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Column

**Title**: Advancing Absolute Environmental Sustainability Assessment: Introducing the First Technical Guidance and a Call for Feedback

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In recent years Absolute Environmental Sustainability Assessment (AESA) has gained prominence within the industrial ecology community. AESA aims at determining whether an anthropogenic activity is environmentally sustainable by comparing its environmental burdens against carrying capacities that represent the maximum pressure the environment can sustain (Bjørn et al., 2020; Paulillo & Sanyé-Mengual, 2024); a well-known example of carrying capacities is represented by the Planetary Boundaries framework. The AESA approach goes beyond the "relative" perspective conventionally adopted in Life Cycle Assessment (LCA) whereby activities are compared against each other to identify which has the lowest environmental impact. A key limitation of the relative approach is that "greener activities" may not in fact be environmentally sustainable; this is because their environmental impacts, even if lower, might still transgress their share of the Earth's carrying capacities, especially in a context of increasing global production and consumption. In essence, whilst LCA is about comparing A against B, AESA compares A with the carrying capacities.

Although relatively new, AESA has gained rapid traction both in academic circles, evidenced by the growing number of publications (Bai et al., 2024), and beyond, with the Science-Based Targets initiative (SBTi) serving as a prominent example of its application in corporate climate target setting. However, this rapid uptake has occurred without a clear reference guidance, which has led to inconsistent terminology[1], methodological choices and assumptions[2] (Paulillo et al., 2025) and ultimately to results that are difficult to compare across studies. Moreover, the application of AESA at scales beyond the product level - the traditional focus of LCA - including at corporate (e.g. SBTi) and national (e.g. for policy monitoring) levels brings additional methodological challenges.

The growing interest in AESA highlights the need for an accessible, broadly applicable guidance to ensure that studies are methodologically consistent. In this column we introduce the first guidance for applying AESA to activities at different scales (Bjørn et al., 2025). The guidance covers the theoretical knowledge and practical tools necessary to conduct AESA across various domains and scales, whilst offering clear instructions on how to structure and carry out an AESA. The intended audience is broad, extending beyond academia to also cover consultancy, industry, government and civil society. To keep the guidance concise and focused on the specificities of AESA, it is expected that readers possess a basic understanding of industrial ecology methods like LCA and environmentally-extended input-output analysis (EE-IOA) and their underlying standards, to which the guidance makes extensive reference.

As shown in Figure 1, the guidance structures AESA around three main phases and nine steps (as well as eleven sub-steps, which are not included in the Figure for clarity) shepherding the practitioner from inception to completion of a study. Each step is illustrated in the guidance via three cross-cutting case studies: a product-level application covering 40 residential buildings in Denmark, a business-level assessment for a major Indian cement company, and a regional-level application linked to the total consumption of the European Union. The guidance is intended to be

[1] For example, AESA is also known as Planetary Boundaries-based Life Cycle Assessment (PB-LCA), Planetary accounting and Context-based sustainability assessment

[2] Including approaches to address mismatches between LCA impact indicators and carrying capacity indicators, handling of temporal and regional dimensions, and allocation of carrying capacities to individual activities -

informative, not normative: it provides key considerations for methodological choices whilst not prescribing any specific AESA method, dataset or principle to allocate carrying capacities. This approach supports high-level implementation of AESA whilst avoiding constraining future methodological developments. In the following paragraphs we provide a brief overview of the AESA phases and steps.

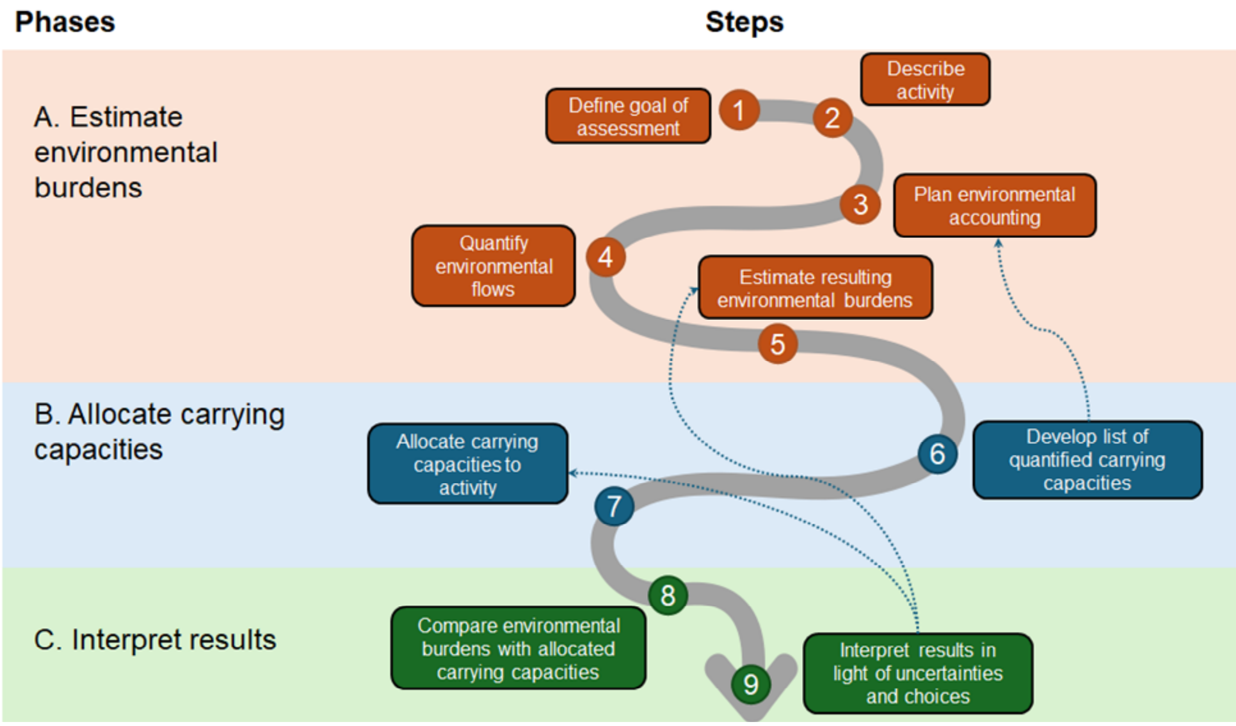


Figure 1: Step-by-step approach to AESA (adapted from Bjørn et al., 2025)

The first phase is familiar to industrial ecologists as it focuses on estimating the environmental burdens of an anthropogenic activity. This phase is primarily based on existing LCA standards (e.g. ISO 14040-44), whilst also allowing for environmental accounting approaches applicable to larger scales, such as corporate environmental footprinting and EE-IOA. The guidance deviates from conventional LCA practice in two areas. First, it requires an attributional accounting approach to ensure that burdens of individual activities are additive and thus comparable with global (or regional) carrying capacities. Second, it restricts the selection of environmental impact categories and indicators to those aligned with the carrying capacities (chosen in the second AESA phase); for example, LCA indicators for resource depletion are not covered by the Planetary Boundaries, which are focused on the stability of the Earth system (Paulillo & Sanyé-Mengual, 2024). Since LCA indicators and carrying capacity indicators are often different, harmonisation is required. Two main approaches exist to address this mismatch.  The first relies on traditional life-cycle impact assessment (LCIA) methods and converts carrying capacities into the indicator used by the chosen LCIA method (e.g. Global Warming Potential for Climate change). The second employs AESA-specific impact assessment models that express environmental burdens in terms of the chosen carrying capacity indicators (e.g. atmospheric $CO_2$ concentration as a Planetary Boundary for Climate change). These approaches generate the same results, provided that assumptions and modelling parameters are identical (a condition not satisfied by existing methods, as shown by Paulillo et al., 2025). The question of which approach, and therefore which categories and indicators, must be informed by the study´s goal and scope - e.g., which area(s) of protection is relevant? is the target audience more familiar with LCA or Planetary boundaries?

The second phase of AESA focuses on identifying and allocating carrying capacities to the studied activity. Allocation is necessary because the Earth's carrying capacities must be shared across numerous anthropogenic activities. The guidance provides a comprehensive, though by no means exhaustive, set of allocation principles and the contexts in which they apply. AESA results are often sensitive to the chosen allocation principle (though in practice environmental burdens frequently exceed carrying capacities regardless of the choice). To address this, the guidance recommends applying at least two principles as a sensitivity check to assess the robustness of the results and conclusions. The selected allocation principles dictate the type of data to be gathered and the equations to be implemented.

The third and final phase of AESA entails comparing quantified environmental burdens with allocated carrying capacities and interpreting the results. This comparison is most commonly performed by calculating the ratio of burdens to allocated carrying capacities for each impact category. Ratios greater than one indicate that the studied activity exceeds its allocated share. The purpose of the interpretation is to determine whether the activity can be considered environmentally sustainable, and if not - as it is often the case – to quantify the extent to which environmental burdens must be reduced.  Importantly, the interpretation follows a strong sustainability perspective, whereby the exceedance of a single boundary is sufficient to classify a system as environmentally unsustainable. In other words, good performance in one impact category cannot compensate for bad performance in another.

At the time of writing, the guidance has been published as a beta version to allow testing and feedback from potential users. Feedback from the industrial ecology community will be crucial to making the guidance as useful as possible for both current and future AESA users. To this end, we invite all interested parties to submit feedback via an online form (https://www.survey-xact.dk/LinkCollector?key=Q8NNSDMMU695) by October 31st, 2025. This feedback will shape the final version, scheduled for release in early 2026.

This guidance marks an important step towards formalizing AESA as a practical decision-support tool. However, further harmonization is required for AESA to reach the level of maturity and standardization seen in LCA. For instance, firm recommendations are needed on how to best link life cycle inventory data to carrying capacities as well as standardized equations and data sources for each allocation principle. At the same time, caution is warranted as the science behind AESA is still rapidly evolving. For example, regionalised impact assessment models and carrying capacities have not yet been developed for all impact categories, and there is little agreement amongst researchers on how best to aggregate regionalized AESA results and communicate them to decision-makers. Overly prescriptive or premature standardization efforts could stifle such scientific innovation. Harmonization efforts should therefore provide a flexible framework that supports, rather than constrains, future AESA developments.

Overall, AESA holds significant potential for real-world applications in support of policy and decision-making. We envision AESA becoming a key component of the industrial ecology toolbox, complementing existing methods. The guidance document was developed to offer a structured, accessible, and practical framework that enables broader application of AESA, while safeguarding scientific rigour, methodological consistency and result comparability. We warmly invite the industrial ecology community to engage with the guidance - your feedback will be essential to shaping its future evolution.

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