CISAMS: Integrated Circularity and Sustainability Assessment of Manufacturing Systems

Deliverable 2: Environmental sustainability indicators list and scoring mechanism

Greece 2.0

Basic Research Financing Action

(Horizontal support of all Sciences)

Sub-action 1: Funding New Researchers

M5

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0.1	25/04/2024	Athanasios Rentizelas, Eleni Aretoulaki, Kostas Florios	Initial draft structure and outline of methodology section.
0.2	15/05/2024	Eleni Aretoulaki	Expanded desk research description; added preliminary indicator longlist and assessment criteria.
0.3	31/05/2024	Eleni Aretoulaki	Integrated full indicator longlist and initial filtering results; added figures and tables.
0.4	15/06/2024	Kostas Florios, Efthymios Simos	Added BBWM and PROMETHEE II methodological descriptions; inserted preliminary weighting outcomes.
0.5	30/06/2024	Athanasios Rentizelas, Eleni Aretoulaki, Kostas Florios	Technical review of methodology, refinement of indicator categories, and consolidation of selection process.
0.9	15/07/2024	Athanasios Rentizelas, Eleni Aretoulaki, Kostas Florios	Final edits to scoring mechanism, discussion, and implications for integrated CISAMS framework.
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 second work package (WP2), titled "Environmental Sustainability Assessment", which aims to define a comprehensive shortlist of environmental sustainability indicators and develop a tailored scoring mechanism for evaluating the environmental performance of manufacturing systems.

The deliverable outlines the systematic approach undertaken to identify, assess, and select the most relevant environmental sustainability indicators from an initial longlist derived from the academic literature. A structured Scopus search yielded 280 papers related to environmental sustainability, of which 40 were identified as directly focused on environmental sustainability indicators in manufacturing or industrial contexts. From these, a longlist of 414 indicators was extracted (38 qualitative, 286 quantitative, and 90 composite). Through a multi-stage refinement process based on explicit ranking criteria, this longlist was reduced to a final shortlist of 32 quantitative and composite indicators, organised into nine environmental sustainability categories that capture the main environmental dimensions relevant to manufacturing systems.

To enable quantitative assessment, a composite Environmental Sustainability Index (ESI) was developed. The weighting of the environmental categories was obtained through the Bayesian BWM, based on a panel of 16 experts, of which 14 consistent responses were retained for the final weighting, resulting in weights in the range 0.0672–0.1627. The ranking of alternatives of a case study example application was performed with the PROMETHEE II method, producing a single composite ESI score for each option based on the weighted indicators.

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