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Archaeological Site Conservation and Enhancement: An Economic Evaluation Model for the Selection of Investment Projects

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Abstract: For sustainable development of the territory, public administrations must guarantee the efficient allocation of available resources. This is also important for the conservation and enhancement of archaeological sites, able to generate multiple effects—not only strictly cultural, but also social, environmental, and financial—in their reference area. Although today, decisions on investments to be implemented are seldom supported by logical and operational methodologies able to rationalize the selection processes. Thus, proposing and implementing survey instruments to optimize the use of funds, in the light of a technical-economic process that is valid on a methodological level—that is repeatable and not complex to use—is likely necessary. This paper proposes a multicriteria evaluation model for the choice among projects concerning archaeological sites. According to pre-established criteria, the analysis protocol is defined using the algorithms of discrete linear programming, already successfully used in urban and territorial planning. These algorithms are written in A Mathematical Programming Language (AMPL); software which allows the consideration of several—both technical and economic—constraints that the system imposes. The model is verified by a case study, highlighting its potential and limits, as well as outlining future research perspectives.

Keywords: archaeological sites; environmental protection; economic evaluation; multicriteria analysis; linear programming

1. Introduction

The elaboration of plans and projects for the conservation and for the enhancement of archaeological sites requires not only historical investigations and technical-design elaborations, but also economic evaluations able to integrate the sustainability themes with a view to intergenerational equity in the decisional process. These aspects are not suitably considered if the traditional income and economic growth indicators are used as tools to express a judgment on territorial policies [1,2]. Multicriteria methodologies are imposed instead, through which it is possible to rationalize choices driven by multiple, complex, and often conflicting objectives. Indeed, it is well known that different effects of the projects are perceived in qualitative terms and are not fully translatable into market terms, however, there is the need to take them into account in the evaluation framework. Multicriteria analyses consider the effects of the projects in their dimensions, recognizing the multidimensionality of the evaluation criteria and, therefore, rejecting the attempt to translate the multiple effects into monetary terms. The comparison among projects is thus done through multidimensional profiles, not homogenized with only the monetary scale but obtained with the use of both quantitative and qualitative scales. In practice, then, the evaluator can select among the different analysis techniques that have been developed over time [3–9].

Actually, the selection of investment options for archaeological areas has to take into account criteria that are not only financial, but also social, cultural, and environmental. This is aimed at maximizing social utility, on the one hand by increasing the production of goods and services, and on the other hand by preserving cultural and environmental resources and ensuring social justice [10]. To this end, the use of economic models, to help with decision making that takes into account the multidimensionality of the problem, becomes important [11–15].

In the exposed sense, the evaluation of the projects in archaeological areas follows the phases of:

(1) identifying financial, social, cultural, and environmental objectives of interventions;
(2) defining the criteria able to measure the ability of the projects to pursue the objectives;
(3) attributing a performance indicator to each criterion.

Therefore, the valuation of the shares is to be based on a set of performance indicators that are defined according to multiple criteria [16].

If the problem consists of selecting a project portfolio, the Operative Research provides optimization algorithms useful for considering several analytical criteria simultaneously by writing an algebraic expression called *objective function* [17]. These algorithms allow the introduction of various constraints which, consequently, can be easily adaptable to the various real situations that may arise.

In Section 2, the principles on which the sustainable management of cultural heritage is founded today are first exhibited. Section 3 then expresses the concepts of conservation and enhancement of archaeological sites in order to establish the criteria for the multicriteria economic evaluation of the projects that concern them. At this point, starting from essential notes on the techniques of Operative Research useful to solve project portfolio selection problems, Section 4 proposes a model of multicriteria analysis with the aim of establishing the optimal allocation of the scarce resources among investments on archaeological sites. The model, written with A Mathematical Programming Language (AMPL) in the logic of Discrete Linear Programming (DLP), is tested in a case study, illustrated in Section 5. The results and political implications of the research are finally set out in Section 6.

2. Sustainable Management of Cultural Heritage

The concept of conservation of cultural heritage, introduced by Italian and European legislation [18] and starting from the 1931 Athens Restoration Charter, was developed with the Venice Charter for the restoration and conservation of monuments and sites of 1964 [19]. This concept, which is the basic assumption in the approach to cultural heritage, has progressively been evolved, over time, to take on a broader meaning: that of an integrated conservation, given the complexity and multiplicity of values characterizing the asset to be protected. In particular, the 1975 Amsterdam Declaration [20] defines the concept of integrated conservation, with the aim of ensuring not only the protection of architectural and environmental worthy buildings, but also incorporating this protection into the more general theme of remodeling the contemporary city, with the precise objective of improving quality of life [21].

The concept of valorization (as defined by the abovementioned code of cultural heritage and landscape) was introduced with the aim of not limiting the approach to cultural heritage to a static conservation or passive defense, but by encouraging dynamically designed protection strategies, including specific profiles of knowledge, restoration, enhancement, and use.

The concept of sustainable management of cultural heritage, elaborated for the first time in the Krakow Restoration Charter in 2000, deals with conservation and enhancement issues with specific attention to change, transformation, and development dynamics, as well as the optimization of operating costs, with the aim of obtaining constant control of the dynamics of change itself, of appropriate choices and results. As an essential part of the conservation process, the risks to which the assets may also be subject to in exceptional cases have also to be identified, and appropriate prevention systems and intervention and emergency plans have to be provided. In a broad sense, conservation of cultural heritage must be an integral part of spatial planning and management, thus contributing to the sustainable development of communities [22].

Recently, great attention to the enhancement of interconnections between cultural heritage and its environment has been posed by the international community, which recognizes the strategic role of cultural heritage for sustainable development. Cultural heritage, as a key to sustainable development, is the subject of the Hangzhou Declaration [23], adopted on 17 May 2013, but also of the Council of Europe conclusions of 21 May 2014 about cultural heritage, as a strategic resource for a sustainable Europe, which invites member states to "enhance the role of cultural heritage in sustainable development, focusing on urban and rural planning and on redevelopment and recovery projects" [24].

The Hangzhou Declaration also highlights the need for a new combination of tradition (understood as tangible and intangible cultural heritage) and innovation, for the resilience of communities to environmental disasters and climate change: "The appropriate conservation of the historic environment, including cultural landscapes, and the safeguarding of relevant traditional knowledge, values and practices, in synergy with other scientific knowledge, enhances the resilience of communities to disasters and climate change". States are also invited to "adopt an integrated approach to policies concerning cultural, biological, geological and landscape diversity". Furthermore, the Hangzhou Declaration recognizes the need to "raise awareness of the economic potential of cultural heritage and to use it, and to consider the specific character and interests of cultural heritage in planning economic policies, in order to make full use of the potential of cultural heritage as a factor in sustainable economic development" [25].

The Heritage Culture Counts for Europe project aims to evaluate the impacts of cultural heritage through the mapping and analysis of a wide range of studies, carried out in Europe and the rest of the world, presenting concrete and documented evidence of positive impacts of cultural heritage on economy, society, environment, and culture and, therefore, "on how cultural heritage, qualitatively and quantitatively, represents a key contribution to the Europe 2020 strategy. A European Strategy for smart, sustainable and inclusive growth" [26]. The project highlights that "at the present time, the three main actors of reference i.e., public administrations/government agencies, cultural organizations and research institutes continue not to use an integrated approach to heritage" [27].

Therefore, wanting to incorporate the regulatory guidelines that have been evolved over the years, a correct strategic approach to cultural heritage in general and archaeological sites in particular, must combine the demands of conservation and enhancement with those of resource management, in compliance with the policies of sustainable development of the territory, through an integrated approach, able to involve the different stakeholders entailed in the process [28].

However, in modern and contemporary practice, strategies for the protection and enhancement of cultural heritage rarely take into account the surrounding environment, limiting themselves to the prediction of episodic, mostly punctual, interventions [29]. So, both because of too much sectorial and limited programming, and due to objective financial limits, the process proves to be unsustainable in the majority of cases [30].

The present study, therefore, intends to approach the problem of conservation and sustainable exploitation of a cultural asset, specifically an archaeological site, with a specific focus on the technical-economic analysis of the process.

3. Actions for the Conservation and Enhancement of Archaeological Sites

Archaeological parks are defined as protected areas reserved for public access, entertainment, and education. They contain both archaeological remains and underlying and underground materials, and must be seen "as a tool for the conservation of archaeological sites on the one hand, and their presentation and interpretation as a means of understanding the shared past of humanity on the other hand" [31]. Furthermore, the archaeological park favors education because it expresses the concept of shared humanity and can also be an example of how sustainable management must be conducted in vulnerable places where important cultural and natural resources are present.

In Italy, the Code of Cultural Heritage distinguishes between an archaeological park and archaeological area [32]. In particular, "the archaeological area is a site characterized by the presence of fossil remains or prehistoric or ancient artefacts or structures". The archaeological park is instead understood as "a territorial area characterized by important archaeological evidence and by the presence of historical, landscape or environmental values, equipped as an open-air museum". Therefore, compared to the archaeological park, the archaeological area presents mostly isolated testimonies, in most cases foreign or semi-unknown to the international tourist circuit [33].

It should be noted that in the last decades the valorization policies have mainly favored the archaeological parks (in Italy examples are Paestum, Pompeii, Erculaneum, Oplonti, etc.), i.e., the most visited and renowned stages of tourist itineraries. In many cases, the other archaeological areas—defined as second or third level of interest, based on the number of visitors—have been abandoned to themselves, surviving only thanks to a minimum often insufficient maintenance, which is due to limited funding available but above all the absence of a long-term valorization strategy. Only recently have there been cases of management for integrated valorization, aimed at connecting neighboring archaeological areas and the consequent valorization on a territorial scale [34–36].

In this paper, in more general terms do we refer to the archaeological site. With respect to it, regardless of the greater or lesser importance of its values, it is necessary to simultaneously bring into account conservation and enhancement needs.

However, what can the interventions for conversation and the enhancement of archaeological sites be?

The reference literature allows us to outline the requisite framework in Table 1, which shows the main actions aimed at the conservation and sustainable valorization of the archaeological site and the context in which it is inserted [31,37].

Table 1. Actions for the conservation and the valorization of archeological sites.

1. Conservation
1.1. Prevention, maintenance, and restoration actions • *Prevention:* activities suitable to limit the risk situations connected to the cultural asset in its context (knowledge, analysis, monitoring, etc.). • *Maintenance:* interventions aimed at checking the conditions of the cultural asset and the maintenance of integrity, functional efficiency, and identity of the good and its parts. • *Restoration:* intervention directed to the asset through a series of operations aimed at material integrity and the recovery of the asset itself.
2. Valorization *2.1. Actions aimed at improving fruition* • Use of augmented reality for the enhancement of archaeological emergencies • Lighting design for monuments enhancement • Accessibility of the archeological area, for an expanded fruition
2.2. Actions aimed at promoting historical and cultural value • Regular opening and updating of the website • Organization of thematic events aimed at enhancing local traditions, at various historical periods • Insertion of the archaeological site within experiential cultural itineraries and sustainable tourism
2.3. Actions aimed at the cultural and economic impact on the context • Traditional infrastructural accessibility • Parking areas • Primary services • Complementary services (reception, bar, restaurant, Bed & Breakfast, bookshop, etc.)

The actions defined in Table 1 lead to a process of integrated and sustainable valorization through a multi-tasking and multi-scale approach, able to take into account the many tangible and intangible factors that characterize the cultural heritage, in this case the archaeological site [38]. This process passes, first of all, through the knowledge, identification, and analysis of the factors that characterize the archaeological site as well as its territorial context, with reference to the physical-material (geographic, infrastructural, typological-morphological, architectural, constructive, material) and immaterial (historical, political, social, cultural, traditional) characteristics. These are all factors allowing the detection of the stratified identities of the cultural asset, on the basis of which the new strategic process and the related management plan must be activated [39].

Archaeological sites, if properly organized, are able to promote and enhance their context, even in areas that are lagging behind, improving their ability to attract visitors and thus launching a virtuous cycle that the entire resident population can benefit from, expecting cultural repercussions as well as employment and financial opportunities [40]. In this sense, in order to select the projects that best pursue the multiple objectives of conservation and enhancement of archaeological sites, it is necessary to implement logics of multi-criteria economic analysis, to be defined on the basis of multiple and different criteria. These can be established according to the ability of the investments to reach the objectives that the actions classified in Table 1 express. In essence, these actions define the panorama of the requirements of the generic project of protection and enhancement of the archaeological site, thus allowing identification in a consistent manner of the criteria on which the analysis model proposed in the following paragraph is to be based.

Among the multi-criteria decision analysis techniques, the nature of the evaluation problem *de quo*, which requires the selection of investment options, as well as the object of the study, i.e., the archaeological site, lead us to choose the algorithms of linear programming, in terms detailed in the next paragraph.

4. An Optimization Algorithm for Multi-Criteria Evaluation of Projects on Archaeological Sites

Operational Research is the discipline that studies, on a quantitative basis, the conceptual models of decision-making processes related to the functioning of organized systems, the methods to predict the behavior of these systems and to identify the choices that optimize their performance, as well as the tools to evaluate the consequences of certain provisions a priori [41,42]. In particular, decision support tools are useful when it is required to manage limited resources to maximize (or minimize) an objective function. Thus, many selection processes can be addressed as optimization models, traceable to a mathematical programming model such as:

$$\begin{cases} \max(\text{o}\min)C(x_1, \ldots, x_n) \\ \varphi_m(x_1, \ldots, x_n) \le b_m \\ x \in X \end{cases} \quad (1)$$

where C(x) is the objective function, (φ_m) the system of constraints to be observed in the calculation of the optimal value, and (x) the set of variables of the problem [43]. The decision problem is then expressed in a formal language expressing the two-way correspondence between real-world relations and mathematical expressions.

The problems of mathematical programming can be classified in one of two ways: (1) *linear programming problems*, if the objective function and the functions that define the constraints are linear; (2) *nonlinear programming problems*, if at least one of the functions defining the problem is not linear.

The hypothesis of linearity finds widespread practical feedback [44,45]. In fact, many real cases can be expressed with sufficient approximation precisely in the terms proposed by linear programming. In particular, this happens with regard to the problems of selection between urban redevelopment projects or for the enhancement of sites with specific functions, even with important historical-architectural values [46,47].

In turn, linear programming problems can be:

a. *of continuous optimization*, with values in R^n;
b. *of whole (or discrete) optimization*, when the values are in Z^n;
c. *mixed*, with both whole and continuous values.

In all cases, choosing the algorithm that best solves the problem in question is fundamental. In fact, the algorithm is associated with an efficiency in terms of resources necessary to determine the solution of the problem. These resources concern the occupied memory and the calculation times, i.e., the times for the algorithm execution.

In the context of the whole linear programming, the main solving algorithms are as follows: *dynamic programming algorithms*, based on Bellman's optimality principle; *implicit enumeration algorithms*, such as Branch and Bound's one (B&B), which are based on the recursive subdivision of the solution space; and *cutting plane algorithms*, like Gomory's one [48].

With the aim of pursuing the multiple objectives of conservation and enhancement of archaeological sites (m, with $m > 1$), which impose a multi-criteria evaluation approach, consider the problem of selection among n projects, not all achievable due to constraints budget.

Such a problem can be summarized by means of linear programming tools. In fact, both the objective function and the relations of the constraints can be expressed in a linear form. Specifically, since the single project cannot be split, the proper algorithms of Linear Discrete Programming (DLP) can be implemented [49].

Among the algorithms of resolution made available by the Operative Research for the selection among n projects, we use B&B's one. Widely applied to solve choice problems with multi-criteria logic, this algorithm allows for the anticipation of the complexity of the problem to be treated with consequent reduction of the calculation time, both with respect to the dynamic programming algorithms and to those of the cutting planes. The B&B is based on a procedure that leads from the resolution of a "difficult" problem to the resolution of two or simpler sub-problems.

Starting from the construction of the admissible solutions tree (*Branch* operation), the solution of the original problem is traced back to the resolution of sub-problems defined on smaller and simpler regions to be solved. Those sub-problems that do not contain the optimal solution (*Bound* operation) are discarded.

To implement the chosen B&B algorithm, we can resort to different software, among which is the algebraic generator of A Mathematical Programming Language (AMPL) models. It allows for the linkage of the algebraic model of the problem with the solver developing the algorithm [50].

It is precisely with AMPL that the model in Table 2 is written for the optimal selection among conservation and valorization of archaeological site projects. The selection is made in the light of four criteria identified according to the objectives described in the previous paragraph:

1. compatibility of interventions with conservation needs in terms of prevention, maintenance, and restoration;
2. level of use of the site following the realization of the investment;
3. ability of the project to guarantee the promotion of the historical and cultural value of the archaeological site;
4. pursuit of financial results.

Table 2. The algorithm for the selection of investment projects on archaeological sites (written in A Mathematical Programming Language (AMPL)).

SELECTION PROBLEM
SETS
set PROJECTS FOR CONSERVATION AND ENHANCEMENT; set INDICATORS; param BUDGET; param INDICATORS_unit {PROJECTS FOR CONSERVATION AND ENHANCEMENT, INDICATORS}; param COST {PROJECTS FOR CONSERVATION AND ENHANCEMENT};
VARIABLES var x {i in PROJECTS FOR CONSERVATION AND ENHANCEMENT} binary;
OBJECTIVE FUNCTION maximize (or minimize) objective: sum {i in PROJECTS FOR CONSERVATION AND ENHANCEMENT, j in INDICATORS} INDICATORS_unit[i, j] · x[i];
CONSTRAINTS s.t. (subject to) constraints_0: sum {i in PROJECTS FOR CONSERVATION AND ENHANCEMENT} COST [i] · x[i] ≤ BUDGET;

The n projects for the conservation and the enhancement of archeological sites (set PROJECTS FOR CONSERVATION AND ENHANCEMENT) are evaluated according to m sustainability indicators (set INDICATORS).

In the section PARAMETERS, the numerical values defining in detail the problem to be solved are explained, these are:

- the available budget (param BUDGET);
- the multi-criteria matrix (param indicators_unit {projects for conservation and enhancement, indicators});
- the carrier that expresses the investment cost for each project (param COST {PROJECTS}).

When the unknown quantity of the problem is defined as (var x {i in PROJECTS} binary), the objective function is:

$$\text{MAXIMIZE (or MINIMIZE) objective: sum \{i in PROJECTS FOR CONSERVATION AND ENHANCEMENT, j in INDICATORS\} indicators\_unit[i, j]} \cdot \text{x[i].}$$

Finally, the COSTRAINT on the overall financial availability is written:

$$\text{s.t. vinc\_0: sum \{i in PROJECTS FOR CONSERVATION AND ENHANCEMENT\} COST[i]} \cdot \text{x[i]} \leq \text{BUDGET.}$$

It turns out that AMPL allows us to structure the model in parametric form. The *.mod* file defines the algorithm without specifying the data that, instead, are written in a specific *.dat* file. The elements of the problem—projects and performance indicators—are treated as sets. The unknown quantities, i.e., the projects to be selected, take on binary value (*var* x *binary*). The objective function is a linear expression maximizing the ability of investments to pursue the multiple objectives of conservation and enhancement of archaeological sites.

Evidently, the model in Table 2 assumes that all the indicators have the same importance for the decision maker. Different weights can be taken into account multiplying the values assumed by the projects evaluated with respect to the j-th criterion to p_j coefficients. This highlights the extreme versatility of the analysis scheme.

5. Case Study

Consider a set of 12 projects proposed for public funding and aimed at the conservation and enhancement of archaeological sites. Because of the limited budget available, projects that can determine the best social, cultural, environmental, and financial repercussions on the territory are going to be financed.

The features of the vast area of interest, the Campania Region in Italy, lead us to evaluate each project according to the following criteria:

1. compatibility of the interventions with conservation needs in terms of prevention, maintenance, and restoration;
2. level of use of the site following the realization of the investment;
3. ability of the project to guarantee the promotion of the historical and cultural value of the archaeological site;
4. pursuit of financial results.

The following corresponding performance indicators are assumed:

(a) compatibility index of interventions (COMPATIBILITY INDEX). A qualitative scale from 1 to 5 is used, with increasing values raising the compatibility of the project with the requirements of conservation;
(b) the average annual number of the site users following the implementation of the interventions (N° USERS);
(c) index of promotion of historical and cultural values (INDEX OF PROMOTION OF HISTORICAL AND CULTURAL VALUES). Based on the opinions provided by experts, the evaluation is expressed on a qualitative scale from 1 to 5, where 1, 2, 3, 4, and 5, respectively, express a very low, low, medium, high, and very high capacity of the project initiatives to favor the promotion;
(d) the Internal Rate of Return (IRR), as inferred from the economic evaluation of the investment.

For the 12 projects, the values of each parameter are shown in Table 3. These values are normalized according to the relation:

$$z_{ij} = \frac{x_{ij} - \mu_j}{\sigma_j} \tag{2}$$

where x_{ij} is the value assumed by the i-th project evaluated according to the j-th indicator, μ_j indicates the arithmetic mean of the values assumed by the *n* projects evaluated according to the same j-th indicator, and σ_j represents the standard deviation of the values x_{ij} corresponding to indicator j.

On the normalized data of Table 4 the multicriteria analysis model is implemented, considering the projects to be selected as binary variables {0,1}, depending on whether the i-th project is included (value 1) or not (value 0) in the investment program.

Table 3. Data matrix. IRR = Internal Rate of Return.

Investment Projects	Cost (Thousands of €)	COMPATIBILITY INDEX	N° USERS	PROMOTION INDEX	IRR
1	2750	2	8500	1	4.35
2	1600	3	12,000	4	6.30
3	2850	1	6500	2	6.12
4	2650	5	28,000	5	11.22
5	1100	3	17,500	2	8.25
6	1400	4	29,000	3	12.40
7	2400	2	14,500	5	9.40
8	3100	1	11,000	3	8.90
9	1680	5	33,000	4	11.65
10	980	4	31,500	5	6.60
11	2800	3	7000	2	4.78
12	1780	3	21,000	5	9.65

Table 4. Matrix of normalized data.

Investment Projects	Cost (Thousands of €)	COMPATIBILITY INDEX	N° USERS	PROMOTION INDEX	IRR
1	2750	−0.74	−0.99	−1.67	−1.47
2	1600	0.00	−0.64	0.40	−0.74
3	2850	−1.48	−1.19	−0.98	−0.81
4	2650	1.48	0.98	1.10	1.08
5	1100	0.00	−0.08	−0.98	−0.02
6	1400	0.74	1.08	−0.29	1.52
7	2400	−0.74	−0.38	1.10	0.41
8	3100	−1.48	−0.74	−0.29	0.22
9	1680	1.48	1.49	0.40	1.24
10	980	0.74	1.33	1.10	−0.63
11	2800	0.00	−1.14	−0.98	−1.31
12	1780	0.00	0.27	1.10	0.50

In algebraic form, the mathematical model of the selection problem includes the objective function and the constraint on the financial allocation available:

$$\begin{cases} \max \sum_{i} (\text{COMPATIBILITY INDEX}_i + \text{N.USERS}_i + \text{PROMOTION INDEX}_i + \text{IRR}_i) \cdot x_i \\ \sum_{i} C_i \cdot x_i \leq \text{BUDGET} \\ x_i \in \{0,1\} (i = 1, \ldots, n) \end{cases} \tag{3}$$

In AMPL, the *.mod* file of Table 2 is associated with the *.dat* file of Table 4, which details the multi-criteria analysis data carried out for each of the 12 conservation and enhancement projects. The *.mod* and *.dat* files are invoked in the AMPL command line, specifying the solver that implements the Branch and Bound algorithm.

Depending on the € 8.5 million budget, the optimal combination is obtained from projects 4, 6, 9, 10, and 12, as indicated in Table 5.

With the aim of allowing the public decision-maker to choose the solution of the evaluation problem closest to his intervention policies, with an *ε-costrained* algorithm we can impose a further constraint on the model:

$$\text{objective}_{(i)} \leq \text{objective}_{(i-1)} - \varepsilon \tag{4}$$

In this way, it is possible to extrapolate, for ε = ‰, the list of the best combinations of projects.

Table 5. Elaborations results.

Combination of Projects	Selected Projects	Total Cost of Investment (Thousands of €)	Value of the Objective Function
1	4-6-9-10-12	8490	17.07
2	2-4-6-9-10	8310	16.32
3	4-5-6-9-10	7810	16.25
4	4-5-9-10-12	8190	15.99
5	6-7-9-10-12	8240	15,92

6. Discussion

Table 5 lists the first five combinations of projects that return the analysis model, associating each of them with the value of the objective function and the investment cost. These are the combinations that, according to the indicated order, allow the best use of public resources.

The optimal combination consists of projects 4, 6, 9, 10, and 12, as indicated at line 1 of Table 5. The corresponding value of the objective function is 17.07, for a total investment cost of 8,490, 000 Euro. Therefore, the available budget of € 8.5 million euros is almost entirely used.

However, as already mentioned, political reasons can lead the public administration to select a combination of investments different from the first in the list. This may happen, for example, due to the need for equalization among areas with different levels of income or infrastructure or services. These reasons may lead to finance projects 2, 4, 6, 9, and 10 (line 2 in Table 5), to which the value 16.32 of the objective function is associated. This value of 16.32 is the best possible if we exclude the first combination provided by the algorithm, i.e., the one that funds projects 4, 6, 9, 10, and 12.

It is evident that by scrolling down the list of selected investments, the values of the objective function decrease, going from the highest value of 17.07 to the one of 15.92. In the light of what has been explained so far, it is clear that a higher value of the objective function expresses the superior capacity of the projects eligible for funding to pursue the multiple objectives of conservation and enhancement of archaeological sites.

7. Conclusions

Archaeological sites are a strategic resource for the development of territories. This is true provided that interventions allow for the pursuit of both conservation and enhancement objectives. In order to verify the effective ability of investments to achieve these objectives, it is essential to use study and economic assessment methods that are able to consider the plurality of social, cultural, environmental, and financial effects, destined to be generated in the reference areas, both in the construction and in the operational phase, therefore, with a typical multi-criteria decision analysis approach.

Downstream of investigations on the issue of sustainable management of cultural heritage and actions for the conservation and enhancement of archaeological sites, the research finds that the economic evaluation of investments on archaeological sites must follow three phases: (1) identification of financial, social, cultural, and environmental objectives of interventions; (2) definition of the criteria able to measure the ability of the projects to pursue the objectives; and (3) attribution of a performance indicator to each criterion. In light of this investigation, the present work defines a model for the projects selection able to maximize the objectives of conservation and enhancement of archaeological sites, taking into account the essential constraints of protection of historical and cultural values, but also using needs of the community according to sustainable development logics of the territory.

Using the Linear Programming algorithms, whose effectiveness is widely demonstrated in Operations Research and in the several disciplines that use this tool, the economic model is structured around an objective function. The writing of coherent constraint conditions manages to take into account all the terms of the outlined problem. Of course, there are many multi-criteria decision analysis techniques. Nevertheless, the nature of the valuation problem under examination, aimed at the selection of investment options, as well as the object of the study, i.e., the archaeological site, easily induced us to implement mathematical schemes of Operational Research.

The calculation algorithm is based on simple polynomial algebraic expressions in the mathematical form and, consequently, is easy to be read and easily adaptable to different case studies. The introduction of specific coefficients in the maximization relationship allows us to assign a different weight to the criteria, thus considering particular political needs. The result obtained by implementing the protocol is the combination of projects that maximizes the objective function, respecting the budget limits and other constraints that can be established from time to time.

The model is tested for a case study, aimed at selecting the best combination of projects for the conservation and enhancement of archaeological sites in the Campania Region (Italy). The elaborations testify the methodological coherence of the evaluation model, the repeatability of the phases necessary for the algorithm implementation, and the effectiveness of Linear Programming as a tool for selecting investments in the perspective of social, cultural, environmental, and financial sustainability.

The results the analysis model gets, in terms of the selection of investments to be financed, are amazing in relation to the general objectives of Economic Policy, aimed at the optimal allocation of available resources.

Obviously, limits of the model derive from the nature of the multi-criteria evaluation approach. The use of qualitative assessment scales introduces components of subjectivity in the study. The weight of the evaluation criteria still responds to subjective judgments. Furthermore, the linear nature of the mathematical functions may not exactly respond to certain economic relationships. In such circumstances, different multi-criterial analysis techniques must be used.

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