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TOWARDS THE BEST CIRCULARITY ASSESSMENT METHODS FOR BUILDINGS

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Abstract

At present, it is commonly accepted that our economy requires to return to a circular system, similar to some pre-industrialized economies though, this time, rushed by environmental and social negative impacts, rather than economic constrains. After decades of circularity assessments of buildings, the construction sector still lacks specialized tools that allow agile assessment of architectural elements. Up to now, the related reviews indicate that life cycle assessment has been the most used methodology. This is probably because it was the closest tool to the topic. Nevertheless, at this moment there are many other circularity assessment approaches available, for instance the standard ISO 59020:2024, which defines a rigorous open methodology for any sector and combinable to other environmental assessment tools. There are also numerous tools specialized on buildings. Some allow agile evaluations such as the European framework for sustainable buildings Level(s). Others present a more case study point of view, like the Detail edition Manual of recycling, while many research papers develop particular methodologies. The present paper reviews these methods in order to draw initial conclusions for the future development of novel agile and rigorous circularity assessment tools for specific case studies. This research paper is part of the project “Waste-based Intelligent Solar-control-devices for Envelope Refurbishment” starts, of “Ecological Transition and Digital Transition Projects” of the Spanish Ministry of Science and Innovation (MICINN) with reference TED2021-130155B-I00, funded by MCIN/AEI/10.13039/501100011033 and by the European Union “NextGenerationEU”/PRTR.

Keywords: circular economy, literature review, LCA, MCDM, recyclability.

1. Introduction

In the present context of high resource consumption, emissions and waste generation from the construction sector [1], our obsolete linear economy has been commonly accepted as the main cause of these environmental negative impacts. To reverse the situation, circular economy has been accepted as the alternative objective, after decades of studying its implications such as: overcoming the concept of waste towards potential resources and defining its relation to the sustainability development by means of reducing the consumption of resources and maximizing the reuse, recovering and recycling at the end of life [2].

To move towards more circular architecture the construction sector needs to introduce more circular solutions. To this end it is crucial to determine the circularity of the available solutions in order to use the most circular and improve the weaknesses of the alternatives less appropriate. To do so, all stakeholders involved require the assistance of tools, methods that can determine the circularity of our buildings and their components.

Up to now numerous previously existing tools have been applied such as life cycle assessments (LCA) and other tools have been developed specifically for this purpose such as the standard ISO 59020:2024, Circular economy — Measuring and assessing circularity performance. Moreover, there are numerous reviews about circular assessments and evaluation tools for circularity of buildings. These reviews have reached several interesting conclusions and mostly agree that all tools have room for improvement so

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the future expects new methodologies to come and ease these assessments. However, it is unclear how this improvement should be done for a specific case study.

This research paper aims to contribute in solving this gap by studying these reviews as well as evaluation tools not present in these reviews. This study will focus on answering the following research questions: 1) What is the essence of circularity related to the building sector? 2) What are the main features and limitations of these available tools? 3) Which would be the most convenient circularity assessment approaches for the case study? and 4) What would be the main advices for future improved circularity tools? This study explains the methods in the following section. Then it presents and discusses the results and finally it draws the main conclusions.

2. Methodology

Fig. 1 presents the steps followed in this research paper:

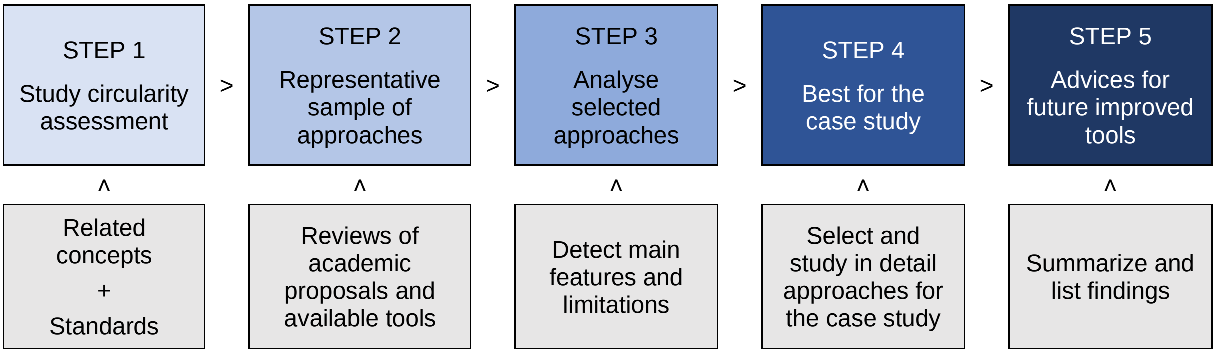

Fig. 1. Steps followed in this research project.

The first step aims to study the evaluation of circularity and its essence by looking at the main related basic concepts and standards. The second step identifies a representative sample of existing approaches for the assessment of circularity. This second step relies on previous literature reviews related to assessment tools for buildings. It aims to include all kinds of approaches, both academic proposals and others more open to the general public. The third step critically analyses the classified circularity assessment approaches while determining their main characteristics and searching for their limitations. The fourth step selects and studies in detail the approaches that would fit best to analyse the circularity of the case study. The final step closes the research project by summarizing and listing the main findings.

3. Results and discussion

This section presents the results of the study starting with the main concepts, then the main features and limitations of the studied existing circularity tools.

3.1. Main concepts related to circularity assessment tools

There are several concepts that are crucial to study these tools. This paper has considered the definitions given by current standard “Circular economy — Measuring and assessing circularity performance” (ISO 59020:2024), in subsection 3.1, to terms such as circular economy, circularity; circularity performance, measurement and assessment; and quantitative and qualitative indicator among others. This paper points out the conception of circularity as the fulfilment of the circular economy pillars, which imply using a systemic strategy to achieve a looping resource flow. This flow is achieved by adding, recovering or retaining the initial value to the resources. Thus, in consequence, circularity contributes to sustainable development. This contribution implies that there are common indicators between circularity and sustainability performances. Considering the most common notion of sustainability as the integration of economic, environmental and social indicators; the aforementioned also implies that there are common indicators between circularity and economic, environmental and social performances and their assessments.

3.2. Standards related to circularity assessment tools

LCA aims to identify the environmental impact of the product at each stage of its useful life in order to modify it through the introduction of improvements. It is a methodological approach based on quantitative data. It is based on the ISO 14000 family of standards from 2006, which focuses on stages from A to C while stage D seems not to be mandatory to be included as it is considered to be beyond the limits of the system). Based on a unit of measurement such as kgC02 or MJ the impact is measured, in order to compare solutions, it will be important to do so with equivalent functional units. This is similar for other environmental performance assessments standards based on life cycle analysis. On one hand, EN 15804:2012+A2:2020 '*Sustainability of construction works. Environmental product declarations. Core rules for the product category of construction products.*' provides the structure for the making of Environmental Product Declarations (EPD), which enables the omission of steps B, C and D for a LCA that is cradle to gate or a cradle to gate with options. On the other hand, EN 15978:2012 '*Sustainability of construction works. Assessment of environmental performance of buildings. Calculation methods.*' is based on a life-cycle approach corresponding to A to C stages while stage D remains as 'beyond the life-cycle of the building' as a non-mandatory scenario to be developed only if it is considered relevant and available.

Circularity aims to close the life cycle of materials through reuse strategies (recycling, reuse, relocation...). Its approach is more conceptual and strategic. It is based on the ISO 59000 family of standards for the year 2024, which must be taken into account when designing the tools. It puts more emphasis on how to carry out the recovery of materials and/or products (D stage), but also if the source of raw materials (stage A1) have renewable or secondary material content. It is measured as a percentage, not with concrete values, of the ability of the system or product to create a closed loop depending on the type of material it is made of, the type of fastening or ease to be dismantled and the economic viability.

There is further study of different end-of-life scenarios for components and materials. An example of this is the ISO 20887 standard 'Sustainability in buildings and civil engineering works. design for disassembly and adaptability. Principles, requirements and guidelines', with the aim of reducing waste, provides guidelines on the characteristics that the system or product must have in order to close its life cycle. Also, ISO 59014 describes a methodology that sets out the steps to recover secondary materials: step 1 determining the collection system and method, step 2 assessing the recovery potential of products and components, step 3 assessing the recovery potential of materials.

3.3. Representative sample of approaches for the assessment of circularity

As previously explained, there are numerous reviews focusing on circularity assessment tools. Table 1 presents recent reviews, which have studied hundreds of circularity assessment approaches. As depicted in the table some are academic studies – frameworks, models – while others are tools that are available online, in some cases open source, for the use of companies, industries, etc. Table 1 also presents their main characteristics and findings that can be useful to find strengths and improvements and future directions for the assessment of circularity tools.

Table 1. Reviews about circularity assessment tools.

Year	Focus on circularity	Main findings	Approaches	Ref.
2025	Measurement	Need to better standardize and systematize data collection and evaluation. Need for a more holistic circularity approach, harmonizing indicators and emerging technologies.	> 50 academic studies, 14 tools	[3]
2025	Wider adoption in construction	Importance of BIM to enhance circularity adoption. Importance of applications, techniques, client and project preferences when defining BIM for circularity.	> 15 academic studies	[4]
2025	Methods for buildings	Material-level methods present different approaches in weighting, etc. Importance of holistic approach, data availability, refine methods and weighting indicators for the assessment.	> 20 academic studies, 8 tools	[5]
2025	Digital technologies (DT) in construction	The main challenges for implementation are design, policies and standards, assessment methods, digitalization and business models. Further research needed, i.e. on DT potential.	> 30 academic studies, 2 tools	[6]
2023	Construction industry	Predominant use of LCA, also common use of MFA. Variety of approaches and indicators used.	> 20 studies, 11 tools	[7]
2021	Economy projects in construction	LCA is the most used method. Most assessments focus on environmental issues. Waste management is the most common category.	> 90 academic studies	[8]

Legend: Ref. means reference.

3.4. Study of approaches and tools for circularity assessment

The previously studied reviews point out the existence of different types of circularity assessment tools regarding its scope: a) being specifically designed for circularity assessments or having broader approaches such as sustainability or environmental impact, in this second case with only some indicators related to circularity issues; b) being international or local, and c) having a general scope or focusing specifically on buildings. The following Tables 2 and 3 depict a representative selection of circularity-centred tools with a general scope or buildings scope respectively.

Table 2. Available circularity assessment tools with a general scope.

Available tools	Scope	Format	Standards followed	Ref.
Circularity calculator	Business	Dynamic webpage	Not found	[9]
CTI Tool & Circular Transition Indicators v3.0	Business	Dynamic webpage	Not found	[10]
Climate & circularity Calculator (ihobe)	Business, service, product	Dynamic webpage	UNE-EN ISO 14064-1: 2018	[11]
PIQET	Product's materials	Dynamic webpage	ISO 14040/14044	[12]
Circular IQ	Product's materials	Dynamic webpage	ISO 59020, GRI, ESRS E5	[13]
Material Circularity Indicator (MCI)	Materials, products	Excel-based	Not found	[14]
CE Analyst	Product	Dynamic webpage	ISO 14040/14044/14025	[15]
Circular Transition Indicators (CTI)	Product's materials	Online tool	Not found	[16]

Legend: Ref. means reference.

Table 3. Available circularity assessment tools with a specific scope on the construction field.

Available tools	Scope	Format	Standards followed	Ref.
RE10: Circularidad	Buildings	Excel-based	UNE-ISO 20887:2023	[17]
Circular Building Assessment (CBA)	Buildings	Digital, BIM-compatible	Not found	[18]
Madaster Circularity Indicator	Buildings	Digital platform	Not found	[19]
Level(s)	Buildings	Excel + digital tool	EN 15978, ISO 14040/14044	[20]
Building Circularity V2	Buildings	Digital tool	ISO 59020	[21]
The Circular Built Tool	Buildings	Digital tool	Not found	[22]
C2C Certified® Circularity	Product	Written guide	Cradle to Cradle Certified ISO 22095	[23]

Legend: Ref. means reference.

Beyond these tools, there are simpler proposals that provide quick general evaluations [24] while others have important limitations, such as Gaby circularity toolkit - not available at present - and those shown in Table 4.

Table 4. Circularity assessment tools with limitations at present.

Available tools	Field	Scope	Format	Limitation	Ref.
Circularise	General	Business	Digital	Access	[25]
Circularity Check	General	Product or service	Dynamic webpage	Presently fixing webpage	[26]
Building Circularity Index (BCI)	Construction	Building	Digital	Limited availability	[27]
GRO	Construction	Building	Digital	Language limitations	[28]
Platform CB'23	Construction	Building, construction product.	Written guide	Format	[29]
C-CalC	Construction	Buildings	Digital	Language limitations	[30]
Circular Toolkit	Construction	Buildings	Digital	In development	[31]

Legend: Ref. means reference.

Moreover, there are tools that aim to assess other topics beyond circularity and can be used to assess some circularity indicators that include among other type of indicators, such as One Click LCA, BREEAM, LEED, etc. Also, there are academic proposals and only once used tools, such as Flex 4.0, MRPI, R-EoL, 3DR Index, EURECA, KAD, Vliet-BCI, BCIX, BWPE, DDAS, PBCI, CCEF, BC, BCES, CE Index, CCS, CC, WBCI [5]. From all these proposals, Whole Building Circularity Indicator with a LCA (WBCI-LCA) is considered the most complete [32] because it improved limitations from its predecessors such as WBCI, MCI and BCI. Regarding the geographic scope, examples of tools with an international scope are CTI [16] and C2C Certified® Circularity [23] while an example of a local tool is [24].

3.5. Circularity assessment tools for the case study

The case study is the façade for the rehabilitation of the Bellvitge school, a primary school in the Barcelona metropolitan area which is the reference building of the second cluster of obsolete educational buildings in need of rehabilitation. Specifically, there are different waste-based alternatives that require to be assessed in terms of their circularity to chose the best solution for this case. Figure 2 presents a general view of the school and the 6 alternatives that have already been assessed regarding their sustainability [33].

Fig. 2. General view of the school and the 6 alternatives that require a circularity assessment.

The authors have considered the circularity assessment tools depicted in Table 5 as the best candidates based on the previous sections. Table 5 analyses in depth seven recent regulations related to circularity: a European Framework, a design guide from a doctoral dissertation, a research framework and two construction field tools. The authors have thoroughly studied them all and classified the number of indicators according to the stages of the building's life cycle and beyond. It is obvious that the circularity assessment tools concerned phases are A and D, with an average range in both cases between 1 and 9 indicators in each stage, whereas phases B and C remain largely unnoticed. This evidence is even more noticeable in the total summary of the indicators in each stage, 32-40 indicators in contrast to 2 indicators.

Table 5. Analysis in detail of the circularity assessment tools that best suit the case study.

Circularity assessment method		Product & Construction Stage A	In-Use Stage B	End of life Stage C	Beyond building life cycle Stage D
Standards	ISO 59020	9	1	-	8
	ISO 20887:2023	3	-	-	5
Framework	Level(s) [20]	4	-	2	4
Guide	Thesis proposal [34]	2	-	-	5
Framework	M-CEF$_{BC}$ [35]	9	1	-	5
Construction field tools	RE10: Circularidad	1	-	-	8
	Building Circularity V2	4	-	-	5
	Total indicators	32	2	2	40

Mainly, this is due to the fact that circularity assessment tools focus primarily on the provenance of the material in the inflow stage (A1-A3), such as the use of recycled or renewable materials (i.e. products with recycled content, average reused content of an inflow, direct reuse of construction elements…) and outflow by the regard of deconstruction (D) in the main building or construction system features to potentially extend the life span of the materials or construction products (i.e. disassembly plan, ease of disassembly, recycling materials in a closed loop, independence and reversible connections...).

4. Conclusions

Based on the previous sections and in answering to the initial research questions and objectives:

- A key factor to understand circularity assessments is the relation between circularity and the expected scope of applied tool. Thus, circularity evaluations based on tools exclusively developed for circular purposes use the full extent of the tool (i.e. MCI). Otherwise, circularity analysis using methods developed for instance for holistic sustainable assessments (i.e. BREEAM, LEED), environmental (i.e. LCA), or economic analysis (LCC) evaluate one or some indicators within the circular economy concept. The latest standard for circularity assessments, ISO 59020, has been sensible to this issue by proposing an open framework that has only six mandatory indicators from a total of 24 indicators. This recent ISO also considers complementary methods such as MFCA, LCA, LCIA, LCC and LCSA among others.
- Buildings require tools specialized in the construction sector because of the particularities in terms of large amount of materials' lifecycle duration and transport issues when compared to other industrial sectors that at present have lower life cycles. When comparing the recently developed circularity-focused standard 59020 to previous standards applied for the assessment of circularity such as ISO 14040, the circularity standard focuses on the life cycle 'stage A1' and 'stage D' while former standards and tools only take into consideration stages A to C. Also, that the obtained results with the tool are in percentages and not in specific units.
- On the other hand, current methods do not incorporate the durability or time dimension of the cycle. This does not allow for differentiating between circularity cycles of different lengths, i.e. between 5 and 50 years. In this sense, future approaches need to incorporate durability into the functional unit, whether standardized or quantitative. This would enhance long-cycle products over shorter ones and would introduce the concept of functional equivalent when comparing products. This concept is fundamental in LCA but is not so in circularity tools or standard, allowing disparate products to be compared thus the obtained results will be inconsistent leading to distorted conclusions.
- The main limitations of the available tools and their application to cases are lacks related to standardization, systematization, holistic approach, etc. (see Table 1). These weaknesses could be solved by incorporating the latest related standards, methods and techniques. For example, by including the specifically related recent ISO 59020, the successfully broadly applied MCDM to structure indicators, bias-reduced techniques to weigh indicators such as Delphi, and methods to integrate results such as the MIVES model non-dimensional value functions among others.

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References

[1] F. Ossio, C. Salinas, and H. Hernández, ‘Circular economy in the built environment: A systematic literature review and definition of the circular construction concept’, Journal of Cleaner Production, vol. 414, p. 137738, Aug. 2023, doi: https://doi.org/10.1016/j.jclepro.2023.137738.

[2] P. G. Palafox-Alcantar, D. V. L. Hunt, and C. D. F. Rogers, ‘The complementary use of game theory for the circular economy: A review of waste management decision-making methods in civil engineering’, Waste Management, vol. 102, pp. 598–612, Feb. 2020, doi: https://doi.org/10.1016/j.wasman.2019.11.014.

[3] J. dos Santos Gonçalves, S. Claes, and M. Ritzen, ‘Measuring Circularity of Buildings: A Systematic Literature Review’, Buildings, vol. 15, no. 4, 2025, doi: https://doi.org/10.3390/buildings15040548.

[4] P. A. Rao, M. M. Rahman, and S. B. Duraman, ‘Adopting circular economy in construction: a review’, Frontiers in Built Environment, vol. Volume 11-2025, 2025, doi: https://doi.org/10.3389/fbuil.2025.1519219.

[5] S. Mani, M. R. Hosseini, G. Karunsena, and T. Kocaturk, ‘Inconsistencies revealed: A critical analysis of circular economy assessment methods for buildings’, Resources, Conservation and Recycling, vol. 218, p. 108203, May 2025, doi: https://doi.org/10.1016/j.resconrec.2025.108203.

[6] C. Keles, F. Cruz Rios, and S. Hoque, ‘Digital Technologies and Circular Economy in the Construction Sector: A Review of Lifecycle Applications, Integrations, Potential, and Limitations’, Buildings, vol. 15, no. 4, 2025, doi: https://doi.org/10.3390/buildings15040553.

[7] S. Muñoz, M. R. Hosseini, and R. H. Crawford, ‘Exploring the environmental assessment of circular economy in the construction industry: A scoping review’, Sustainable Production and Consumption, vol. 42, pp. 196–210, Nov. 2023, doi: https://doi.org/10.1016/j.spc.2023.09.022.

[8] L. Lovrenčić Butković, Mihić ,Matej, and Z. and Sigmund, ‘Assessment methods for evaluating circular economy projects in construction: a review of available tools’, International Journal of Construction Management, vol. 23, no. 5, pp. 877–886, Apr. 2023, doi: https://doi.org/10.1080/15623599.2021.1942770.

[9] IDEAL&CO Explore BV, ‘Circularity Calculator’. [Online]. The referenced item does not yet have a DOI number. Available: https://circularitycalculator.nl/#works

[10] Roy Vercoulen, CTI TOOL. [Online]. The referenced item does not yet have a DOI number. Available: https://ctitool.com/

[11] ihobe, ‘Climate and circularity calculator’. [Online]. The referenced item does not yet have a DOI number. Available: https://www.ihobe.eus/climate-circularity

[12] Lyfecycle Strategies Pty Ltd, ‘PIQET’. [Online]. The referenced item does not yet have a DOI number. Available: https://piqet.com/metrics

[13] Circular IQ, ‘Circular IQ’. [Online]. The referenced item does not yet have a DOI number. Available: https://circular-iq.com/

[14] Ellen MacArthur Foundation, ‘Material Circular Indicator’. [Online]. The referenced item does not yet have a DOI number. Available: https://www.ellenmacarthurfoundation.org/material-circularity-indicator

[15] CE Analyst, ‘CE Analyst’. [Online]. The referenced item does not yet have a DOI number. Available: https://tools.katche.eu/analyst/

[16] WBCSD, ‘Circular Transition Indicators v4.0’. [Online]. The referenced item does not yet have a DOI number. Available: https://www.wbcsd.org/resources/circular-transition-indicators-v4/

[17] Generalitat Valenciana, Instituto Valenciano de la Edificación, ‘RE10’. [Online]. The referenced item does not yet have a DOI number. Available: https://productos.five.es/producto/re10-circularidad

[18] BAMB, BRE, ‘CBA’. [Online]. The referenced item does not yet have a DOI number. Available: https://cbapoc.azurewebsites.net/Home/Help

[19] Madaster, ‘Madaster’. [Online]. The referenced item does not yet have a DOI number. Available: https://madaster.com/circularity-insights/

[20] M. Honic and C. De Wolf, ‘Applying EU Level(s) framework indicators to improve circularity: A case study’, IOP Conference Series: Earth and Environmental Science, vol. 1196, no. 1, p. 012041, Jun. 2023, doi: https://doi.org/10.1088/1755-1315/1196/1/012041.

[21] One Click LCA, ‘Building Circularity V2’. [Online]. The referenced item does not yet have a DOI number. Available: https://oneclicklca.zendesk.com/hc/en-us/articles/15602310529820-Building-Circularity-V2

[22] Circular Built, ‘The Circular Built Tool’. [Online]. The referenced item does not yet have a DOI number. Available: https://circularbuilt.be/circular-built-tool

[23] Cradle to Cradle Products Innovation Institute Inc, ‘C2C Certified® Circularity’. [Online]. The referenced item does not yet have a DOI number. Available: https://c2ccertified.org/the-standard/circularity-certification

[24] Fundación Vida Sostenible, ‘Calculadora del indice de circularidad (Circularity index calculator)’. [Online]. The referenced item does not yet have a DOI number. Available: https://www.vidasostenible.org/proyectos/red-de-entidades-hacia-la-sostenibilidad/calculadora-del-indice-de-circularidad/

[25] EIT RawMaterials, ‘Circularise’. [Online]. The referenced item does not yet have a DOI number. Available: https://www.circularise.com/

[26] ecopreneur.eu, ‘Circularity Check’. [Online]. The referenced item does not yet have a DOI number. Available: https://ecopreneur.eu/publications/circularity-check-landing-page/

[27] Planon Building Connections, ‘Building Circularity Index (BCI). Planon Software Suite. Version: L106’, 2024. [Online]. The referenced item does not yet have a DOI number. Available: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://webhelp.planoncloud.com/en/Building%20Circularity%20Index%20Solution/Building%20Circularity%20Index.pdf

[28] Vlaamse overheid, Wallonie service public, bruxelles environment, ‘GRO’. [Online]. The referenced item does not yet have a DOI number. Available: https://gro-tool.be/telecharger-gro/?lang=fr
[29] Platform CB’23, ‘Platform CB’23’. [Online]. The referenced item does not yet have a DOI number. Available: https://platformcb23.nl/english/
[30] Cenergie, CES group, ‘C-CalC’. [Online]. The referenced item does not yet have a DOI number. Available: https://www.cenergie.be/c-calc-tool
[31] Arup, Ellen MacArthur Foundation, ‘Circular Toolkit’. [Online]. The referenced item does not yet have a DOI number. Available: https://ce-toolkit.dhub.arup.com/
[32] N. Khadim, R. Agliata, Q. Han, and L. Mollo, ‘From circularity to sustainability: Advancing the whole building circularity indicator with Life Cycle Assessment (WBCI-LCA)’, Building and Environment, vol. 269, p. 112413, Feb. 2025, doi: https://doi.org/10.1016/j.buildenv.2024.112413.
[33] T. Masseck, O. París-Viviana, S. Habibi, and O. Pons-Valladares, ‘Integrated sustainability assessment of construction waste-based shading devices for the refurbishment of obsolete educational public building stock’, Journal of Building Engineering, vol. 87, p. 109024, Jun. 2024, doi: https://doi.org/10.1016/j.jobe.2024.109024.
[34] Paula Martín Goñi, ‘Regeneración perfectible, adaptable y sostenible. Análisis y propuesta de criterios para la regeneración de los polígonos residenciales construidos en los años 60 y 70 en Europa. (Perfectible, adaptable, and sustainable regeneration. Analysis and proposal of criteria for the regeneration of residential estates built in the 1960s and 1970s in Europe.)’, UPC. [Online]. The referenced item does not yet have a DOI number. Available: https://upcommons.upc.edu/handle/2117/340973
[35] I. Amarasinghe, Y. Hong, and R. A. Stewart, ‘Development of a material circularity evaluation framework for building construction projects’, Journal of Cleaner Production, vol. 436, p. 140562, Jan. 2024, doi: https://doi.org/10.1016/j.jclepro.2024.140562.