Decision Support System for the Management of Interventions on Buildings in the Historic Centre of Florence: From Conservation to Regeneration

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Abstract. The goal of this paper is defining a methodology for assessing priorities among interventions in the historic center of Florence, going from the conservation to the regeneration of its heritage. The possibility to re-use a building with new characterizations depends on binding and administrative issues while the optimization of resources depends on the planning and organization of the construction sites. The proposed methodology falls within the so called "mixed methods", as it integrates within a multi-criteria model, specific degradation analysis methods and parameters for construction cost optimization. This research proposes a model that interfaces and integrates projects already running in the area already included in the. This, data will be included in the Geographic Information System with the aim of carrying out comprehensive analysis, monitoring, and management of the building heritage in the historic center of Florence that is under development. The methodology can be considered as a contribution to the Management Plan of the site of the Historic Center of Florence. In addition, the defined method, besides being is in accordance with some action projects of the second macro-area of the management plan is also in keeping with the provisions of the Municipal Operational Plan, which in Sect. 4.3 calls for a reinterpretation of the existing building stock. With the aim to preserve them, we will start from individual building monitoring, moving on to study the condition promoting the creation of joint construction sites, thus optimizing costs. Hence the methodology selects areas suitable for regeneration, whose different transformation alternatives are evaluated (HIA) and hierarchized (MCDA).

Keywords: Management · Cultural Heritage · DSS

1 Introduction

The old city center of Florence has been on the World Heritage List since 1982 [1]. To make its safeguard more incisive and the heritage better protected and monitored, UNESCO, since 2004, has recommended the adoption of a Management Plan to all the sites on its List. The Management Plan follows an embedded strategies combining

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cultural heritage protection and conservation with the development needs (referring to socio-economics aspects) of the area in order to guarantee choices sustainability.

To meet the needs related to the drafting, implementation and monitoring of the Management Plan, the UNESCO Office was set up within the municipal organizational structure in 2005.

In 2016 the Municipality of Florence approved the second Management Plan [2] after the first version released in 2006. In 2018 it was also presented a monitoring plan. The lattes signed a fundamental phase both for the management of the World Heritage site and for the implementation of UNESCO requirements. These objectives were achieved as result of the collaboration between the Region of Tuscany and the University of Florence. In fact, it was born Here Lab - Heritage Research Lab [3] within the Department of Architecture (DIDA) which was involved both in the research applied to the Management Plan and in defining the monitoring plan.

Indeed, a monitoring plan is fundamental to guarantee the implementation of a Management Plan providing all the needed information to review, adapt and update it.

The monitoring process of the Management Plan for the Historic Centre of Florence is structured into:

1. checking projects consistency in terms of both respecting to the Mission of the site and the maintenance of its Outstanding Universal Value;
2. checking projects breakthroughs, establishing monitoring indicators and verifying whether the project objectives are being achieved on time.
3. The monitoring plan drawn up in 2018 was updated in 2022 with Preliminary Document to the 2022 Management Plan, monitoring 33 projects, divided into 5 macro-areas (Fig. 1).

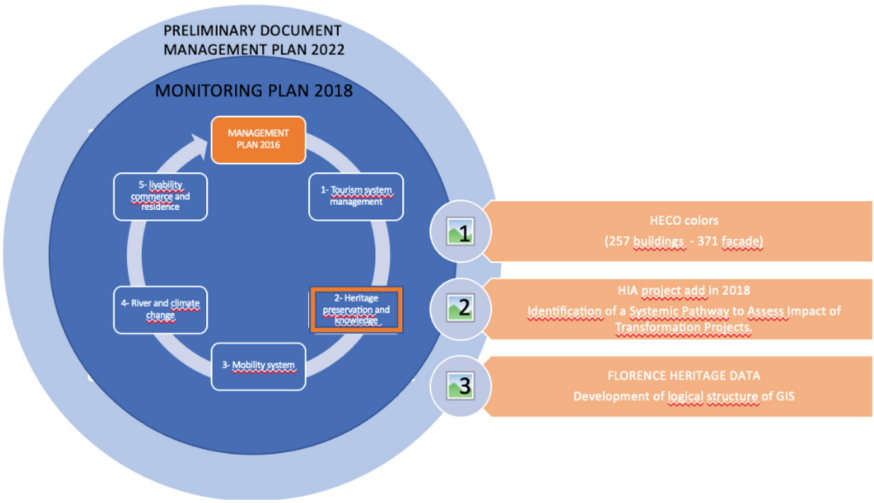

Fig. 1. Management Plan outline

Basically, the methodology presented here aims at implementing and linking the results achieved in 3 projects (HECO Colors, HIA and Florence Heritage Data) belonging to macro area no. 2 (Heritage Conservation and Knowledge) through a new approach based on 4 main steps:

1. Creation of a degradation index, referred to a single building as if it was stand-alone;
2. Definition of an opportunity matrix, relating possible interventions on the different buildings of a block;
3. Outline of possible regeneration interventions and evaluation of their impacts.
4. Multi-criteria analysis, for the choice of the best regeneration hypothesis aimed at achieving the objectives of the Management Plan.

The proposed methodology belongs to the so-called "mixed methods" as it integrates within a multi-criteria model, specific methods of degradation analysis and definition of intervention opportunities. It is applied to buildings in the historic center of Florence and its buffer zone. In particular, the degradation study focuses on vertical and horizontal opaque structures (elevations and roofs). Although constructed and applied according to the UNESCO context of the Historic Centre of Florence, the methodology lends itself to being adaptable also to other contexts and in this sense to be applied in the management plans of historic centers or sites.

2 State of the Art

2.1 Evaluation Tool for Cultural Heritage

While urban context has evolved and changed steadily with population growth, cultural heritage has continued expressing the historical evolution of cities. Indeed, Cultural Heritage and its safeguard and sustainable development plays a fundamental role in maintaining the link between the past and the future. Due to rapid urbanization of historical city, heritage properties can be threatened by the development of urban areas. This discrepancy between heritage preservation and urban development has led to several challenges in the historic urban environment.

Recognizing this challenge, the Heritage Impact Assessment is an assessment tool to identify and analyze the potential impacts of new projects on World Heritage cultural properties. The HIA is a version of the Environmental Impact Assessment (EIA) tailored for cultural heritage properties, specifically focusing on its preservation.

Environmental Impact Assessment (EIA)
Since 1970, EIA has been the official tool "to identify the environmental, social and economic impacts of a project prior to decision-making. It aims to predict environmental impacts at an early stage of planning and design, to find ways and means to reduce negative impacts, to shape projects to fit the local environment and to present predictions and options to decision-makers".

To achieve its objectives, EIA should be incorporated into the management system at urban and regional levels. In this regard, the International Association for Impact Assessment (IAIA) and the UK's IEA have indicated as a primary goal for EIA implementation to "address and incorporate development decision-making" and to

"promote development that is sustainable and optimizes resource use and management opportunities".

EIA results has an useful assessment tool providing an integrated methodology reviewing projects drafts, assessing their impacts and facilitate decision-making process thus defining mitigation strategies. Furthermore, EIA has become a legally binding tool in several countries around the world to prevent adverse effects of development proposals before important decisions are taken [4].

In 1999, the IAIA published the principles of EIA as an interdisciplinary process [5]. In this document, the IAIA presents culture, traditions and the value of communities as characteristics that should be respected and taken into account in Environmental Impact Assessment. Subsequently, in many EIA guidelines, cultural heritage is considered as a separate and sensitive element that must be taken into account in order to protect its qualitative characteristics.

As indicated by UNESCO, heritage assets are 'non-renewable resources' of any community extremely linked to its identity and sense of belonging. The World Heritage Convention of 1972 recognized Outstanding Universal Values (OUV) as a central concept in reference to World Cultural and Natural Heritage, which deserves to be protected and passed on to subsequent generations. Safeguarding heritage values is a key factor in the management and protection of World Cultural Heritage [6].

Therefore, identification and mitigation of potential threats to values must be an integral part of heritage conservation.

"Value has always been the basis of heritage conservation. It is evident that no society strives to preserve what it does not value". In this regard, Member States have a responsibility to safeguard the OUV and its associated attributes, taking into account the integrity and authenticity of World Heritage properties from significant negative impacts imposed by change and development. As a result, EIAs do not explicitly address OUV: "If the cultural heritage sections of EIAs do not clearly focus on OUV attributes, they do not meet the desired standards in managing changes in World Heritage properties".

Heritage Impact Assessment

To meet this challenge, in the context of the 'Environmental Impact Assessment' (EIA), the Cultural Heritage Impact Assessment (HIA) has been developed in recent years which considers the specific characteristics and qualitative values of World Heritage properties as a key factor in the management and protection of cultural heritage [7]. Heritage Impact Assessment is a procedure to identify and analyze the potential impacts of human-induced threats on cultural heritage and, therefore, supports better protection and management of cultural heritage. The need for development and change and heritage conservation may cause conflicts between stakeholders dealing with new development in historic urban areas. Heritage Impact Assessment is a tool that can bridge the gap between urban development and heritage conservation needs. In addition, the HIA provides a new assessment tool to facilitate heritage conservation within broader sustainable development policies [8].

HIA is an assessment methodology based on the indications contained in the Guidance on Heritage Impact Assessments for Cultural World Heritage Properties of ICOMOS International (2011, hereafter ICOMOS Guidelines) [9]. It aims to assess, through

a systematic and consistent process, the positive/negative impact of one or more transformation projects affecting the values, attributes, authenticity, and integrity of World Heritage sites. The assessment is useful to indicate recommendations and possible mitigation measures to reduce or avoid possible negative effects on heritage and should be used to monitor the rehabilitation of large complexes and new infrastructure projects located both in the World Heritage site and its Buffer Zone.

HIA is currently only recommended for large-scale heritage, such as historic centers instead it is a widespread tool (and in some cases mandatory) for archaeological areas [10].

An effective approach to large-scale HIA is to proceed step by step, introducing the assessment into studies at different levels (e.g. constraint studies, environmental impact assessments, etc.).

The key to a successful HIA is the production of an adequate inventory of the attributes that give the site an Outstanding Universal Value; this inventory, organised in a database, must be linked to a GIS (GIS-linked database) and must contain basic information on the location of the property and its components, information on the regulatory constraint and information on the value of the property [11].

The Guidance on Heritage Impact Assessments for Cultural World Heritage Properties (ICOMOS, 2011) provides a methodology enabling heritage impact assessment by considering the attributes making up the OUV as separate entities. Also, it allows assessing them in a systematic and consistent manner.

2.2 Project for the Safeguarding of Florence Historical City Center

The Historic Centre of Florence was inscribed on the World Heritage List after the Sixth Session of the UNESCO World Heritage Committee, held in Paris at the headquarters of the United Nations Educational, Scientific and Cultural Organisation (December 1982). Based on the data provided each State is responsible for disseminating a list of World Heritage properties considered to be of outstanding universal value. Also, it is mandatory indicating the Cultural Heritage Properties in danger that need to be protected as well as the restoration work and eventually the assistance required. After a strong call by UNESCO in 2000, each Member State is responsible for providing even old cultural heritage sites with a management plan. In Italy in 2005 there was an abrupt acceleration about this topic when a the Ministry of Cultural Heritage and Activities and the managers of World Heritage sites was implemented. Regarding Florence and its historical center, among the peripheral state administrations and the municipality there was only a minimal awareness that was inscribed on the World Heritage List. As evidence, this unique feature was mentioned in any official document, regulation or spatial planning instrument.

In order to assess the need of drawing up a document for the preservation and enhancement of the site the Municipality of Florence, the body responsible for the site, set up the “UNESCO office” specifically dedicated to the drafting and monitoring of the Management Plan. The Office also deal with the following tasks:

- Promoting the conservation, enhancement and sustainable management of the Historic Centre of Florence by drafting and monitoring the Management Plan envisaged by the World Heritage Convention.

- Coordinate public and private actors as well as the stakeholders operating in the Historic Centre of Florence.
- Co-ordination and management of the funding allocated to the Management Plan and the related Action Plan.
- Create periodical reports about the state of conservation of the Historic Centre and on modifications to the Management Plan and the Action Plan.
- Implementation and monitoring of projects financed by Law no. 77 of 20 February 2006 "Special measures for the protection and enjoyment of Italian sites of cultural, landscape and environmental interest included in the "World Heritage List", under the protection of UNESCO.

The 2022 management plan was recently drafted, updating the previous 2016 version. With the aim to track the progress of this plan, a monitoring plan is carried out every two years. It involves public and private actors of the projects selected within the management plan and monitors 33 projects subdivided into 5 macro areas: 1) management of the tourist system; 2) conservation and knowledge of the monumental heritage; 3) mobility system; 4) Arno River and climate change; 5) livability, commerce and residence in the historic center.

The methodology proposed in this work focuses on "Conservation and knowledge of the monumental heritage" and aims to link three action projects:

1. HECO _[12] financed by the MiBACT funds of Law 77/2006 "Special measures for the protection and enjoyment of Italian sites of cultural, landscape and environmental interest, included in the 'world heritage list', under the protection of UNESCO"- is an open data system of the architecture of the Historic Centre and is based on the recognition of the color language of architecture and aims to develop guidelines to be used in urban prevention and maintenance.
2. HIA_ [13] Implementation of a Heritage Impact Assessment (HIA) protocol for the assets of the Historic Centre of Florence and experimentation of possible applications of the model on concrete cases of ongoing transformations. The HIA project - financed with the MiBACT funds of Law 77/2006 "Special measures for the protection and enjoyment of Italian sites of cultural, landscape and environmental interest, included in the 'World Heritage List', under the protection of UNESCO" - was born from the synergy between Heritage_CITYlab, a joint laboratory between the University of Florence and UNESCO that makes a multidisciplinary approach possible. The experimentation, in accordance with the Guidelines issued by ICOMOS (2011), aims at assessing, through a systematic and coherent path, the positive/negative impact of transformation projects that affect the values, attributes, authenticity and integrity of the World Heritage Site, the Historic Centre of Florence.
3. Florence Heritage Data [14]_ the project proposes to define and develop the logical and physical structure of a Geographic Information System intended for the analysis, monitoring and integrated management of the transformations of the building heritage and open spaces of the Historic Centre of Florence. This system will consist of an information infrastructure potentially open to interaction with databases in use by different entities, applied to different sectors, which share the objective of promoting the enhancement of the city's excellence, its active protection and the valorization of its cultural heritage. The Information System that constitutes the objective of the

project can be considered as a fundamental 'spatial index' able to allow the connection of databases available or being implemented, pertaining to public and private entities, engaged in institutional or economic valorization activities, having as their object the consistency, state of preservation and conditions of use of the building heritage of the Historic Centre.

3 About the Method

The proposed method belongs to the so called mixed-methods which systematically combines and integrates different methods in an evaluation process where both quantitative and qualitative data are collected and analyses. These are mainly adopted when:

- Each question has more than one answer, so that several evaluation methods are required.
- Accuracy and consistency of the results need to be increased.
- Several steps are involved in the evaluation process. Also, the results obtained by one method are useful for subsequent steps.

It is evident that more methods are able to capture a wider range of perspectives. Specifically in this paper, an experimental evaluation based on four steps is used:

1. Definition of a degradation index, referring to each building as stand-alone.
2. Creation of an opportunity matrix, which relates possible interventions on the different buildings of a block.
3. Outline of possible regeneration interventions and evaluation of their impacts.
4. Multi-criteria analysis, for the choice of the best hypothesis to comply with the objectives of the Management Plan.

3.1 Definition of a Degradation Index, Referring to Each Building as Stand-Alone

Following a careful and thorough analysis, a synthetic index is defined for each building indicating its level of degradation (id1, id2, id3,…, idn). The index is calculated as the ratio of the damaged areas of the facade and roof to the total area of the facade and roof multiplied by factors related to the type and severity of degradation. In this way, specific evaluation criteria and indicators of degradation (limited to facades and roofs) define the conservation status of the envelope of each building. This phase can be carried out independently or as an extension of the HECO (Heritage Colors) project. HECO is an integrated open data system to monitor the state of deterioration of public and private buildings, suggesting methods of execution for the management of planned interventions.

3.2 Creation of an Opportunity Matrix, Which Relates Possible Interventions on the Different Buildings of a Block

By relating buildings to each other costs are optimized and restoration and reuse activities are concentrated according to economies of site and scale. The rows and columns of the matrix refer to the buildings in a block. Each quadrant resulting from the intersection is

filled according to the degradation index, proximity of buildings, continuity of building site areas, and homogeneity of the technological envelope. In this way, the matrices provide a clear view of the blocks where the need for joint interventions is greatest. All the information can be collected and integrated into Florence Heritage Data, a Geographic Information System designed for the joint analysis, monitoring and management of the transformations of the built heritage and open spaces of the Historic Center of Florence.

3.3 Outline of Possible Regeneration Interventions and Evaluation of Their Impacts

Once suitable blocks for regeneration have been selected, urban planning constraints and regulations are analyzed and various solutions are designed taking into account different scenarios. The goal of this phase is to outline multiple project alternatives. For each project, a HIA (Heritage Impact Assessment) is conducted to strategically assess the corresponding potential impacts (both direct and consequential) on the cultural heritage, particularly on the OUV.

Basically, HIA is a process of identifying, predicting, evaluating, and communicating impacts that integrates results during the development of each phase of the project. Stakeholders (municipality, ministry, region, citizens) are involved to minimize impacts and identify possible mitigation. In the assessment process, we used the standard classifications for assessing heritage attributes (very high, high, medium, low, negligible) and standard criteria for assessing the weight of changes brought by each project We relied on the model created by HeRe Lab in collaboration with the UNESCO City Center Office.

3.4 Multi-criteria Analysis, for the Choice of the Best Hypothesis to Comply with the Objectives of the Management Plan

Once the eligible interventions have been identified, the last step is to specify the criteria for selecting the best alternative or at least the best compromise to achieve the objectives of the Management Plan. At this stage, it is essential to clearly state the needs and strategic objectives of regeneration. In general, these goals should aim to address issues such as the impact of mass tourism on city life, the effect of which has been a decrease in the number of residents in urban centers.

Useful tools for achieving these goals are provided in a number of documents already issued. Among them, the "Urban Regulations," one of the projects included in the Management Plan of the Municipality of Florence, defines the discomfort/disturbance factors affecting the livability conditions of the historic center and the factors impoverishing the urban image, while the "Regulations for the Protection and Enhancement of Historic and Traditional Florentine Economic Activities" deals with the protection of small commercial activities that were traditionally carried out in the city. In general, in the field of decision-making, multi-criteria analyses have become a widespread tool that can address problems involving more than one objective.

These, in addition to the possibility of considering data of different natures (quantitative and qualitative) offer the opportunity to assign different weights to identified criteria, manage conflicts between objectives, and infer priorities among alternatives.

Analysis of the main scientific literature with applications of multi-criteria analysis to decision-making problems concerning cultural heritage reveals the importance of using combined methodologies, which are particularly useful for dealing with complex situations and capable of structuring more inclusive decision-making processes aimed at greater sharing of choices [15].

Generally speaking multi-criteria analyses can be classified as follows:

- Outranking methods
- Full aggregation methods
- Target, aspiration, or reference level methods

As previously illustrated, multicriteria analysis techniques are various, and the choice of which method to adopt is rarely trivial. The steps that follow propose an investigation of some specific techniques that, based on the literature review, have been proved to be most effective in the context of cultural heritage evaluation. This is to identify the analysis best suited to solve the decision-making problem at hand.

The in-depth study starts with outranking methods and in particular ELECTRE (Elimination Et Choix Tradusiant la Realité) methods, which consist of the so-called outranking relationship..

The two principal processes featuring ELECTRE are: a) multiple-criteria aggregation procedure that constructs one or more outranking relations to compare each pair of alternatives comprehensively; b) exploitation procedure that can provide results depending on how the problem is approached, choosing, ranking or ordering.

ELECTRE methods make it easy to skip inter-criteria compensation and any normalization process, which distorts the original data. The disadvantage is that they require various technical parameters, which are not always easy to read. Also in the field of outranking methods is PROMETHEE "Preference Ranking Organization METHods for Enrichment Evaluations," which is based on pairwise comparisons between alternatives in which the decision maker's preference is de-ranked according to the distance between two hypothetical alternatives for each individual criterion.

The PROMETHEE method allows one to operate directly on the variables included in the decision matrix without requiring any normalization and is applicable even when there is insufficient information. Nevertheless, when there are many criteria involved, method development becomes complex, making it difficult for decision makers to get a good picture of the problem.

Regarding the "Technique for Order Preferences by Similarity to an Ideal Solution" (TOPSIS), the idea behind this method is to choose the best alternative between the one closest to the optimal solution and the one furthest from the worst solution. Every alternative is represented by a vector whose elements describe the performance of the alternative for each decision criterion.

Thus, the best solution turns out to be the one that maximizes performance for the criteria associated with a benefit (output) and minimizes performance for the criteria associated with a cost (input). The advantage of this method is that it requires only little input from the decision maker and its result is easy to understand. However, in the case of multidimensional problems, vector normalization must be used, making the decision-making process particularly complex (Fig. 2).

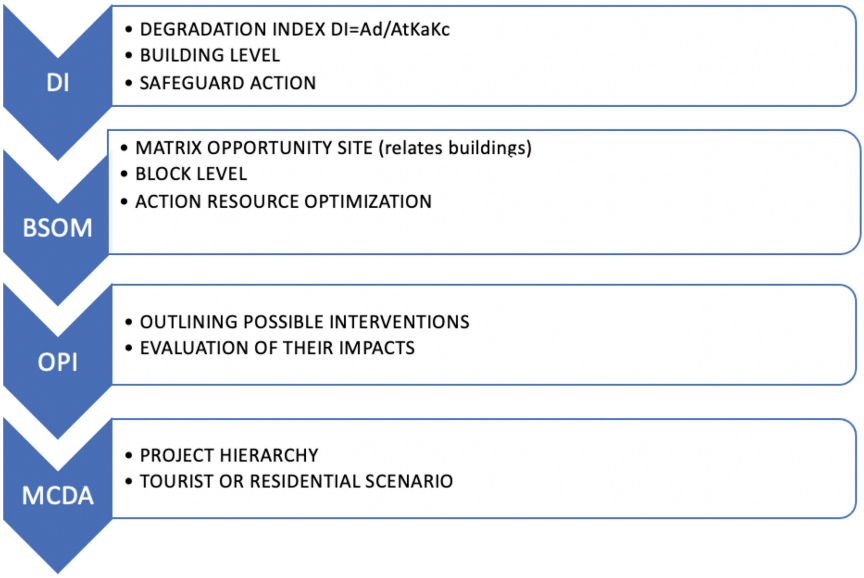

Fig. 2. Summarizing scheme of methodological steps

4 Conclusions

The research conducted so far aims to coordinate and aggregate outputs from three action projects contained within the Management Plan for the Historic Center of Florence in order to optimize their results:

- HECO_financed by MiBACT funds of Law 77/2006 "Special measures for the protection and enjoyment of Italian sites of cultural, landscape and environmental interest, included in the 'world heritage list', placed under the protection of UNESCO"-is an integrated open data system of the architecture of the Historic Center.
- HIA_Realization of a Heritage Impact Assessment (HIA) protocol for the assets of the Historic Center of Florence and testing of possible applications of the model on concrete cases of ongoing transformations.
- Florence Heritage Data_the project aims to define and develop the logical and physical structure of a Geographic Information System intended for the analysis, monitoring and integrated management of the transformations of the built heritage and open spaces of the Historic Center of Florence.

The defined mixed method makes use of a series of assessments involving the calculation of a degradation index, the definition of a matrix of opportunities for intervention, the definition of different types of intervention and the choice of the best alternative (among the types of intervention) using multi-criteria analysis. Thus, methodologies based on both quantitative (e.g., degradation index calculation) and qualitative (e.g., definition of intervention opportunity matrix) data are alternated.

Generally, heritage regeneration interventions concern single portions of buildings (e.g., their envelope); through the application of the proposed methodology, the aim is

instead to consider a broader perspective, which does not only take into account the external envelope of buildings but also the set of infrastructures serving them, so as to ensure a deep regeneration action.

Although still in the experimental stage, the method is easily exportable to other systems (e.g., different technical elements that make up the building) given the flexibility and generality of the individual methods that comprise it.

The natural development of the research is based on the experimentation/application of the method to the reference context, after the selection of buildings falling within the historic center of Florence and its buffer zone. Following this experimentation, eventually, it will be possible to define any points or phases of the method that need further implementation.

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