sustainability

MDPI

Article

Quali—A Quantitative Environmental Assessment Method According to Italian CAM, for the Sustainable Design of Urban Neighbourhoods in Mediterranean Climatic Regions

Enrico Sicignano *, Giacomo Di Ruocco and Anna Stabile

Department of Civil Engineering, University of Salerno, 84084 Fisciano (SA), Italy
* Correspondence: e.sicignano@unisa.it; Tel.: +39-3286050023

Received: 30 July 2019; Accepted: 20 August 2019; Published: 24 August 2019

Abstract: In recent decades, the international scientific debate has focused on maximizing the energy performance of the building organization during the operational phase. However, the energy performance is only partially in line with the strategic environmental objectives defined by the European Commission which, with Communication 2003/302, also defined the guidelines for the drafting of the National Action Plans on Green Public Procurement (NAP GPP). Law no. 296 of 27 December 2006 provided for "... the implementation and monitoring of an Action Plan for the environmental sustainability of public administration consumption", drawn up by the Ministry of the Environment and the Protection of Land and Sea. This work moves in the direction of identifying design strategies, relating to construction and urban restructuring, compatible with the criteria of energy and environmental sustainability provided for in the New Code of Public Procurement (Legislative Decree 50/2016), in accordance with the directives of the European Community. The parameters that define the methodological articulation (choice of case studies, scope of reference of stakeholders, etc.) orient the use of the results towards similar cases, i.e. design of urban districts located in regions with a Mediterranean climate.

Keywords: minimum environmental criteria; bioclimatic design; passive design strategies; low-carbon design; soil consumption reduction; global warming mitigation; rating systems

1. Introduction

The fourth report of the Intergovernmental Panel for Climate Change (IPCC, 2007) [1] highlighted the main responsibility of human action in the emission of greenhouse gases responsible for climate change: "The global increase in the concentration of carbon dioxide is mainly due to the use of fossil fuels and changes in land use, while increases in methane and nitrous oxide are mainly due to agriculture." In September 2008, the authoritative international programme Global Carbon Project published the results of the Carbon Budget 2007 [2], according to which the annual increase in CO_2 in the chemical composition of the atmosphere for 2007 was equal to 2.2 ppmv (parts per million volume) compared to 1.8 ppmv in 2006, while in the last twenty years it was equal to 1.5 ppmv. This increase brought the concentration of carbon dioxide in the atmosphere to 383 ppmv in 2007; i.e., 37% above that existing at the beginning of the Industrial Revolution (equal to about 280 ppmv). The latest data on atmospheric CO_2 concentration measurements, published on the US National Oceanic and Atmospheric Administration (NOAA) website, show that the average global concentration of carbon dioxide is constantly increasing: 410.24 ppm in April 2018, 413.32 ppm in April 2019 [3]. The scientific community has documented that the current concentration is the highest in 800,000 years [4]. The European Commission [5] is directing operators in the sector towards a wide range of technological solutions that can be used to drastically reduce the energy consumed by real estate assets. The energy consumption of a building is influenced by several factors, such as the geometry and orientation of the building [6,7], the performance of the building envelope [7,8] and the efficiency of building systems, as well as usage patterns, energy management and user behaviour.

Italian legislation has implemented the strategic environmental objectives defined by the European Commission [9] (in agreement with the National Action Plan on Green Public Procurement—NAP GPP [10]) through the issuing of the New Italian Code of Public Procurement (Legislative Decree 50/2016) [11,12], adopting the "Minimum environmental criteria for the award of design services and new construction, renovation and maintenance of public buildings" (Ministry of the Environment, Decree 11 October 2017) [13,14].

In the literature there are various approaches for assessing the sustainability of construction/restructuring interventions, with reference to the Italian national context. The study by Fantozzi F. et al. [15] shows that, in Italy, there are many attempts to apply technical-economic evaluations on energy saving strategies. In this regard, there are experiments relating to optimal conditions of comfort in relation to costs for school buildings [16]. Similar approaches have been applied to residential buildings [17].

However, fewer studies consider life cycle cost analysis (LCC) based assessment approaches. LCC is a management accounting tool for the economic assessment of choices made at the planning stage [18], and these choices can affect up to 80% of post-construction life cycle costs [19].

In particular, the study by Fantozzi et al. [15] shows that the life-cycle costs of a demolition and reconstruction operation are higher than those of a renovation operation. And, in the case of demolition and rebuilding, the costs of selective demolition are higher than those of mechanical demolition.

The study by Bellia L. et al. [16] discusses a methodological approach to the design of energy remediation measures based on an in-depth energy audit with in situ measurements allowing the complete characterisation of the building's HVAC system and internal conditions. Subsequently, the cost-optimal approach is applied to compare different retrofit scenarios, considering both the interventions on the building envelope and on the plant systems. The energy efficiency package, which combines the installation of heat recovery systems, device regulation for HVAC and LED lamps with automatic control, leads to significant energy savings and a reduction in polluting emissions (−33%) as well as the greatest reduction in overall cost (−35%).

An interesting study developed by Plebankiewicz E. et al. [20] compares the costs and benefits of certified buildings, comparing the cost simulation of a certified office building with a non-certified office building. The comparison was made using the life cycle cost idea and calculating the LCC, following the example of a six-storey building. This document is mainly about cost comparisons. The potential benefits of green buildings, in addition to the financial benefits, require further research (e.g., the impact on the environment and the working conditions of employees in the office building).

The present study defines a model for assessing the environmental sustainability of a multifunctional urban neighbourhood in Mediterranean climate regions. The method allows identification of, among a series of projects, the one most compatible with the environmental parameters of the Italian CAM (Criteri Ambientali Minimi), as well as the costs necessary to reach the minimum thresholds, and, after exceeding them, by obtaining the rewarding scores. In this way, it is possible to direct the economic investment choices of the operators in the sector [21].

In particular, the work aimed to deepen the following points:

- Identification of critical factors, of a project of an urban district, with respect to the minimum thresholds defined by the parameters of the Italian CAM;
- Identification of the strategies, and the relative costs, for the achievement of the basic minimum thresholds;
- Identification of the strategies, and the relative costs, for the exceeding of the above-mentioned thresholds; that is to say, for the achievement of the bonuses;
- Evaluation, among various project solutions, of the most suitable one for the choice of the financial investment.

2. The Role of Italian CAM in Environmental Certification Protocols

The Italian CAM are environmental requirements defined for the various stages of the purchasing process, aimed at identifying the best design solution, product or service from the environmental point of view throughout the life cycle.

CAM are divided into basic and rewarding environmental criteria. The basic criteria are mandatory minimum thresholds to be respected for each criterion and sub-criterion; the award criteria provide for the assignment of additional scores, proportional to the number of basic criteria for which a higher environmental performance is expected than that provided for in the basic criteria.

The update to the Italian Code of Public Contracts [10,13] shows that, "In order to completely define the design choices made in the specific case, the project must include the drafting of special tender specifications for the construction of the work and an exhaustive methodological report. To this end, the contracting authority may find it useful to select the projects subject to a valid verification phase for the subsequent certification of the building according to one of the protocols of energy and environmental sustainability of buildings (rating systems) at national or international level (some examples of such protocols are: Breeam, Casaclima, Itaca, Leed, Well). To better clarify the role of these protocols, it must be said that they are different from each other and do not contain all the criteria in this document or even when they contain them, do not always require the same levels of quality and performance as in this document of CAM, so the contracting station can use these protocols to verify compliance with a criterion only if, for the award of certification, are included the requirements of the criteria included in this document of CAM with equal or higher levels of quality and performance." This definition shows that sustainability protocols, currently used at the national and international levels, are different from each other, do not contain all the criteria contained in the Italian CAM, or, even when they contain them, do not always require the same levels of quality and performance as in the CAM document.

If the project is subject to a verification phase valid for the subsequent certification of the building according to one of the protocols of energy-environmental sustainability of buildings (rating systems) mentioned above, compliance with the CAM criterion can only be demonstrated if the international protocol meets all the requirements relating to environmental performance referred to by the same CAM criterion. This provision refers to the conformity of the individual criterion, which can be proved by the adoption of the protocol, provided, however, that the criterion is contained in the specific protocol [13,14].

The adoption of traditional environmental certification protocols (Breeam, Casaclima, Itaca, Leed and Well), therefore, although based on common principles, is not sufficient to meet the CAM criteria, since it is necessary to verify conformity for each individual criterion, which must be demonstrated in the chosen certification. The Italian regulation hopes that the international protocol organizations will define the verification and/or compatibility grids of the criteria and requirements, contained in the respective protocols, with respect to the criteria included in the CAM.

For this reason, GBC Italia (Green Building Council Italia) has issued a document entitled "Guidelines for the use of LEED-GBC (Leadership in Energy and Environmental Design—Green Building Council) protocols in support of CAM Construction," which is a very useful tool for operators for the reasoned application of the LEED protocol with reference to CAM [13,14].

3. Materials

3.1. Indicators

For the purposes of methodological development, the indicators used were the criteria contained in the Italian CAM, with regard to the design of urban districts ("technical specifications for groups of buildings"—article 2.2 of the CAM decree) [13,14]. The structure of CAM for groups of buildings includes ten categories of intervention, each of which provides a series of indicators and sub-indicators (Table A1, available in Appendix A).

3.2. Multi-Criteria Analysis

The contribution was aimed at developing an innovative methodology for the qualitative and quantitative assessment of the environmental sustainability of projects in urban areas [22], for the verification of the application of the "technical specifications for groups of buildings" (article 2.2 of the decree) of the minimum Italian environmental criteria [13]. The CAM structure comprises ten categories of intervention, each of which includes a series of indicators and sub-indicators. In the literature there are different methodologies able to carry out multi-criteria analyses, for the verification of environmental compatibility. These methodologies are able to provide weighting vectors that allow the comparison of different factors or criteria [23,24]. The most used are: The pair comparison method [25–27], the AHP method [28–30] and the Delphi method [27,31].

Comparing the methods, it appears that the AHP method is based on the comparison in pairs, but in order to be applied correctly, alternatives must be identified in order to achieve the final objective; the Delphi method involves the continuous use of questionnaires to be provided to groups of people until a unanimous answer is reached. Therefore, given the high number of elements to be evaluated, the method of comparison in pairs is the only one that allows to carry out a multi-criteria analysis in a simple way by giving a weight to each criterion.

Given the complexity of the structure of the minimum environmental criteria, a methodology has been identified that can translate the individual criteria into numbers that can be compared with each other. In this regard, the method of comparison in pairs has been used: This method allows the sorting of factors or criteria according to their relative importance.

3.3. Case Studies

The case studies, considered significant for the purposes of this study, concern interventions for the design of urban districts in southern Italy, in territories characterized by Mediterranean climate. The typology of these neighbourhoods (to which the application of the method is addressed) has the following characteristics:

- Urban area extension: From 20,000 to 50,000 m^2;
- Project functions: Residential and commercial buildings, appurtenant car parks, outdoor areas used as public spaces, parks, parking areas;
- Construction of primary and secondary infrastructure works;
- Climatic characteristics of the area: Temperate Mediterranean climate.

3.4. Stakeholders

The persons identified for the evaluation and assignment of weights to the relevant parameters, were chosen with these criteria:

1. Academic teaching staff;
2. Freelancers.

(1) With regard to the selection of academic staff, first and second level teachers (full and associate professors) have been identified, belonging to the university institutions of Southern Italy, belonging to the disciplines related to the topics under study: Technical architecture, environmental impact assessment, urban planning technique, technical environmental physics, water resource management, energy and environmental sustainability and economic evaluation of projects;

(2) With regard to the selection of freelancers, professionals in the sector (private or associated) operating in Southern Italy have been identified, with over ten years of experience in the field of architectural and urban design of public works, directly involved in the dynamics of transformation of the urbanized territory.

In order to obtain the most objective results possible, the group of people involved has the same number of subjects inside and outside the university; in this way it was possible to compare the responses obtained by two groups operating in different sectors (university → studies and research; external public procurement → public procurement).

4. Methods

The methodology is divided into the following phases:

- First phase: Definition of the questionnaire to be administered to the stakeholders, on the basis of the methodology of the comparison in pairs, for the determination of the weights to be assigned to each parameter;
- Second phase: Elaboration of the data and determination of the weights of the indicators and sub-indicators, through the development of the model;
- Third phase: Application of the model to the case studies for the purpose of assessing the compliance rate of the basic CAM;
- Fourth phase: Improvement strategies for the achievement of the minimum thresholds of CAM, as well as for the possible exceeding of the same in order to obtain the rewarding scores.

4.1. Definition of the Questionnaire to Be Administered to the Stakeholder

For the objective application of the method, questionnaires were administered to the stakeholders identified with the criteria expressed in Section 3.4.

The questionnaire was articulated with the method of comparison in pairs; i.e., asking the compiler to express a relative preference among the various sub-indicators.

The factors belonging to each category were compared to each other in order to assign a weight to each of them; where there is a single factor, the latter was compared only with the fictitious factor F, thus resulting in a winner.

Each question allowed three answer options (0/0.5/1) and for each of them it was possible to obtain a convergence towards only one of the possible values for which the weight resulting from most of the answers was that then attributed to a given criterion [30].

Depending on the questions and on the basis of the majority of the answers, a weight was assigned to each factor. Tables were then constructed, with the head of the tables being the factors considered and the columns representing the pairs to be compared without repetition. Here are some examples for a better understanding.

4.2. Elaboration of the Data and Determination of the Weights of the Indicators and Sub-Indicators

The sorting of the factors according to their relative importance is carried out through the systematic comparison of pairs of factors; for each pair of factors the evaluation group is called upon to identify the "winning" factor to which the score 1 is assigned, while the "losing" factor is assigned score 0. In case of equal importance or "tie," both factors are given a score of 0.5. A fictitious factor F must also be added to the list of factors to be evaluated. By definition, this factor is less and less important; therefore, it is a loser, compared to all the other factors studied; the fictitious factor is inserted to prevent one of the real factors from having a final zero score.

The evaluation is carried out by constructing a table, the leaders of which are the different factors or criteria and the column shows the values that result from their comparison in pairs. N is the number of factors to be considered. The number of columns required will be equal to $N(N-1)/2$, which will also coincide with the sum of the scores awarded. Below is a table as an example (Table 1).

Table 1. Example of the calculation scheme of the results, resulting from the comparison in pairs.

Indicators	A-B	A-C	A-F	B-C	B-F	C-F	Score	Weight
A	1	1	1	-	-	-	3	0.5
B	0	-	-	0	1	-	1	0.17
C	-	0	-	1	-	1	2	0.33
F	-	-	0	-	0	0	0	0

At the end of the systematic comparison between all pairs of factors, we proceeded to the sum of the scores achieved by each factor. The overall score of each factor is divided by the total sum of the scores, equal to the number of pairs without repetition, providing the coefficient of importance or weight of the criterion. The set of weights constitutes the weighting vector of the factors considered; this vector has the following properties:

- All weights are pure numbers included in the interval [0;1];
- The sum of all weights is always equal to 1.

The processing of the collected data has allowed to define the relative weights between the various parameters of the CAM (Table 2).

Table 2. Summary of the results of the weights in percentages, obtained for each macro-category.

Italian CAM Parameters (for Design of Groups of Buildings)	Weights
Naturalistic and Landscape Integration	12%
Green Areas Design	7%
Soil Consumption Reduction and Maintenance of Soil Permeability	13%
Conservation of Morphological Characters	7%
Energy Supply from Renewable Sources	12%
Reduction of the Impact on the Microclimate and Air Pollution	13%
Reduction of the Impact on the Surface and Underground River Basin System	11%
Primary Infrastructure	8%
Secondary Infrastructure and Sustainable Mobility	10%
State of the Environment Report	7%
	100%

4.3. Application of the Model to the Case Studies for the Purpose of Assessing the Compliance Rate of the Basic CAM

Given the complexity of the structure of the minimum environmental criteria, it is necessary to identify a method capable of providing a qualitative and quantitative model for the assessment of the application of these criteria. Some of them are quantitatively measurable, others are qualitative.

In order to translate the previous scheme into numbers, an evaluation scale has been identified for each criterion, ranging from 0 to 10: The minimum score for compliance with a CAM is 6/10 for each criterion. For qualitative indicators, the score will always be 6/10 (if they respect the CAM); for quantitative indicators the score can vary and be higher than 6, if they exceed the minimum limits allowed by CAM.

For the criteria that exceed the minimum threshold set by the CAM, two evaluation scales are identified [32]: The first has a linear course and is used for a maximum overrun of up to 50% of the minimum set by the criteria and is based on the following mathematical equation: $y = 0.08x + 6$ (Figure 1).

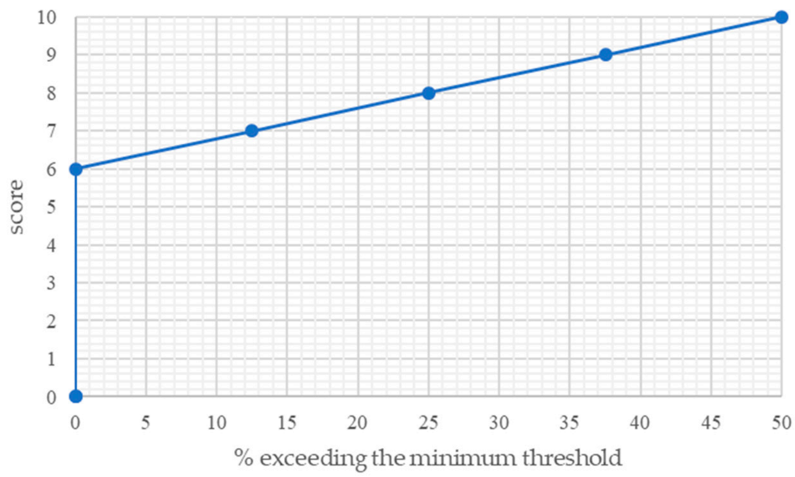


Figure 1. Score of criteria exceeding, by up to 50%, the minimum thresholds of the CAM (Criteri Ambientali Minimi).

The second has an exponential trend, according to the law $y = x^2$ (Figure 2).

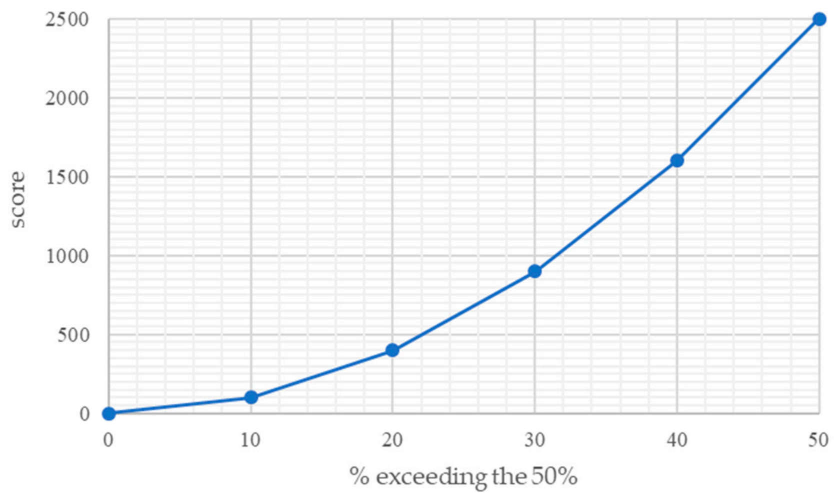


Figure 2. Score of criteria exceeding, by more than 50%, the minimum thresholds of the CAM.

This last equation is used, starting from the first one; that is, when there are criteria that exceed the minimum threshold by more than 50%: In this case each percentage increase above 50% that is read in the abscissa corresponds to a value squared in the ordinate. Each criterion is then assigned the score that is read on the axis of the ordinates: Each criterion must, however, have its own weight with respect to the whole. To determine the weight of each criterion, as already mentioned above, the method of comparison in pairs was chosen, which allows the criteria to be sorted according to their relative importance [24]: This method involves the presence of an evaluation group that highlights the relative importance between the factors considered; a systematic comparison is made between pairs of factors in which the group must assign the score 1 to the "winning" factor, 0 to the "losing" factor and 0.5 to both in the case in which they have equal importance [26].

The evaluation is carried out by drawing up a table in which the head of origin are the factors or criteria considered and the results of the comparison are shown in the column; to the list of criteria to be considered, a fictitious criterion "F" that will always be loser compared to the others (so it will always have zero score) must also be added. It is necessary to avoid some real criterion having a score of 0. The number of pairs to be compared with each other should not be repeated so, given N factors to be compared, the number of comparisons will be equal to N(N−1)/2 which will also be equal to the number of columns in the table to be filled in [24]. Once the table is completed, the sum of the scores for each row (and therefore for each criterion) is made and this score is divided by the total sum, equal to the number of pairs without repetition: Once this is done, the weight of each criterion is obtained. The set of weights of all the criteria provides a weighting vector that has certain characteristics:

- All weights are numbers in the range [0,1];
- The sum of all weights is always equal to 1.

In order to apply the method objectively, it was decided to provide a series of questionnaires to operators in the sector [32], belonging to the geographical context of reference for the case study (southern Italy/Mediterranean climate region). Each question allows three answer options (0/0.5/1) and for each of them it was possible to obtain a convergence towards only one of the possible values, for which the weight resulting from most of the answers was that then attributed to a given criterion [30]. Depending on the questions and on the basis of the majority of the answers, each factor was given a weighting. Tables were then constructed, with the head of the tables being the factors considered and the columns representing the pairs to be compared without repetition. The weight of each criterion is multiplied by the respective score, which is read from the previous graphs, in order to obtain a weighted score: It may happen that a single criterion has a very high score but, at the same time, has a very low weight so that the final weighted score (obtained by multiplying the score by the weight) will be lower. Once the weighted scores of each criterion have been identified, they must be added together in order to obtain an overall score to be attributed to the project under study. Beyond the weight given to each criterion, necessary for the identification of an overall score of the project, it is interesting to know the level of compliance with CAM. On the basis of questionnaires similar to those used in the previous phase, comparisons are made in pairs, between the categories of intervention, in order to obtain a percentage for each of them. Starting from the percentages relative to each category, we obtain those relative to the criteria belonging to each category, on the basis of the weights previously calculated: The weight of each criterion indicates a certain percentage of the category of intervention.

Table 3 shows the weights and percentages assigned to each criterion: If a category has only one criterion, it assumes the weight and percentage of the entire category.

Table 3 shows the model parameters, each of which is divided into further sub-parameters. The model has been generated by imposing the value "1," for each of the parameters, as the maximum weight to satisfy the requirement. This value "1" is broken down into the relative weights of the various sub-parameters that define each parameter. Therefore, it has been imposed that the sum of the sub-parameters of each parameter must be equal to "1." It is evident, therefore, that the weight of each sub-parameter has been compared only with the weight of the other sub-parameters of the same reference parameter. This means that, for the same method of defining the model, it is not possible to compare the weight of two sub-parameters that belong to two different parameters.

Table 3. Model development.

	Weight	Percentage
1. Naturalistic and landscape integration	**1**	**12%**
1.1 Conservation of habitats in the area	1	12%
2. Green areas design	**1**	**7%**
2.1 Using native species with low allergen pollens	0.23	1.61%
2.2 In the case of species with moderate to high allergenic power, favour female plants, sterile or with entomophilous pollination	0.23	1.61%
2.3 Avoid stinging or spiny species	0.07	0.49%
2.4 Use deep-rooting herbaceous species in the case of steeply sloping green areas	0.23	1.61%
2.5 Do not use tree species with fragile roots, stems or foliage.	0.23	1.61%
3. Soil consumption reduction and maintenance of soil permeability	**1**	**13%**
3.1 Avoiding the construction of new buildings or the extension of existing buildings in protected areas	0.07	0.91%
3.2 Permeable land area of not less than 60% of the project area not built	0.17	2.21%
3.3 Area to be allocated to green areas equal to at least 40% of the project area not built on and 30% of the total area of the lot	0.24	3.12%
3.4 In public green areas, at least 40% tree cover and at least 20% shrub cover with native species must be guaranteed.	0.24	3.12%
3.5 Use of drainage materials for pedestrian and vehicular urban areas	0.21	2.73%
3.6 In the execution phase, the realization of a surface scotic of at least 60 cm must be envisaged.	0.07	0.91%
4. Conservation of morphological characters	**1**	**7%**
4.1 Maintenance of existing morphological profiles	1	7%
5. Energy supply from renewable sources	**1**	**12%**
5.1 Construction of cogeneration/trigeneration plants	0.166	2%
5.2 Installation of photovoltaic parks	0.166	2%
5.3 Installation of solar thermal collectors for domestic hot water heating	0.166	2%
5.4 Installation of low-enthalpy geothermal systems	0.166	2%
5.5 Installation of heat pump systems	0.166	2%
5.6 Installation of biomass systems	0.166	2%
6. Reduction of the impact on the microclimate and air pollution	**1**	**13%**
6.1 Use plant species with CO_2 absorption capacity for green areas	0.30	3.9%
6.2 Use permeable materials for pedestrian and driveway areas with an SRI Index of at least 29	0.20	2.6%
6.3 Use of garden roofs should be preferred for roofs.	0.25	3.25%
6.4 For roofs other than garden roofs, materials with an SRI index of 29 for slopes greater than 15% and 76 for slopes less than or equal to 15% must be used.	0.25	3.25%
7. Reduction of the impact on the surface and underground river basin system	**1**	**11%**
7.1 Preserve and/or restore the naturalness of river ecosystems, river beds and their riparian belt, excluding the release of unpurified effluents.	0.23	2.53%
7.2 Ordinary and extraordinary maintenance through the removal of waste and woody material deposited along the riverbed and in the ditches	0.20	2.2%
7.3 Realize plants for the purification of first rain water from draining surfaces subject to pollution	0.17	1.87%
7.4 Carry out interventions to prevent or prevent phenomena of compaction, landslides or floods	0.20	2.2%
7.5 Controlling the release of pollutants into the soil and subsoil	0.20	2.2%
8. Primary infrastructure	**1**	**8%**
8.1 Road system (Interventions for parking areas)	0.17	1.36%
8.1.1 Coverage with suitable masts equal to at least 10% of the gross area	0.051	0.41%
8.1.2. The perimeter shall be bounded by a green belt at least 1 m high and more than 75% opaque.	0.034	0.27%
8.1.3 Creating roofs with photovoltaic shelters to serve the lighting system of the car park	0.0425	0.34%
8.1.4 Provide space for motorcycles, mopeds and bicycle racks based on the number of potential inhabitants	0.0425	0.34%
8.2 Collection, purification and reuse of rainwater	0.19	1.52%
8.2.1 Create a system for the purification and de-oiling of water coming from polluting surfaces according to UNI/TS 11,445 standard for the reuse for irrigation purposes or to feed the storage boxes of toilets		
8.3 Public green areas irrigation network	0.17	1.36%
8.3.1 Use drip irrigation systems powered by renewable energy sources designed according to UNI/TS 11,445		
8.4 Material and waste collection and storage areas	0.14	1.12%
8.4.1 Establishing areas for local separate collection		
8.5 Public lighting system	0.17	1.36%
8.5.1 Designing a public lighting system in compliance with the requirements of the CAM document "Lighting" issued by the Ministerial Decree of 23 December 2013		
8.6 Subservices/channels for technological infrastructures	0.17	1.36%
8.6.1 Creating channels to place all technological networks for proper management of underground space		

Table 3. *Cont.*

	Weight	Percentage
9. Secondary infrastructure and sustainable mobility	**1**	**10%**
9.1 Provide a mix of residences, workplaces and services to contain travel	0.30	3%
9.2 Implementing public services or short-distance underground stations	0.20	2%
9.3 Provide shuttle services to reach public services (if not within a short distance)	0.17	1.7%
9.4 Bicycle racks at interchange points	0.10	1%
9.5 Network of protected footpaths and/or cycle paths with suitable tree and/or shrub accommodation	0.23	2.3%
10. State of the environment report	**1**	**7%**
10.1 The planned measures must lead to an environmental improvement of the site	1	7%

The results obtained from the previous table can be inserted on a graph, that on the axis of the abscissa, shows the percentage of satisfaction of the CAM and on the axis of the ordinates for the weighted score of each criterion. In the ideal case, the CAM are 100% satisfied and each criterion reaches at least the minimum score (i.e., 6); this situation is therefore obtained (Figure 3):

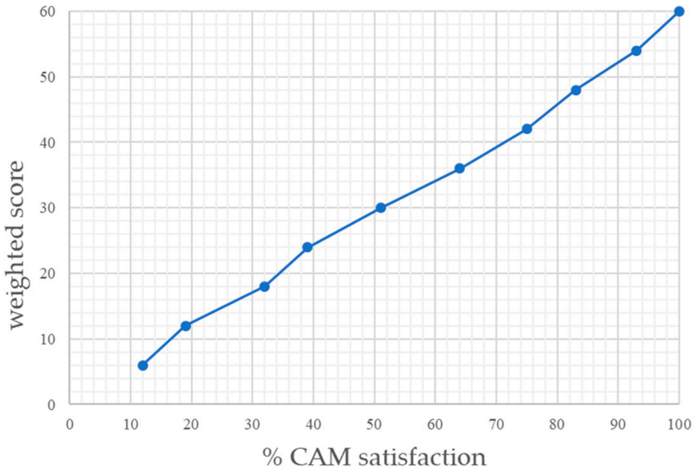
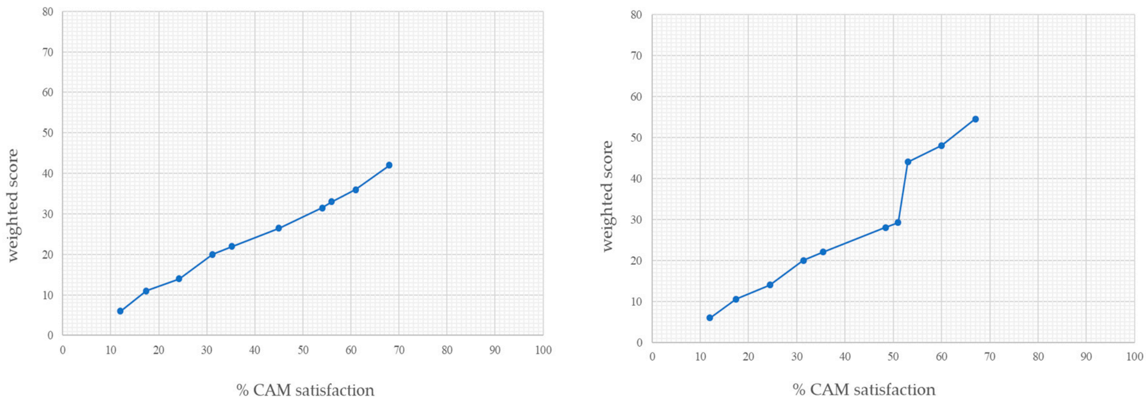


Figure 3. Score of criteria exceeding, by more than 50%, the minimum thresholds laid down for CAM.

When estimating the score of a real project, however, not all the criteria are met, and therefore reach a minimum value of 6, just as it is possible that some criteria exceed the minimum compared to those provided for, thus reaching a score above 6; moreover, it is difficult to identify a real project that includes all the interventions identified by the CAM, and that meets the target 100%. From this it follows that, in the analysis of real projects, the graph will present a different trend from that just seen. The model thus formulated is completely generic; for a clearer understanding, two projects have been identified, both falling within the same city (close to Salerno, Campania Region, Southern Italy), which concern the redevelopment of urban areas through the construction of residential and tertiary settlements. The two case studies have been analysed on the basis of the indications found in the technical-illustrative reports and in the design graphs, in order to certify compliance with the minimum environmental criteria. The following graphs (Figure 4) show the results obtained.

In the first case the trend is almost linear while in the second case you notice a jump due to the excessive score of one of the criteria. A higher score does not necessarily mean a better quality of the project: A higher score may be associated with a lower percentage, and conversely, with the same percentage of CAM satisfaction (as it happens for the two case studies analysed in which the percentage is almost identical) it is preferable to choose the project with the highest score.



(**a**) Case study 1 (**b**) Case study 2

Figure 4. Percentage-weighted score of CAM satisfaction: (**a**) In the first case a percentage of CAM satisfaction of 68% is reached with a score of 42; (**b**) in the second case a percentage of 67% is reached with a score of 54.5.

4.4. Improvement Strategies for the Achievement of the Minimum Thresholds of CAM

By comparing criteria with other criteria, it can be seen that the case study 1 is the one which, between the two, meets the minimum thresholds set by the CAM least, and also reaches a lower score than the second: It was decided to use the first case study as a reference for carrying out improvements. The aim was to identify a design solution capable of obtaining an improvement in the minimum environmental criteria, i.e., awards, without intervening on the type of buildings and their planimetric system. The project area is identified in Figure 5, and in particular, action is taken on the three buildings highlighted, which are the same in shape, size and planimetric system.

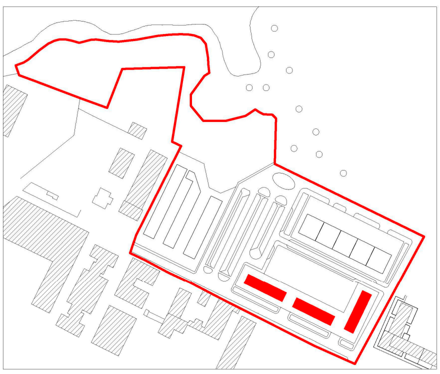


Figure 5. Plan of case study 1.

The methodological approach identifies two strategic actions aimed at optimising:

(a) Arrangement and orientation of buildings within the area;
(b) Interventions concerning the entire building complex.

(a) Arrangement and orientation of buildings within the area

Changing the position of buildings inside the area necessarily implies a different arrangement of outdoor spaces compared to the original state: Given the complexity of CAM, it is possible to identify a key parameter able to suggest the best solution among the different proposals, without the need to necessarily analyse the whole list of criteria. Looking at the percentages of the categories of intervention (Table 3), it appears that category 3, "Reduction of soil consumption and maintenance of soil permeability" has the highest percentage together with category 6, "Reduction of the impact on the microclimate and atmospheric pollution": Among the criteria belonging to those categories, only criterion 3.2 relating to the minimum percentage of permeable surface area compared to the entire project surface was taken as a reference. The choice falls on this criterion because it depends exclusively on the surface of the entire sector (which does not vary according to the changes); the other criteria, moreover, are dependent on the permeable surface itself. Following these considerations, three provisions were analysed (Figure 6):

(**a**) hypothesis 1 (**b**) hypothesis 2 (**c**) hypothesis 3

Figure 6. Representation of the three project hypotheses: (**a**) Original orientation/different layout; (**b**) west-east orientation; (**c**) north-south orientation for the calculation of the score of the criteria that exceed the minimum thresholds of the CAM by more than 50%.

Once the three different provisions have been identified, the percentage of permeable land area is calculated with the relative variation in the awarding score (Table 4).

Table 4. Summary of model results. Comparison between the variation of the percentage of permeable surface area and the variation of the rewarding score, for the three hypotheses.

	Hypothesis	Δ Permeable Territorial Area (CAM Threshold)	Δ Reward Score
1	original orientation/but different layout of buildings	+7%	0.42
2	west-east orientation	+11%	0.65
3	north-south orientation	+8%	0.23

The above table shows that in the second hypothesis it is possible to achieve the best result, so the west-east orientation is the solution chosen.

(b) Interventions concerning the entire building complex

For the purpose of achieving the minimum environmental thresholds imposed by the CAM, given the characteristics of the case study, the following parameters, of Table A1, were considered to be improvable:

- Reduction of soil consumption and maintenance of soil permeability.

(3.2) Permeable territorial area;
(3.3) Area to be used as green area;
(3.4) Arboreal and shrub cover in public green areas;
(3.5) Drainage materials for pedestrian and driveway surfaces.

- Reduction of the impact on the surface and underground river basin system.

(7.3) Realize first rain water purification plants.

- Primary infrastructure.

    (8.1) Roads (Interventions for parking areas);
    (8.1.1) Cover with masts suitable for parking;
    (8.1.3) To realize the covers of the parking lot with photovoltaic shelters;
    (8.1.4) Provide space for motorcycles, mopeds and bicycle racks;
    (8.2) Collection, purification and reuse of rainwater;
    (8.2.1) Establish a separate network for collecting rainwater;
    (8.3) Irrigation network of public green areas;
    (8.3.1) Use drip irrigation systems powered by renewable energy sources;
    (8.4) Areas for collection and storage of materials and waste;
    (8.4.1) Establishing areas for local separate collection.

- Secondary infrastructure and sustainable mobility.

    (9.5) Network of protected cycle and pedestrian paths with adequate tree and/or shrub accommodation.

- *Improvement of Parameter Number Three (Reduction of Soil Consumption and Maintenance of Soil Permeability).*

This category is directly linked to the layout of the buildings within the lot: The interventions also concern criteria already met by the original project, but which are affected by the new land area, so they vary according to it (Table 5).

Table 5. Comparison between the minimum threshold set by the CAM and the results of the project, in relation to parameter number 3.

CRITERION	CAM THRESHOLD	PROJECT	VARIATION RESPECTED to CAM THRESHOLD
(3.2) Permeable territorial area not less than 60%.	26,434 m^2	29,368 m^2	+11%
(3.3) Surface to be assigned to green:			
At least 40% of the project area	15,398 m^2	19,140 m^2	+24%
At least 30% of the total area of the lot	13,217 m^2		+45%
(3.4) In public green areas:			
40% tree cover	2325 m^2	2520 m^2	+8.5%
20% shrub cover	1163 m^2	1221 m^2	+6%

Point 3.5 provides for the use of draining materials for urbanised pedestrian and cycle areas: Open mesh concrete is used for parking areas. While filtering concrete, which is permeable thanks to its porosity, is useful for both squares and pedestrian areas (Table 6).

Table 6. Results from the forecast of interventions related to the improvement of parameter number 3—reduction of soil consumption and maintenance of soil permeability.

CRITERION	SCORE	% CAM SATISFACTION
(3.1) Avoid the construction of new buildings or extension of existing buildings in protected areas	0.07×6	0.91%
(3.2) Permeable territorial area not less than 60%.	6.88×0.17	2.21%
(3.3) Surface to be assigned to green:		
At least 40% of the project area	7.92×0.12	1.56%
At least 30% of the total area of the lot	9.6×0.12	1.56%
(3.4) In public green areas:		
40% tree cover	6.68×0.12	1.56%
20% shrub cover	6.48×0.12	1.56%
(3.5) Use of drainage materials for pedestrian and vehicular crossings	0.21×6	2.73%
TOTAL	6.53	12,11%

The following is a comparison between the initial project scores and the improvement proposal scores:

	SCORE	% CAM SATISFACTION
INITIAL PROJECT (CASE STUDY)	3.29	6.76%
POST-MODIFICATION PRJECT	6.53	12.10%
DIVERGENCE	+3.24	+5.34%

Considering the interventions foreseen for the external accommodation, the percentage rises to 73.41% compared to the initial state with a score of 45.2.

- *Improvement of Parameter Number Seven (Reduction of the Impact on the Surface and Sub-Surface River Basin System).*

The compliance with parameter number 7 consists, in the forecast, of a water purification plant for the first rain water, able to guarantee interventions for the correct flow of the surface water from the waterproofed surfaces (Table 7).

Table 7. Results from the forecast of interventions related to the improvement of parameter number 7—reduction of the impact on the surface and underground hydrographic system.

CRITERION	SCORE	% CAM SATISFACTION
(7.3) Construction of water purification plants for first rain water and ensure interventions for the proper flow of surface water from the waterproofed surfaces	0.17 × 6	1.87%
TOTAL	1.02	1.87%

In this case, we reach a score of about 43 with a percentage of 70%: An intervention of this kind, therefore, involves a small variation in terms of score and percentage of compliance with CAM, but it is excellent from an environmental point of view, as a realization of this type allows to avoid spills into the ground, thus avoids pollution of both the ground itself and underground aquifers.

- *Improvement of Parameter Number Eight (Primary Infrastructure)*

(8.1) Roads (Interventions for Parking Areas)

In order to obtain this parameter, it was necessary to intervene on the parking areas: The new position of the buildings leads to the absorption of a small part of the area intended for public parking, which is compensated through the creation of level parking in the area of intervention. The need to provide sufficient room for manoeuvring has led to the reduction of green areas on the sidewalk that divides the two rows of parking: It is possible, however, to provide for the installation of photovoltaic shelters to cover the parking spaces.

The CAM provide for a green cover of at least 10% of the gross area of the car park: This criterion has been met by creating an adequate green cover for the new car parks along the perimeter of the intervention area.

In the latter case, the minimum is exceeded by 60%, so that, only for the green coverage of the parking areas, a score of about 5.61 is reached (Table 8).

Table 8. Results from the forecast of interventions relating to the improvement of parameter number 8.1—road conditions (interventions for parking areas).

UNDER-CRITERION	SCORE	% CAM SATISFACTION
(8.1.1) At least 10% of the car park is covered with trees	0.051×10 0.051×10^2	0.41%
(8.1.3) Realizing photovoltaic shelters for the roofing of car parks	0.0425×6	0.34%
(8.1.4) Provide space for motorcycles, mopeds and bicycle racks	0.0425×6	0.34%
TOTAL	6.12	1.09%

Remember that up to 50% of the minimum threshold is exceeded using the linear graph (in this case $0.051 \times 10 = 0.51$); for the remaining 10% the score is calculated using the second graph (in this case $0.051 \times 10^2 = 5.1$).

It is interesting to note that, in this case, a rather high score is obtained, which does not correspond to an equally high percentage of CAM satisfaction: This occurs because these are sub-criteria belonging to the criterion "road system," which in turn belongs to the category "Primary infrastructure" (point 8 of the Table A1), so their weight compared to the others is lower.

Additionally in this case, the intervention concerns criteria that are already satisfied in the original project, so it is necessary to evaluate the difference between the initial project and the project following the planned interventions:

	SCORE	% CAM SATISFACTION
INITIAL PROJECT (CASE STUDY)	0.60	0.75%
POST-MODIFICATION PRJECT	6.12	1.09%
DIVERGENCE	+5.52	+0.34%

The interventions provided for in compliance with criterion 8.1 allows the project to achieve a score of 67.5 with 68.4% of compliance with the minimum environmental criteria.

- *Improvement of Parameter Number Eight (Primary Infrastructure)*

(8.2) Collection, purification and reuse of rainwater

Compliance with this parameter requires the construction of a water purification plant for first rainwater: the reuse of rainwater allows the preservation of the water resource because the recovered water can be reused for irrigation of green areas and for domestic use, for non-drinking uses.

This point foresees, in particular, the presence of two separate networks (Table 9):

- the first collection network, sends water directly to the tanks;
- the second network first purifies the water (if it comes from polluted surfaces such as roads) and then sends it to the tanks (this is linked to the point "Reducing the impact on the surface and underground hydrographic system").

Table 9. Results from the forecast of interventions related to the improvement of parameter number 8.2—collection, purification and reuse of rainwater.

CRITERION	SCORE	% CAM SATISFACTION
(8.2) Construction of a separate network for the collection and reuse of rainwater	0.19×6	1.52%
TOTAL	1.14	1.52%

The improvement, in terms of CAM satisfaction, resulting from this intervention is 43 points and the percentage of CAM satisfaction is 69.4%.

- *Improvement of Parameter Number Eight (Primary Infrastructure)*

(8.3) Irrigation network of public green areas

The irrigation of public green areas involves the use of drip systems powered by renewable energy sources: in this case it is possible to use the energy produced by photovoltaic shelters to operate the irrigation system (Table 10).

Table 10. Results from the forecast of interventions relating to the improvement of parameter number 8.3—network of irrigation of public green areas.

CRITERION	SCORE	% CAM SATISFACTION
(8.3) Use drip irrigation systems powered by renewable energy sources	0.17 × 6	1.36%
TOTAL	1.02	1.36%

The improvement, in terms of CAM satisfaction, resulting from this intervention is 43 points and the percentage of CAM satisfaction is 69.4%.

- *Improvement of Parameter Number Eight (Primary Infrastructure)*

(8.4) Areas for collection and storage of materials and waste

Compliance with this parameter requires the creation of an area for the temporary storage of waste, in compliance with the regulation on the separate collection of waste (Table 11).

Table 11. Results from the forecast of interventions relating to the improvement of parameter number 8.4—areas of collection and storage of materials and waste.

CRITERION	SCORE	% CAM SATISFACTION
(8.4) Localization of areas for local separate collection	0.14 × 6	1.12%
TOTAL	0.84	1.12%

This type of intervention involves a low variation, reaching 69.2% of CAM satisfaction and a score of 43; the low result is due to the fact that the weight of this criterion is lower than the others.

- *Improvement of Parameter Number Nine (Secondary Infrastructure and Sustainable Mobility)*

The project involves the design of adequately protected pedestrian paths: The residential area is flanked by a long sidewalk, as a boundary between the built area and the undeveloped area. The improvement proposal included the design of a covered tunnel to make the pedestrian path more comfortable, especially in case of rain (Table 12).

Table 12. Results from the forecast of interventions relating to the improvement of parameter n.9.5—network of protected cycle and pedestrian paths and with adequate tree and/or shrub accommodation.

CRITERION	SCORE	% CAM SATISFACTION
(9.5) Creation of a network of protected footpaths with adequate tree and/or shrub accommodation	0.23 × 6	2.3%
TOTAL	1.38	2.3%

This type of intervention does not involve a significant increase, both in terms of score and percentage of CAM satisfaction, allowing the achievement of 70.4% and 43.3 points.

Table 13 summarises the results achieved, in terms of percentage of CAM satisfaction and relative score.

Table 13. Interventions on the whole sector, with relative the percentages of CAM satisfaction and corresponding scores.

	Satisfaction CAM	Score
3. Soil consumption reduction and maintenance of soil permeability		
3.2 Permeable land area of not less than 60% of the project area not built 3.3 Area to be allocated to green areas equal to at least 40% of the project area not built on and 30% of the total area of the lot 3.4 In public green areas, at least 40% tree cover and at least 20% shrub cover with native species must be guaranteed. 3.5 Use of drainage materials for pedestrian and vehicular urban areas	+5.34%	+3.24
7. Reduction of the impact on the surface and underground river basin system		
7.3 Realize plants for the purification of first rain water from draining surfaces subject to pollution	+1.87%	+1.02
8. Primary infrastructure		
8.1 Road system (Interventions for parking areas) 8.1.1 Coverage with suitable masts equal to at least 10% of the gross area 8.1.3 Creating roofs with photovoltaic shelters to serve the lighting system of the car park	+0.34%	+5.52
8.2 Collection, purification and reuse of rainwater	+1.52%	+1.14
8.2.1 Create a system for the purification and de-oiling of water coming from polluting surfaces according to UNI/TS 11,445 standard for the reuse for irrigation purposes or to feed the storage boxes of toilets		
8.3 Public green areas irrigation network		
8.3.1 Use drip irrigation systems powered by renewable energy sources designed according to UNI/TS 11,445	+1.36%	+1.02
8.4 Material and waste collection and storage areas	+1.12%	+0.84
8.4.1 Establishing areas for local separate collection		
9. Secondary infrastructure and sustainable mobility		
9.5 Network of protected footpaths and/or cycle paths with suitable tree and/or shrub accommodation	+2.3%	+1.38

4.5. Economic Evaluations

The economic aspect has a decisive influence on the policy of choosing interventions. The verification of the environmental compatibility of a project determines the forecast of a series of works (partly not foreseen in the initial project), with a consequent increase of the costs of realization of the intervention.

The attention, therefore, was focused on the convenience of providing for certain interventions, based on the ratio between the cost of the individual intervention and the percentage increase in compliance with environmental requirements (CAM).

The initial amount of the project is 16,748,700,00 € (calculated on the basis of Italian costs), for an intervention having the following characteristics:

- Residential function: 1200 m^2;
- Commercial function: 1800 m^2;
- Arrangement of outdoor areas (parking, public gardens, sidewalk and rest areas): 38,000 m^2.

The cost of each additional intervention (necessary to reach the minimum thresholds of the CAM) has, therefore, been calculated. The costs of the various interventions (relating to the fulfilment of the parameters) were related to the contribution (in percentage) that each intervention is able to provide in terms of satisfaction of the CAM.

The following table (Table 14) shows the percentage increase in the initial cost, in relation to the implementation of each individual intervention.

Table 14. Percentages of increase of initial costs, relative to the implementation of every single intervention.

CRITERION	% MODIFICATION RESPECT TO INITIAL PROJECT COST
(C3) Reduction of soil consumption and maintenance of soil permeability	+0.5%
(C7.3) Construction of first rain water purification plants	+0.06%
(C8.1) Construction of photovoltaic shelters	+2.3%
(C8.2) Construction of a separate stormwater collection network	+0.1%
(C8.3) Construction of drip irrigation systems	+0.45%
(C8.4) Creation of areas for the separate collection of waste	+0.04%
(C8.5) Construction of a covered pedestrian crossing	+0.4%
TOTAL	+3.85%

5. Discussion

It can be noted that the interventions, taken individually, do not bring great variations in the score of the project compared to the initial state; for the hypothesis of being able to achieve everything that was expected, we obtained a variation of +14% for the satisfaction of CAM and +14 for the score. The project, compared to the initial state, has undergone changes that lead to an improvement from the point of view of compliance with minimum environmental criteria, retaining the initial design ideas. It is possible to construct a weighted-percent score graph of CAM satisfaction after the interventions (Figure 7).

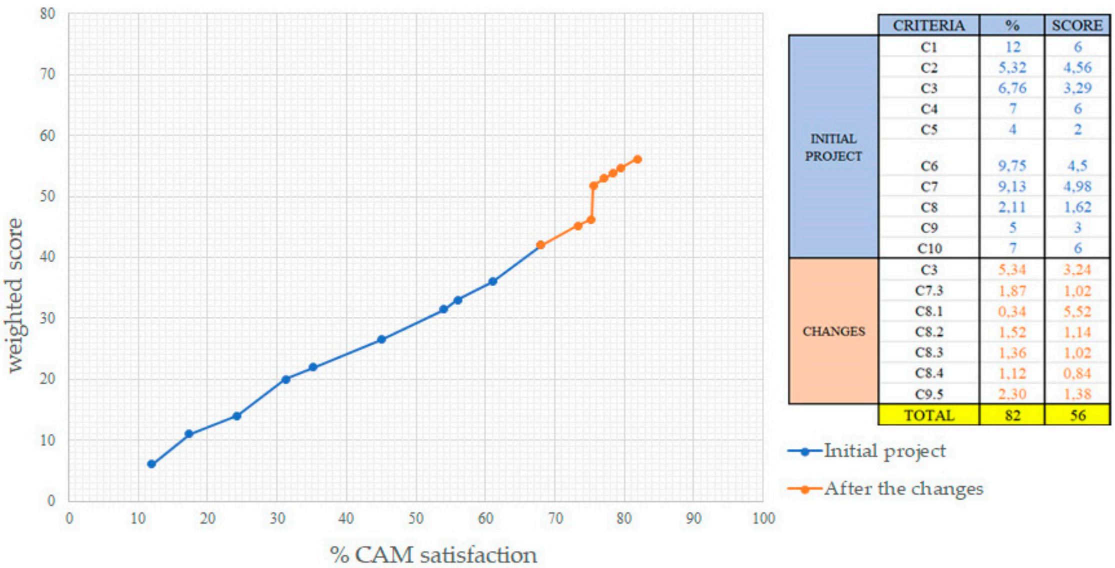


Figure 7. Percentage satisfaction CAM-score weighted as a result of the interventions.

The choice of suitable materials and the optimal rotation of the buildings, allows us to increase the percentage of satisfaction CAM from 68% to 82%; the score increases from 42 to 56 points. The proposed interventions represent one of the possible solutions, but not the only one, that allows us to respect the new environmental indications foreseen, without changing the initial project.

As far as the evaluation of costs is concerned, it is possible to note that, in order to carry out all the possible interventions for the maximum fulfilment of the minimum environmental criteria, in relation to the case under examination, it is necessary to face an increase in the cost of intervention equal to about 3.85% of the cost of the initial project.

The results of Table 15, graphically represented in Figure 8, show the trend of the increase in costs, according to the percentage of CAM satisfaction, for each intervention.

Table 15. Comparison between type of intervention, costs, and percentage of compliance with environmental criteria.

CRITERION	Δ INITIAL COSTS	SCORE	% CAM SATISFACTION
(C3) Reduction of soil consumption and maintenance of soil permeability	+0.5%	3.24	+5–34%
(C7.3) Construction of first rain water purification plants	+0.06%	1.02	+1.87%
(C8.1) Construction of photovoltaic shelters	+2.3%	5.52	+0.34%
(C8.2) Construction of a separate stormwater collection network	+0.1%	1.14	+1.52%
(C8.3) Construction of drip irrigation systems	+0.45%	1.02	+1.36%
(C8.4) Creation of areas for the separate collection of waste	+0.04%	0.84	+1.12%
(C9.5) Construction of a covered pedestrian crossing	+0.4%	1.38	+2.3%
TOTAL	+3.85%	14.16	+13.85

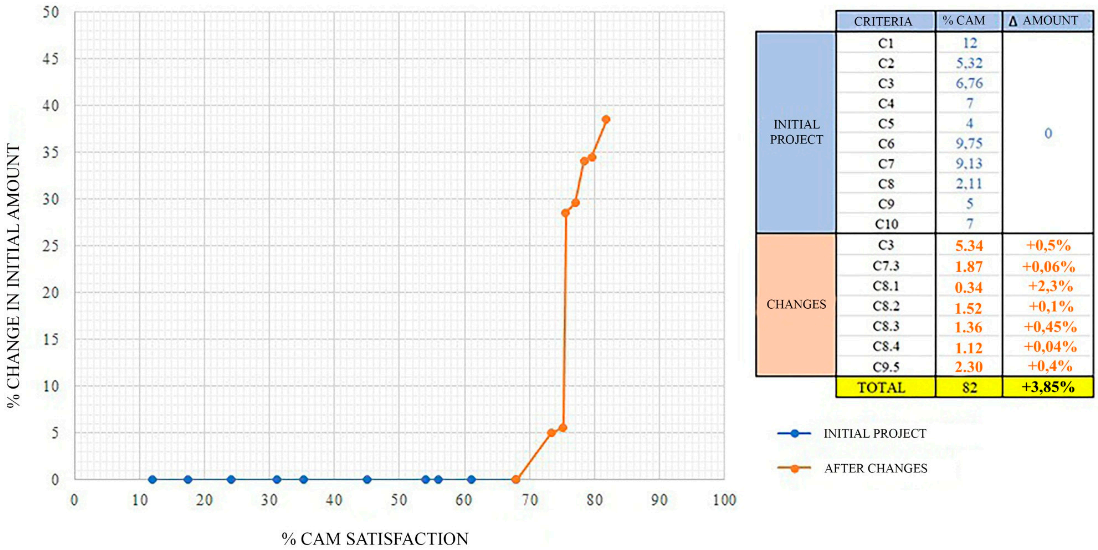


Figure 8. Percentage graph of satisfaction of CAM-costs of interventions.

The economic aspect could be one of the objectives behind the choice of the integrative interventions necessary for the improvement of the environmental performance of the project. However, the choice of priorities for action must be assessed on a case-by-case basis and depend on the type of objective to be achieved: Economic savings, higher scores and greater compliance with environmental requirements.

6. Conclusions

The Italian Minimum Environmental Criteria (CAM) represent, in theory, a valid regulatory tool for the implementation of sustainability policies initiated by the Commission of The European Communities [33]. The obligation to apply these parameters is very recent, so there are no methodological studies in the literature aimed at verifying the application in real cases. To date, the contracting authority does not have a parametric model for assessing whether the environmental requirements imposed by the regulations have been met (or exceeded). The methodology developed makes it possible to analyse any project (new construction or redevelopment of groups of buildings) and to obtain a score according to the peculiarities of the individual project: The analysis of the case studies identified gives different results, even though they are similar projects. The mathematical relationships allow to identify objectively, a score for each criterion and then to compare them in order to obtain an overall view of the project; the results obtained are specific to each project as they vary depending on the characteristics of the site, and the needs and peculiarities of the project itself. The study proposed here is aimed, in perspective, at the drafting of Project Standards, as an appendix to the Italian CAM, or guidelines, which can allow the contracting stations to assess the level of sustainability of a project for the construction or renovation of a group of buildings, with a double objective: To verify the compliance of the project with the parameters of the CAM, and for the awarding of points, for the purpose of awarding contracts, in case of exceeding the above thresholds.

The method tested is also able to provide useful indications to investors, in order to orient themselves, among a series of projects, towards the one most suitable for the award of the contract [21].

The adoption of traditional environmental certification protocols (LEED, BREEAM, and ITACA, just to mention the most used), even though based on common principles, is not sufficient to meet the CAM criteria, since it is necessary to verify conformity for each individual criterion, which must be demonstrated in the chosen certification. The Italian regulation [13,14] hopes that the international protocol organizations will define the verification and/or compatibility grids of the criteria and requirements, contained in the respective protocols, with respect to the criteria included in the CAM.

Table 16 shows the comparison between the weights (by macro-category) of the parameters defined in this study, and the parameters of the international protocols (rating systems) derived from the literature of the sector [34–37].

Table 16. Comparison between the weights of the parameters, by macro-category, between the CAM decree and international environmental protocols (rating systems).

	LEED	**BREEAM**	**ITACA**	**CAM**
	(generic for all types of new construction)	(generic for all types of new construction)	(generic for all types of new construction)	(specific for groups of buildings)
SITE	21%	18%	5%	26%
RESOURCES	56%	50%	44%	36.6%
ENVIRONMENTAL PRESSURES	4%	12%	18%	25.7%
INDOOR QUALITY	15%	11%	14%	
SERVICES		9%	19%	11.7%
GENERAL QUALITIES	4%			
	100%	100%	100%	100%

The following considerations emerge from the values shown in Table 16: The model tested in this study, in relation to the environmental assessment of an intervention for the design of an urban district, favours the factors that concern the protection of the site and the environmental pressures, with a slight reduction in resources and services. It should be noted that the absence of the parameter indoor quality is due to the fact that this factor is considered in other technical specifications of the CAM (technical specifications of the building—article 2.3 of the decree). In the same way, the general qualities are provided for in a specific section of the CAM (article 2.6 of the decree).

The final consideration that emerges from the comparison, therefore, is that the parameters of the CAM guarantee the possibility of specific evaluation for each type of intervention (on a scale of neighbourhood, building, and building components), compared to the parameters of international protocols that are generalized and adaptable, in an undifferentiated manner, for each type of intervention.

It is hoped, therefore, that this model can be recognized and adopted at an international level, overcoming the generalized approach of the traditional protocols of the rating system.

Author Contributions: E.S., G.D.R. and A.S. designed and structured the article. E.S. deepened the analysis of the current environmental legislation, through the comparison between the international protocols of sustainability, with the Minimum Italian Environmental Criteria. E.S. also deepened the scientific framework of the contribution, within the international scientific community. G.D.R. defined the objectives, deepened the methodological approach, through the identification of significant indicators, and conceived the strategic project hypotheses. A.S. contributed to the development of the method, based on the objectives set and the application of the method to the case study. A.S. and G.D.R. also contributed to the drafting of tables and graphs summarizing the results obtained.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Minimum environmental criteria—technical specifications for groups of buildings.

1. Naturalistic and landscape integration (*)
The project must indicate a selection of tree and shrub species to be planted in these areas, taking into account the function of absorption of pollutants in the atmosphere, and regulation of the microclimate and using species that have the following characteristics: reduced water requirement; resistance to phytopathology; absence of harmful effects on human health (allergenic, stinging, thorny, poisonous, etc.).
1.1 Conservation of habitats in the area
2. Green areas design (*)
The project must include actions to facilitate subsequent management and maintenance, so that the positive effects of adopting the environmental criteria adopted in the project can continue. During the execution of the works, techniques for the maintenance of the existing green heritage must be adopted with control interventions (e.g., mowing) prior to the flowering period in order to avoid the spread of pollen. 2.1 Using native plant species with low allergen pollens 2.2 In the case of species with moderate to high allergenic power, favour female plants, sterile or with entomophilous pollination 2.3 Do not use stinging, thorny or toxic plant species (es. *Gleditsia triacanthos* L.—Spino di Giuda, *Robinia pseudoacacia* L.—*Falsa acacia*, Pyracantha—Piracanto, *Elaeagnus angustifolia* L.—Olivagno) or toxic (es. *Nerium oleander* L.—Oleandro, *Taxus baccata* L.—Tasso, *Laburnum anagyroides* Meddik—Maggiociondolo) 2.4 Use deep-rooting herbaceous species in the case of green areas with steep slopes or subject to landslides 2.5 Do not use tree species with fragile roots, stems or foliage that could cause damage in the event of intense weather events
3. Soil consumption reduction and maintenance of soil permeability (*)
The project must ensure a reduction in soil consumption by containing the new building, increasing the permeable surface area and using draining materials. 3.1 Avoiding the construction of new buildings or the extension of existing buildings in protected areas 3.2 Permeable land area of not less than 60% of the unbuilt project area not built 3.3 Area to be allocated to green areas equal to at least 40% of the project area not built on and 30% of the total area of the lot 3.4 In public green areas, at least 40% tree cover (trees at least 5 m high) and at least 20% shrub cover (bushes or hedges) with native plant species must be guaranteed 3.5 Use of draining materials (capable of absorbing rainwater and disposing of it underground in a natural way) for pedestrian and vehicular urbanised areas 3.6 In the execution phase, a surface scotic of at least 60 cm must be provided for the areas where excavations and embankments are planned
4. Conservation of morphological characters (*)
The project must justify the choice of suitable and functional plant species for the site of inclusion. The best possible vegetative conditions and the quality of the substrates must be guaranteed. Instructions must be given on the next technique for the maintenance of green areas. 4.1 Maintaining existing morphological profiles, i.e., preserving the natural course of the land in which the project will be carried out
5. Energy supply from renewable sources (*)
The project must provide for the reduction of greenhouse gas emissions into the atmosphere, through the use of plants powered by renewable sources. The share of coverage by renewable sources of the energy needs of the complex of buildings cannot be less than the sum of the specific shares of the individual buildings, as increased in accordance with the provisions of criterion 2.3.3 below (e.g., in the case of a complex made up of two buildings A and B with different uses and requests for coverage by different renewable sources for each of the two buildings, the coverage by renewable sources of the overall energy needs is increased by a share of at least 10%). Is required an energy supply system capable of covering part or all of the requirements through one or more of the following systems: 5.1 Construction of cogeneration/trigeneration plants 5.2 Installation of photovoltaic parks 5.3 Installation of solar thermal collectors for domestic hot water heating 5.4 Installation of low-enthalpy geothermal systems 5.5 Installation of heat pump systems 5.6 Installation of biomass systems

Table A1. *Cont.*

6. Reduction of the impact on the microclimate and air pollution (*)
In order to reduce emissions into the atmosphere and limit the effects of solar radiation (heat island effect), the design of new buildings or the renovation of existing buildings must provide for the creation of a green area with a high biomass that ensures adequate absorption of pollutant emissions into the atmosphere and promotes sufficient evapotranspiration, in order to ensure an adequate microclimate. For new planting areas, native tree and shrub species with reduced water requirements, resistance to phytopathology and a preference for species with predominantly entomophilous reproductive strategies should be used. A management and irrigation plan for green areas must be prepared. 6.1 Use plant species with adequate capacity to absorb CO_2 so as to ensure evapotranspiration and promote an adequate microclimate (for the types of plant species to be used see the table in the decree of 11 October 2017 [13]) 6.2 Use permeable materials for pedestrian and driveway areas with an SRI Index of at least 29, to facilitate proper rainwater drainage [13]) 6.3 The use of garden roofs should be preferred for roofs. 6.4 For roofs other than garden roofs, materials with an SRI index of 29 for slopes greater than 15% and 76 for slopes less than or equal to 15% must be used.
7. Reduction of the impact on the surface and underground river basin system (*)
The project should include actions aimed at the maintenance and conservation of river ecosystems and corresponding riparian strips, in order to ensure the proper flow of rainwater and reduce the risk of erosion of these ecosystems. 7.1 To preserve and/or restore the naturalness of river ecosystems, river beds and their riparian belt by avoiding the discharge of untreated waste water. 7.2 Ordinary and extraordinary maintenance through the removal of waste and woody material deposited along the riverbed and in the ditches 7.3 Realize first rain water purification plants (first 5 mm of each independent rain event) from draining surfaces subject to pollution 7.4 Preventing or preventing erosion, compaction, landslides or floods (gullies or consolidation of banks and slopes along ditches) 7.5 Preventing the release of pollutants into the soil and subsoil through control and purification measures
8. Primary infrastructure (*)
The project will have to include: *the use of "cold" type flooring (reinforced grass, brick, light stone, cobblestone, gravel, wood, limestone and opting for permeable self-locking);* *the conveyance of unpolluted water (from pavements, pedestrian or cycle paths and areas, gardens, etc.) into collection basins for reuse for irrigation or to feed the storage boxes of toilets. The water coming from draining surfaces subject to pollution (driveways, car parks) must be previously conveyed to purification and de-oiling systems, also of a natural type;* *in order to minimize water consumption, installation of automatic drip irrigation systems (reusing rainwater), powered by renewable energy sources;* *special areas for the separate collection of waste from residences, offices, commerce, etc., such as paper, cardboard, glass, aluminium, steel, plastic, textiles/leather/leather, rubber, wet, WEEE;* *realization of canalizations of the technological networks foreseen, for a correct management of the space in the subsoil.*
8.1 Road system (Interventions for parking areas)
8.1.1 Coverage with suitable masts equal to at least 10% of the gross area 8.1.2. The perimeter shall be bounded by a green belt at least 1 m high and more than 75% opaque. 8.1.3 Creating roofs with photovoltaic shelters to serve the lighting system of the car park 8.1.4 Provide space for motorcycles, mopeds and bicycle racks based on the number of potential inhabitants
8.2 Collection, purification and reuse of rainwater
8.2.1 Create a system for the purification and de-oiling of water coming from polluting surfaces according to UNI/TS 11445 "Installations for the collection and use of rainwater for uses other than human consumption -Design, installation and maintenance" [38] and the UNI EN 805 standard "Water supply—Requirements for systems and constituents outside buildings"
8.3 Public green areas irrigation network
8.3.1 Use drip irrigation systems powered by renewable energy sources designed according to UNI/TS 11445 standard [38]
8.4 Material and waste collection and storage areas
8.4.1 Special areas must be provided for, which may be used for the local separate collection of waste from residences, offices, commerce, etc. such as paper, cardboard, glass, aluminium, steel, plastic, textiles/leather/leather, rubber, wet, WEEE, in line with municipal regulations of waste management.

Table A1. *Cont.*

8.5 Public lighting system
8.5.1 Designing a public lighting system respecting the requirements of the CAM document "Lighting" (decree 23 December 2013) [39]
8.6 Subservices/channels for technological infrastructures
8.6.1 Creating channels to place all technological networks in order to properly manage underground space
9. Secondary infrastructure and sustainable mobility (*)
The project must provide the necessary infrastructure to reduce the movement of people. In addition, it must ensure and encourage sustainable mobility, through the use of bicycles or environmentally friendly shuttles, in order to reduce the environmental pressure associated with the movement of people. 9.1 Provide a mix of residences, workplaces and services to contain travel (expressed in% of internal travel) 9.2 To realize public services or metropolitan stations at short distance less than 500 m from the houses, in case of residential projects; metropolitan stations at less than 800 m and/or railway stations at less than 2.000 m from the new complex. 9.3 Provide shuttle services to reach public services (if stations are not available at less than 800 m) 9.4 Bicycle racks at interchange points 9.5 Network of protected footpaths and/or cycle paths with suitable tree and/or shrub accommodation
10. State of the environment report (*)
10.1 The planned interventions must guarantee an environmental improvement of the site, through the preparation of a report (Report on the State of the Environment) drawn up by a qualified professional who reports on the ante-operam status, the planned interventions and the post-operam status.

(*) The indicators and sub-indicators have been described briefly. More detailed information for each of them can be found in the CAM decree [13]. In order to demonstrate compliance with this criterion, the designer must submit a technical report, with annexes to the graphic works, highlighting the ante-operam status, the planned interventions, the consequent achievable results and the post-operam status. If the project is subject to a verification phase valid for the subsequent certification of the building according to one of the protocols of energy/environmental sustainability of buildings (rating systems) at the national or international level, compliance with this criterion can be demonstrated if the certification meets all the requirements relating to environmental performance referred to in this criterion. In such cases, the designer is exempted from the presentation of the above documentation, but the presentation of the drawings and/or documents required by the specific sustainable building certification protocol pursued is required.

References

1. IPCC. *Climate Change 2007, Synthesis Report*; Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change; Pachauri, R.K., Reisinger, A., Eds.; IPCC: Geneva, Switzerland, 2007; Available online: https://www.ipcc.ch/reports/ (accessed on 6 May 2019).
2. GCP-Global Carbon Budget team: Pep Canadell, Philippe Ciais, Thomas Conway, Christopher B. Field, Corinne Le Quéré, Richard A. Houghton, Gregg Marland, Michael R. Raupach. Available online: https://www.globalcarbonproject.org/carbonbudget/archive/2008/CarbonBudget_2008.pdf (accessed on 6 May 2019).
3. Earth System Research Laboratory–Global Monitoring Division. Trends in Atmospheric Carbon Dioxide. Available online: http://www.esrl.noaa.gov/gmd/ccgg/trends (accessed on 6 May 2019).
4. Lüthi, D.; Le Floch, M.; Bereiter, B.; Blunier, T.; Barnola, J.M.; Siegenthaler, U.; Raynaud, D.; Jouzel, J.; Fischer, H.; Kawamura, K.; et al. High-Resolution Carbon Dioxide Concentration Record 650,000-800,000 years Before Present. *Nature* **2008**, *453*, 379–382. Available online: https://www.researchgate.net/publication/5370384 (accessed on 6 May 2019). [CrossRef] [PubMed]
5. Comunicazione Della Commissione al Consiglio e al Parlamento Europeo Politica integrata dei prodotti Sviluppare il concetto di "ciclo di vita ambientale". Bruxelles, 18.6.2003 COM (2003) 302. Available online: https://eur-lex.europa.eu/lexuriserv/lexuriserv.do?uri=com:2003:0302:fin:it:pdf (accessed on 7 May 2019).
6. Mokrzecka, M. Influence of Building Shape and Orientation on Heating Demand: Simulations for Student Dormitories in Temperate Climate Conditions. Volume: E3S Web of Conferences 44 July 2018, doi:10.1051/e3sconf/20184400117. Available online: https://www.researchgate.net/publication/326150554 (accessed on 22 May 2019).

7. Hidayah, N.; Rodzi Ismail, M. A Review on the Impact of Building Geometry Factors of Glass Façade High-rise Buildings. In Proceedings of the 3rd International Conference-Workshop on Sustainable Architecture and Urban Design 2017 (ICWSAUD2017), Penang, Malaysia, 13–15 November 2017; Available online: https://www.researchgate.net/publication/327070097 (accessed on 22 May 2019).
8. Sicignano, E.; Di Ruocco, G.; Melella, R. Mitigation Strategies for Reduction of Embodied Energy and Carbon, in the Construction Systems of Contemporary Quality Architecture. *Sustainability* **2019**, *11*, 3806. [CrossRef]
9. Legge 27 Dicembre 2006, n. 296, Disposizioni Per la Formazione del Bilancio Annuale e Pluriennale Dello Stato (Legge finanziaria 2007). Available online: http://www.parlamento.it/parlam/leggi/06296l.htm (accessed on 8 May 2019).
10. Canton, M. *Codice Degli Appalti e Norme Collegate: Aggiornato al 1° Gennaio 2019-5a ed*; Epub: Mario Canton, 2019.
11. Commission Staff Working Document–Technology Assessment Accompanying the document–Energy Technologies and Innovation–Brussels, 2.5.2013, SWD (2013) 158 Final, p.68, 2013. Available online: https://ec.europa.eu/energy/sites/ener/files/swf_2013_0158_en.pdf (accessed on 13 May 2019).
12. Crepaldi, G. Gli acquisti eco-sostenibili nel nuovo Codice dei Contratti Pubblici Italiano: Considerazioni sul life cycle costing. *Rev. do Direito* **2018**. [CrossRef]
13. Decreto 11 ottobre 2017–Criteri Ambientali Minimi per L'affidamento di Servizi di Progettazione e Lavori per la nuova Costruzione, Ristrutturazione e Manutenzione di Edifici Pubblici. Available online: http://www.anit.it/wp-content/uploads/2017/11/DM-11-ottobre-2017.pdf (accessed on 5 April 2018).
14. Cellura, T.; Cellura, L. *Il Nuovo Manuale dei Criteri Minimi Ambientali in Edilizia*; Maggioli Editore, Santarcangelo di Romagna: Rimini, Italy, 2018; pp. 7–8.
15. Fantozzi, F.; Gargari, C.; Rovai, M.; Salvadori, G. Energy Upgrading of Residential Building Stock: Use of Life Cycle Cost Analysis to Assess Interventions on Social Housing in Italy. *Sustainability* **2019**, *11*, 1452. [CrossRef]
16. Bellia, L.; Borrelli, M.; De Masi, R.F.; Ruggiero, S.; Vanoli, G.P. University building: Energy diagnosis and refurbishment design with Cost-Optimal approach. Discussion about the effect of numerical modelling assumptions. *J. Build. Eng.* **2018**, *18*, 1–18. [CrossRef]
17. Corrado, V.; Ballarini, I.; Paduos, S.; Tulipano, L. A new procedure of energy audit and cost analysis for the transformation of a school into a nearly zero-energy building. *Energy Procedia* **2017**, *140*, 325–338. [CrossRef]
18. Sharif, S.A.; Hammad, A. Simulation-Based Multi-Objective Optimization of Institutional Building Renovation Considering Energy Consumption, Life-Cycle Cost and Life-Cycle Assessment. *J. Build. Eng.* **2018**, *21*, 429–445. [CrossRef]
19. Stokes, E.; Akram, S. *Project Management in Construction*; McGraw-Hill: New York, NY, USA, 2008; ISBN1 8389780615. ISBN2 9788389780614.
20. Plebankiewicz, E.; Juszczykorcide, M.; Kozik, R. Trends, Costs, and Benefits of Green Certification of Office Buildings: A Polish Perspective. *Sustainability* **2019**, *11*, 2359. [CrossRef]
21. Di Ruocco, G.; Nesticò, A. Archaeological Site Conservation and Enhancement: An Economic Evaluation Model for the Selection of Investment Projects. *Sustainability* **2018**, *10*, 3907. [CrossRef]
22. Gerundo, R.; Fasolino, I.; Grimaldi, M. ISUT Model. A composite index to measure the sustainability of the urban transformation. In *Smart Energy in the Smart City. Urban Planning for a Sustainable Future*; Papa, R., Fistola, R., Eds.; Springer: Berlin/Heidelberg, Germany, 2016; pp. 117–130, Scopus code: 2-s2.0-85013449838.
23. Grimaldi, M.; Pellecchia, V.; Fasolino, I. Urban Plan and Water Infrastructures Planning: A Methodology Based on Spatial ANP. *Sustainability* **2017**, *9*, 771. [CrossRef]
24. Munier, N. *Multicriteria Environmental Assessment-A Practical Guide*; Kluwer Academic Publishers: Dordrecht, The Netherlands, 2004.
25. Brown, S. A primer on Q Methodology. *Operant Subj.* **1993**, *16*, 91–138.
26. Leskinen, P. Comparison of alternative scoring techniques when assessing decision maker's multi-objective preferences in natural resource management. *J. Environ. Manag.* **2007**, *85*, 363–370. [CrossRef] [PubMed]
27. Belgiorno, V.; Naddeo, V.; Zarra, T. *Tecniche per la Valutazione di Impatto Ambientale*; ASTER onlus Editore, Fisciano: Salerno, Italy, 2011.
28. Saaty, T.L. *The Analytic Hierarchy Process*; McGraw-Hill: New York, NY, USA, 1980.
29. Handfield, R.; Walton, S.V.; Sroufe, R.; Melnyk, S.A. Applying environmental criteria to supplier assessment: A study in the application of the Analytic Hierarchy Process. *Eur. J. Oper. Res.* **2002**, *141*, 70–87. [CrossRef]

30. Franeka, J.; Krestaa, A. Judgment scales and consistency measure in AHP. In Proceedings of the Enterprise and the Competitive Environment 2014 conference (ECE 2014), Brno, Czech Republic, 6–7 March 2014; p. 166.
31. Carter, L.W.; Kamath, J. Questionnaire checklist for cumulative impacts. *Environ. Impact Assess. Rev.* **1995**, *15*, 311–339.
32. Zidane, Y.J.; Johansen, A.; Ekambaram, A. Project Evaluation Holistic Framework–Application on Megaproject Case. *Procedia Comput. Sci.* **2015**, *64*, 409–416. [CrossRef]
33. Comunicazione Della Commissione Europea–Sviluppo sostenibile in Europa per un mondo migliore: Strategia dell'Unione Europea per lo Sviluppo Sostenibile. Bruxelles, 15.5.2001 COM (2001)264. Available online: https://eur-lex.europa.eu/legal-content/it/txt/pdf/?uri=celex:52001DC0264&from=en (accessed on 7 May 2019).
34. LEED v4 for Building Design and Construction. Available online: https://www.certificazioneleed.com/blogcl/wp-content/uploads/2017/10/LEED-v4-BDC-Italian_0.pdf (accessed on 16 July 2019).
35. Breeam International New Construction 2016. Available online: https://hbreavis.com/wp-content/uploads/2017/06/BREEAM-International-New-Construction-2016.pdf (accessed on 16 July 2019).
36. Protocollo Itaca 2009. "Norme per l'edilizia sostenibile" "Linee Guida e Disciplinare Tecnico" Valutazione Energetico–Ambientale Edifici Residenziali: Nuova Costruzione e Recupero. Available online: http://www.itaca.org/documenti/protocollo_itaca/lineeguidaItaca.pdf (accessed on 16 July 2019).
37. Tam, V.Y.; Le, K.N. *Sustainable Construction Technologies: Life-Cycle Assessment*; Butterworth-Heinemann: Oxford, UK, 2019.
38. Norma UNI/TS 11445, Impianti per la raccolta e utilizzo dell'acqua piovana per usi diversi dal consumo umano-Progettazione, installazione e manutenzione. 2012.
39. Decreto Ministeriale 23 dicembre 2013, Criteri ambientali minimi per l'acquisto di lampade a scarica ad alta intensità e moduli led per illuminazione pubblica, . . . , e successivo Decreto 27 settembre 2017. Available online: https://www.gazzettaufficiale.it/eli/id/2014/01/23/14A00271/sg (accessed on 14 November 2018).