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Review

A Review of Terminologies and Methodologies for Evaluating Conservation Interventions

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Abstract: The main purpose of the review is to analyze the terminology and methodologies for conservation treatment in cultural heritage conservation, in particular, to define key terminology (such as quality, compatibility, efficacy, and durability); to identify methodologies for assessing conservation interventions; to examine case studies where these assessment techniques have been applied. A summary of the various definitions of terms such as quality, compatibility, efficacy and durability found in the literature is provided. This is followed by a presentation of some theoretical approaches found in the literature on how to evaluate different aspects of conservation interventions. Some more practical examples are then considered, with a focus on mural paintings. Finally, the importance of monitoring interventions over time in the context of preventive conservation is highlighted. The present review emphasizes that key concepts such as compatibility, efficacy, and durability are inherently flexible and context-dependent, often overlapping and evolving according to cultural heritage typology, intervention methods, and environmental conditions.

Keywords: quality; compatibility; efficacy; durability; conservation intervention

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1. Introduction

Conservation interventions on heritage materials play a very important role in contrasting the effects of time, environmental conditions, vandalism and the constituent materials of the artworks themselves. Although the interventions are carried out with the intention of protecting and maintaining the cultural goods, it is always difficult to predict their effects in specific environments and on specific materials, and sometimes they have been revealed to be distant from their objectives [1]. From that, it is necessary to review the interventions conducted to understand the benefits and drawbacks of various procedures, ensuring they meet both current and future durability needs. Although welcome for conservators, who very often have to deal with issues like lack of information on previous interventions and not having an evaluation of the effects of past treatments, this topic is rarely addressed in the literature [2]. If a qualitative assessment of past treatments is rare, it is even more sporadic when it comes to semi-quantitative data.

The need to assess conservative interventions is also mentioned in the "ICOMOS Charter—Principles for the analysis, conservation and structural restoration of architectural heritage" [3], which reports that the specificity and complex history of heritage structures requires organizing studies and proposals in defined steps, similar to the ones used in medicine: anamnesis, diagnosis, therapy and controls. These steps correspond, respectively, to the collection of information, identification of the causes of damage, choice of the measures that need to be taken and control of intervention efficiency.

- To examine some of the methodologies proposed to evaluate conservative interventions (methodology for intervention assessment);
- To examine applications in case studies, where more detailed information is also given on the techniques used for the evaluation of the parameters describing the intervention (evaluation methods on different materials and/or on case studies).
- Recognizing the challenges in practically evaluating conservation interventions, we identified and analyzed three key macro-topics to aid in this process. First, we examined the terminology used in conservation interventions, focusing on critical aspects such as quality, compatibility, efficacy, and durability. Second, we explored methodologies for the semi-quantitative evaluation of these aspects, incorporating real case studies to illustrate their application. Finally, the study aims to highlight the limitations in the practical application of theoretical evaluation frameworks for conservation interventions and, where possible, propose simplifications or potential solutions.

2. Discussion on the Terminology in Conservation Intervention: Quality, Efficacy, Compatibility and Durability

The literature about the proposal of methodologies for evaluating conservative interventions frequently reports terms such as quality, compatibility, efficacy, efficiency, effectiveness and durability, often used in different contexts or not always with a unique meaning. These terms are crucial to describe the characteristics and the expected outcomes of an intervention, and getting some clarity on them can open new perspectives on this matter. Therefore, we have reported some significant definitions of these concepts, as cited in the literature (Tables 1–5), and suggest the definitions that, in our opinion, better summarize the most important features of each term.

In the following paragraphs, the key terms (quality, compatibility, efficacy, and durability) will be analyzed in detail.

2.1. Quality

Table 1 presents the definition of quality as gathered from the literature, followed by the authors' considerations.

Table 1. Definitions of quality quoted as such from the literature. In *italics,* the definitions are translated from the original languages into English.

Quality	
Source	**Definition**
ICOMOS, 2020 [4]	"Quality is a concept of relative and subjective nature that may depend on the perspective of individuals, the community, the local or wider context, historical and geographic location, the cultural asset, and the aims of the planned intervention".
Cambridge Dictionary [5]	"Quality": "how good or how bad something is"; "a high standard"; "the degree of excellence of something, often a high degree of it"
UNI 11897:2023 [6]	"*Quality intervention is the one where the degree of interaction with the matter is controllable during the operative phases and/or over time through technical andanalytical values; quality of the intervention: objective correspondence between the result of the intervention established in the design and that achieved during the operative phases and/or over time*".

Table 1. *Cont.*

Quality	
Source	**Definition**
Musso 2022 [7]	"The quality may depend on the perspective of individuals, communities, local contexts, the historical condition and geographical location, the characteristics of the heritage involved and the objectives of the planned intervention".
Guidelines for the quality of architecture restoration projects (*Documento di indirizzo per la qualità dei progetti di restauro dell'architettura*), 2023 [8]	*"From the in-depth knowledge derives then an essential part of the quality of the design product. The quality derives from the adequacy of the method, from the consistent selection of tools and from the correspondence between premises and results [. . .]"*
Carlessi et al., 2021 [9]	*"«Quality» is then a polyhedric concept, which is possible to try to decline in its facets relating it, for example, to some themes that most help to highlight its meanings and complexities"*.

The Cambridge Dictionary proposes the definition of quality as "how good or how bad something is" [5]. Based on this general definition, the ICOMOS document reports that quality depends not only on the intervention itself but also "on the prerequisites set, on the transparency of the procedures, on the design phases and on the documentation of a project. It also depends on the completeness, depth, detail, and accuracy of the information and the technical specifications and economic figures of any proposal of intervention, as well as on the constant monitoring of the decision-making processes". [4]. The document provides a theoretical approach to quality, highlighting its complexity while also offering guidelines for achieving quality in interventions.

The UNI 11897:2023 standard [6] provides a definition based mainly on technical aspects. It states that a quality intervention is one in which the degree of interaction with the material is controllable during the operational phases and/or over time by means of technical and analytical values. In addition, the standard reports that the quality of the intervention is defined as the objective correspondence between the intended outcome of the intervention, as specified in the design, and the results achieved during the operative phases and/or over time. Furthermore, the document [6] stresses that materials and procedures must be respectful of the values and meaning of the cultural asset to ensure the quality of the intervention.

The document of the *Società Italiana per il Restauro dell'Architettura* (SIRA) [8], although specific to the architectural heritage, is in line with the descriptions of quality and gives indications on the restoration and the criteria to guarantee quality interventions. This document stresses the importance of intervention design. In fact, it is planning that designs the objectives, the limits and the criteria that make it possible to define quality. The document defines other important points related to quality in conservative treatments, such as the inclusion of different technical figures, the involvement of local communities, the importance of the definition of the objectives of the work, the suitability of the method, the consistent selection of tools and the correspondence between the premises and the results, following similar considerations to the ones from ICOMOS [4].

Therefore, the quality derives either from the completeness of the planning process or from the use of a methodology addressed to obtain consistency between the initial premises and the planned results. The guarantee of a minimum quality standard in interventions is what ensures the preservation of the morphological and material characteristics of the heritage (specifically in the case of historical buildings, as in the study from which this statement is taken [10]).

In general, a quality intervention fulfills the project's expectations and is defined by various factors, mainly technical, socio-cultural, and environmental. Quality must be an implicit objective for any intervention, and compatibility, efficacy, effectiveness, efficiency, and durability, which are often repeated and used in the consulted documents and papers, even if not explicitly defined, are all elements contributing to the definitions of conservation treatments' quality.

2.2. Compatibility

Table 2 reports the definition of compatibility as gathered from the literature.

Table 2. Definitions of compatibility are quoted from the literature. In *italics*, the definitions are translated from the original languages into English.

Compatibility	
Source	**Definition**
ICOMOS, 2020 [4]	"Compatibility of design solutions: «use adequate materials, techniques and detailing» in regard to the material and physical-chemical-mechanical interactions between the new and the existing".
Bruschi et al., 2022 [11]	*"The term refers to items «which can stay together, which can coexist, and which can tune into something else»"*.
Delgado Rodrigues et al., 2007 [12]	"Compatibility is certainly one of the most frequently used words in the conservation practice. Used with its current significance, «in harmony with. . .», the term is applicable in an endless number of possible situations, but it has already acquired a kind of status that turns it into a key concept in many interpretations of some more or less complex concrete situations".
UNI EN 15898:2019 [13]	*"The extent to which one material can be used with another material without putting cultural significance or stability of the object at risk"*.
Revez et al., 2016 [14]	"The extent to which one material [or action] can be used with another material without putting significance or stability at risk".
Zendri et al., 1997 [15]	*"Compatibility refers to the ability of a new material to adapt in a general chemical-physical and mechanical sense to an old one, which is in fact already in particular conditions of equilibrium with the environment"*.
Groot et al., 2022 [16]	"Compatibility is achieved through functional and aesthetic harmonization of the repair mortar with the original material [. . .]".
Dal Pozzo et al., 2024 [17]	"[. . .] a consolidant material should at least guarantee [. . .] compatibility (i.e., not cause undesired changes in the substrate) [. . .]. For each of these criteria, multiple parameters can be adopted as relevant metrics: for example, [. . .] compatibility indicators can include effect on color change, pore size distribution, water absorption and others".
Pagnin et al., 2023 [18]	"Protective barrier and coatings applied on Cultural Heritage surfaces in outdoor conditions should satisfy specific requirements [. . .] that can be summarized as follows: compatibility (no changes in optical properties, aesthetic characteristics of the surface and perception) [. . .]".

Table 2. *Cont.*

Compatibility	
Source	**Definition**
Vecchiattini, 2008 [19]	"*The concept of compatibility between materials [. . .] involves not only chemical and micro-structural affinities but also mechanical and physical ones*, and it can depend on both the materials and the application methods of the latter".
Sassoni et al., 2016 [20]	"Two treatments were evaluated in terms of [. . .] compatibility (i.e., lack of any negative consequence on the original substrate by assessing mechanical match, color change, new phases composition pore size distribution, water and water vapor transport properties, drying rate and thermal behavior)".
Guidelines for the quality of architecture restoration projects (*Documento di indirizzo per la qualità dei progetti di restauro dell'architettura*), 2023 [8]	"The term compatibility has many variations [in the operational field], relating to usage, structures, materials, the social context, the cultural context, and the landscape".

Most authors are consistent in what they mean by using the concept of compatibility. This is generally linked both to the ideas of adequacy, harmony, coexistence, agreement, adaptation, absence of change or risk of a material (or an action) with the original substrate to which it is applied and to adapt to chemical, physical, mechanical, and aesthetical properties of the artwork's material without creating a risk and without changes in the substrate. Compatibility can often be divided into different types, such as chemical, physico-chemical, mechanical, and aesthetic. The fragmentation of the concept of compatibility in different typologies (also diverse from the ones mentioned above) has already been reported in [8]. Another interesting study related to compatibility is that of Apostolopoulou et al. [21], where it is stated that compatibility, referring to the substrate, is evaluated among the others in chemical, dimensional (mechanical), hygric behavior, historical and aesthetical terms, giving a comprehensive view on compatibility concept. A different view of the term compatibility is proposed by Sasse and Snethlag [22], which states that the term is ambiguous. In fact, although physical/chemical/mechanical compatibility with the original stone material is a necessary requirement for all new techniques, restricting the field only to those that are "chemically similar", hinders the potential use of more promising techniques. As reported in Rodrigues and Grossi [12], it is interesting to highlight that there is no point in considering compatibility if the intervention cannot resolve the observed problem, the solution of which was defined as the ultimate goal during the planning phase (and therefore, if it is not efficacious/effective).

Therefore, compatibility refers to the ability of a material (or an action) to harmonize with the original substrate to which it is applied. It encompasses the capacity of a material (or an action) to adapt without altering the substrate or compromising its significance or stability. Compatibility must address the physical-chemical properties of materials in relation to the substrate to which they are applied, as well as the specific environmental conditions of the context. To define this capacity, a series of evaluations are needed based on the objectives to be achieved, and the various aspects of compatibility must be carefully balanced according to their relative importance (for instance, for the consolidation of a stone, the penetration of the product is more critical than for a protective coating). Thus, different indicators may have varying levels of significance, and they must be set up during the design phase of the conservative project.

The above report refers to the compatibility in terms of chemical, physical and mechanical characteristics of the materials (originals and used for the intervention). The materials' compatibility is a necessary but not sufficient criteria for the achievement of the compatibility in its whole significance, which include social aspects and the use of the cultural heritage, as reported in [8]. Again, we are faced with a very complex concept whose application cannot be based on fixed rules but depends on the specific case in the specific context. It is also evident that compatibility plays an important role in determining the quality of the interventions. However, while quality aims to fulfil the project's expectations, compatibility suggests the characteristics that the actions/materials must have to achieve these expectations. These two visions have many descriptors in common, particularly in terms of cultural and social aspects. Thus, the compatibility of the materials is a necessary condition for achieving quality in the conservative intervention.

2.3. Efficacy and Effectiveness

Table 3 reports the definition of efficacy, and Table 4 of effectiveness, as collected by the literature.

Table 3. Definitions of efficacy are quoted from the literature. In *italics*, the definitions are translated from the original languages into English.

Efficacy	
Source	**Definition**
ICOMOS, 2020 [4]	"Efficacy: the desired results must be formulated and agreed upon in advance".
Bruschi et al., 2022 [11]	"*With* Efficacy *is meant the ability to fully reach the desired effect*". The term is strictly correlated with those of efficiency.

Table 4. Definitions of effectiveness are quoted from the literature. In *italics*, the definitions are translated from the original languages into English.

Effectiveness	
Source	**Definition**
Delgado Rodrigues et al., 2007 [12]	"[. . .] the capacity to solve the «problem» and this is appropriately described with the concept of effectiveness".
Dal Pozzo et al., 2024 [17]	"[. . .] a consolidant material should at least guarantee effectiveness (i.e., provide a significant strengthening action to the substrate) [. . .]. For each of these criteria, multiple parameters can be adopted as relevant metrics: for example, effectiveness might be evaluated in terms of increase in modulus of elasticity or flexural, compressive or tensile strength [. . .]".
Pagnin et al., 2023 [18]	"Protective barrier and coatings applied on Cultural Heritage surfaces in outdoor conditions should satisfy specific requirements [. . .] that can be summarized as follows: protection effectiveness (protective efficacy against water and humidity, UV irradiation, etc.) [. . .]".
Sassoni et al., 2016 [20]	"Two treatments were evaluated in terms of effectiveness (i.e., ability to restore cohesion and mechanical properties, by measuring penetration depth, dynamic elastic modulus, tensile strength, resistance to abrasion) [. . . .]".

In the case of "efficacy", most of the time, the term is intended to refer to the ability to reach the desired or planned results [11]. However, sometimes, this meaning is also given to the word "effectiveness", which is also intended as the capacity to solve a problem [12] or to guarantee to perform a certain action on the substrate [17]. In the article by Bruschi et al. [11], one of the words used is "*efficienza*", which would be translated as "efficiency" in English and which is, compared to the other words, defined in a different way. As a matter of fact, it is meant to be the ability to intervene using a minimal amount of resources and is therefore linked to the concept of sustainability. This "blurred" distinction, where efficacy and effectiveness seem to have more similar meanings compared to efficiency, is also something that can be deduced from the definitions provided by the Collins Dictionary [23–25]. However, these terms have specific and distinct meanings in certain fields, such as medicine [26].

To avoid any potential misunderstanding, we suggest considering efficacy and effectiveness, referring to the ability of a material or a technique to achieve a determined goal and solve a problem, as this appears to be the most widely accepted definition.

In general, the definition of these terms depends on the parameters used to measure them and/or the properties related to them. This suggests that if the parameters used to evaluate efficacy and effectiveness are the same, these terms can be considered synonymous. When, as stated in [27], the term effectiveness also includes assessments of the compatibility of interventions—understood as "the extent to which an action may be performed upon a heritage object without threatening its present or future significance"—then the term takes on a different (and broader) meaning than efficacy.

Similarly, the concept of efficiency shifts the meaning of efficacy and effectiveness toward the concept of sustainability.

Ultimately, if the focus is on achieving the conservation objective, the term efficacy is the most appropriate. The term effectiveness can be used when emphasizing the compatibility of the intervention, while efficiency is suitable for highlighting its sustainability aspects.

2.4. Durability

Table 5 reports the definition of durability, as collected by the literature.

Table 5. Definitions of durability are quoted from the literature. In *italics*, the definitions are translated from the original languages into English.

Durability	
Source	**Definition**
Bruschi et al., 2022 [11]	"*Durability of the conservative treatment is also part of the descriptors, and it strictly derives from the characteristics of the previously expressed* Compatibility. *It then defines an intervention able to last over time*".
UNI EN15898:2019 [13]	"*Capacity of resisting wear effects in usage conditions and over time. Durability should not be confused with permanence*".
Groot et al., 2022 [16]	"[. . .] durability concerns the long-term behavior of the repair mortars in the environment where each structure is placed".
Dal Pozzo et al., 2024 [17]	"[. . .] a consolidant material should at least guarantee [. . .] durability (i.e., maintain the strengthening action over time)".
Mandal et al., 2024 [28]	"The chemical stability and durability (i.e., the compatibility with substrates) of a coating surface is also an important factor to consider for use as engineered materials in a variety of applications. A durable coating surface needs to be able to withstand extreme conditions, such as corrosive, dust and high temperatures".

Table 5. *Cont.*

Durability	
Source	**Definition**
Provinciali, 1995 [29]	"A parameter to evaluate the effectiveness of a product is the durability—i.e., the capacity to maintain the effect obtained for a sufficient time without causing an acceleration of damage".
Sassoni et al., 2016 [20]	"The consolidant effectiveness should not be lost as a consequence of exposure to environmental weathering processes, and the consolidant itself must not give rise to harmful products as a consequence of aging".
Sassoni et al., 2016 [30]	"However, effectiveness and compatibility are only two of the main requirements that a valid stone consolidant must fulfill, as it must also guarantee proper durability, intended as the ability of not losing its effectiveness as a consequence of exposure to environmental weathering processes and not giving rise to harmful products as a consequence of aging".
Guida et al., 2003 [31]	"The durability of a building structure and restoration intervention is determined by the capacity of the material, constituting the structure, to last in the course of time, resisting the aggressive action of the environment, guaranteeing the performance for which it was designed".

Regarding durability, this term is used broadly: durability refers to the ability to last, resist, maintain, and withstand in time. An important aspect of durability is mentioned in the standard UNI 15898:2019 [13]. In this document, it is noted that the concept of durability does not have to be confused with permanence. Therefore, there is a difference between the fact that a certain material is still detectable on the surface and the fact that this material, beyond being recognizable, is still effective or performing [32,33]. Some articles, such as Corradi [34], aim to verify the "effectiveness in time", which could potentially overlap with the concept of durability. This possible overlap can also be deduced from Alonso-Villar et al. [35], where an almost identical sentence is repeated twice, with the phrase "long-term efficacy" replaced by "durability" in the second instance. A relation in this sense is proposed in Guidolin and Tognini [36] (p. 21), where it is stated that "the effectiveness of repair is largely demonstrated in the long run by its durability". There is indeed a difference between finding a treatment that works well in the short term and being sure that it will continue to work over time, especially if outdoors [37]. The durability of the material is a necessary condition, but it is not sufficient to ensure overall durability.

Degradation can arise from factors unrelated to the material's lack of durability but may be connected to poor compatibility of the materials/methods used, bad workmanship and structural incompatibility [31]. An interesting work where durability, (in)compatibility, and effectiveness are all related is Sassoni et al. [30]. Here, the authors stated that effectiveness and compatibility are two of the principal requisites that stone consolidants must meet because they must also ensure proper durability. According to the authors, an additional important aspect influencing durability is the potential incompatibility between the consolidated and unconsolidated substrate, which may occur when the treated stone is exposed to environmental weathering. Based on the findings reported so far, some papers juxtapose durability with other aspects of conservation, treating them as equally important—sometimes maintaining their different meanings, sometimes implying they are synonymous. In contrast, other studies present compatibility, efficacy (effectiveness and efficiency), and durability as subordinate to one another, serving as descriptors or parameters of each other. Durability is also related to quality, and it is the ability of an intervention to last in time, maintaining its effect for a sufficient period without causing an acceleration of damage.

As a general consideration, the focus of most of the articles evaluating an intervention is to assess the performance of that treatment, which aligns with the concept of quality intended as "how good or how bad something is" [4] (p. 19). This evaluation is related to assessing different concepts: compatibility, efficacy (declined in all its lexical variations) and durability. In turn, these concepts must be qualitatively and/or quantitatively evaluated through specific indicators, which can be obtained through various methodologies, as neatly divided in [12,20,30,38,39].

3. Discussion on Theoretical Approaches for the Assessment of Conservation Interventions

Although it would be advantageous to have a methodology for evaluating the various aspects of a conservation treatment, this possibility is generally considered to be very complex and difficult to implement. Developing a methodology for analyzing and monitoring interventions on various works of art over time may be achieved with a Cost-Effectiveness Analysis (CEA). In fact, CEA has demonstrated that routine maintenance is slightly more costly but ultimately more effective than extraordinary maintenance [27]. Furthermore, post-intervention monitoring helps reduce maintenance costs [40], which can also have environmental repercussions.

In real case studies, efficacy and compatibility (along with durability) are the primary indicators used to assess the quality of an intervention. Their evaluation is typically based on the comparison and monitoring of the conditions before and after the intervention. Generally, these evaluations need detailed information about the intervention methodologies, which are very often omitted; therefore, the prerequisites for proper quality control are rarely satisfied. The lack is especially true of the products adopted, the method of application, and the environmental situation at the time, and this increases the difficulty in evaluating the results of past interventions [41]. As suggested in [42], a possible solution to collect information could be a standardized graphic schedule detailing the diagnosis and subsequent conservation actions.

3.1. A Preliminary Approach to the Assessment of Conservation Interventions

Stone conservation emerged as a solid research field in the early Seventies, and it can be taken as the starting point in the development of preventive conservation strategies (see as an example the contributions reported in *1^er^ Colloque International sur la deterioration des pierres en oeuvre*; La Rochelle, 1972; *La conservazione delle sculture all'aperto*, Bologna, 1969), but there is no recognized doctrine on how to integrate experimental data on a decision-making process to evaluate effectiveness and harmfulness of stone treatments. One of the first significant contributions to the topic is from Sasse and Snethlag [22], which proposes relevant hints into the assessment of the effectiveness of different methods and their compatibility with the original stone material. A method is proposed to calculate an "effectivity number", derived from the selected properties to facilitate the comparison of different conservation materials and methods. Even if the proposed method is thought to be used only by experts and cannot be schematic in any case, sophisticated analytical methods were intentionally omitted.

More recently, only a few authors, such as Revés and Delgado, have coped with the problem of conservation intervention assessment based on the compatibility/incompatibility assessment [14,43–45]. They have proposed a methodology that can be used as a general guideline for conducting a comprehensive and precise evaluation of conservation interventions or their individual steps. These papers propose more or less the same concept in different forms and with various aims, sometimes referring to specific case studies [43,45]. The study in which this model is fully detailed can be found in

Rodrigues and Grossi [12]. The proposed method aims to provide a management tool with the compatibility model as its central operational component, a concept also utilized in Revés and Delgado [14,43–45]. Its ultimate goal is to establish the compatibility approach as a standard element of the conservation process, particularly for assessing incompatibility potential or risks.

The model considers not only technical (physical and chemical) criteria but also operational, environmental, social and cultural ones. Since compatibility is described by multiple elements and is a complex concept, it has been decomposed into more workable parameters called "compatibility indicators". The main criteria (physical-chemical, operational, environmental and socio-cultural) are the primary branches in a "compatibility tree," where the compatibility indicators are the secondary branches (basic components). However, caution is necessary when using compatibility indicators. There should not be too many, as this could lead to the mistake of describing the same property with multiple indicators [12]. Therefore, a selection should be operated, even if it is not easy to define in advance parameters that need to be monitored as they have to be selected case by case [40]. Rodrigues and Grossi [12] also stressed the importance of monitoring past interventions to evaluate best and bad practices and support decisions to be taken on conservation actions. The final goal of this method is to minimize the degree of incompatibility, which effectively reduces risk and aligns with the principle of minimum intervention.

In the work presented by Grossi et al. [43], a new approach for assessing the compatibility of conservation treatments is proposed and transformed into an IT tool running on software conceived as a web-based application (which, at the moment, is no longer accessible). This idea has already been mentioned in Rodrigues and Grossi [12], where it is stated that the formulation offered aims to include information into a structured system of analysis and to constitute a Decision Support System (DSS) that will make an important IT Tool for conservation practitioners' usage. Therefore, the DSS is used to assess the level of incompatibility of conservation treatments. Here, in Grossi et al. [43], some case studies are specifically mentioned. In this case, updated analytical methodologies were adopted to characterize both archaeological materials and past conservation actions, as well as to analyze the environmental conditions impacting them. The objective was to learn from past interventions and draw inspiration from their concepts to develop improved methods and more appropriate approaches [43].

Once again, the authors express hope that this approach may become a standard component of the conservation process, assessing the incompatibility potential or risks as part of integrated conservation planning. The possible use of a comprehensive record or database, including information to use in the conservation field, is mentioned in different articles [37,46–50]. However, significant challenges remain unresolved, including difficulties in maintaining digital records over long periods and difficulty in persuading researchers to contribute information to these systems and to use it in future years.

3.2. Alternative Proposals: Participatory Approaches and Multicriteria Analyses

The study by Revés and Delgado [14] is focused on the application of the already proposed compatibility-based approach for the assessment of conservation actions specifically for cleaning interventions. Also, in this case, the idea of using this model for the evaluation or analysis of past interventions is maintained.

In Revez and Delgado [14], a stronger association of the compatibility analysis with the (in)compatibility risk assessment by the introduction of a (cleaning) risk matrix, validated using the DELPHI method, has been proposed. The DELPHI method allows the structure of the communication of a group of experts, and the incompatibility risk assessment reduces a complex concept into simpler parameters in different categories. This procedure needs to be considered as a guide, not as a prescription. Indeed, it can be used to evaluate both past interventions (with the necessary amount of information) and, using the same pattern, to address also other steps of conservation intervention. To the extent of our knowledge, this method has been used so far only by the authors themselves on two stone monuments.

Beyond the DELPHI method, another method is the Analytical Hierarchy Process (AHP). The use of this method in intervention planning has been found only in Cessari and Gigliarelli [51], which focused on buildings with historical-artistic value and minor architectural structures. AHP is part of the system of multicriteria analysis (MCA), which "refers to a family of approaches that compare alternative options by combining a set of criteria. It is a participatory tool used to "[. . .] explore different perspectives in a systematic way" [52], involving a series of experts, which also have different significance in the final decision. This method was used to better define how to perform each step of the conservation intervention previously planned. The procedure should then be tailored to the needs of the specific types of cultural heritage under investigation. Multicriteria analysis can also be combined with Geographical Information System (GIS) to obtain spatial MCA (SMCA) or GIS-based MCA (GIS-MCA), which can be thought of as a collection of methods and tools for transforming and combining spatial (geographical) data and preferences to obtain information for decision making [53,54].

One last general approach found in the literature considering the participation of experts on this topic is proposed by Raoufi and Mansour [55]. The aim of this study is to propose an approach to increase the validity of the assessment process and to improve the accuracy of the results. In this case, only qualitative parameters are considered. The information related to the intervention was provided to local conservationists through a semi-structured, in-depth interview. For the evaluator's interpretation of the intervention to be consistent with reality, the evaluator should know the state of conservation and exactly what values are conserved or destroyed in the monument. The authors suggest that, by taking into account the object's character and its environmental context, this strategy can be repeatedly applied to evaluate different conservation interventions, even though it seems more useful in the evaluation post interventions, and it is not mentioned for planning treatments. Although some methods are suggested to identify the best intervention choice in relation to a specific aim, it is also necessary to remark that some authors have highlighted the impossibility of immediately assessing the efficacy of operative choices [1].

4. Discussion on Conservation Interventions Evaluation in Case Studies

4.1. Methodologies for the Evaluation of Conservation Interventions on Mural Paintings

Regarding mural paintings, the most used techniques to evaluate the performance of the interventions over time [29,35,56–67] are visual and optical techniques and colorimetry. It is interesting to notice how IR thermography is used more often than in other contexts. This technique allows the non-invasive in situ analysis of large surfaces and spatial mapping at an adequate resolution, which is useful both to identify degraded areas, previous interventions and the adhesion degree in different moments of the artwork's life [61]. Different approaches allow for the identification of different factors [68]. An interesting reference is made to the Scotch Tape Test (STT) used by Bourguignon et al. [56], which was tried on samples exposed in a site in Florence, Italy. This test allowed for some consideration regarding the surface's cohesion; however, due to its invasive nature, it is challenging to apply it to real case studies, even though the results could be highly useful. This is also probably the closest methodology to mechanical analysis that can be used for the investigation of thin layers. As a matter of fact, Duchene et al. [65] mention that drill resistance measurements and ultrasonic velocity, which are considered more classical evaluation systems, are not suitable for rating thin layers' strength.

4.2. General Insight on Methodologies for Conservation Interventions Assessment

Apart from the suggestions brought by standards and by some papers in the literature, as mentioned in this review, different authors have coped with the necessity of evaluating a conservation intervention or materials used for specific treatments. These evaluations have been carried out with the support of different analytical techniques both in situ and in the laboratory. In particular, non-destructive techniques (NDTs) can be utilized specifically to assess performance [69]. Other interesting reviews on the most common methods and NDTs used in the monitoring and preservation of historical surfaces have been proposed by Doehne and Price [37] and Zendri et al. [58].

Most of the tests should be concerned with measuring properties that are known to change in time or with assessing the goals reached by it. The most common analytical methods, suggested in a significant selection of papers [20,29,30,32,38,46,47,56–58,60–67,70–112], aim at understanding water or product interaction with the substrate (contact angle, water absorption by capillarity or low pressure, absorption coefficient, water vapor permeability, product penetration, etc.), physical properties (including hardness and porosity), color change (through colorimetry and spectral reflectance) and optical and visual analysis (cameras and microscopes at different magnitudes).

The techniques mentioned above are considered with no reference to their invasiveness and to the fact that they are applied in situ or in a laboratory. Many of these studies focus on the evaluation of different products for treatments, with the final choice generally based on a comparison of the performance characteristics of various products [81]. Most of the time, the analyses are conducted exclusively in a laboratory, while in situ analyses—conducted without withdrawing or creating samples—are less common.

The laboratory environment and the withdrawal of samples certainly allow the possibility of performing different and more analyses than in situ. Nevertheless, the national standard UNI 11897:2023 [6] provides guidelines on how to evaluate the results from different conservation treatments, and it stresses that the evaluation process should not be based only on laboratory analysis of ad hoc samples, but also on in situ analyses, possibly through non or less invasive methods. Laboratory analytical procedures are pointed out in the national Italian regulation (Normal 20/85 [113]) related to conservative interventions. Within its corpus, one of the paragraphs discusses the preliminary evaluation of the efficacy of materials and methods for conservation interventions through laboratory analytical procedures.

4.3. Monitoring Conservation Interventions over Time

Post-intervention monitoring is another crucial aspect that helps assess the durability and effectiveness of the intervention [114]. To monitor the product's performance over time, many authors include the use of artificial aging, which is also used preliminary before natural or artificial exposure [20,30,65,70,74,103–105]. On the other hand, natural aging, although it requires long experimentation to yield significant results, can be considered the most reliable test to assess the effectiveness of the products over time. In fact, unlike natural weathering, artificial aging makes it challenging to replicate the exact conditions of real materials. As a result, achieving a realistic and comprehensive reproduction of the effects of natural aging is difficult [46,73]. However, it is possible to have a fulfilling confirmation or relationship between the results obtained in the laboratory and those from case studies [105,106], suggesting that markers found through artificial aging can be used in real cases to monitor their state of preservation [105]. The obtained results from artificial weathering permit a "relative evaluation" of the weathering behavior [115]. Therefore, the use of aging for the evaluation of durability (especially in the case of outdoor heritage, as mural art often is) should be based on the comparison between natural aging outdoors and artificial aging in a laboratory, and this is very challenging [17]. Only a few studies have presented both types of aging, and some of them are [35,88,98,101]. Possible considerations on the relations between artificial and natural aging are many and intricate, and this topic is not further treated in this review.

5. Conclusions

There are guiding principles in the field of conservative interventions that are indispensable and generally aim to solve a conservation problem without creating new ones. This is usually expressed through concepts of compatibility, efficacy, and durability. In our opinion, these concepts have a particular characteristic of flexibility, which depends on the cultural heritage, intervention and conservation environment typology and, therefore, specific needs. The interconnection between these three aspects is remarked, and there is partial overlapping among them. For example, durability and efficacy are based on the same principles, with durability being the extension of efficacy over time. Efficacy, effectiveness, and efficiency, on the other hand, emphasize different aspects of the attention needed to achieve the conservation objective (efficacy): emphasizing its compatibility aspects (effectiveness) or highlighting its sustainability aspects (efficiency).

Interesting is the distinction and, at the same time, the overlap between quality and compatibility, which have many descriptors in common and make compatibility of the materials a necessary condition, but not sufficient, to achieve the quality in the conservative intervention.

These concepts should be integrated with the economic and environmental aspects, which are considered more and more significant.

Regarding the social aspects, particularly the need to share the conservation intentions with the community, we consider this participation fundamental, in line with the Faro Convention, even though the technical aspects remain the responsibility of experts (architects, heritage scientists, art historians, conservators, etc.). For what concerns the evaluation of the three concepts (compatibility, efficacy, durability), the literature reports a lot of possible methodologies to measure specific parameters related to these concepts.

More attention must be paid to the possibility of measuring these parameters over time directly on the artwork, even by simple tests. This is on the basis of the monitoring process and, therefore, preventive conservation.

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References

1. Pesenti, S. Atto Quarto: Il Tempo Della Verifica. In Proceedings of the La prova del tempo. Verifiche degli interventi per la conservazione del costruito in Atti del XVI Convegno Internazionale Scienza e Beni Culturali, Bressanone, Italy, 27–30 June 2000; Edizioni Arcadia Ricerche: Venice, Italy, 2000; pp. 31–40.
2. Horie, C.V. *Materials for Conservation: Organic Consolidants, Adhesives and Coatings*, 2nd ed.; Butterworth-Heinemann: Amsterdam, The Netherlands; Boston, MA, USA, 2010; ISBN 978-0-7506-6905-4.
3. ICOMOS Charter Principles for the Analysis, Conservation and Structural Restoration of Architectural Heritage-International Council on Monuments and Sites. Available online: https://www.icomos.org/en/about-the-centre/179-articles-en-francais/ressources/charters-and-standards/165-icomos-charter-principles-for-the-analysis-conservation-and-structural-restoration-of-architectural-heritage (accessed on 21 January 2025).

4. Dimitrova, E.; Lavenir, M.-L.; McMahon, P.; Mūrniece, B.; Musso, S.F.; Nagy, G.; Rauhut, C.; Rourke, G.D.; Sciacchitano, E.; Selfslagh, B. *European Quality Principles for EU-Funded Interventions with Potential Impact upon Cultural Heritage-Revised Edition November 2020*; ICOMOS: Charenton-le-Pont, France, 2020.
5. *Cambridge Dictionary*; Cambridge University Press: Cambridge, UK, 2019; Available online: https://dictionary.cam-bridge.org/dictionary/english/quality (accessed on 27 March 2025).
6. *UNI 11897:2023-Conservazione Del Patrimonio Culturale-Linee Guida per l'applicazione Dei Criteri Generali Di Qualità Negli Interventi Di Conservazione e Restauro Dei Beni Culturali*; Uni: Rome, Italy, 2023.
7. Musso, S.F. "Quality" of Interventions on Built Cultural Heritage. *RA Restauro Archeologico* **2022**, *30*, 78–83.
8. Documento Di Indirizzo per La Qualità Dei Progetti Di Restauro Dell'architettura. In Proceedings of the Restauro Dell'architettura Per un Progetto di Qualità, Napoli, Italy, 15–16 June 2023.
9. Carlessi, M.; Kluzer, A. La Qualità Nel Progetto per Il Patrimonio Costruito. Alcune Declinazioni Di Un Concetto Sostanziale e Poliedrico. In Proceedings of the La Qualità Dell'intervento sui Beni Culturali in Atti del XXXVII Convegno Internazionale Scienza e Beni Culturali, Bressanone, Italy, 2 December 2021; Edizioni Arcadia Ricerche: Venice, Italy, 2021; Volume XXXVII, pp. 27–29.
10. Boriani, M.; Renoldi, F.; Brembilla, M.; Cassia, E. Un Manuale Di Procedura per Normare La Qualità Minima Degli Interventi Di Manutenzione Sull'edilizia Storica Diffusa. In Proceedings of the Ripensare alla manutenzione. Ricerche, Progettazione, Materiali, Tecniche in Atti del XV Convegno Internazionale Scienza e Beni Culturali, Bressanone, Italy, 29 June–3 July 1999; Edizioni Arcadia Ricerche: Venice, Italy, 1999; Volume XV, pp. 377–386.
11. Bruschi, G.; Saetta, A.; Faccio, P.; Antonelli, F.; Peron, F.; Zendri, E.; Berto, L.; Squassina, A.; Cimino, D.; De Maria, M.; et al. Compatibilità, Efficacia, Sostenibilità Come Indicatori per l'intervento e La Manutenzione Tra Tradizione e Innovazione. In Proceedings of the La Qualità Dell'intervento sui Beni Culturali in Atti del XXXVII Convegno Internazionale Scienza e Beni Culturali, Bressanone, Italy, 5–7 July 2022; Edizioni Arcadia Ricerche: Venice, Italy, 2022; pp. 71–82.
12. Rodrigues, J.D.; Grossi, A. Indicators and Ratings for the Compatibility Assessment of Conservation Actions. *J. Cult. Herit.* **2007**, *8*, 32–43.
13. *UNI EN 15898:2019-Conservazione Del Patrimonio Culturale-Termini Generali e Definizioni*; Uni: Rome, Italy, 2019.
14. Revez, M.J.; Delgado Rodrigues, J. Incompatibility Risk Assessment Procedure for the Cleaning of Built Heritage. *J. Cult. Herit.* **2016**, *18*, 219–228.
15. Zendri, E.; Biscontin, G.; Driussi, G. La Compatibilità Negli Interventi Di Restauro: Alcune Considerazioni Sui Possibili Parametri Indicativi. In Proceedings of the Lacune in Architettura: Aspetti Teorici ed Operativi in Atti del XIII Convegno Internazionale Scienza e Beni Culturali, Bressanone, Italy, 1–4 July 1997; Edizioni Arcadia Ricerche: Venice, Italy, 1997; Volume XIII, pp. 315–326.
16. Groot, C.; Verga, R.; Papayianni, I.; Van Hees, R.; Secco, M.; Alvarez, J.I.; Faria, P.; Stefanidou, M. RILEM TC 277-LHS Report: Lime-Based Mortars for Restoration-a Review on Long-Term Durability Aspects and Experience from Practice. *Mater. Struct.* **2022**, *55*, 245.
17. Dal Pozzo, A.; Masi, G.; Sassoni, E.; Tugnoli, A. Life Cycle Assessment of Stone Consolidants for Conservation of Cultural Heritage. *Build. Environ.* **2024**, *249*, 111153.
18. Pagnin, L.; Guarnieri, N.; Izzo, F.C.; Goidanich, S.; Toniolo, L. Protecting Street Art from Outdoor Environmental Threats: What Are the Challenges? *Coatings* **2023**, *13*, 2044. [CrossRef]
19. Vecchiattini, R. Compatibilità Tra Materiali e Sostenibilità Delle Scelte Progettuali Nel Restauro Architettonico. In Proceedings of the Restaurare i restauri. Metodi, Compatibilità, Cantieri in Atti del Convegno Internazionale Scienza e Beni Culturali, Bressanone, Italy, 24–27 June 2008; Edizioni Arcadia Ricerche: Venice, Italy, 2008; pp. 439–448.
20. Sassoni, E.; Graziani, G.; Franzoni, E. An Innovative Phosphate-Based Consolidant for Limestone. Part 1: Effectiveness and Compatibility in Comparison with Ethyl Silicate. *Constr. Build. Mater.* **2016**, *102*, 918–930.
21. Apostolopoulou, M.; Aggelakopoulou, E.; Bakolas, A.; Moropoulou, A. Compatible Mortars for the Sustainable Conservation of Stone in Masonries. In *Advanced Materials for the Conservation of Stone*; Hosseini, M., Karapanagiotis, I., Eds.; Springer International Publishing: Cham, Switzerland, 2018; pp. 97–123, ISBN 978-3-319-72259-7.
22. Sasse, H.R.; Snethlage, R. Methods for the Evaluation of Stone Conservation Treatments. In *Saving Our Architectural Heritage: The Conservation of Historic Stone Structures; Report of the Dahlem Workshop on Saving our Architectural Heritage: The Conservation of Historic Stone Structures, Berlin, Germany, 3–8 March 1996*; Dahlem Workshop Reports; Wiley: Chichester, UK, 1997.
23. EFFICACY Definition and Meaning | Collins English Dictionary. Available online: https://www.collinsdictionary.com/dictionary/english/efficacy (accessed on 21 January 2025).
24. EFFECTIVE Definition and Meaning | Collins English Dictionary. Available online: https://www.collinsdictionary.com/dictionary/english/effective (accessed on 21 January 2025).
25. EFFICIENCY Definition and Meaning | Collins English Dictionary. Available online: https://www.collinsdictionary.com/dictionary/english/efficiency (accessed on 21 January 2025).
26. Patel, P. Efficacy, Effectiveness, and Efficiency. *Natl. J. Community Med.* **2021**, *12*, 33–39.

27. Revez, M.J.; Coghi, P.; Rodrigues, J.D.; Vaz Pinto, I. Analysing the Cost-Effectiveness of Heritage Conservation Interventions: A Methodological Proposal within Project STORM. *Int. J. Archit. Herit.* **2021**, *15*, 985–999.
28. Mandal, S.; Kumar, P.; Satpathy, B.; Das, K.; Das, S. Nanostructured Metal Oxide Based Coating for the Protection and Conservation of Cultural Heritage: A Comprehensive Review. *J. Cult. Herit.* **2024**, *69*, 94–112.
29. Provinciali, B.; Iazurlo, P. A Method of Controlling Two Mural Paintings Consolidation. In Proceedings of the International Colloquium Methods of Evaluating Products for the Conservation of Porous Building Materials in Monuments, Rome, Italy, 19–21 June 1995; ICCROM: Rome, Italy, 1995; pp. 213–223.
30. Sassoni, E.; Graziani, G.; Franzoni, E. An Innovative Phosphate-Based Consolidant for Limestone. Part 2: Durability in Comparison with Ethyl Silicate. *Constr. Build. Mater.* **2016**, *102*, 931–942.
31. Guida, A.; Fatiguso, F.; Mecca, I. Setting of the Restoration Project for Durability. In *Structural Studies, Repairs and Maintenance of Heritage Architecture*; WIT Press, Wessex Institute of Technology: Southampton, UK, 2003; pp. 705–714.
32. Apollonia, L.; Bevilacqua, F.; Di Francesco, C.; Pinna, D. Verifica Dello Stato Di Conservazione Di Monumenti Ferraresi Dopo Alcuni Decenni Dagli Interventi Di Restauro. In Proceedings of the La Prova del Tempo. Verifiche Degli Interventi per la Conservazione del Costruito in Atti del XVI Convegno Internazionale Scienza e Beni Culturali, Bressanone, Italy, 27–30 June 2000; Edizioni Arcadia Ricerche: Venice, Italy, 2000; pp. 163–171.
33. Moreau, C.; Simon, S.; Haake, S.; Favaro, M. How to Asess the Efficiency of Stobe Consolidant: The Example of the Bologna Cocktail. In Proceedings of the 7th European conference SAUVEUR—Safeguard cultural heritage: Understanding & Viability for the Enlarged Europe, Prague, Czech Republic, 31 May–3 June 2006; pp. 197–205.
34. Corradi, M. "Travailler à Bien Pensér": Alcune Considerazioni Sugli Interventi Di Consolidamento Della Cupola Di S. Gaudenzio a Novara. In Proceedings of the La Prova del Tempo. Verifiche Degli Interventi per la Conservazione del Costruito in Atti del XVI Convegno Internazionale Scienza e Beni Culturali, Bressanone, Italy, 27–30 June 2000; Edizioni Arcadia Ricerche: Venice, Italy, 2000; pp. 297–308.
35. Alonso-Villar, E.M.; Rivas, T.; Pozo-Antonio, J.S.; Pellis, G.; Scalarone, D. Efficacy of Colour Protectors in Urban Art Paintings under Different Conditions: From a Real Mural to the Laboratory. *Heritage* **2023**, *6*, 3475–3498. [CrossRef]
36. Guidolin, L.; Tognini Folli, R. La Grande Guglia Del Duomo Di Milano: Efficacia e Durabilità Dell'intervento Del 1845. In Proceedings of the La Prova del Tempo. Verifiche Degli Interventi per la Conservazione del Costruito in Atti del XVI Convegno Internazionale Scienza e Beni Culturali, Bressanone, Italy, 27–30 June 2000; Edizioni Arcadia Ricerche: Venice, Italy, 2000; pp. 21–30.
37. Doehne, E.F.; Price, C.A. Stone Conservation: An Overview of Current Research. In *Research in Conservation*, 2nd ed.; Getty Conservation Institute: Los Angeles, CA, USA, 2010.
38. Pozo-Antonio, J.S.; Otero, J.; Alonso, P.; Mas I Barberà, X. Nanolime- and Nanosilica-Based Consolidants Applied on Heated Granite and Limestone: Effectiveness and Durability. *Constr. Build. Mater.* **2019**, *201*, 852–870.
39. García, O.; Malaga, K. Definition of the Procedure to Determine the Suitability and Durability of an Anti-Graffiti Product for Application on Cultural Heritage Porous Materials. *J. Cult. Herit.* **2012**, *13*, 77–82.
40. Zendri, E.; Balliana, E.; Izzo, F.C.; Melchiorre, M.; Falchi, L.; Biscontin, G.; Sgobbi, M. The Monitoring of Architectural Stone Surface Treatments: Choice of the Parameters and of Their Thresholds Limit Values. In Proceedings of the International Conference on Preventive Conservation of Architectural Heritage, Nanjing, China, 29–30 October 2011.
41. Calia, A.; Mecchi, A.; Quarta, G. La Valutazione Degli Interventi: Apporti e Limiti Della Documentazione Rispetto Alla Realtà Di Cantiere. In Proceedings of the Lacune in Architettura: Aspetti Teorici ed Operativi in Atti del XVI Convegno Internazionale Scienza e Beni Culturali, Bressanone, Italy, 27–30 June 2000; Edizioni Arcadia Ricerche: Venice, Italy, 2000; pp. 141–149.
42. Fancelli, P. Graphic Schedule for the Diagnosis and Conservation Practice. In *The Conservation of Stone II, Part A*; Centro per la conservazione delle sculture all'aperto: Bologna, Italy, 1981; pp. 513–520.
43. Grossi, A.; Delgado Rodrigues, J.; Akili, T.; Chahoud, A.; Bulgarelli, A.; Doughman, M. Compatibility in Conservation Interventions. An IT Tool Developed by the PROMODEA Project. *Int. J. Des. Sci. Technol.* **2006**, *13*, 93.
44. Delgado Rodrigues, J. Compatibility of Conservation Intervention in Archaeological Sites—Theoretical Background and Practical Perspectives. In Proceedings of the Symposium on Conservation of Ancient Sites, Dunhuang, China, 22–24 September 2008; pp. 94–105.
45. Revez, M.J.; Raposo, M.; Delgado Rodrigues, J. The PROMODEA Phasing and Compatibility Indicators as Tools for the Planning and Design of Conservation Interventions. Assessment and Validation in the Santa Clara-a-Velha Monastery (Coimbra, Portugal). In Proceedings of the 12th International Congress on the Deterioration and Conservation of Stone, New York City, NY, USA, 22–26 October 2012.
46. Sansonetti, A.; Pasetti, A.; Trivella, L. Una Proposta per Una Metodologia i Monitoraggio Degli Interventi Di Integrazione Delle Lacune. In Proceedings of the La Prova del Tempo. Verifiche Degli Interventi per la Conservazione del Costruito in Atti del XIII Convegno Internazionale Scienza e Beni Culturali, Bressanone, Italy, 1–4 July 1997; Edizioni Arcadia Ricerche: Venice, Italy, 1997; pp. 271–279.

47. Cadignani, R. *La torre Ghirlandina. 2: Storia e Restauro = History and Restoration*; Luca Sossella Editore: Rome, Italy, 2010.
48. Treccani, G.P. La Prova Del Tempo Tra Errori Ed Omissioni. In Proceedings of the Lacune in Architettura: Aspetti Teorici ed Operativi in Atti del XVI Convegno Internazionale Scienza e Beni Culturali, Bressanone, Italy, 27–30 June 2000; Edizioni Arcadia Ricerche: Venice, Italy, 2000; pp. 65–70.
49. Toniolo, L.; Paradisi, A.; Boriani, M.; Giambruno, M.; Battistelli, A.; Simonelli, R. Il "Restauro" Dei Restauri Nell'edilizia Storica Diffusa: Un Serio Problema Di Compatibilità Di Materiali. In Proceedings of the Restaurare i Restauri. Metodi, Compatibilità, Cantieri in Atti del XXIV Convegno Internazionale Scienza e Beni Culturali, Bressanone, Italy, 24–27 June 2008; Edizioni Arcadia Ricerche: Venice, Italy, 2008; pp. 121–129.
50. Sanchez, M.; Ponti, M.; Clavel, I. Il Murale Contemporaneo e Il Suo Restauro Nella Comunità Valenziana: Nuovi Concetti e Nuovi Materiali. In Proceedings of the Sulle Pitture Murali—Riflessioni, Conoscenze, Interventi in Atti del XXI Convegno Internazionale Scienza e Beni Culturali, Bressanone, Italy, 12–15 July 2005; Edizioni Arcadia Ricerche: Venice, Italy, 2005; pp. 717–726.
51. Cessari, L.; Gigliarelli, E. *Metodologie Di Valutazione Della Compatibilità Degli Interventi Conservativi. Applicazione Su Edifici Di Valore Storico-Artistico e Sull'architettura Minore*; Gangemi Editore: Rome, Italy, 2016.
52. Multicriteria Analysis—An Overview | ScienceDirect Topics. Available online: https://www-sciencedirect-com.ezproxy.uniroma1.it/topics/earth-and-planetary-sciences/multicriteria-analysis (accessed on 21 January 2025).
53. Malczewski, J. Multicriteria Analysis. In *Comprehensive Geographic Information Systems*; Elsevier: Amsterdam, The Netherlands, 2018; pp. 197–217.
54. Borellini, G.C.; Cavagnini, G.; Coccoli, C.; Mapelli, M. La Documentazione Degli Interventi Sui Dipinti Murali Attraverso l'utilizzo Della Tecnolofia G.I.S.: Il Caso Del Monastero Di Cairate (VA). In Proceedings of the Sulle Pitture Murali—Riflessioni, Conoscenze, Interventi in Atti del XXI Convegno Internazionale Scienza e Beni Culturali, Bressanone, Italy, 12–15 July 2005; Edizioni Arcadia Ricerche: Venice, 2005; pp. 307–316.
55. Raoufi, Z.; Mansour, K. An Approach to Enhance the Validity of Qualitative Evaluations in Conservation Interventions of Hishtorical Monuments—Case Study: Khajeh Tomb in Kerman. *Bagh-e Nazar* **2021**, *18*, 5–18.
56. Bourguignon, E.; Tomasin, P.; Detalle, V.; Vallet, J.-M.; Labouré, M.; Olteanu, I.; Favaro, M.; Chiurato, M.A.; Bernardi, A.; Becherini, F. Calcium Alkoxides as Alternative Consolidants for Wall Paintings: Evaluation of Their Performance in Laboratory and on Site, on Model and Original Samples, in Comparison to Conventional Products. *J. Cult. Herit.* **2018**, *29*, 54–66.
57. Becherini, F.; Durante, C.; Bourguignon, E.; Li Vigni, M.; Detalle, V.; Bernardi, A.; Tomasin, P. Aesthetic Compatibility Assessment of Consolidants for Wall Paintings by Means of Multivariate Analysis of Colorimetric Data. *Chem. Cent. J.* **2018**, *12*, 98.
58. Zendri, E.; Falchi, L.; Izzo, F.C.; Morabito, Z.M.; Driussi, G. A Review of Common NDTs in the Monitoring and Preservation of Historical Architectural Surfaces. *Int. J. Archit. Herit.* **2017**, *11*, 987–1004. [CrossRef]
59. Bianchin, S.; Favaro, M.; Vigato, P.A.; Botticelli, G.; Germani, G.; Botticelli, S. The Scientific Approach to the Restoration and Monitoring of Mural Paintings at S. Girolamo Chapel–SS. Annunziata Church in Florence. *J. Cult. Herit.* **2009**, *10*, 379–387. [CrossRef]
60. Daffara, C.; Fontana, R.; Melchiorre Di Crescenzo, M.; Scrascia, S.; Zendri, E. Optical Techniques for the Characterization of Surface-Subsurface Defects in Painted Layers. In *Optics for Arts, Architecture, and Archaeology III*; SPIE Optical Metrology: Munich, Germany, 2011.
61. Melchiorre Di Crescenzo, M.; Zendri, E.; Daffara, C.; Fontana, R.; Scrascia, S. Thermal Imaging for the Examination and Conservation of Contemporary Mural Paintings. In Proceedings of the Art'11 10th International Conference, Florence, Italy, 13–15 April 2011.
62. Pozo-Antonio, J.S.; Alonso-Villar, E.M.; Rivas, T.; Márquez, I. Evaluation of a Protective Acrylic Finish Applied to Surfaces Painted with Acrylic Paints for Outdoor or Indoor Uses. *Dye Pigments* **2023**, *212*, 111141.
63. Mariotti, P.I.; Ciardi, A.; Lanterna, G. Materiali Consolidanti Della Pellicola Pittorica Nelle Pitture Murali Eseguite a Secco. *OPD Restauro* **2019**, *31*, 246–262.
64. Ropret, P.; Zoubek, R.; Škapin, A.S.; Bukovec, P. Effects of Ageing on Different Binders for Retouching and on Some Binder–Pigment Combinations Used for Restoration of Wall Paintings. *Mater. Charact.* **2007**, *58*, 1148–1159.
65. Duchene, S.; Detalle, V.; Favaro, M.; Ossola, F.; Tomasin, P.; De Zorzi, C.; El Habra, N. Nanomaterials for Consoldation of Marble and Wall Paintings. In Proceedings of the 12th International Congress on the Deterioration and Conservation of Stone, New York, NY, USA, 22–26 October 2012.
66. Natali, I.; Saladino, M.L.; Andriulo, F.; Chillura Martino, D.; Caponetti, E.; Carretti, E.; Dei, L. Consolidation and Protection by Nanolime: Recent Advances for the Conservation of the Graffiti, Carceri Dello Steri Palermo and of the 18th Century Lunettes, SS. Giuda e Simone Cloister, Corniola (Empoli). *J. Cult. Herit.* **2014**, *15*, 151–158.
67. Kerr-Allison, A. Outdoor Public Murals: Materials, Advocacy and Conservation. In Proceedings of the Annual Student Conference, Harvard University Art Museums, Cambridge, MA, USA, 19 October 2007.

68. Rosina, E.; Ludwig, N.; Pracchi, V.; Suardi, G. Compatibilità e Durabilità Dei Restauri Degli Affreschi in Condizioni Microclimatiche Severe. In Proceedings of the Restaurare i Restauri. Metodi, Compatibilità, Cantieri in Atti del XXIV Convegno Internazionale Scienza e Beni Culturali, Bressanone, Italy, 24–27 June 2008; Edizioni Arcadia Ricerche: Venice, Italy, 2008; pp. 537–546.
69. Moropoulou, A.; Labropoulos, K.C.; Delegou, E.T.; Karoglou, M.; Bakolas, A. Non-Destructive Techniques as a Tool for the Protection of Built Cultural Heritage. *Constr. Build. Mater.* **2013**, *48*, 1222–1239.
70. Natali, I.; Tomasin, P.; Becherini, F.; Bernardi, A.; Ciantelli, C.; Favaro, M.; Favoni, O.; Pérez, V.J.F.; Olteanu, I.D.; Sanchez, M.D.R.; et al. Innovative Consolidating Products for Stone Materials: Field Exposure Tests as a Valid Approach for Assessing Durability. *Herit. Sci.* **2015**, *3*, 1–13.
71. Ferreira Pinto, A.P.; Delgado Rodrigues, J. Consolidation of Carbonate Stones: Influence of Treatment Procedures on the Strengthening Action of Consolidants. *J. Cult. Herit.* **2012**, *13*, 154–166.
72. Karatasios, I.; Theoulakis, P.; Kalagri, A.; Sapalidis, A.; Kilikoglou, V. Evaluation of Consolidation Treatments of Marly Limestones Used in Archaeological Monuments. *Constr. Build. Mater.* **2009**, *23*, 2803–2812.
73. Chen, W.; Dai, P.; Yuan, P.; Zhang, J. Effect of Inorganic Silicate Consolidation on the Mechanical and Durability Performance of Sandstone Used in Historical Sites. *Constr. Build. Mater.* **2016**, *121*, 445–452.
74. Bonazza, A.; Vidorni, G.; Natali, I.; Ciantelli, C.; Giosuè, C.; Tittarelli, F. Durability Assessment to Environmental Impact of Nano-Structured Consolidants on Carrara Marble by Field Exposure Tests. *Sci. Total Environ.* **2017**, *575*, 23–32.
75. Biscontin, G.; Riva, G. Study about Water Vapour Permeability in Stone Materials after Protective Treatment. In *Conservation of Stone II, Part B*; Centro per la conservazione delle sculture all'aperto: Bologna, Italy, 1981; pp. 689–697.
76. De Rosario, I.; Elhaddad, F.; Pan, A.; Benavides, R.; Rivas, T.; Mosquera, M.J. Effectiveness of a Novel Consolidant on Granite: Laboratory and in Situ Results. *Constr. Build. Mater.* **2015**, *76*, 140–149. [CrossRef]
77. Rossi-Manaresi, R.; Rattazzi, A.; Toniolo, L. Long Term Effectiveness of Treatments of Sandstone. In Proceedings of the International Colloquium Methods of Evaluating Products for the Conservation of Porous Building Materials in Monuments, Rome, Italy, 19–21 June 1995; ICCROM: Rome, Italy, 1995; pp. 225–244.
78. Biscontin, G.; Frascati, S.; Marchesini, L. Colour Variations in Old Bricks and Stones as a Result of Consolidation with Resin. In *The Conservation of Stone I*; Centro per la conservazione delle sculture all'aperto: Bologna, Italy, 1975; pp. 731–747.
79. Alaimo; Alberghina, M.F.; Brai, M.; Enea, D.; Fernandez, F.; Fontana, D.; Livreri, P.; Longo, A.; Marrale, M.; Proietto, V.; et al. Valutazione Dell'efficacia e Durabilità Di Protettivi Nanostrutturati Applicati Su Campioni Di Marmo Di Carrara. In *Diagnostic for Cultural Heritage: Analytical Approach for an Effective Conservation*; Università degli Studi di Palermo: Palermo, Italy, 2013; pp. 24–30.
80. Alaimo, G.; Alberghina, M.F.; Codan, B.; Enea, D.; Fernandez, F.; Fontana, D.; Livreri, P.; Todaro, L.; Tranchina, L.; Brai, M. Prodotti Nanostrutturati per La Protezione Di Superfici Lapidee: Valutazione Dell'efficacia Mediante Tecniche Fisiche Non Invasive. In *Diagnostic for Cultural Heritage: Analytical Approach for an Effective Conservation*; Università degli Studi di Palermo: Palermo, Italy, 2013; pp. 16–23.
81. Aldi, A.; Alessandrini, G.; Casarino, A.; Pedemonte, E.; Peruzzi, R. Evaluation of the Effectiveness of Protective Treatments for Slate from the Val Di Lavagna (Italy). In Proceedings of the International Colloquium Methods of Evaluating Products for the Conservation of Porous Building Materials in Monuments, Rome, Italy, 19–21 June 1995; ICCROM: Rome, Italy, 1995; pp. 285–300.
82. Alessandrini, G.; Aglietto, M.; Castelvetro, V.; Ciardelli, F.; Peruzzi, R.; Toniolo, L. Comparative Evaluation of Fluorinated and Unfluorinated Acrylic Copolymers as Water-Repellent Coating Materials for Stone. *J. Appl. Polym. Sci.* **2000**, *76*, 962–977.
83. Apollonia, L.; Fassina, V.; Matteoli, U.; Mecchi, A.M.; Nugari, M.P.; Pinna, D.; Peruzzi, R.; Salvadori, O.; Santamaria, U.; Scala, A.; et al. Methodology for the Evaluation of Protective Products for Stone Materials. Part II: Experimental Tests on Treated Samples. In Proceedings of the International Colloquium Methods of Evaluating Products for the Conservation of Porous Building Materials in Monuments, Rome, Italy, 19–21 June 1995; ICCROM: Rome, Italy, 1995; pp. 301–316.
84. Alvarez De Buergo Ballester, M.; Fort González, R. Basic Methodology for the Assessment and Selection of Water-Repellent Treatments Applied on Carbonatic Materials. *Prog. Org. Coat.* **2001**, *43*, 258–266.
85. Bugini, R.; Folli, L.; Sansonetti, A.; Surace, A. La Verifica Dell'efficacia Degli Interventi Nei Siti Archeologici. In Proceedings of the Lacune in Architettura: Aspetti Teorici ed Operativi in Atti del XVI Convegno Internazionale Scienza e Beni Culturali, Bressanone, Italy, 27–30 June 2000; Edizioni Arcadia Ricerche: Venice, Italy, 2000; pp. 217–226.
86. Butlin, R.N.; Yates, T.J.S.; Martin, W. Comparison of Traditional and Modern Treatments for Conserving Stone. In Proceedings of the International Colloquium Methods of Evaluating Products for the Conservation of Porous Building Materials in Monuments, Rome, Italy, 19–21 June 1995; ICCROM: Roma, 1995; pp. 111–119.
87. Cantisani, E.; Fratini, F.; Manganelli Del Fà, C.; Rava, A.; Rescic, S. L'arenaria Utilizzata Nell'Abbazia Di S. Maria Di Vezzolano (AT): Verifica Dei Trattamenti Di Consolidamento. In Proceedings of the Lacune in architettura: Aspetti teorici ed operativi in Atti del XVI Convegno Internazionale Scienza e Beni Culturali, Bressanone, Italy, 27–30 June 2000; Edizioni Arcadia Ricerche: Venice, Italy, 2000; pp. 151–162.

88. Caselli, A. Methods Used to Evaluate the Efficacy of Consolidants on an Australian Sandstone. In *International Colloquium Methods of Evaluating Products for the Conservation of Porous Building Materials in Monuments*; ICCROM: Rome, Italy, 1995; pp. 121–130.
89. Cherido, M.M.; Fassina, V.; Fresa, F.M. Venezia. Verifica Dell'efficacia Dei Trattamenti Protettivi Applicati Nel Corso Del Restauro Di Una Facciata Lapidea. In Proceedings of the Lacune in Architettura: Aspetti Teorici ed Operativi in Atti del XVI Convegno Internazionale Scienza e Beni Culturali, Bressanone, Italy, 27–30 June 2000; Edizioni Arcadia Ricerche: Venice, Italy, 2000; pp. 95–105.
90. Crova, C.; Muraglia, F. Indagini Diagnostiche Non Invasive e Manutenzione Programmata. Analisi Di Un Caso Di Studio: La Torre Del Monte Di Scauri. *Archeomatica* **2019**, *4*, 20–24.
91. Cuttano, M.; Mastronardi, P.; Rossi-Manaresi, R. Alveolar Weathering of the "Tuff" of Matera—Mechanism of Deterioration and Effectiveness of Preservation Treatments. In *The Conservation of Stone II, Part A*; Centro per la conservazione delle sculture all'aperto: Bologna, Italy, 1981; pp. 355–377.
92. David, P.R. Prove in Corso e Verifiche a Posteriori Nel Trattamento Di Superfici Lapidee Con Prodotti Organici e Inorganici. In Proceedings of the Lacune in Architettura: Aspetti teorici ed Operativi in Atti del XVI Convegno Internazionale Scienza e Beni Culturali, Bressanone, Italy, 27–30 June 2000; Edizioni Arcadia Ricerche: Venice, 2000; pp. 117–127.
93. Drdácký, M.; Lesák, J.; Rescic, S.; Slížková, Z.; Tiano, P.; Valach, J. Standardization of Peeling Tests for Assessing the Cohesion and Consolidation Characteristics of Historic Stone Surfaces. *Mater. Struct.* **2012**, *45*, 505–520.
94. Esbert, R.M.; Alonso, J.; Alonso, F.J.; Ordaz, J. Suggested Properties for Evaluating the Behavior of a Waterproofed Limestone under Aggressive Environmental Conditions. In Proceedings of the International Colloquium Methods of Evaluating Products for the Conservation of Porous Building Materials in Monuments, 19–21 June 1995; ICCROM: Rome, Italy, 1995; pp. 331–339.
95. Franchi, R.; Frediani, P.; Galli, G.; Manganelli del Fà, C.; Matteoli, U.; Tiano, P. Use of Fluorinated Products as Water Repellents: Study of Their Behaviour on Stone Material. In Proceedings of the 3rd International Congress on the Deterioration and Preservation of stones, Fondazione Giorgio Cini, Venice, Italy, 24–27 October 1979; pp. 327–331.
96. Garcia Pascua, N.; Sanchez De Rojas, M.I.; Frias, M. Study of Porosity and Physical Properties as Methods to Establish the Effectiveness of Treatments Used in Two Different Spanish Stones: Limestone and Sandstone. In Proceedings of the International Colloquium Methods of Evaluating Products for the Conservation of Porous Building Materials in Monuments, 19–21 June 1995; ICCROM: Rome, Italy, 1995; pp. 147–162.
97. Kertész, P.; Marek, I. Testing of the Effectiveness of Conservation on Hungarian Stones. In *The Conservation of Stone II, Part B*; Centro per la conservazione delle sculture all'aperto: Bologna, Italy, 1981; pp. 711–720.
98. Kumar, R.; Ginell, W.S. Evaluation of Consolidants for Stabilization of Weak Maya Limestone. In Proceedings of the International Colloquium Methods of Evaluating Products for the Conservation of Porous Building Materials in Monuments, 19–21 June 1995; ICCROM: Rome, Italy, 1995; pp. 163–178.
99. Maravelaki-Kalaitzaki, P.; Kallithrakas-Kontos, N.; Korakaki, D.; Agioutantis, Z.; Maurigiannakis, S. Evaluation of Silicon-Based Strengthening Agents on Porous Limestones. *Prog. Org. Coat.* **2006**, *57*, 140–148.
100. Petriaggi, R.; Davidde, B.; Ricci, S.; Priori, G.F. Verifica Dell'efficacia Delle Malte Idrauliche Utilizzate per Il Restauro Di Strutture Romane Nel Parco Sommerso Di Baia. In Proceedings of the Restaurare i Restauri. Metodi, Compatibilità, Cantieri in Atti del XXIV Convegno Internazionale Scienza e Beni Culturali, Bressanone, Italy, 24–27 June 2008; Edizioni Arcadia Ricerche: Venice, Italy, 2008; pp. 491–497.
101. Rossi-Manaresi, R. Effectiveness of Conservation Treatments for The Sandstone of Monuments in Bologna. In *The Conservation of Stone II, Part B*; Centro per la conservazione delle sculture all'aperto: Bologna, Italy, 1981; pp. 665–688.
102. Zendri, E.; Biscontin, G.; Longega, G.; Battagliarin, M. Valutazione Del Comportamento Nel Tempo Di Trattamenti Protettivi a Base Di Polimeri Acrilici. In Proceedings of the Lacune in architettura: Aspetti Teorici ed Operativi in Atti del XVI Convegno Internazionale Scienza e Beni Culturali, Bressanone, Italy, 27–30 June 2000; Edizioni Arcadia Ricerche: Venice, Italy, 2000; pp. 173–180.
103. Favaro, M.; Simon, S.; Menichelli, C.; Fassina, V.; Vigato, P.A. The Four Virtues of the Porta Della Carta, Ducal Palace, Venice—Assessment of the State of Preservation and Re-Evaluation of the 1979 Restoration. *Stud. Conserv.* **2005**, *50*, 109–127.
104. Favaro, M.; Mendichi, R.; Ossola, F.; Russo, U.; Simon, S.; Tomasin, P.; Vigato, P.A. Evaluation of Polymers for Conservation Treatments of Outdoor Exposed Stone Monuments. Part I: Photo-Oxidative Weathering. *Polym. Degrad. Stab.* **2006**, *91*, 3083–3096.
105. Favaro, M.; Mendichi, R.; Ossola, F.; Simon, S.; Tomasin, P.; Vigato, P.A. Evaluation of Polymers for Conservation Treatments of Outdoor Exposed Stone Monuments. Part II: Photo-Oxidative and Salt-Induced Weathering of Acrylic–Silicone Mixtures. *Polym. Degrad. Stab.* **2007**, *92*, 335–351. [CrossRef]
106. Pinto, A.P.F.; Rodrigues, J.D. Stone Consolidation: The Role of Treatment Procedures. *J. Cult. Herit.* **2008**, *9*, 38–53.
107. López-Arce, P.; Gomez-Villalba, L.S.; Pinho, L.; Fernández-Valle, M.E.; De Buergo, M.Á.; Fort, R. Influence of Porosity and Relative Humidity on Consolidation of Dolostone with Calcium Hydroxide Nanoparticles: Effectiveness Assessment with Non-Destructive Techniques. *Mater. Charact.* **2010**, *61*, 168–184. [CrossRef]

108. Moropoulou, A.; Haralampopoulos, G.; Tsiourva, T.; Theoulakis, P.; Koui, M. Long Term Performance Evaluation of Consolidation Treatments in Situ. In Proceedings of the Lacune in architettura: Aspetti teorici ed operativi in Atti del XVI Convegno Internazionale Scienza e Beni Culturali, Bressanone, Italy, 27–30 June 2000; Edizioni Arcadia Ricerche: Venice, Italy, 2000; pp. 239–249.
109. Moropoulou, A.; Kouloumbi, N.; Haralampopoulos, G.; Konstanti, A.; Michailidis, P. Criteria and Methodology for the Evaluation of Conservation Interventions on Treated Porous Stone Susceptible to Salt Decay. *Prog. Org. Coat.* **2003**, *48*, 259–270. [CrossRef]
110. Stefanidou, M.; Karozou, A. Testing the Effectiveness of Protective Coatings on Traditional Bricks. *Constr. Build. Mater.* **2016**, *111*, 482–487. [CrossRef]
111. Tsakalof, A.; Manoudis, P.; Karapanagiotis, I.; Chryssoulakis, I.; Panayiotou, C. Assessment of Synthetic Polymeric Coatings for the Protection and Preservation of Stone Monuments. *J. Cult. Herit.* **2007**, *8*, 69–72. [CrossRef]
112. Serra, C.L.; Formia, A.; Zerbinatti, M.; Sangermano, M.; Tulliani, J.M. Conservation of Outdoor Plaster Finishes in an Architectural Complex: The Case of the Sacro Monte Di Varallo Sesia. In Proceedings of the La Conservazione del Patrimonio Architettonico All'aperto. Superfici, Strutture, Finiture e Contesti in Atti del XXVIII Convegno Internazionale Scienza e Beni Culturali, Bressanone, Italy, 10–13 July 2012; Edizioni Arcadia Ricerche: Venice, Italy, 2012; pp. 857–867.
113. Normal 20/85-Conservazione Dei Materiali Lapidei: Manutenzione Ordinaria e Straordinaria.
114. Zendri, E.; Balliana, E.; Izzo, F.C.; Di Crescenzo, M.M.; Falchi, L.; Sgobbi, M.; Biscontin, G. The Choise of Parameters for the Monitoring and the Maintenance of Architectural Stone Surfaces. *Int. J. Herit. Digit. Era* **2012**, *1*, 331–336. [CrossRef]
115. Hoffmann, D. On the Differences in the Behaviour of Artificial Weathered Lime Plasters and Their Equivalents Found in External Structures: A Comparative Study. In *Deterioramento e Conservazione Della Pietra*; Fondazione Giorgio Cini: Venice, Italy, 1979; pp. 549–556.