# COMPLEXITY THEORY AS AN EPISTEMOLOGICAL APPROACH TO SUSTAINABILITY ASSESSMENT METHODS DEFINITION

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## Abstract

It is since the last thirty years that the world community has formally recognized the necessity of approaching the changes occurring to the social environmental and economic structure of society. Yet, the fact itself that sustainability has to represent a crucial shift for the architectural and urban design practice is still object of a debate characterized by contrasting positions. Despite since 1992, when UN released the Agenda 21 and called for 'better measurement tool' to assess the sustainable practice, the definition of an assessment method able to gauge the complexity of the changes that are occurring in our societies and to suggest management strategies is as well a subject of an open discussion and work by both the academic and the industrial world. This paper proposes the application of the complexity theory as an epistemological approach to overcome limits in the current sustainable assessment methods, and proposes a system to gauge and to value the complexity of sustainable architectural and urban projects and development processes.

**Keywords**: Sustainability, Architecture and urban design, Design management, Complexity

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# 1 INTRODUCTION

It is since the 1987, with the publication of the Brundtland Report that the world community has formally recognized the necessity of approaching the changes occurring to the social environmental and economic structure of our society. Since then, many efforts have been done to implement strategies to apply sustainable principles to many fields. In this context, the field of architecture and urban design has faced a paradigmatic shift in many instances, from the proposal of new design strategies, to the definition of many systems to manage the emerging social, environmental and economic challenges. Yet, the fact itself that sustainability has to represent a crucial shift for the architectural and urban design practice is still object of an open debate, characterized by contrasting positions (Hosey, 2012). Despite since 1992, when UN released the Agenda 21 and called for 'better measurement tool' to assess the sustainable practice, the definition of an assessment method able to gauge the complexity of the changes that are occurring in our societies seems not to be fully achieved yet. The definition of such methods is still the focus of an open discussion and work by both the academic and the industrial world (Caradonna, 2014), as a reflection to the general controversial approach that seems to exists on sustainability in architecture and urban design. The aim of this work is to explore a possible epistemological approach to understand the complexity of the current state of practice of sustainability in architecture and urban design.

# 2 COMPLEXITY THEORY AS AN EPISTEMOLOGICAL APPROACH TO SUSTAINABILITY ASSESSMENT METHODS DEFINITION

Caradonna (2014) identifies at least twenty-two assessment methods that have been developed and applied since the Un released the Agenda 21 in 1992, such as the Ecological Footprint Analysis (EFA), Carbon Footprint, Life Cycle Analysis, Index of Social Health, Leadership in Energy and Environmental Design (LEED Certification), Triple Bottom Line (TBL), and many others. Despite the recognized effectiveness of these methods, one of the limits is that they tend to focus on only part or one characteristic or dynamic of the system, rather than trying to gauge the interconnections between the overall projects characteristics. Many systems focus on the environmental characteristics of building and urban projects, whereas others concentrate on social and/or economic aspects. Yet, rarely these systems are able to gauge the reciprocal influence that each of these areas of analysis may establish onto each other. This paper proposes an epistemological approach that consider the development of sustainable building projects - as well as the projects themselves - as a complex system and therefore to define an assessment method that can gauge its complexity in order to understand and respect differences, to enhance relations and interconnections, and therefore to highlight development opportunities. It largely recognized that buildings are unique, complex, fix, bulky, costly, lasting products, related to their site characteristics - i.e. climate, materials, people and availability of technical skills (Turin, 1981). Many of these characteristics correspond to the aspects that characterize the complex system as defined in the complexity theory (Simon, 1962). According to Gandolfi (2008), a complex system is characterized by: high number of constituting elements, interaction between elements, delayed effects, existence of feedback, open system, network based systems, multi scalar nature, dynamic, robustness, innovative, unpredictable in its feedback loops, responsive to external and internal input, hierarchy organized, partial autonomy of its constituting elements, and existence of internal paradoxes. On the basis of these similarities between the traditional characterization of building and the one of the complex systems, this paper is aimed at exploring the management of sustainable buildings and urban projects development, through approaching their assessment as one would approach a complex system. The rationale behind this approach relies on the multi-folding nature and importance of the concept of sustainability, and therefore to the multiple effects and areas that such concept can relate to, by embracing disciplines such economy, environmental, engineering and social sciences. By considering the simultaneous effects that all these disciplines can produce on building and urban projects developments, this work attempts to suggest a methodological approach that could at the same time: explore all the opportunities that projects development process offers to foster sustainability; and understand the nature of the simultaneous effects that sustainability could generate, trying to highlight the importance of the complexity of making sustainable decisions within a context of a changing world.

## 3 THE METHODOLOGICAL APPROACH

The methodology adopted to test complexity of sustainable project as epistemological approach is to define an analytical system able to respect differences and to enhance opportunities that characterise sustainable projects. This is achieved by respecting their complexity, rather than focusing on specific disciplinary outcomes. To do so, an analytical method is defined on the basis of the simultaneous and mutual relation between principles of economic, social and environmental sustainability in both building and urban projects. These relations are explored both for constituting projects elements, and dynamics of development processes, trying to understand the relation between design decisions and characteristics, and sustainable effects produced. This method is then applied to both buildings and urban projects in order to test its effectiveness, as well as to attempt producing a visualization of the complexity that lies behind the development of these projects. This methodological approach is aimed at proposing a possible method to assess, visualize and highlight the importance of complexity within the context of sustainable building and urban projects development. This understanding can be critical both in practice and in the academic context, to fully understand the potential of the design process and the responsibilities and opportunities that lie behind the development of projects.

## 4 A POSSIBLE METHOD TO RESPECT DIFFERENCES AND TO ENHANCE OPPORTUNITIES

Many authors (Edmonds, 1999; Bertuglia e Staricco, 2000; Dioguardi, 2000) attempted to measure complexity, but it seems that the most effective manner to gauge its nature is to consider its elements and its connections and 'treat' them as such, trying to understand their relations and cause-effect behaviour. An analytical method is here proposed to tease out and understand the sustainable development opportunities, results, and responsibilities in the development of building and urban projects. To do so, this assessment method is aimed at trying to gauge both the characteristics of the constituting elements of the complex system as well as detecting their interconnections, rather than measure the single constituting elements within their own specificity. Such method could be used both to assess holistically existing projects, and to understand the nature of the design decisions adopted; as well as to map possible final effects of design decisions already in the early phase of the preliminary design process or meta-design.

The proposed method firstly, describes the constituting elements of the complex system (both process and product), and secondly, through assessing their impacts, responsibilities and results in terms of sustainability, teases out and shed light on their interconnections, in such way to identify cause-effect behaviours of the complex system. Specifically, the first step unfolds the project development process by relying on project management principles and areas of analysis (financing, commissioning, program, shape and space, specifications, worksite and construction organization, testing, drawing system, project control, drawing approval system, work coordination, contractual relations, and maintenance), as well as describes building products in its components as suggested by the EU building directive 2010/31/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL OF 19 May 2010 (dimensions, shape, floor number, access and circulation, structure, environmental control systems, water treatment). The second step is to measure the social, environmental and economic impacts and results of each of the descriptive characteristics highlighted in the first step, by ad-hoc parameters based on the UN principles on the sustainable development of each of these disciplines. This step is conducted by assessing the ex-built effects that design decisions generated, on the projects analysed. Examples of these types of effects, as highlighted in Table 1, are for instance: mixitè, social inclusion, wealth, education, safety for the social discipline; market expansion, competitive advantage, comparative advantage, knowledge acquisition, property/land value increase for the economic discipline; and emission reduction, resource generation, waste reduction, environmental sustainable strategy introduction, technological performance increase for the environmental discipline. These areas of analysis are explored by assessing on a scale from one to five the intensity of their impacts and their results. The impact is analysed by relying on the parameters suggested by Henderson and Clark (1990) on in their theory about innovation, which help understand the type of change - called impact in this instance - in which design solution are assessed on a scale of degree of change from the standard practice (irrelevant change), to total novelty (radical change). Moreover, for each of the design solutions adopted on the project and their processes, this

assessment method is aimed at detecting the responsibilities of each decision along the development process, to identify who are the actors in the best position to foster change and sustainable innovation.

*Table 1. The table below shows the assessment parameters utilised in the proposed assessment method*

| EFFECTS | TYPE OF CHANGE | SCALE OF EFFECTS | TYPE OF EFFECTS |
|---|---|---|---|
| Social Effects | Irrelevant, Modular, Incremental, Architectural, Radical | 1 to 5 | Mixitè, social inclusion, health, wealth, education, safety, et cetera |
| Economic Effects | Irrelevant, Modular, Incremental, Architectural, Radical | 1 to 5 | Market expansion, competitive advantage, comparative advantage, knowledge acquisition (patents), property/ land value increase |
| Environmental Effects | Irrelevant, Modular, Incremental, Architectural, Radical | 1 to 5 | Emission reduction, resources generation, waste reduction, sustainability strategy introduction, technological performance increase |

## 5 A POSSIBLE METHOD TO VISUALIZE COMPLEXITY

The application of the method proposed relies on a working framework organized on an excel spreadsheet and can be applied both to building projects and/or urban design projects. As showed in Figure 3, the working frame is organized with placing the areas of analysis in the first column (both in the case of building as product, and in its development process), and in the remaining columns all the analytical parameters to conduct the project assessment. The first step of this method application is to describe the project and process characteristics descriptions and then, as a second step to establish: degree of impact, responsibilities allocation of each choice analysed, and environmental, social and economic results achieved, in relation to the concepts explained in the previous sections as analytical parameters. The examples presented in the following images are the application of the assessment method to two projects of different scale and nature: a large residential building project called *'25 verde*' developed in Turin between 2007 and 2012, Italy; and a smaller intervention of tactical urbanism called *'MiraOrti'* in Turin, Italy started in 2010. These two projects were analysed to test the method and see how this method could teas out different aspects and project characteristics that were able to highlight cause-effect relations between design and organizational decisions and results achieved, as well as highlighting further sustainable development opportunities.

*Figure 1. The image show the project 25 verde completed in 2012 in Turin (Photo Source: http://www.lucianopia.it/)*

*Figure 2. The images shows actions and organization of common vegetable gardens by the group Miraorti in Turin, which is active since 2010 (Photo source: http://miraorti.com/)*

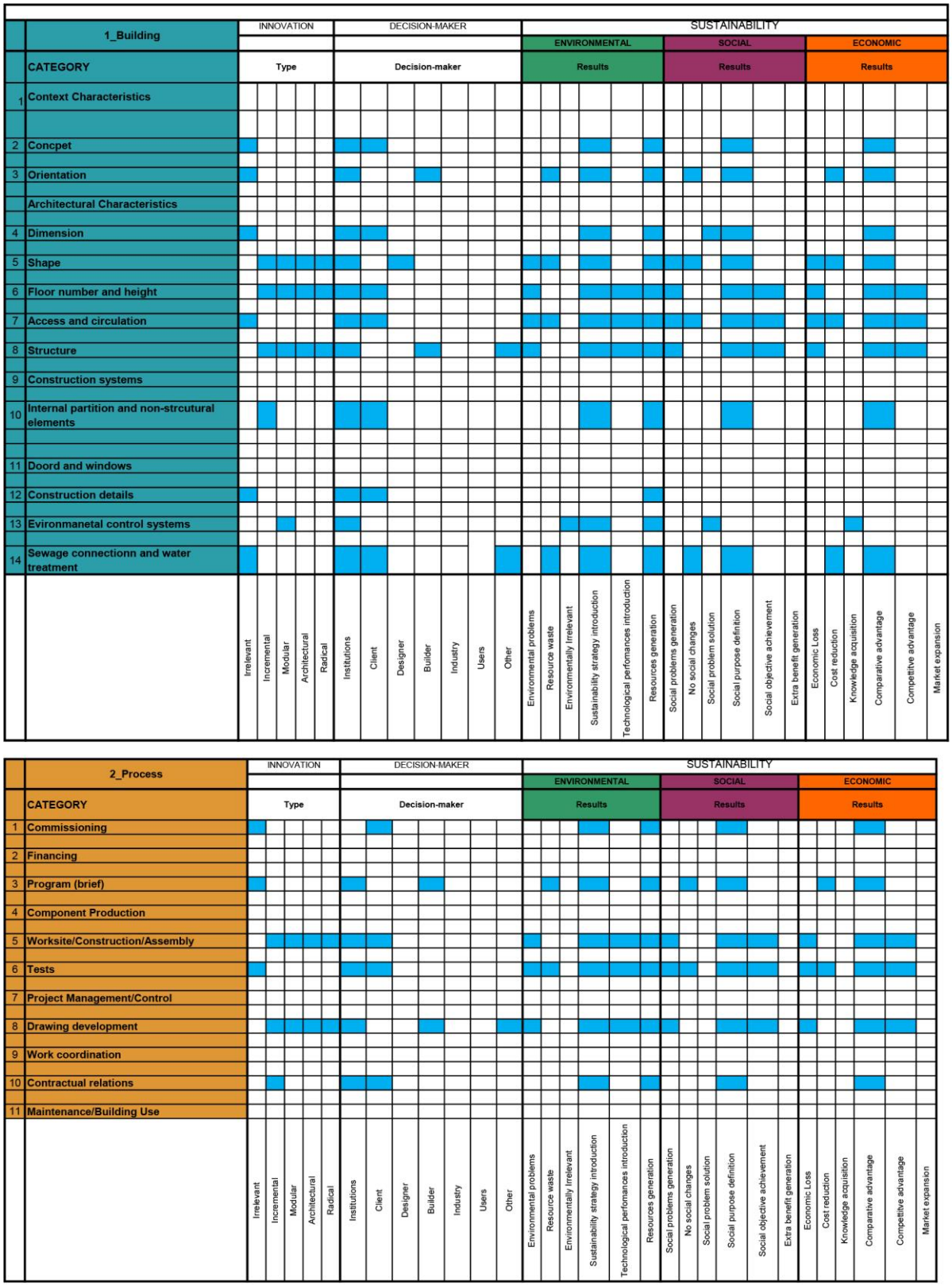


*Figure 3. Example of the working frame utilised for the assessment, both for projects and development process*

The output of the analysis is composed by two graphic sets of data representation: the first one (as showed in Figure 4) allows the comparison between impact of environmental, social and economic design decisions and results achieved. This comparison shows as well the relation between components and development process and impact and results achieve in each of these areas. In the image below, for example, different strategies have been developed and the relation with the results achieved varied along

the development process, in relation to social, environmental and economic characteristics differently. For instance, the project *'25 verde'* seems to be characterised by a greater impact in the economic area and its results, whereas the social impact and results seem to be more relevant in the *'miraorti*' project.

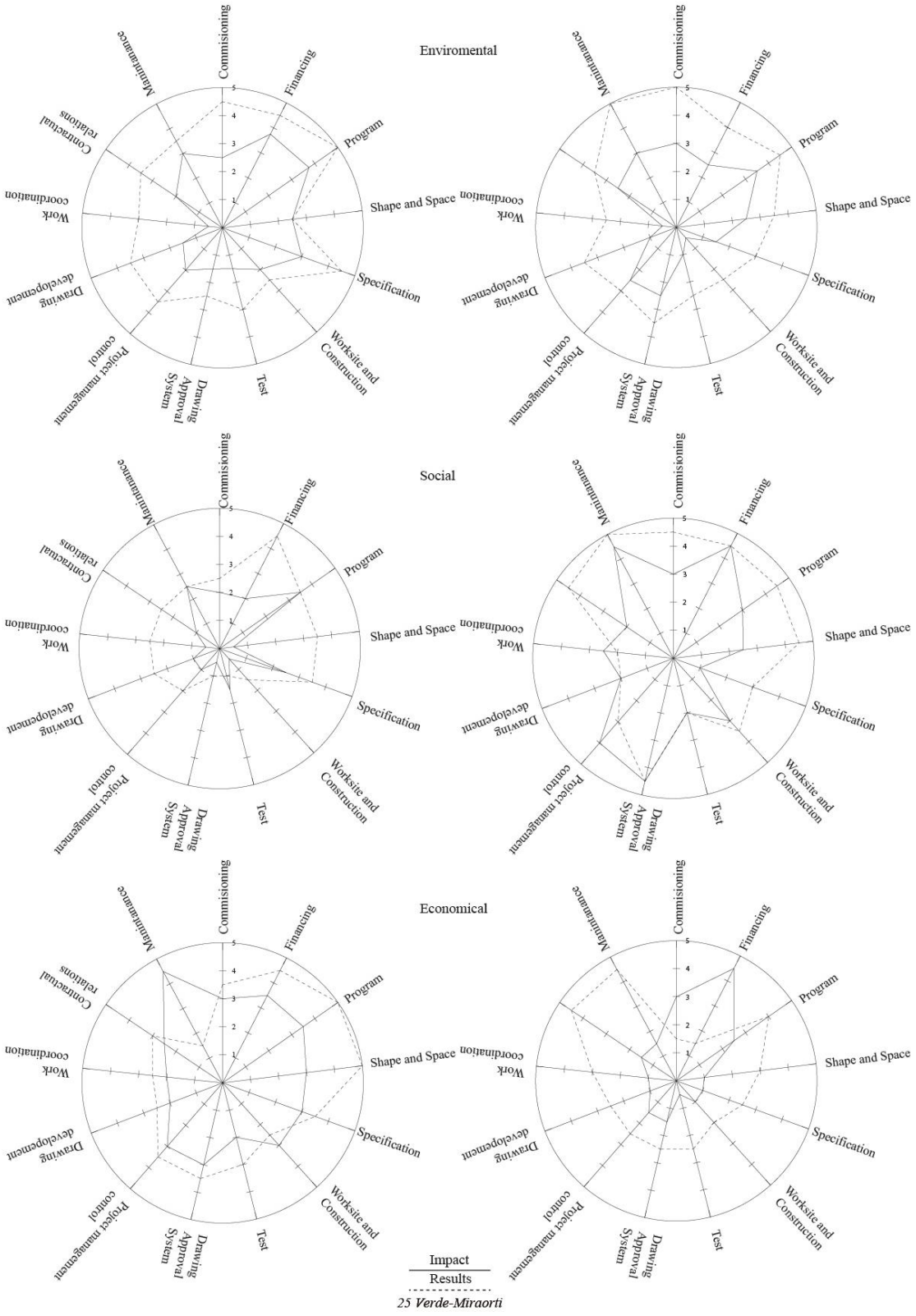


*Figure 4. Example of the application of the assessment method proposed to two sustainable projects of different scale and nature*

The second set of graphic data (as showed in Figure 5) allow the understanding of the role and responsibilities of all the actors involved in the building process. The image below shows for example a different involvement on the two projects of different actors. In the case of the project *'25 verde'* the designer and builder involvement is greater than the one in the project of '*Miraorti*', in which the presence of the users and the institution seems to be more significant.

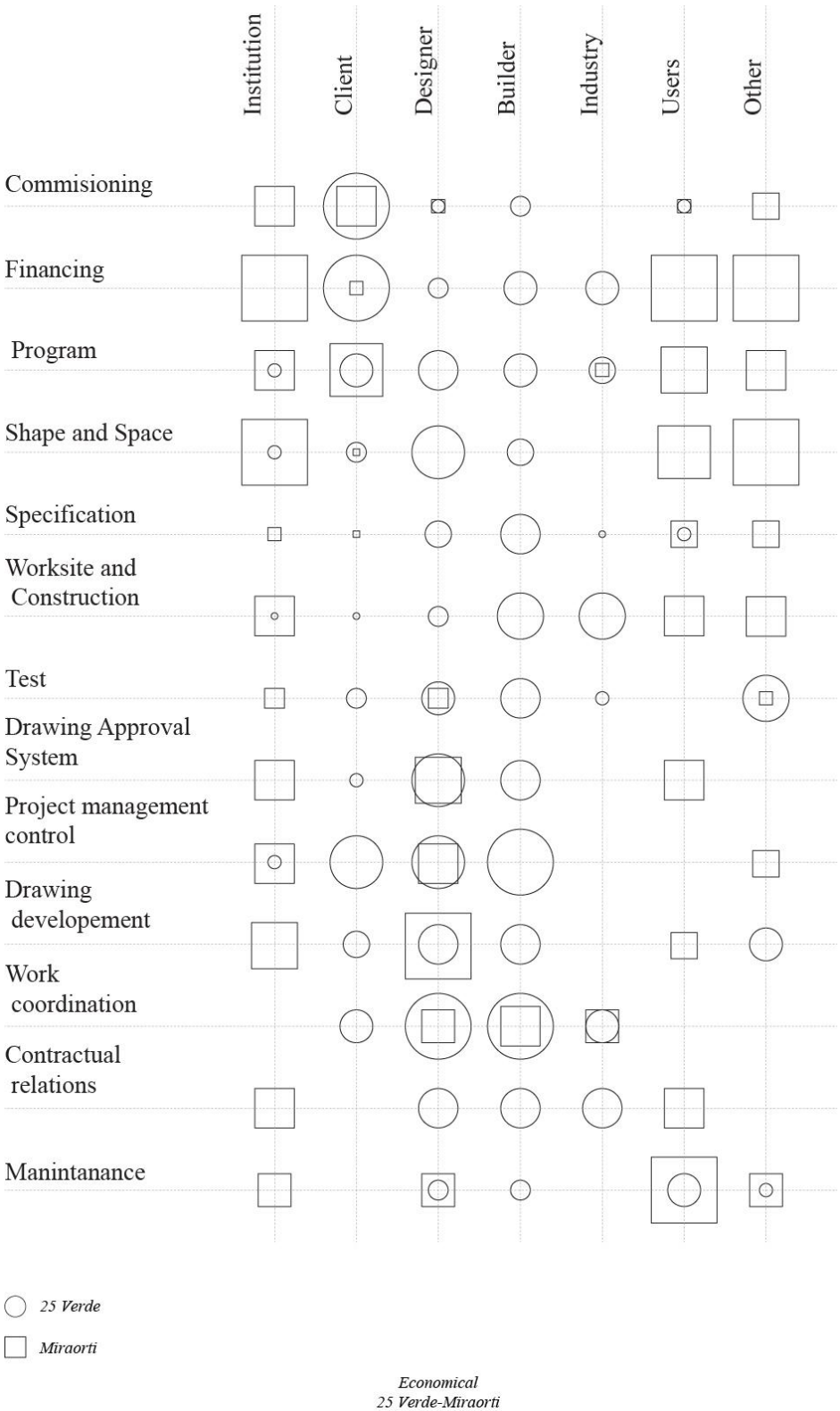


*Figure 5. Example of the assessment method in which the comparison of the actors involvement in the project development is highlighted*

## 6 DISCUSSION

The examples of method application showed that there is a close relation between process, design decisions, and role and responsibilities. Specifically, the analytical method proposed a support to understand the relation between the type of impact of a design or organizational decision and the results achieved, as well as simultaneously identifying roles and responsibilities along the development process. Moreover, the method can show within the same projects different investment in the economic, environmental or social areas, helping the decision-making process and the reciprocal influences that these three areas of analysis can have onto each other. The significance of the method proposed relies in its ability to inform decision-makers, designers and actors involved in sustainable projects on the effects of design decisions in an simultaneous manner along the development process. The method can be applied in as built circumstances or also as a modelling systems of the cause-effect relations of the design and organizational decisions in a programming phase of projects developments. The novelty of this method can be found in its ability to gauge the interconnection between different parts of the complex system analysed without losing the ability of understanding the specificity of the analytical areas taken into consideration. Moreover, the method proposed a possible graphic visualization of complexity, in such way to facilitate the direct feedback of the design decisions in relation to the social, economic and environmental effects generated or to be generated, and therefore to inform design processes.

## 7 CONCLUSIONS

The epistemological approach of applying the complexity theory to the development of sustainable building and urban design projects can help understand, gauge, and eventually manage the complexity of the built environment in a changing world. This approach can be relevant to deal with changing circumstances and complex problems that are affecting currently our built environment, in such way to be able to consider simultaneously parameters and conditions of different nature, as well as addressing emerging issues, proposing solutions and envisioning future sustainable scenarios. Therefore, the approach of analysing sustainable architectural and urban design strategies as a complex system can help define policies and design approaches in such way to contribute to the debate on the importance of implementing sustainable practice for the development of our common future. Moreover, by considering sustainable projects as complex system can produce a shift in the paradigm of designing processes. This latter could potentially widen the field of action by understanding all the simultaneous, multiscale and multi-folding aspects that characterize the process of designing and governing a complex system.

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