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REVIEW OF CIRCULARITY ASSESSMENT TOOLS IN THE BUILT ENVIRONMENT

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ABSTRACT

Adopting circular economy in the built environment requires a change in the approach of designing, constructing, operationalizing and deconstructing the buildings. The transition from a conventional building approach towards a circular economy in the built environment requires assessment tools that can evaluate environmental performance and the integration of circular economy (CE) principles across all building lifecycle stages. This study presents a comparative evaluation of 16 circularity assessment tools using two key dimensions: lifecycle coverage and circularity based on CE integration. In order to assess circularity, a standardized scoring system between 1 and 5 was developed, aligned with Ellen MacArthur Foundation's ReSOLVE framework. This study indicates that tools such as BAMB and Madaster offer high levels of CE integration, offering features as varied as material passports, lifecycle tracking, and design-for disassembly. Conventional Life Cycle Assessment (LCA) tools like SimaPro and GaBi, while good in modelling the environment, lack dedicated circularity indicators. Tools such as Circulytics and Level(s) show strength in strategic or organizational-level assessment, but do not provide technical detail regarding material recovery or component reuse. This comparative framework provides valuable insights for academics, practitioners, and policymakers seeking to select or adapt circularity tools. In the Indian context, where sustainable urbanization is a national priority, contextualizing and integrating these tools with existing rating systems like GRIHA and LEED India could accelerate the adoption of circular construction practices.

Keywords: *Circular Design Indicators; Circular Economy; Circularity Assessment Tools; Life Cycle Assessment; Material Passports.*

1. INTRODUCTION

The construction industry is one of the largest contributors to environmental degradation worldwide. There is a great deal of natural resource consumption, and an enormous amount of waste and emissions are produced. The United Nations Environment Programme (UNEP, 2020) estimates that the building and construction sector contributes roughly 39% to global carbon emissions. This data illustrates the unsustainable nature of the current linear economic model, which is based on the "take-make-dispose" economic model. This model places immense pressure on ecosystems and global resources due to

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the growth of urban populations and the growing demands for infrastructure (Pomponi & Moncaster, 2017). Circular economy (CE) concepts have gained global attention as a means of addressing these pressing challenges. Contrary to a linear model, CE emphasizes resource efficiency, material reuse, recycling, waste minimization, and regenerating resources as long as possible, thus reducing the need to extract virgin materials (Kirchherr et al., 2023; European Commission, 2021; Ellen MacArthur Foundation, 2015a). As a result, it promotes the design of buildings that are durable, adaptable, easier to repair, upgradable, extendable, reusable, easy to disassemble or recyclable for their components (Hasani & Riggio, 2025).

Many researchers have emphasized the implementation of R-framework to integrate circular economy in construction sector. The traditional 3R framework including Reduce, Reuse, Recycle has evolved to address complexities in resource use and waste management. Some studies propose extended frameworks of up to 9Rs, including Rethink, Refuse, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle, Recover, and Regenerate (Garusinghe et al., 2023). In the construction sector, these R-principles are increasingly embedded across building lifecycle stages, material flow management, and design practices. (Cimen, 2023) integrated 14 extended R-principles into the Inception-to-Circulation (I2C) framework, encompassing all lifecycle phases from planning to post-use circulation, while Gowsiga et al. (2023) research 17R principles through literature review. Out of these, Reduce and Recycle remain foundational, minimizing material input and enabling secondary material use (Cimen, 2021) while, Repair, Refurbish, and Remanufacture act as a key to longevity of building components, particularly in modular and adaptable systems (Hasani & Riggio, 2025). Rethink and Refuse prompt early-stage shifts in design logic and material selection, integrating system-level innovation (Gowsiga et al., 2023), while Regenerate and Responsible use are the recent additions that emphasize ecosystem restoration and ethical procurement (Garusinghe et al., 2023). While each R-principle is conceptually distinct, many overlap in practice. This entanglement is reflected in integrative models such as Bocken’s narrowing, slowing and closing loops framework (Hasani & Riggio, 2025) and the ReSOLVE model (Gowsiga et al., 2023). The evolution from 3Rs to 17Rs in construction thus reflects a growing sophistication in circular economy thinking, which can result in reducing environmental impacts and increasing economic innovation and resilience (Ghisellini et al., 2016). In order to measure how effectively circular practices are being applied, clear, reliable methods are needed. An assessment tool that focuses on circularity plays a crucial role in this process. Architects, designers, engineers, and policymakers can use these tools to assess materials' sustainability, track environmental impacts, and set measurable circularity targets. Based on data on reuse potential, embodied carbon, lifecycle performance, and material recovery, they offer guidance in decision-making.

To support this transition, several circularity assessment tools have been developed. A few of the examples include Madaster, which allows the creation of material passports; Level(s), developed by the European Commission; the Ellen MacArthur Foundation's Material Circularity Indicator (MCI); One Click LCA, a lifecycle assessment software; and Building Circularity Indicator (BCI), which measures circular potential and reusability. A building's lifecycle can be tracked, measured, and evaluated by using tools to assess its circular performance (Pomponi & Moncaster, 2017). It is important to note that each of these tools has unique features and methods of assessment that support sustainable construction techniques (Linder et al., 2017; Morseletto, 2020). While many of these tools aim to support circular construction, their scope, lifecycle coverage, and specific indicators vary. Therefore, it is important to determine which tools are most appropriate for evaluating circularity in buildings.

Despite their growing use, limited comparative research has been conducted on how these tools align with circular economy principles. To choose the right tool for specific project goals and regional contexts, one must understand their scope, depth, and limitations. A review and comparison of 16 circularity assessment tools are conducted in this paper to fill that gap. This paper examines their lifecycle coverage and circularity integration depth, providing insight into how these tools can help guide the construction industry's transition to a circular economy. However, the study primarily relies on tool documentation and literature reviews rather than empirical data gathered from the stakeholders in the built environment. The scoring framework is qualitative and based on document analysis. Thus, the evaluation lacks performance-based metrics or outcomes from tool implementation by the stakeholders in the construction industry.

Although these limitations are present in the current study, it offers a much-needed starting point for understanding and comparing circularity assessment tools. It provides direction for integrating circular economy principles in Indian urban development thereby supporting national agenda of reducing construction waste and enhance resource efficiency. It offers a comparative framework that can guide policymakers, urban planners, and developers in selecting appropriate tools. This research paper will trigger the discussion on contextualizing these for Indian construction industry by creating a database considering Indian construction material, technology and practices to accelerate India’s transition toward circular construction and sustainable building practices.

2. METHODOLOGY

The purpose of this study is to evaluate various circularity assessment tools applicable to the construction and building sector through a qualitative and comparative method of research. Circular economy principles (CE) are meant to be incorporated and promoted throughout the entire lifecycle of a building, starting with its design, moving on to its construction and operation, and finally ending with its deconstruction or reuse. There are three main components to the methodology. In the first step, a comprehensive literature review was conducted. For this purpose, academic papers, industry reports, and international guidelines were studied to understand the current research and application of CE in the built environment. The study helped identify the key principles and criteria that define circularity in the construction industry.

The study analysed the official documentation and user manuals of selected circularity assessment tools. The documents provide an overview of how each tool works, how it uses indicators, and how it evaluates circularity. Several aspects of the circular economy were considered when selecting the tools, such as resource efficiency, closed material loops, and design for disassembly. A special focus was placed on tools specifically designed for the construction industry, covering lifecycles from design to end-of-life (One Planet Network, 2020). In the review, tools focusing on general sustainability were differentiated from those designed to assess circularity more specifically. Credibility and reliability were ensured by selecting tools developed by well-recognized organizations.

Finally, a comparative framework was developed to assess the tools based on the findings of the literature review and documentation analysis. In addition to covering all lifecycle stages, this framework also includes evaluating a tool's ability to measure reuse and recovery of materials, its ability to support flexible or adaptable design, and its compliance with circularity principles- R principles discussed in the introduction. By combining these approaches, the study aims to identify which tools are most effective in supporting the transition towards a circular built environment and provide useful insights to stakeholders.

2.1 DATA COLLECTION

Several academic and industry-related sources were reviewed in order to collect data. Science Direct, Scopus, Google Scholar, Springer Link, and Wiley Online Library were used to collect academic research as they cover a wide range of construction and sustainability studies. Also, official documentation available on the websites of the circularity assessment tools such as Madaster, One Click LCA, and eTool LCA, the documents from sustainability rating organizations such as the German Sustainable Building Council (DGNB) and the Green Business Certification Inc. (GBCI) were also included.

Data collection phase involved specific search terms used to find relevant information. It included phrases such as "circular economy in construction," "circularity assessment tools for buildings," "lifecycle assessment in architecture," "material passports" (Open Planet Network, 2020), "BIM and circularity", and "circular design indicators for buildings" (Pomponi & Moncaster, 2017; Geissdoerfer et al., 2017). In addition to providing an overview of a wide range of tools and frameworks, these search terms provided the basis for a comprehensive analysis of the study.

2.2 TOOL SELECTION CRITERIA

To ensure the study was relevant and comprehensive, a set of rules was used to select the right circularity assessment tools. The tools had to meet these conditions: (i) They must emphasize circularity, either directly or indirectly, by using supporting indicators; (ii) They need to be relevant for building projects, construction materials, and architectural design processes; (iii) at least one of these areas should be evaluated: resource reuse, lifecycle impact, design adaptability; R-principles and (iv) They should be discussed in academic studies, recognized by sustainability certifications such as LEED or BREEAM, or backed by policies from institutions such as the European Commission (European Commission, 2021; World Business Council for Sustainable Development, 2022). After applying these rules, 16 tools were selected from an initial list of 20 found during the literature review (See Annexure 1). These 16 tools were chosen because they were technically strong, applied to a variety of situations, and had detailed documentation that made them easy to compare.

2.3 COMPARATIVE FRAMEWORK

A comparative chart was developed in spreadsheet format, with column headers including: tool name, type of tool (e.g., digital or framework), tool developer, key principles and focus areas addressed, type of analysis offered (qualitative or quantitative), practical applications, parameters considered, missing circularity parameters, and the life cycle phases in which the tool is applicable (See Annexure 1). First, the tool type identifies the tools according to categories such as digital platforms (e.g. Madaster), software applications (e.g. SimaPro, One Click LCA), certification systems (DGNB, GBCI), and conceptual frameworks (e.g., BAMB). Secondly, Quantitative Capabilities assesses the tools' ability to provide measurable results, such as embodied carbon, energy usage during operation, and material flow metrics (Pomponi & Moncaster, 2017). Thirdly, Qualitative Capabilities examine how well the tools support design-based circular strategies, such as flexibility, reuse, reversibility, and design for disassembly including other R-principles (Geissdoerfer et al., 2017). Circularity Focus examines how closely the tool aligns with circular economy (CE) principles, such as maintaining resources in use, adaptability, and recovery after use (Ellen MacArthur Foundation, 2013). It also considers which stages of the building lifecycle each tool covers, namely design, construction, operation, and demolition (European Committee for Standardization, 2012). An evaluation framework was developed to assess 16 circularity tools relevant to the built environment, and each tool was rated on a scale of 1 to 5 for its potential to support circularity, using key characteristics aligned with the Ellen MacArthur Foundation's ReSOLVE framework (Ellen MacArthur Foundation, 2015b) as shown in Table 1. A detailed comparison allows for highlighting the strengths and weaknesses of each tool for supporting CE strategies. This analysis is presented in a comparison table and is accompanied by detailed explanations for the ratings, based on both technical details and literature references (See Table 2).

3. CIRCULARITY EVALUATION CRITERIA AND ANALYSIS

Table 1: Circularity evaluation

Score	Definition	Key Characteristics
1 – Low	Basic sustainability focus, no circularity metrics.	Measures energy use or carbon only; no focus on reuse, adaptability, or material recovery.
2 – Limited	Environmental impact tools without reuse or disassembly support.	Uses LCA to show environmental impact but does not track reusability or circular flows.
3 – Moderate	Some circular ideas at material or product level.	Focuses on recyclability, material health, or reuse at a small scale.
4 – Strong	Covers multiple circular strategies across building phases.	Includes reuse, design for disassembly, and tracks materials through stages.
5 – Comprehensive	Full circular economy integration across lifecycle.	Has material passports, BIM links, reuse scores, and supports circular planning from start to end.

To evaluate life cycle coverage, we analysed how comprehensively each tool addresses different phases of the building life cycle (see Table 2). Tools were assessed for their ability to promote circular strategies such as reuse, recycling, material efficiency, design flexibility, and disassembly and adoption of other R-principles. Ratings were derived from official manuals, scholarly articles, and comparative studies. A bar graph was prepared to visualize the comparative performance of the tools across circularity assessment and life cycle coverage as shown in Figure 1.

Table 2: Tool comparison matrix

Tool Name	Category	Type	Lifecycle Phases Covered	Lifecycle Coverage	Circularity	Strengths	Limitations
BAMB (Buildings As Material Banks)	Framework	EU Research Framework	All Phases	5	5	Holistic CE integration; enables reversible building and material banking	Research-phase; limited adoption
Circulytics	Tool	Organizational Tool	Organizational Operation	1	4	Evaluates CE at organizational level, including resource loops	Not specific to buildings/ materials
Madaster	Tool	Material Passport Platform	Design, Construction, End-of-life	3	4	Tracks reuse and recycling potential of materials	Limited focus on operational energy
Level(s)	Framework	EU Assessment Framework	Design, Construction, Use	3	4	CE indicators include adaptability, durability, resource efficiency	Complex to apply practically
MCI (Material Circularity Indicator)	Framework	Circularity Metric (EMF)	Use, End-of-life	2	4	Measures material reuse and recovery	Limited to product-level assessment
BCI (Building Circularity Indicator)	Tool	Building-Level Assessment Metric	Design, Construction	2	4	Scores circularity at building level	Needs detailed material data
Circularity Assessment for Building Elements	Tool	Research Tool	Design, Demolition	2	4	Evaluates reuse potential of components	Time-intensive; manual process
DGNB	Certification	Certification System	Design, Construction, Operation	3	4	Integrates lifecycle and disassembly metrics	Region-specific (Europe); complex setup

Tool Name	**Category**	**Type**	**Lifecycle Phases Covered**	**Lifecycle Coverage**	**Circularity**	**Strengths**	**Limitations**
eTool LCA	Software	LCA Software	Design, Construction, Operation	3	3	Robust LCA and energy modelling	No circularity-specific features
One Click LCA	Software	LCA and Carbon Tool	Design, Construction, Operation	3	3	Fast LCA; integrates with BIM and EPDs	Limited direct CE indicators
CTI (Circular Transition Indicators)	Tool	Company-Level Assessment Tool	Production, Use	2	3	Measures global resource flow and efficiency	Not building-specific
GBCI (LEED, TRUE)	Certification	Certification System	Design, Construction, Operation	3	3	Promotes sustainable practices and material reuse	Circularity not directly measured
GaBi	Software	LCA Software	Design, Manufacturing, End-of-life	3	2	Detailed environmental performance analysis	Lacks reuse/ recyclability metrics
SimaPro	Software	LCA Software	Design, Production, Operation	3	2	Detailed environmental impact analysis	Not CE-focused
ICE (Inventory of Carbon & Energy)	Database	Embodied Carbon Database	Design, Procurement	2	2	Provides embodied carbon data	No reuse or circularity indicators
IESVE	Software	Simulation Software	Design, Operation	2	1	Energy and daylight optimization	No material circularity data

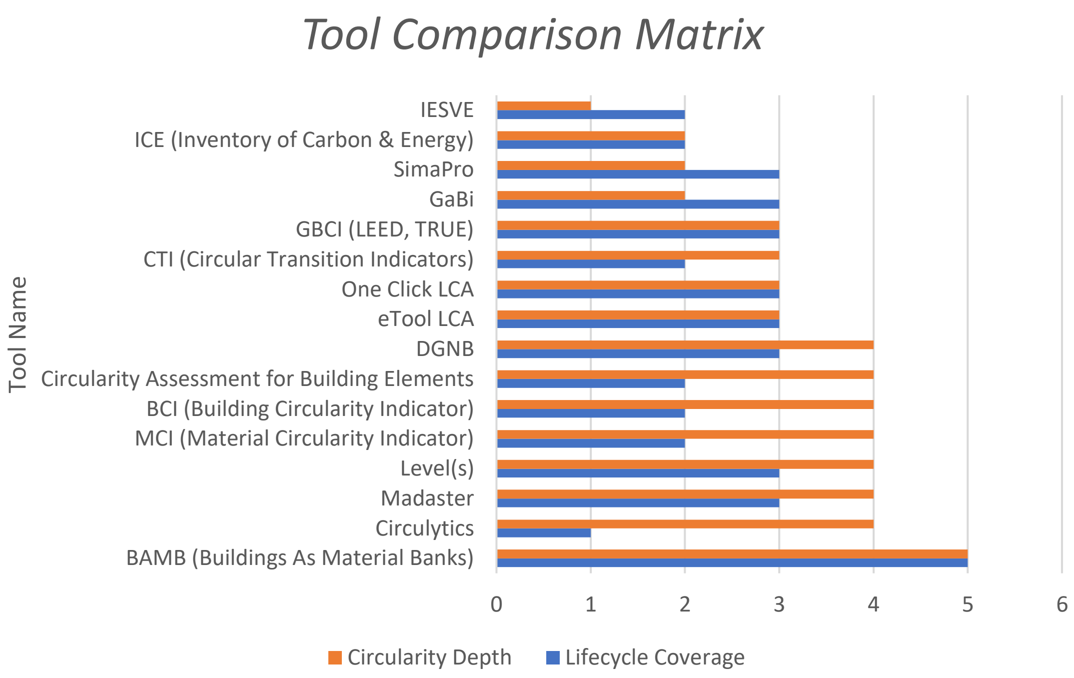

Figure 1: Circularity of assessment tools in built environment

3.1 Evaluation of Circularity Assessment Tools

The following section provides a rationale for evaluating 16 tools and their degree of integration with circular principles.

3.1.1 Highest Circularity Integration

BAMB (Buildings as Material Banks) developed under the EU Horizon 2020 initiative, provides a comprehensive framework for circularity in the built environment. The tool can be applied throughout all design phases, from early concept to end-of-life, and it integrates both qualitative and quantitative analysis through tools such as Material Passports. BAMB aims to facilitate materials recovery, reuse, and flexible adaptation of buildings over time. One of its key strengths lies in enabling future material reuse by documenting product histories and encouraging modular, easy to disassemble design. Compared with tools that address only isolated lifecycle stages, it stands out due to its deep lifecycle integration (Buildings and Materials Bank, 2020; Debacker et al., 2016).

3.1.2 High Circularity Integration

Madaster, developed in the Netherlands, is a digital platform that generates material passports and circularity scores at the building and product level. During the design and operation stages of buildings, it is especially relevant. Despite its strengths in tracking and documenting material data, including embodied value and potential reuse, it lacks the ability to model energy performance, which can be a limitation in full lifecycle sustainability assessments. Among its key differentiators is its integration with building information modelling (BIM) platforms in real time, which promotes transparency in material sourcing and waste reduction (Madaster, 2021).

Level(s) is a voluntary reporting framework initiated by the European Commission that integrates life cycle thinking into building assessments. Performance-based and design-based indicators such as adaptability, resource efficiency, and life cycle environmental impact are most useful during early design and usage phases. Level(s) does not provide direct circularity metrics, but its structured indicators support long-term circularity (Dodd et al., 2021, European Commission, 2021).

Material Circularity Indicator (MCI), a key advantage of this tool is that it aligns with EU sustainability goals, unlike technical calculators such as MCI or BCI (European Commission, 2021), Material Circularity Indicator (MCI), introduced by the Ellen MacArthur Foundation, measures the degree of circularity in products based on input-output flows, such as the proportion of recycled and reused content. It is primarily used during the design and manufacturing stages of a product. Although MCI provides clear, quantifiable metrics for circularity, its limitations include its limited application to whole-building assessments. In addition to its numerical simplicity, it has a wide range of industry application and serves as a useful tool for quantifying closed-loop material flows (Ellen MacArthur Foundation, 2015b).

Building Circularity Indicator (BCI) offers a building-scale score based on criteria like disassembly potential and modularity. The tool is most useful during the design and refurbishment phases of a project. However, BCI does not consider energy or a lifecycle's impact when identifying reuse potential. The main benefit of this tool is that it provides architectural planning for deconstruction and flexible design, which makes it stand out from more general LCA tools (Honic et al., 2019).

Circularity Assessment for Building Elements (CABE) Circularity Assessment for Building Elements (CABE) is focused on assessing individual building components, particularly in design and renovation contexts. In addition to considering disassembly potential, recyclability, and reusability of materials, it does not consider the system-level operations of buildings. Its strength is enabling component-level reuse strategies, and it differs from building-scale tools in its granular focus (One Planet Network, 2024).

DGNB (German Sustainable Building Council) DGNB (German Sustainable Building Council) certification incorporates circular economy concepts within a broader sustainability framework. This method applies to all phases of construction, but it focuses on the design and operational phases. Although DGNB is not solely focused on circularity, it promotes resource conservation, modular construction, and material efficiency. In addition to its integrative, performance-based approach, it is included in one of the most respected green certification schemes in Europe (Deutsche Gesellschaft für Nachhaltiges Bauen, 2020).

Circulytics, by the Ellen MacArthur Foundation, measures an organization’s circularity performance, focusing on strategy, operations, and enabling factors rather than specific buildings or materials. Instead of being used during design or construction phases, it is useful during strategic planning or portfolio management. A key strength of this tool is its ability to evaluate corporate circular readiness, and its unique contribution is that it focuses on macro-level circular performance, making it unique among building-specific tools (Ellen MacArthur Foundation, 2020).

3.1.3 Moderate Circularity Integration

One Click LCA integrates Life Cycle Assessment (LCA) with BIM workflows and supports early to mid-design phases. The tool enables the evaluation of carbon, material, and circular impacts. Although it includes circular economy modules, its primary focus remains on environmental impact assessment rather than circularity. The key strength of One Click LCA is that it is compatible with numerous databases and software platforms (One Click LCA, 2023).

eTool LCA is another LCA-based platform with some circularity features, especially useful in the concept and construction documentation stages. Although it supports environmental impact assessments, it is not equipped to evaluate reuse or design-for-disassembly strategies. In addition to its detailed energy and carbon modelling, it can model multiple design scenarios over the lifecycle of a building (eTool, 2022).

GBCI (Green Business Certification Inc.) administers rating systems such as LEED and WELL. Material reuse, lifecycle impact, and adaptive reuse are included in these certifications, especially during the design and refurbishment phases. Their primary focus is on sustainability performance, rather than directly measuring circularity. One of GBCI's strengths is its market recognition, and its unique role is to set standardized benchmarks for green building practices (U.S. Green Building Council, 2020).

Circular Transition Indicators (CTI), developed by the World Business Council for Sustainable Development, helps organizations measure material flows and identify circular opportunities. It is useful for managing corporate resources and construction supply chains, although it is not specific to buildings. One of its limitations is that it lacks spatial or structural specificity. The main advantage of this tool is that it enables you to track your progress toward circular procurement and materials management (World Business Council for Sustainable Development, 2022).

3.1.4 Low Circularity Integration

GaBi is a robust LCA tool widely used for assessing the environmental impacts of products and systems. In addition to the design and procurement phases, it does not include modules for assessing circular strategies such as reuse or disassembly. It offers detailed impact analysis across many sectors, but it differs from circularity tools by focusing solely on environmental impacts without reuse metrics (Burhan, 2018; Sphera, 2023).

SimaPro offers similar capabilities to GaBi, emphasizing in-depth lifecycle environmental assessments. Despite its suitability for early-stage design and specification, it lacks features that support circular design decisions. Because of its depth and transparency, it is useful for academics and consultants, but unlike circularity tools, it does not integrate feedback on material reversibility or modularity (PRé Sustainability, 2023).

ICE (Inventory of Carbon and Energy) is a dataset rather than a tool, providing embodied energy and carbon values for various building materials. While it applies to design and procurement, it does not assess circularity indicators. The advantage of this tool lies in its ability to select materials based on their carbon footprint quickly. What makes ICE different is its focus on static embodied energy values without lifecycle modelling or reuse potential (Hammond & Jones, 2011; Inventory of Carbon & Energy, 2024).

3.1.5 Very Low Circularity Integration

IESVE (Integrated Environmental Solutions Virtual Environment) is a simulation platform used for modelling energy performance, thermal comfort, and daylight. Despite its effectiveness in optimizing building performance, it does not address circularity features such as material reuse, modularity, or lifecycle adaptability. The strength of the tool lies in energy and comfort modelling, and it stands out more as an energy efficiency tool than as a circularity tool (Integrated Environmental Solutions, 2022).

4. CONCLUSION

The study analysed and compared 16 tools for measuring circularity in the built environments. Tools were evaluated based on how well they support circular economy strategies like reuse, recycling, disassembly, and adaptability and how many stages of a building's life they cover. Due to their focus on circular design and full lifecycle coverage, tools like BAMB and Madaster scored the highest. IESVE and Simapro, although useful for environmental assessments, showed limited circularity support. Each tool serves a different purpose - some are best suited for building-level evaluations, while others focus on specific products, organizations, or materials. The ratings were based on the ReSOLVE framework, and comparison studies. In general, circular construction goals were better supported by tools that included both detailed data and practical design strategies. Most of the tools evaluated are developed for international contexts and may not completely align with the local materials, construction practices, or regulatory frameworks prevalent in India. This limits insights into actual usability and adoption in Indian contexts. As India continues to grow and build at a rapid pace, circular economy strategies become increasingly important. Therefore, adapting or creating tools suited to India’s unique materials, methods, and challenges is necessary. In addition to supporting long-term environmental goals, this will help make buildings more sustainable and reduce waste. The current evaluation of circularity assessment tools is theoretical and comparative in nature. The future research may involve field validation or pilot testing of tools in actual building projects, which can offer practical validation of their effectiveness. Also, the future research can emphasize on the operationalization of integration of these tools with Indian rating systems like GRIHA and LEED India and the challenges it might present. The awareness of these tools in the community of academicians, architects and developers in India is unknown. Future research should focus on the evaluation of the awareness of circularity tools among the stakeholders of the built environment in India and on making these tools more accessible and relevant to the Indian construction industry.

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7. ANNEXURE 1: Comparative chart for circularity assessment tools

RESOURCE	TOOL NAMES	TYPE OF TOOLS	INVENTOR OF TOOL	QUANTITATIVE ANALYSIS	QUALITATIVE ANALYSIS	KEY PRINCIPALS
https://madaster.com/	Madaster	Digital tool for Material Tracking and Management	Thomas Rau, a Dutch architect	Embodied Carbon Calculation, Material Composition Analysis,Life Cycle Assessment (LCA), Material Circularity Index (MCI), Resource Scarcity Assessment, Financial Valuation of Materials	Material Reusability Potential, Compliance with Sustainability Standards, Design for Disassembly, Health & Toxicity of Materials, Transparency & Documentation, Supply Chain Traceability	Circular Economy, Sustainability, Transparency
https://www.dgnb.de/en/certification/important-facts-about-dgnb-certification/about-the-dgnb-system	DGNB Certification System (Deutsche Gesellschaft für Nachhaltiges Bauen)	Framework for Planning and Optimization Tools for Sustainable Construction	Founded by the German Sustainable Building Council (DGNB) in 2007	Life Cycle Assessment (LCA)	Design and architectural quality	Holistic Sustainability, Life-Cycle Orientation, Performance-Based Assessment
https://oneclicklca.com/	One Click LCA	Digital tool for Carbon Designing	Bionova Ltd (Finland)	Global Warming Potential (kg CO_2e), Embodied Carbon, Energy Consumption (MJ/m².), Water Consumption (m³), Waste Generation (kg/m².),	Design Optimization, BIM Integration, Lifecycle Thinking, Circular Economy Insights,Regulatory Compliance (EU Taxonomy, Carbon Neutrality goals, and National Regulations)	Whole-life carbon assessment
https://www.iesve.com/software	IES Virtual Environment (IESVE)	Digital tool for Building performance simulation software	Integrated Environmental Solutions (IES)	Energy consumption, thermal comfort levels, daylight factor, CO_2 emissions, HVAC efficiency	Design strategies for sustainability, building usability, climate adaptability	Energy modeling, thermal comfort, daylight analysis, HVAC analysis, carbon impact assessment
https://c2ccertified.org/	Cradle to Cradle Certified	Calculation tool for Sustainability certification	McDonough Braungart Design Chemistry (MBDC)	Material composition, recyclability %, renewable energy use, water efficiency	Social fairness, material health, design for circularity	Material health, material reutilization, renewable energy, water stewardship, social fairness
https://bregroup.com/about/bre-trust	BRE Trust Design for Deconstruction	Framework for sustainable building deconstruction	BRE Trust (Building Research Establishment)	Material reuse potential, embodied carbon reduction, waste diversion rates	Ease of disassembly, adaptability of design, long-term sustainability	Circular economy, ease of disassembly, reuse potential, embodied carbon reduction
https://environment.ec.europa.eu/topics/circular-economy/levels_en	Circular Footprint Formula	Calculation tool for Life Cycle Assessment (LCA) methodology	European Commission, PEF/OEF Initiative	Carbon footprint (kg CO_2e), resource depletion %, recyclability rates	Environmental impact reduction strategies, eco-design principles	Carbon footprint, material resource efficiency, environmental impact, recyclability
https://weathershift.com/	WeatherShift	Digital tool for Climate scenario analysis	Arup	Temperature variations, precipitation changes, extreme weather probability	Climate resilience strategies, adaptation measures	Future climate projections, temperature shifts, precipitation changes, resilience planning
https://rheaply.com/	Rheaply	Digital tool for marketplace for material reuse	Rheaply Inc.	Quantity of materials diverted from landfills, cost savings from reuse	Circular economy participation, collaboration between stakeholders	Circular economy, resource sharing, material tracking, waste reduction
https://www.athenasmi.org/	Athena Impact Estimator	Calculation tool for Life Cycle Assessment (LCA) software	Athena Sustainable Materials Institute	Embodied carbon (kg CO_2e), energy consumption, material lifecycle impact	Sustainable material selection strategies, ecological benefits	Embodied carbon, material lifecycle impact, energy use, emissions calculation
https://go.materialsmarketplace.org/	Materials Marketplace	Digital Tool exchange platform for material reuse	U.S. Business Council for Sustainable Development (US BCSD)	Waste reduction metrics, material exchange rates, CO_2 impact	Industrial symbiosis, corporate sustainability initiatives	Circular economy, material repurposing, industrial symbiosis, carbon footprint reduction
https://act.speckle.arup.com/login	Arup Carbon Digital Tool	Digital tool for Carbon assessment and design tool	Arup	Operational and embodied carbon (kg CO_2e), energy intensity	Carbon reduction strategies, sustainable design optimization	Embodied carbon calculation, operational carbon analysis, carbon reduction strategies
https://environment.ec.europa.eu/levels_en	Level(s)	Sustainability framework for buildings	European Commission	Life cycle carbon footprint, energy use, water consumption, indoor air quality	Circular economy principles, eco-design strategies, social impact	Sustainable building performance, EU policy compliance
https://ecorglobal.com/circularity/	ECOR Circularity Platform	Circular material innovation	ECOR	Waste upcycling %, circularity index	Material innovation, waste repurposing	
https://planonsoftware.com/uk/news/building-circularity-index-bci-partner/	Building Circularity Index (BCI)	Circularity performance indicator	BCI Initiative	Circularity score, material reusability	Circular economy in buildings	
https://simapro.com/	Sima Pro	Life Cycle Assessment (LCA) software	PRé Sustainability	Carbon footprint, toxicity impact	Circular product design	
https://sphera.com/product-stewardship/life-cycle-assessment-software-and-data/?nab=0	Gabi LCA	Life Cycle Assessment (LCA) software	Sphera	Resource depletion, environmental impacts	Product sustainability strategies	
https://cerclos.com/products/etool/	eTool LCA	Whole-building LCA tool	eTool Global	Embodied energy, operational carbon	Carbon reduction strategies	
nepfi.org/wordpress/wp-content/uploads/2021/12/PRB-Guidance-Resource-Efficiency.pdf	PREP (Product Resource Efficiency Principles)	Circular economy guideline for product design	European Commission	Resource efficiency tracking, embodied energy, material recoverability	Sustainable design guidance, eco-design principles	Product longevity, material efficiency, end-of-life recovery
https://zwia.org/zwh/	Zero waste Hierarchy (ZWIA)	Zero-waste design and policy framework	Zero Waste International Alliance (ZWIA)	Waste diversion %, landfill reduction impact, material reuse potential	Waste prevention strategies, sustainable consumption	Waste hierarchy, landfill reduction, closed-loop material flow

FOCUS AREA	Application	PARAMETERS	MISSING PARAMETER	Phase of building
Real Estate and Infrastructure	Material Passports, Circularity Insights, Life Cycle Assessments	Embodied Carbon, Material Composition, Reusability	no real-time prediction model for reuse feasibility.	Design, Construction, End-of-Life
Buildings and Districts in Various Life Cycle Phases	New Construction, Renovations, Buildings in Use, Urban Districts	Carbon footprint, resource efficiency, indoor air quality, thermal comfort, economic viability, recyclability	do not actively influence procurement strategies for cities, governments, and developers.	Design, Construction, End-of-Life
Building construction	BREEAM, LEED, DGNB, and other green building certifications	Global Warming Potential (GWP)	track carbon & energy impacts but lack detailed insights on material adaptability & reuse potential.	Design, Construction, End-of-Life
Building energy modeling, HVAC efficiency, daylight analysis	Green building design, net-zero energy projects, LEED certification support	Solar gain, ventilation rates, building envelope efficiency, indoor air temperature	No direct circularity scoring for building materials.	Design, Operation
Product sustainability, material health, circular economy	Certified products (textiles, packaging, furniture), Apple's material innovation	Material toxicity, biodegradability, carbon footprint, closed-loop design potential	do not actively influence procurement strategies for cities, governments, and developers.	Material Selection, Construction, End-of-Life
Circular construction, modular building	Adaptive reuse projects, prefabricated buildings	Component reusability, ease of dismantling, structural longevity, carbon savings	no real-time prediction model for reuse feasibility.	Design, Construction, End-of-Life
Life cycle assessment, carbon emissions tracking	Eco-friendly product manufacturing, EU environmental impact assessments	Material efficiency, energy consumption, waste generation, transportation emissions	Lacks a clear material circularity indicator (focuses mostly on emissions). No real-time tracking of waste diversion or reuse potential.	Material Selection, Operation, End-of-Life
Climate impact prediction, extreme weather adaptation	Future-proofing cities, flood mitigation planning, sustainable urban development	Temperature rise, humidity levels, precipitation trends, sea-level rise risk	No material or waste tracking integration (purely focused on climate adaptation). Lacks direct connection with LCA tools to measure long-term material impact.	Design, Operation
Waste reduction, resource-sharing economy	University surplus materials, corporate asset reuse programs	Material tracking, cost savings, CO_2 reduction from reuse, resource circularity	do not quantify the embodied carbon or energy savings from reuse	Construction, End-of-Life
Life cycle impact of buildings and infrastructure	LCA for LEED projects, net-zero carbon developments, sustainable retrofits	Embodied carbon, transportation impact, operational energy, end-of-life impact	track carbon & energy impacts but lack detailed insights on material adaptability & reuse potential.	Material Selection, Construction, Operation
Circular economy, material repurposing	Manufacturing waste reuse, industrial material exchanges	Waste diversion rate, lifecycle savings, carbon emissions avoided, material lifespan	do not quantify the embodied carbon or energy savings from reuse	Construction, End-of-Life
Low-carbon building design, net-zero strategies	Carbon footprint analysis for infrastructure, green building projects	Material impact, operational energy use, decarbonization pathways, emission hotspots	no real-time prediction model for reuse feasibility.	Design, Construction, Operation
Sustainable building performance, EU policy compliance, whole-life impact assessment	Green public procurement, sustainable residential & commercial buildings	Life cycle carbon assessment, energy efficiency, resource efficiency, indoor comfort	No policy enforcement tool that tracks how much circularity is being implemented in a project compared to regulations.	Design, Construction, Operation, End-of-Life
Circular economy, material reuse	Packaging, interior panels, furniture	Recycled content, energy-efficient processing	do not quantify the embodied carbon or energy savings from reuse	Material Selection, End-of-Life
Building reuse, circular design	Renovations, adaptive reuse projects	Material lifespans, adaptability	No post-occupancy tracking of circular performance over time.	Design, Construction
LCA, environmental impact	Sustainable product development	Carbon emissions, material toxicity	No detailed tracking of material reusability & adaptability.	Material Selection, Construction
LCA, eco-design	Sustainable supply chain optimization	Water use, emissions impact	track **carbon & energy impacts** but lack **detailed insights on material adaptability & reuse potential**.	Material Selection, Manufacturing
Whole-building lifecycle sustainability	Net-zero buildings, carbon accounting	Operational energy, material impacts	track **carbon & energy impacts** but lack **detailed insights on material adaptability & reuse potential**.	Design, Construction, End-of-Life
Product longevity, material efficiency, end-of-life recovery	Industrial product manufacturing, sustainable procurement	Product lifespan, recyclability index, energy efficiency, **remanufacturing feasibility, modular component recovery, repairability score**	Lacks quantitative weightage for circularity in decision-making.	Material Selection, Manufacturing, End-of-Life
Waste hierarchy, landfill reduction, closed-loop material flow	City-wide zero-waste initiatives, circular economy businesses	Resource recovery, composting efficiency, landfill diversion rate, **toxicity elimination, extended producer responsibility (EPR), redesign for reuse**	No carbon footprint analysis linked to waste reduction.	Construction, Operation, End-of-Life