

CISAMS: Integrated Circularity and Sustainability Assessment of Manufacturing Systems



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Deliverable 1: Circularity indicators list and scoring mechanism

Greece 2.0

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Version	Date	Author(s)	Changes made
0.1	15/04/2024	Athanasios Rentizelas, Eleni Aretoulaki, Kostas Florios	Initial draft outline (WP1 early stage)
0.2	15/05/2024	Eleni Aretoulaki	Expanded literature review & initial longlist compiled
0.3	20/05/2024	Eleni Aretoulaki	Updated methodology, filtering steps, intermediate indicator list
0.4	15/6/2024	Eleni Aretoulaki, Kostas Florios, Efthymios Simos	Integration of ranking criteria, thresholding logic, and MCDA pre-selection
0.9	15/07/2024	Athanasios Rentizelas, Eleni Aretoulaki, Kostas Florios, Efthymios Simos	Pre-final internal review, figures updated, consistency checks
1.0	31/07/2024	Athanasios Rentizelas, Eleni Aretoulaki, Kostas Florios, Efthymios Simos	Final version for submission

1 EXECUTIVE SUMMARY

This deliverable presents the outcomes of the first work package (WP1) titled "Circularity Assessment", which aims to define a comprehensive shortlist of circularity indicators and develop a tailored scoring mechanism for evaluating the circularity of manufacturing systems.

The deliverable outlines the systematic approach undertaken to identify, assess and select the most relevant circularity indicators from an initial longlist derived from the academic literature. Through a rigorous evaluation process, indicators were shortlisted based on their relevance, applicability, and potential for real-world implementation in the manufacturing sector. The work started from a Scopus search that yielded 211 relevant papers on circularity, of which 59 were identified as directly focused on circularity indicators in manufacturing. From these, a longlist of 590 indicators was extracted (105 qualitative, 381 quantitative and 104 composite). Through a multi-stage refinement process based on explicit ranking criteria, this longlist was reduced to a final shortlist of 51 quantitative and composite indicators, organised into nine circularity categories that cover the full product and material lifecycle.

To enable quantitative assessment, a composite Circularity Index (CI) was developed. The weighting of the circularity categories was obtained through the Bayesian Best–Worst Method (BWM) using input from 16 experts (15 retained after consistency screening), resulting in balanced weights in the range 0.0888–0.1419. The ranking of alternatives was performed with the PROMETHEE II method, producing a single composite CI score for each option of a worked example based on the weighted indicators.

The shortlisted indicators and the Circularity Index constitute the circularity pillar of the integrated circularity-environmental-social sustainability framework that will be developed in WP4. They provide a scalable and consistent basis for evaluating circularity performance in manufacturing contexts.