topics they covered. It was noted, for example, that while FPSMS (Government of Japan, 2018) proposed a large number of indicators concerning topics related to competitiveness and innovation, other programmes such as CHCEIS (NDCR, 2017) or GREP (BMUB, 2016) did not propose any indicators on this subject. As de Pascale et al. (2021) noted, the absence of uniformity in CE assessments is a limitation to the understanding and measurement of the CE and also hinders progress towards more circular systems, hence more research on this topic is needed.

Additionally, further shortcomings were identified regarding the exclusion of essential aspects related not only to circularity but also to sustainability. On the one hand, most of the frameworks, despite focusing on categories related to Input/Output material resources, neglected issues related to water and energy management. On the other hand, only 2 of the 8 frameworks analysed considered aspects related to the implementation of circular business models, the investment in R&D projects based on the CE, or in sustainability reporting, among others. These facts clash with the idea that the CE is a holistic tool that makes it possible to promote sustainability as a whole (Schroeder et al., 2019; Opferkuch et al., 2021). Consequently, although territorial frameworks can be used as a basis for the study of circularity in organisations, as affirmed by Rincón-Moreno et al. (2021), these frameworks need to broaden the range of aspects considered in order to improve the diagnosis of circularity and also promote a more sustainable global behaviour, not only of territories but also of organisations.

Therefore, regarding RQ1 (What indicators can be used to measure the advance of organisations towards a circular economy?), it is important to highlight that to measure circularity in organisations over time, it is necessary to cover the essential issues of circularity, bearing in mind the broader concept of CE as a tool for promoting sustainability and green growth worldwide (Welfens et al., 2017). These CE issues need to consider several categories, not limited to solely environmental aspects, but also include others of a social or economic nature, as recommended by Reichert and Mendes (2014) or Opferkuch et al. (2021). According to the results presented in Stage I, it was seen as essential to combine all the CE issues considered by the 8 frameworks under study, since no single proposal was considered complete enough. This differs from other studies, such as Rincón-Moreno et al. (2021), which were based on a single framework. The CE proposed categories included those related to *Production and consumption*, *Waste management*, *Secondary raw materials* and *Competitiveness and innovation*, proposed by Eurostat (2021), but also took into account aspects related to the environmental impact and the extension of the lifespan, which are essential in terms of circularity, according to the European "*New Circular Economy Action Plan*" (COM 98, 2020).

After putting forward the CE categories, a proposal for a set of initial indicators was developed. According to the results presented in Stage I, a large number of the "territorial CE indicators" identified were applicable or adaptable to organisations, confirming the conclusions reached by Rincón-Moreno et al. (2021). However, after their adaptation, some additional indicators also needed to be incorporated into the initial proposal, since they were mainly based on the disclosure of primary flows (inputs/outputs of production) related to reuse, recycling and recovery issues, which are considered insufficient from the CE perspective (Dagiliene et al., 2020; Valls-Val et al., 2022). The additional indicators were related to these CE strategies and based on the results obtained in Stage II. Some examples of these additional indicators were the measurement of good practices related to the use and redesign of packaging, the efforts made by organisations to use efficient equipment and machinery (including dematerialisation), the investment in environmental compensation actions, and the communication of information about products through its labelling. Note that, combining indicators from different sources, to complete those proposed by GRI, was also highlighted by Tiossi and Simon (2021) as a useful practice to support the integration of sustainability with the CE in CSRs.

Finally, 34 circularity indicators were proposed to measure the progress of organisations towards a CE. They were classified into the 10 proposed CE categories, mainly depending on the life cycle stages of an organisation and covering the current essential aspects of the CE (COM 98, 2020).

Regarding RQ2 (What are organisations communicating in their CSRs related to their circular behaviour?) and according to the results of Stage II, the information communicated by organisations through CSRs covered many aspects of circularity but varied significantly from one company to another. In accordance with Dagiliene et al. (2020) and Fortunati et al. (2020), the information disclosed is scarce and in many cases confusing. Therefore, organisations need better guidance in order to harness the full potential of a CSR as a tool to redirect the business towards more circular models (Sihvonen and Partanen, 2017; Scarpellini et al., 2020).

Most of the circularity aspects identified when reviewing the CSRs (see Fig. 5) were related to the *Inputs* category, followed by the *Production* and *Outputs* categories. Specifically, the circularity aspects disclosed by most of the organisations were *Greenhouse Gas Emissions*, disclosed in more than 90% of the CSRs under study; *Total Energy Consumed*, in about 85%; and *Waste Generation* (*hazardous* + *non-hazardous*), included in more than 70%. This was in line with results from Stewart and Niero (2018) who identified the environmental aspects as the most widely mentioned in CSRs (around 50%), either in relation to resource scarcity, climate change or, more generally, environmental pressures.

Conversely, the circularity strategies were the aspects that were less widely disclosed, since 25 of the 71 circularity aspects (35%) related to

these strategies were reported by barely 20% of the organisations. Some examples were the incorporation of *Ecodesign* strategies or *Reverse Logistics*, reported by only 7% of the organisations analysed. These findings are in agreement with Calzolari et al. (2021), who highlighted the ambiguous attitude towards the implementation of CE practices that deal with rethinking product design/functions and business models. One of the least communicated CE strategies was related to the use of collective facilities and equipment, reported in only 3% of the CSR analysed. This aspect can be linked to the concern about sharing, identified by Tiossi and Simon (2021) as one of the issues that should be considered when communicating circularity by means of CSR. The reason for these omissions could be that organisations are not incorporating these circularity strategies in their companies or do not consider it relevant to include them in their CSRs. It is important to note that reports evaluate CE practices that have already been adopted by the company, thus taking an ex-post view and omitting intentions or future actions (Calzolari et al., 2022). Despite the fact that tools for measuring the level of circular economy implementation attribute great importance to the CE strategies (Valls-Val et al., 2022), given that sustainability reporting practices are generally driven from internal preferences of organisations (Lozano et al., 2016), not only guidance but also motivation and awareness are key factors in improving their transparency.

As Fig. 6 shows, some aspects of circularity were reported using a variety of different names and many different metrics/units. This fact could generate confusion when comparing the level of circularity of different organisations. That is, it seems that organisations find it difficult to choose appropriate indicators and metrics to declare their behaviour or intentions related to CE issues (Janik et al., 2020), which also shows the disparity in different understandings of the CE concept (Corona et al., 2019; De Pascale et al., 2021). This could be solved if a set of standardised indicators and metrics were established to disclose the information, such as those proposed in this study.

And finally, regarding RQ3 (How would it be possible to calculate circularity indicators with the information that organisations are communicating in their Sustainability Reports?), it can be said that organisations could measure circularity indicators, with some effort, through the information they are currently communicating in their CSRs. The specific case study carried out in section 4.4 (see Table 4) showed that 25 of the 34 indicators of the proposal (74%) can be measured with the proposed metrics by means of the information included in the CSR of the organisation under study. Therefore, the proposal and methodology applied can be considered adequate. This is in line with the claims by Rincón-Moreno et al. (2021), which emphasised that companies calculating circularity could use the information already disclosed in their CSRs as a good starting point. However, in accordance with Maia et al. (2021), caution is required when using CSR data to draw conclusions on the actual performance of organisations, due to the lack of patterns and diversity in the reporting practices identified in section 4.3.

In this context, enlarging the size of the sample of CSRs reviewed would improve the research study by allowing conclusions to be drawn in a more general way. Related to the case study, and as an avenue of future research, it would be recommendable to apply the methodology to other CSRs, from both national and international organisations. Additionally, enlarging the time scope of CSRs to analyse different years for the same organisation would allow a longitudinal exploration of the activities of the organisations.

6. Conclusion

The measurement of the level of circularity and the subsequent presentation of the results can be beneficial for the image of organisations, not only because it implies they present a strategy based on transparency towards society at large, but also because it allows them to stand out as innovative companies committed to a more circular economy.

This study contributes to improving the measurement and communication of CE issues in organisations. On the one hand, a set of CE indicators was proposed that can act as a form of guidance for research and companies, when measuring circularity in organisations and exploring their potential to contribute to different dimensions of sustainability. On the other hand, based on the results of the case study, some recommendations were given related to the disclosure of quantitative information to increase the accuracy and reliability of data contained within future CSRs. Some of these recommendations include the communication of more information regarding circularity strategies, such as reverse logistics or ecodesign; to consider scope 3 when calculating and communicating the carbon footprint of organisations; and to provide a more specific declaration of reuse strategies, both in terms of materials and heat/waste energy. Finally, the proposal can also help organisations to easily identify a company's weak points related to circularity and establish future interventions in their transition to a more circular business model.

The applied methodology is general and can be implemented in the future to expand the number of CE evaluation programmes or evaluate those of a specific country/region in Stage I. In the same way, the number of CSRs evaluated can be expanded or focused on another specific country/region in Stage II. Finally, and as a line of future research, it is proposed to extend the case study to a wider and more representative sample of organisations. In this way it would be possible to verify, in general terms, the indicators that can be measured with the information currently communicated in the CSRs, and to identify what information organisations typically have to add to be able to measure and monitor their circularity with the set of indicators proposed in this study.

Author statement

V Ibáñez-Forés: supervision, conceptualization and methodology, data acquisition and curation, investigation, formal analysis, writing-review & editing. **Virginia Martínez-Sánchez**: data acquisition and curation, formal analysis, writing original draft. **Karen Valls-Val**: investigation, writing review version. **María D Bovea**: funding acquisition, project administration, conceptualization and methodology, 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.jenvman.2022.115784.

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