

A Multilevel Method to Manage the Complexity of the Sustainable Construction Works



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Summary

The nature of the sustainable **approach** is complex, because of the large number of components involved and relationships between disciplines, objects, phases of the **life cycle**, aspects and variables of any actual project or construction works process.

Complexity is one of the major features of the conceptual model on which the new European standard family of **CEN TC 350**, still in progress, is based. The approach for managing the complexity in construction works suggested by the standard family is **multidisciplinary**.

The future developments of the standards are expected to go more and more into the direction of the **integration** of the three major components: environmental, social, economic and their related aspects, impacts and performances, as actually declared: "In the future, the assessment methodologies within this standard framework may be part of an **overall assessment of integrated building performance**. The assessment methodologies may also be extended to an assessment of the neighbourhoods and wider built environment".

And yet, in the definitions, sustainability assessment of buildings is described as a "combination of the assessments of environmental performance, social performance and economic performance taking into account the technical requirements and functional requirements of a building or an assembled system (part of works), expressed at the building level".

The identification of a multi-scale **and multilevel strategy**, aimed at supporting the **decision-making process**, applied to the "Leonardo da Vinci Sustainable Campus" project in Milan, with respect to the energy, environmental, social and economic performances, is focused on **key objectives / criteria / indicators**.

The **holistic approach** and the involvement of the stakeholders in the method, supported by multiple criteria decision making (MCDM) models and methods, aims at giving transparent and shared answer to the search of the best technical solutions and strategies in a large sustainable perspective.

Keywords: Sustainable construction works, Integrated approach, CEN TC 350, Holistic, Multilevel, Multi-scale, Life cycle, Evaluation systems, Assessment tools

Introduction

The purpose of the research, whose title is "Sustainable management of construction works from the building to the context" is offering a contribution to the definition of methods and guidelines for the management of sustainability in constructions [1] [2], to support decisions by the actors of the construction process involved in the decision making stages (i.e. public and private managers, designers, developers, policy makers).

The case study is the "Città Studi Sustainable Campus" project (www.campus-sostenibile.polimi.it, Fig. 1), a multi- and inter-disciplinary intervention aiming improving the quality of campus life formed by Politecnico di Milano, Università degli Studi di Milano, including the up-grading [3] [4] of the building estate of Politecnico di Milano and the transforming of the university [5] district into a model part of the city in terms of quality of life and environmental sustainability [6] [7]. The building so-called "Nave" is in particular the case study selected for the application at the building scale. The project "Città Studi Sustainable Campus" is member of the ISCN (International Sustainable Campus Network www.international-sustainable-campus-network.org) and inserted in the European Peripheria framework (<http://peripheria.eu>).

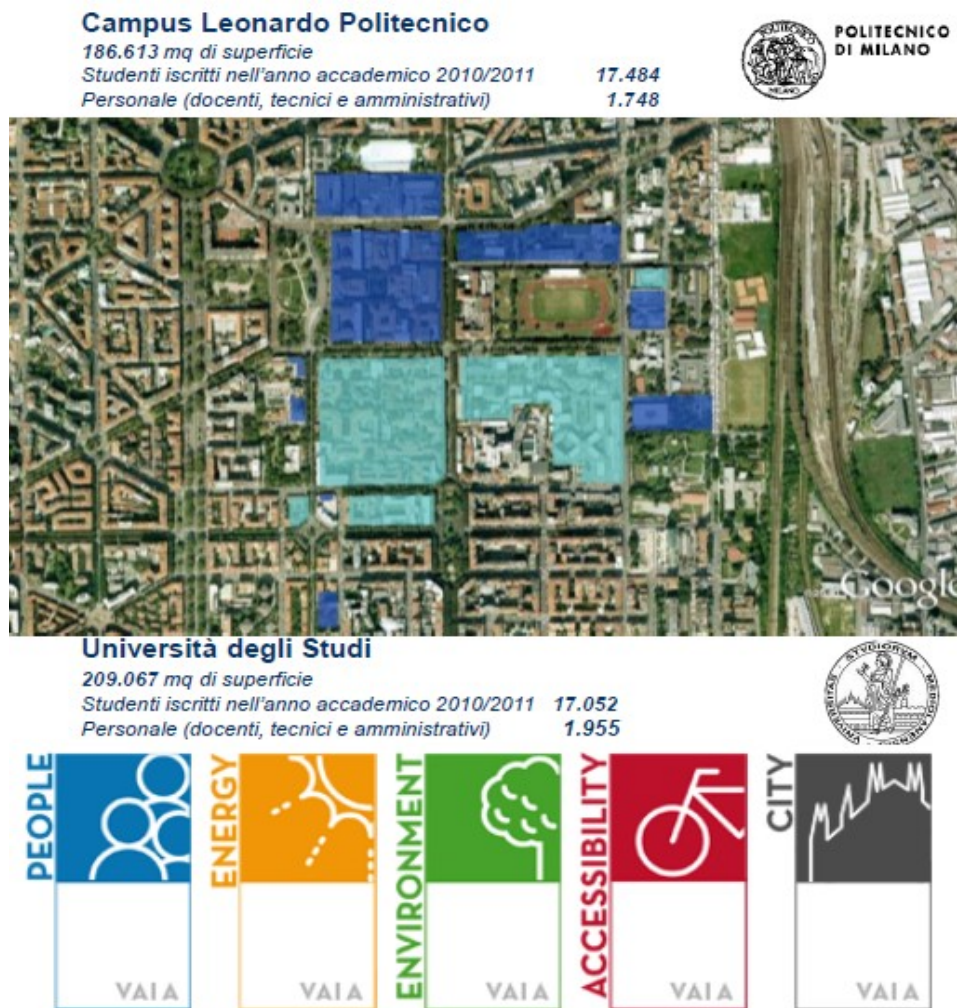


Fig. 1 Città Studi Sustainable Campus

Methodology

Initial Analysis

An analysis of the state of the art shows that for the assessment of sustainability of the life cycle [8] in constructions:

- The most commonly used tools [9] available today, such as development of the classical Multi-criteria Method, are national protocols related to their respective trade marks (of which the best known are Leed, Breeam, DGNB, CASBEE, Minergie, Itaca), using indicators (so called "of first-generation") and methodologies [10], generally inconsistent one with each other.

- At European level, there is an ongoing process of **harmonization by the CEN TC 350** [11] [12], in order to reduce the indicators to a shared set ("core") indicators (so called "of second generation"), identifying a common general approach (life cycle oriented), giving an innovative and strategic direction of approach.
- It is still under development the identification of sets of shared indicators, since some have been identified but there are others validated by research and which could be integrated in the next future.
- It is expected that, in the coming years, the **core indicators** and a common approach will provide inputs for the further development of the national protocols, which will receive them for alignment with the European standards.

The strategic guidelines declared in European standards aim substantially to:

- Manage the decision-making [13] processes aimed at optimizing sustainability [14] throughout **Aspects / Impacts / Performances** [15], described by **Indicators** [16]
- Move from a mono / multi-disciplinary approach as the current one, in which for each alternative are identified aspects / impacts / performances referred to environmental / social / economic [17] [18] areas, to an inter / trans - disciplinary approach in which the identification of relationships between the variables in the three above areas helps to predict cause-effect processes associated to design alternatives, expected to be aided by tools and methods "**multi-level**" or "**multi-layer**" in a so-called "**integrated**" **perspective** [19].
- Expand, in the assessment, the **boundaries of the system** in which we study the performances of the design options, that is, as already experienced in the field of LCA [20], beyond the building. The new approach "**multi-scale**" suggests, therefore, to examine the impacts of each project, in a larger scale, i.e. **territorial**. Still now, in the common decision-making processes the relapses / effects / impacts in wider scales are not considered, or even the decision makers do not have sufficient awareness of the boundaries of systems on which they are working.

In the area of international research, experiments of these strategies on real cases are still in the early, yet little explored. In particular, in the Italian context, a gap appears, between the use of sustainability assessment tools applied to the building and the existing territorial quality ranking systems, as the most known Ecosistema urbano, Legambiente-Sole 24 ore, EcoSistema Metropolitano Milano [21], moreover not directly considering the contribution of the buildings on the urban sustainable performances [22] [23] [24].

The present research aims at contributing to fill this gap.

In particular, applying them to the case study, the research attempts to understand:

- If the European core-indicators are sufficient.
- If the specific conditions that allow all three strategies approach indicated by CEN TC 350 (use of the new European harmonized indicators, **interdisciplinarity** and **integration**, multiscale approach) and above mentioned.
- How can they be implemented.
- Benefits of implementation.
- Implementation limits.
- Conditions of transferability of this approach to other situations and contexts.

Development Stages

Starting from the core indicators identified in the EN 15643-1-2-3-4 standards and in the related 7 Framework Program projects (Open-House, SuPerBuildings), a first panel of 43 indicators has been set (Fig. 2), grouped in environmental [25], social and economic [26] [27] indicators.

A deeper analysis shows that **many interrelations** exist between the three sets and this actually suggests an **integrated approach**, as by CEN TC 350 recommended.

Thanks to a further recognition in literature reporting the results of researches validating additional indicators, **an additional list of 12 indicators** [28] [29] [30] [31] has been selected (Fig. 2, 3).

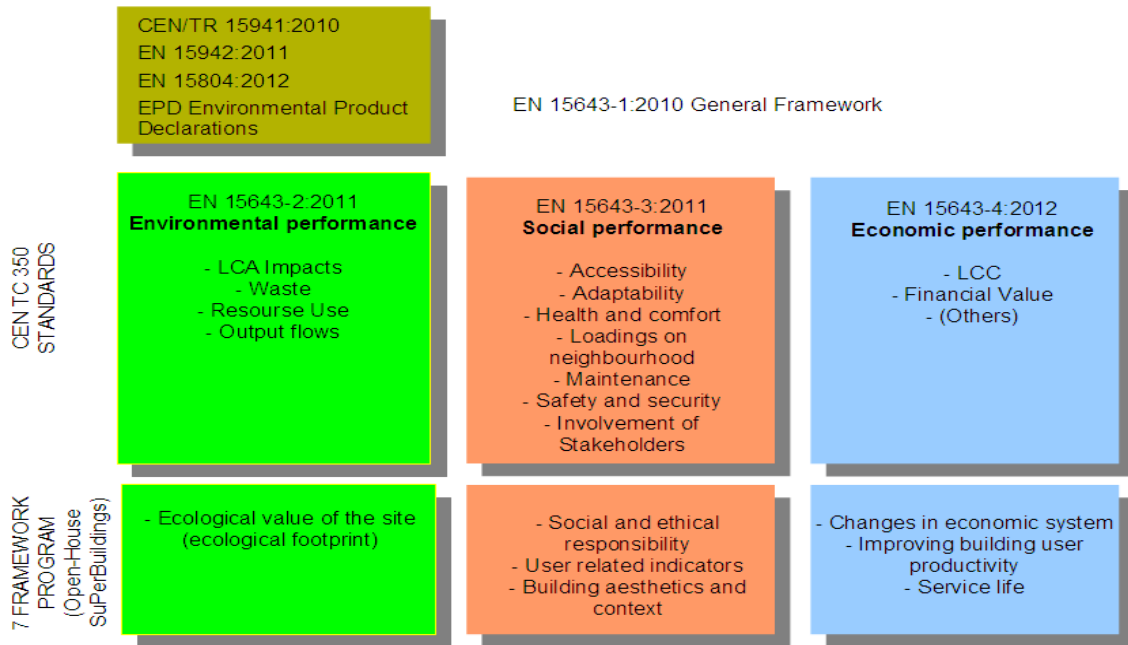
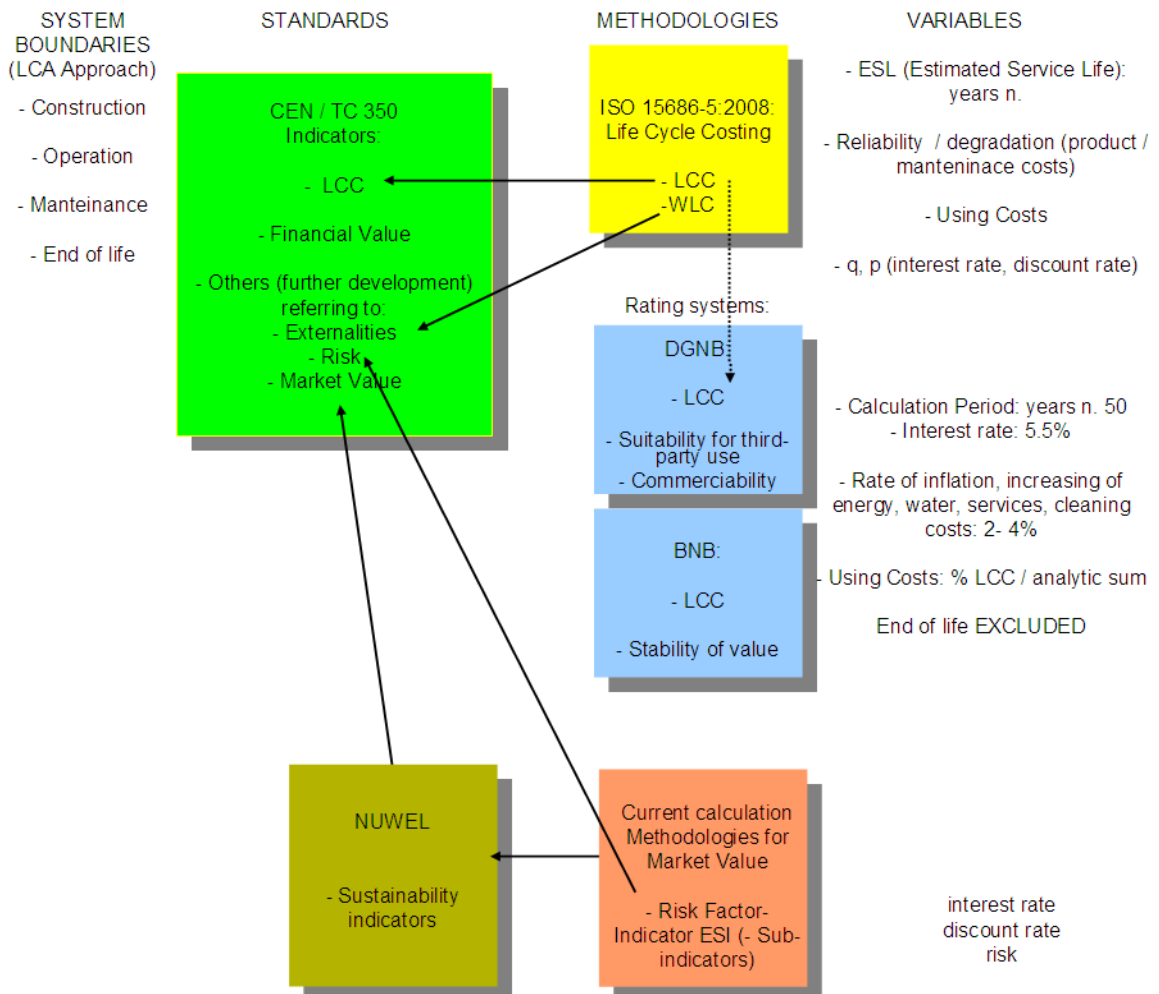


Fig. 2 CEN TC 350 “Sustainability of construction works” Family Standards: Overview of the sets of indicators. Fig. 3 Overview of the Economic indicators.



The second main step has aimed at identifying the boundaries of the territorial systems affected by hypothetical construction works on the building case study.

A **conceptual model** reporting the levels of the building, the campus, the city [32], the metropolitan area and the national-European framework has been built to study the territorial contextualization of the European indicators, describing aspects / impacts / performances (Fig. 3, 4).

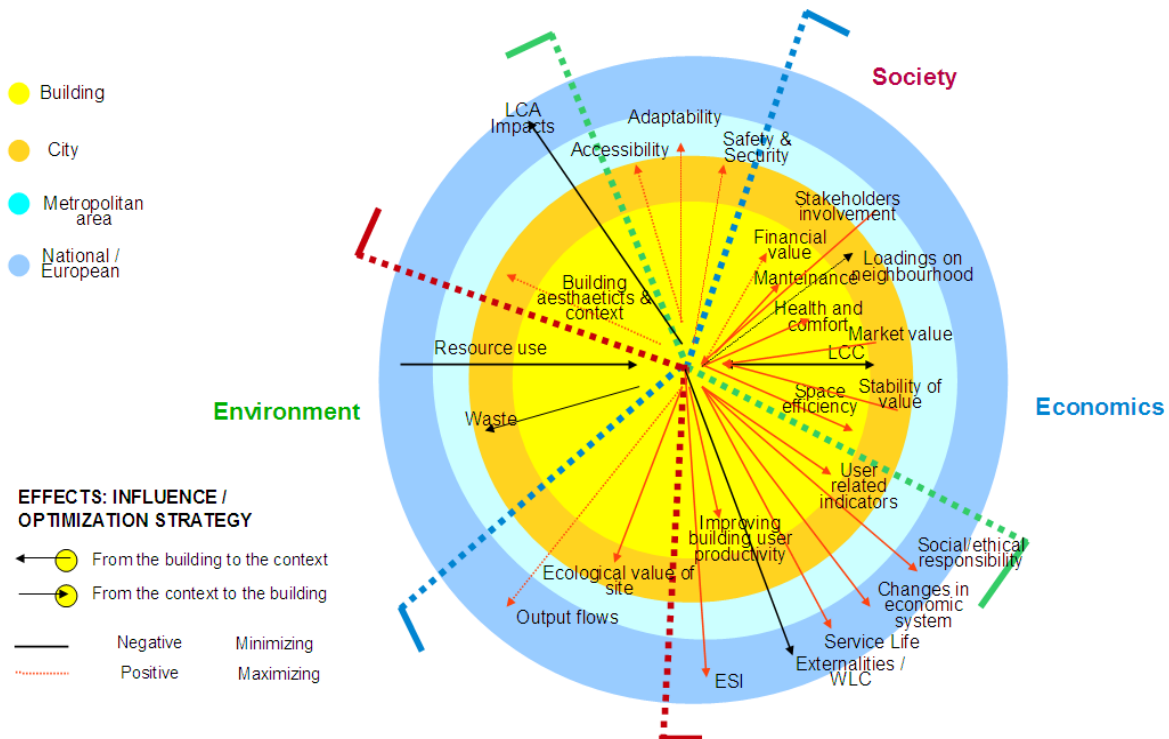
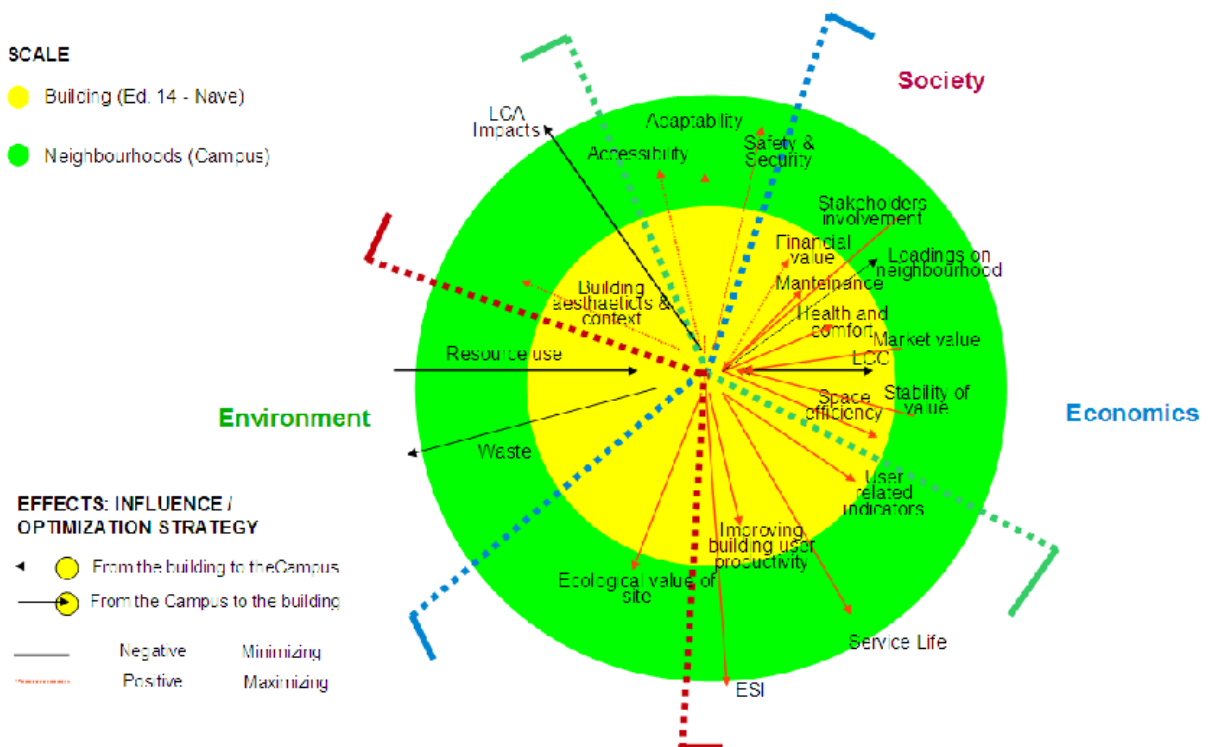


Fig. 3 Multi-Scale effects of construction works from building to the wider context described by the European Indicators. Fig. 4 Multi-Scale effects of construction works from building to the neighbourhoods (Campus) described by the European Indicators.



The following step has concerned to the identification of **existing evaluation systems at different scales** applied to the Milan area and the search of **interrelations** between the respective domains of indicators.

The comparison between the panels of indicators (the European one and and 3 territorial) has shown such similarities and congruences.

The set up harmonization tables will support the Politecnico di Milano management staff to plan future strategies [33] [34] creating **synergies** between interventions and policies implemented at different scales.

Moreover, some more applications of the so set up method have been done. In particular:

- The **association** of aspects / impacts / performances described by the building indicators related to a set of 40 design options and combinations thereof (including replacement of windows, insulation, heating [35] and air conditioning renovation, lighting installation) with the territorial scales involved, in order to introduce sustainability targets, referred to the territorial scales, in a multi-criteria analysis decision-making supporting.
- The **harmonization** of the different scales indicators sets with the guide set of ISCN with the European harmonized indicators. From this analysis it appears that the first sets are more accurate and the correlation of indicators belonging to the parallel panels of related systems at different scales can be strategic to achieve the performance of continuous improvement both at the level of campus and urban [36] which are the principles of the ISCN assessment and reporting.
- The **identification** of 10 sets of variables involved in decision-making, complex [37] in nature, aimed at building interventions in the context of the case study "Città Studi Sustainable Campus" and the possible relations, with particular reference to the areas of responsibility (environmental / social / economic [38]). A navigation matrix highlights the crucial nodes, characteristics and sensitivity of the decision-making processes and the areas most commonly affected, resulting a pretential management supporting tool for further decisions.

Results and Discussion

The results of the activities carried on evaluation systems and indicators [38] [39] applied to the case study show essentially that:

- The harmonized European panel of **43 core indicators** could be completed with **12 indicators** validated at European level but not yet shared to describe the impacts / performances of the building.
- **Interrelations** exist between the indicators belonging to different fields (environment / society / economy) [40].
- There is a relationship between the panel of European indicators of the **building** and the **territory**, namely relations with different scales (building, campus-area), due to the relapse of effects (impacts) produced by building operations and consequently affecting the territorial performances from a sustainable point of view.
- The study of the relationship between the building and the territorial scales **enlarges** the perspective of observation and evaluation of construction works in a sustainable key.
- In Italy and in the Milan area are available systems of sustainable territorial performance evaluation (ranking, reporting) interacting with the CEN TC 350 indicators system referred to the building.
- At this point you can select the **strategic key indicators** on which to **calibrate** building interventions that facilitate **synergies** to **improve** the sustainability of the **major scales**.

Conclusions and Acknowledgements

As one can easily see, the above suggested approach / method has potentially many possible applications and implementations.

These considerations could be, actually, usefully enhanced and integrated into the framework of an analysis / evaluation of sustainability aimed at a choice amongst alternatives, since this means that by acting on some **key performances** it can be more effectively to achieve improvements also on others (e.g. energy saving – LCC reducing) [26] [41], but also can improve the regional [42] [43] sustainability.

Making use of the MCDM techniques this result can be translated into logical and mathematical relationships between variables, defining hierarchies and constructing weight matrices of the indicators, according to a goal that **exceeds** the sustainability [44] [45] of each building / project alternative in an "absolute" or taken out of context way, but compare that to the **sustainability targets** of the territory in which the building is located.

Based on the above observations, the next steps of development of the research will include the selection of a restricted set of indicators TC 350 – "EcoSistema Metropolitano Milano" and analyse the interrelations between counterparts and/or interconnected indicators. After the identification of reference values, the development of methods of assessment of the indicators will aim to obtain, as a downstream of a MCDM analysis on a limited number of design options, the result corresponding to the "**most territorially sustainable solution**".

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