# Special Issue

# Heritage under Threat. Endangered Monuments and Heritage Sites

## Message from the Guest Editors

Monuments and heritage sites worldwide are constantly being affected by environmental and other types of factors that bring about the deterioration of materials, structures and landscapes. Other acute threats are considered more impactful and require immediate action, including floods and fire, hurricanes and cyclones, earthquakes and landslides. Climate change is today considered to be the main driving force accelerating previously existing threats, as well as introducing new ones. However, there are also anthropological threats, ranging from urban sprawl to neglect, from irresponsible interventions to downright vandalism and mere ignorance. In addition, we need to acknowledge the collateral and sometimes deliberate destruction of heritage during war. The aim of this Special Issue is therefore to put a spotlight on the numerous risks and threats that our built heritage is being faced with. This Special Issue also wishes to highlight possible adaptation and mitigation measures to deal with these threats, as well as indirect consequences to the intangible, including livelihoods and wellbeing.

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# About the Journal

## Message from the Editorial Board

*Heritage* is an international, peer-reviewed, open access journal that focuses on knowledge, conservation, interpretation and management of cultural and natural heritage, by presenting and enabling novelty and advances in sensing technologies, novel methods, best practices and policies. *Heritage* has the ambition to become a “cultural forum”, where scientists and experts offer answers to significant issues affecting cultural and natural heritage, by creating a knowledge bridge between different technological and social disciplines. *Heritage* has an Editorial Board of eminent international leaders and this ensures rigorous peer-review processing for high quality and novel papers. We strongly recommend *Heritage* for the rapid and professional publication of your innovative research and case studies.

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*Review*

# Landslides and Cultural Heritage—A Review

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**Abstract:** Cultural heritage sites can be affected by landslides, often causing damage to their integrity, value, and accessibility. Several studies worldwide were focused on the assessment of the potential threats that landslides can pose to the preservation of cultural heritage sites. This article aims to review landslide studies at cultural heritage sites worldwide, analyzing the publications' temporal distribution, selected methods, geographical and climate contexts, and investigated landslide types. We analyzed a database of 331 publications from 2000 to 2023 in study areas distributed across 47 countries, compiled through systematic queries of the Web of Science and Scopus catalogs. The results show an increase in the number of publications from 2012 onwards, with most studies performing landslide susceptibility analyses on cultural heritage sites. The majority of the studies deployed a geomorphological approach address slope instability mechanisms that threaten site integrity, with a significant number of publications presenting model-based, multidisciplinary and engineering geological approaches. Europe, North America, and Asia and the Pacific concentrate the majority of studies, with Italy and China having the highest number of case studies. The threats to cultural heritage sites located in Latin America and the Caribbean, and Africa are the least studied. Block slides, earth slides, and rock falls are the most studied processes, with fewer studies dealing with other landslide types.

**Keywords:** landslides; slope instability; hazard; cultural heritage



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## 1. Introduction

Landslides are a widespread natural process that plays an important role in the evolution of mountainous landscapes [1], being driven by gravity and triggered by climatic factors (rainfall, snowmelt, etc.) and tectonic factors (earthquakes, volcanic eruptions, etc.) [2–6]. As a function of landslide frequency and magnitude, built infrastructure and populations can be seriously threatened if they are exposed to landslides [3,5,7]. The occurrence of natural hazards, including landslides, has increased in the last few decades, and further increases are expected due to the effects of climate change on temperature patterns and rainfall intensity and frequency [8].

Cultural heritage can be defined as the oral and material registers inherited from past generations that document the development and way of life of the populations that created them [9,10]. According to UNESCO, cultural heritage comprises artifacts, monuments, groups of buildings, and sites that can have a multiplicity of values (scientific, ethnological, anthropological, symbolic, historic, artistic, aesthetic, etc.) [10]. Cultural heritage can be tangible or intangible, and tangible heritage can be further subdivided into immovable cultural heritage (archaeological sites, historical buildings, etc.) and movable cultural heritage (artworks, artifacts, documents, etc.) [11].

UNESCO maintains the World Heritage List (WHL) of natural, cultural, and mixed World Heritage Sites (WHS) whose value transcends national borders, thus being considered a heritage of the present and future generations of all humanity [10]. The Outstanding Universal Value (OUV) of those sites is derived from their unique scenic beauty, their importance as registers of Earth's geological history and of the evolution of life, and their outstanding architectural features [10,12]. Currently, 1199 properties are inscribed in the UNESCO WHL in 168 countries, with 48 transnational heritage properties (https://whc.unesco.org/en/list/, accessed on 28 September 2023). Some UN countries also maintain their own list of heritage properties considered of national importance, with different regulations on the management and protection of those assets from country to country.

In the 1972 World Heritage Convention, UNESCO established the List of World Heritage in Danger (currently with 56 UNESCO WHS), aiming to raise international awareness and efforts to protect endangered sites [10,13]. As a consequence of their exposure to changing environmental conditions, cultural heritages can be subject to natural and human-induced processes that can threaten their integrity, accessibility, and value, and their protection plays a central role in the United Nations' 2030 Agenda for Sustainable Development (Goal #11) [14–19]. Landslides are among the most significant natural threats to the integrity of the UNESCO WHS [20], and the increase in landslide frequency and magnitude can seriously threaten the integrity of archaeological sites, buildings, and architectonic complexes, and cultural landscapes [12,18].

In 2007, a UNESCO report outlined the alterations in precipitation and temperature regimes, sea-level variations, and the intensification of human-induced threats (e.g., pollution) due to climate change as threats to cultural heritage sites [12]. Shortly after the report's publication, UNESCO issued a policy document with guiding principles for the management, monitoring, and reporting of threats to WHS aimed at raising the awareness of decision-makers, scientists, and stakeholders on the effects of climate change on WHS preservation [21]. Previous reviews summarized the state of knowledge, methodologies, and publication temporal distribution for the analysis of the effects of climate change and geohazards on cultural heritage sites, including topics on potential landslide threats. Daly [22] reviewed the impacts of climate change on archaeological sites, indicating that an increase in landslide frequency due to intense rainfall and increased ice and snow melt is a significant threat to the conservation of archaeological sites in temperate regions. Zhou et al. [23] reviewed the applications of space-borne and ground-based differential radar interferometry for deformation monitoring in cultural heritage sites and discussed the perspectives for those techniques. Nicu [9] presented a review of hydrological, geomorphological, climatic, and biotic processes that can negatively impact immovable cultural heritage. The review by Cigna et al. [24] explored the suitability of the existing datasets at global, continental, and national scales for the quantitative evaluation of geological and mining-related hazards at the UNESCO WHS of the United Kingdom.

Fatorić and Seekamp [25] performed a systematic review of the effects of climate change on cultural resources, concluding that little research was carried out in Asia, Africa, and South America and emphasizing the need for more multidisciplinary, interdisciplinary, and transdisciplinary methods in the field. Orr et al. [26] updated the review by Fatorić and Seekamp [25], showing a significant growth in interest in the topic and the inclusion of cultural heritage in climate change adaptation and mitigation strategies. However, the authors outlined that most research was performed in Europe and North America, with few instances of international cooperation between institutions located in different geopolitical regions. Sesana et al. [16] outlined that major impacts on cultural heritage can result from changes in the frequency and magnitude of natural hazards due to climate change, including landslides. The authors also highlighted a paucity of research in Asia, Africa, and Latin America.

Quesada-Ganuza et al. [27] presented a critical review of climate change risk evaluation methodologies for urban cultural heritage. The authors conclude that most research on the

topic was focused on assessing the physical vulnerability of urban heritage sites to floods, indicating a gap in studies capable of integrating different dimensions of vulnerability. They also indicate the need for reviews focused on cultural heritage and individual hazards, such as wildfires, cold and heat waves, and landslides.

This article aims to review landslide studies in cultural heritage sites worldwide, analyzing the publications' temporal distribution, selected methods, geographical and climate contexts, and landslide types. The review is focused both on the UNESCO WHS and on heritage properties not inscribed in the WHL but considered relevant at national levels. Therefore, the article is intended to provide the scientific community, policy-makers, and stakeholders with a review of landslide studies at cultural heritage sites, hence filling the gap brought forward by Quesada-Ganuza et al. [27].

## 2. Materials and Methods

The review process encompassed four main steps (Figure 1). First, databases were queried using a restricted set of terms to identify the most recurrent keywords used by studies focused on the analysis of landslide susceptibility, hazard, vulnerability, and risk performed at cultural heritage sites. This was carried out by trial and error using international bibliographical databases and analyzing the most frequent keywords displayed in the keywords filter. Afterward, we defined a set of synonyms for those terms based on our knowledge of the landslide science literature. Being aware of the search field constraints of each platform, the search query was focused on the publication Title, Keywords and Abstract. Database management comprised the removal of duplicated registers, the removal of non-eligible papers, and the manual inclusion of eligible publications cited in previous reviews. Next, publications were reviewed and categorized according to the study scope, approach-based categories regarding the applied methods, geographic distribution, climatic context, and analyzed landslide types.

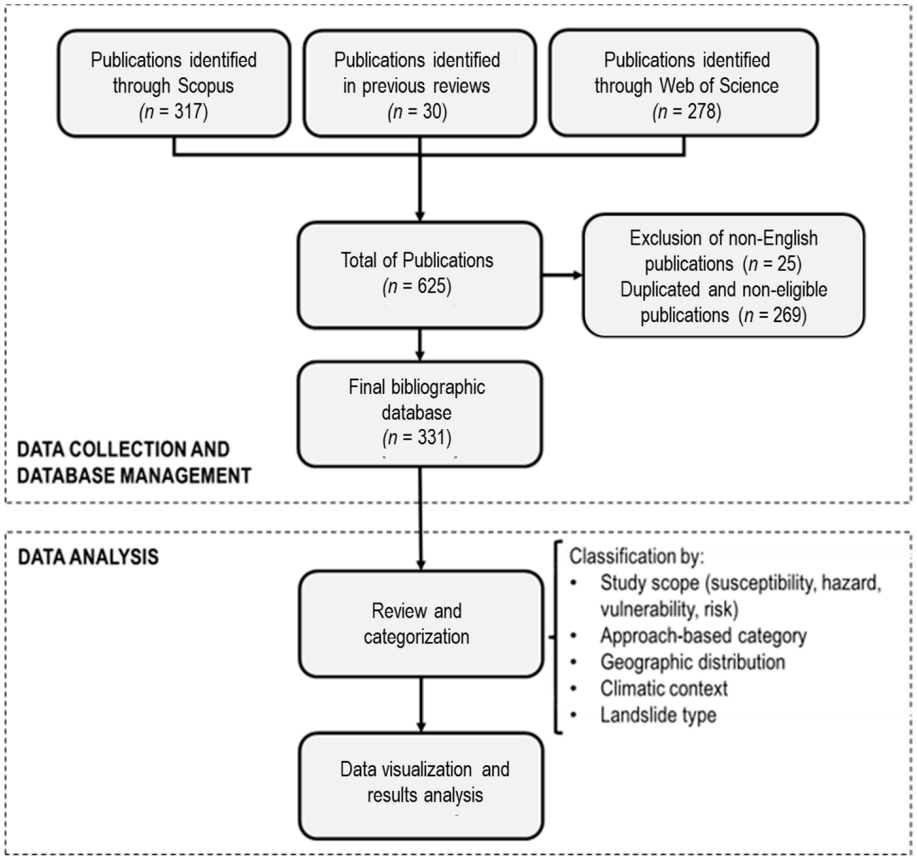


**Figure 1.** Diagram of the reviewal process and information on retrieved publications.

### *2.1. Definition of the Search Criteria, Catalog Querying, and Database Management*

The Web of Science and Scopus catalogs were consulted to create the bibliographic database comprising articles, conference proceedings, and book chapters using the following search query: ({Landslid*} OR {slope deformati*} OR {slope movemen*} OR {slope instabilit*} OR {slope stabilit*} OR {mass movement*} OR {landslid* susceptibility} OR {landslid* hazard} OR {landslid* vulnerability} OR {landslid* risk} AND {Cultural heritag*} OR {Cultural-heritag*} OR {UNESCO World Heritag*} OR {archaeological heritag*}). We have considered only indexed publications in the English language. The variations of the term cultural heritage were included in the search query, aiming to identify studies in sites of cultural and historical significance that fit the scope of this review. All publications were checked for their eligibility to ensure database consistency, and Zotero performed the duplicate detection and database management.

A publication was considered eligible and included in this review if it was written in English and described a case study regarding one or more cultural heritage sites applying quantitative, qualitative, or integrated methods to analyze landslide susceptibility, hazard, vulnerability, and/or risk. To assess publication eligibility, we combined an initial screening of the title, keywords, and abstract, followed by a full-text screening for the publications that did not display enough information in their titles, abstracts, and keywords. Aiming to broaden the bibliographic database, references cited in previous reviews were thoroughly checked. Eligible references that were not detected by the search query were manually added to the database.

### *2.2. Publication Review and Classification*

Publication review and classification was carried out by qualitative content analysis of the full text [28], aiming to outline the selected methods, scope of the case studies, geographical and climatic contexts, and the analyzed landslide type. To analyze the selected methods for landslide studies in cultural heritage sites, we defined six approach-based categories (Table 1), aiming to assemble publications that applied similar methods. This categorization mode follows the approach used by Seuring and Gold [28] for publication content analysis and that of Sarkar et al. [29] for the analysis of selected methods for the assessment of climate-related coastal risks.

**Table 1.** Approach-based categories regarding the selected methods.

| Approach-Based Category | Methods and/or Tools Used |
| --- | --- |
| Survey and monitoring using geomatic techniques | Detailed mapping and monitoring of exposed cultural heritage by means of UAV-DP, TLS surveys, SAR interferometry, and related techniques [1] |
| Model-based | Statistical-, physically-based, and semiquantitative modeling for the assessment of landslide susceptibility, hazard, vulnerability, and risk |
| Index-based | Indexes elaborated by expert-weighting of variables related to landslide susceptibility, hazard and risk, and exposure of cultural heritage sites |
| Geomorphological | Empirical slope instability mapping, regional and detailed geomorphological mapping, extensive field campaigns |
| Engineering geological | Geophysical methods, geotechnical monitoring and characterization, geotechnical mapping |
| Multidisciplinary | Combined use of two or more of the approach-based categories and/or other methods (questionnaires, dendrochronology, etc.) |

[1] Abbreviations: UAV-DP: uncrewed aerial vehicle—digital photogrammetry; TLS: terrestrial laser scanner; SAR: synthetic aperture radar.

Subsequently, publications were sorted by year and classified according to their scope in non-exclusive groups as susceptibility, hazard, vulnerability, or risk studies. For comparison purposes, we opted to interpret the results presented in each publication and categorize them using the following standard nomenclature for susceptibility, hazard, vulnerability, and risk:

- Susceptibility is the spatial probability of occurrence of a given landslide type based on terrain conditions that are static over time and without considering landslide frequency and magnitude [3,30–32];
- hazard is the spatiotemporal probability of the occurrence of a landslide of a given size and magnitude in a specified time frame and area, considering the probable trajectories of the landslide [3,32–34];
- vulnerability is the expected degree of loss of an element or set of elements in the area affected by a specific landslide type with a given magnitude, usually obtained by analyzing the physical or socioeconomic characteristics of the exposed elements [7,32,35];
- risk is the expected damage and loss derived from the adverse consequences of the occurrence of a landslide. For example, damages comprise casualties, damage to properties, infrastructures, cultural heritage, and the interruption of services [32]. Risk assessments result from the joint analysis of hazards and the value of the exposed elements, given by the element vulnerability [3].

Afterwards, the case studies presented in each publication were classified according to the geographical distribution, the climatic context based on the Köppen–Geiger classification, and the landslide types according to Cruden and Varnes [2]. The only addition to the latter landslide classification was the deep-seated gravitational slope deformation (DGSD) [36], which we opted to include since its occurrence was explicitly reported by some authors.

We opted to consider each case study since some publications presented one or more case studies, and the consideration of only one geographical location and climatic context per publication would be misleading. Therefore, for the geographical and climatic classifications, the reported percentages refer to the total number of case studies and not to the total number of publications. For the geographical distribution classification, we indicated the country and the UNESCO regional group of the study areas.

## 3. Results

In this section, the main results from the review process are presented. First, an overview of the publications by year, the study scope, and the approach-based category are provided, along with the presentation of a set of publications that are illustrative of each approach. Furthermore, the geographical distribution, the climatic context, and the landslide type of each case study are presented.

### *3.1. Publications by Year, Study Scope and Approach-Based Categories*

The bibliographical database comprises a total of 331 papers published between 2000 and 2023. Considering the 111 papers reviewed by Nicu [9] (which also comprised hazards other than landslides), this represents an increase in the number of publications from 2017 to 2023 and indicates a substantial growth in the interest of the international scientific community on the natural threats to immovable cultural heritage.

The years with the highest number of publications are 2013 and 2015, with 33 publications each (Figure 2). This can be related to the publishing of a volume of Landslide Science and Practice in 2013 as outlined by Nicu [9] and a volume of Engineering Geology for Society and Territory in 2015. Both volumes presented a series of studies focused on the interface between natural hazards and cultural heritage sites. Up to the date we queried the publication catalogs (28 June 2023), there were 17 landslide studies in cultural heritage sites published in 2023.

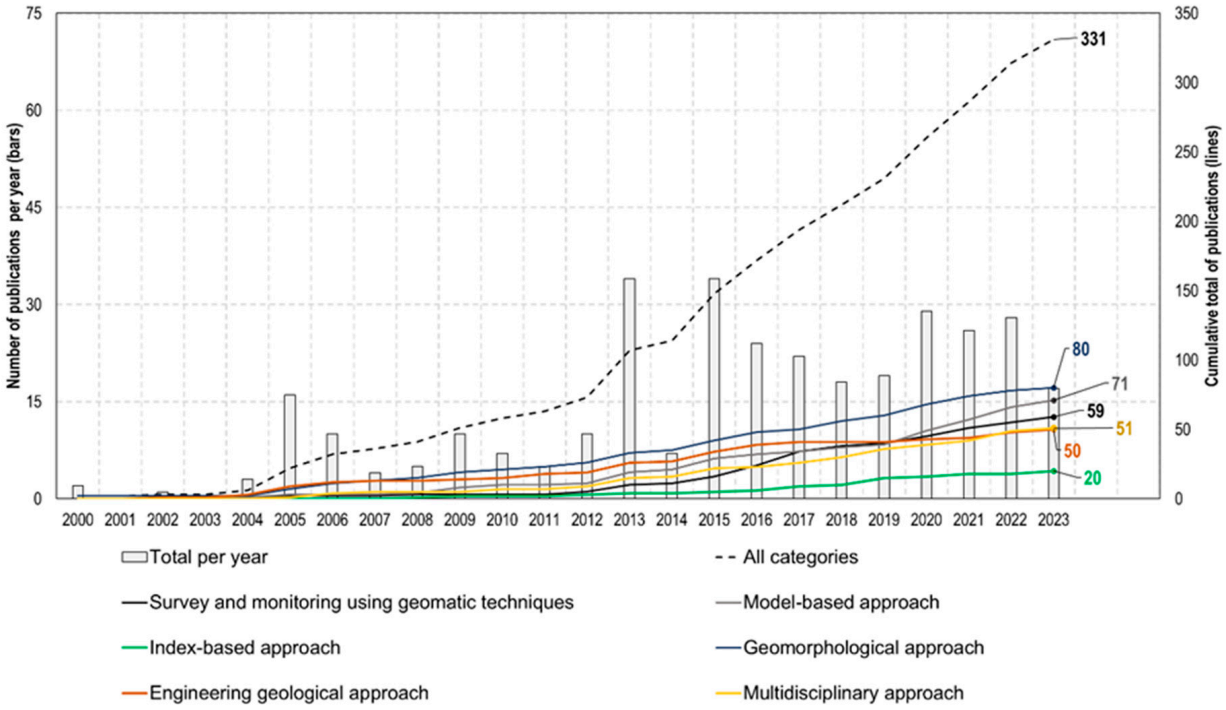


**Figure 2.** Publications by year and approach-based category, with total publications per year (bars, plotted to the main y-axis) and cumulative totals of publications (lines, plotted to the secondary y-axis).

The majority of publications fit the geomorphological approach (80) (Figure 2), comprising studies that applied geomorphological methods such as extensive field surveys, empirical instability mapping, and geomorphological mapping. This category displays a regular growth tendency from 2000 to 2023 (Figure 2), highlighting its importance to landslide studies in cultural heritage sites, both as final products and to subsidize future studies. This approach is the most recurrent for susceptibility analysis (31%) (Figure 3).

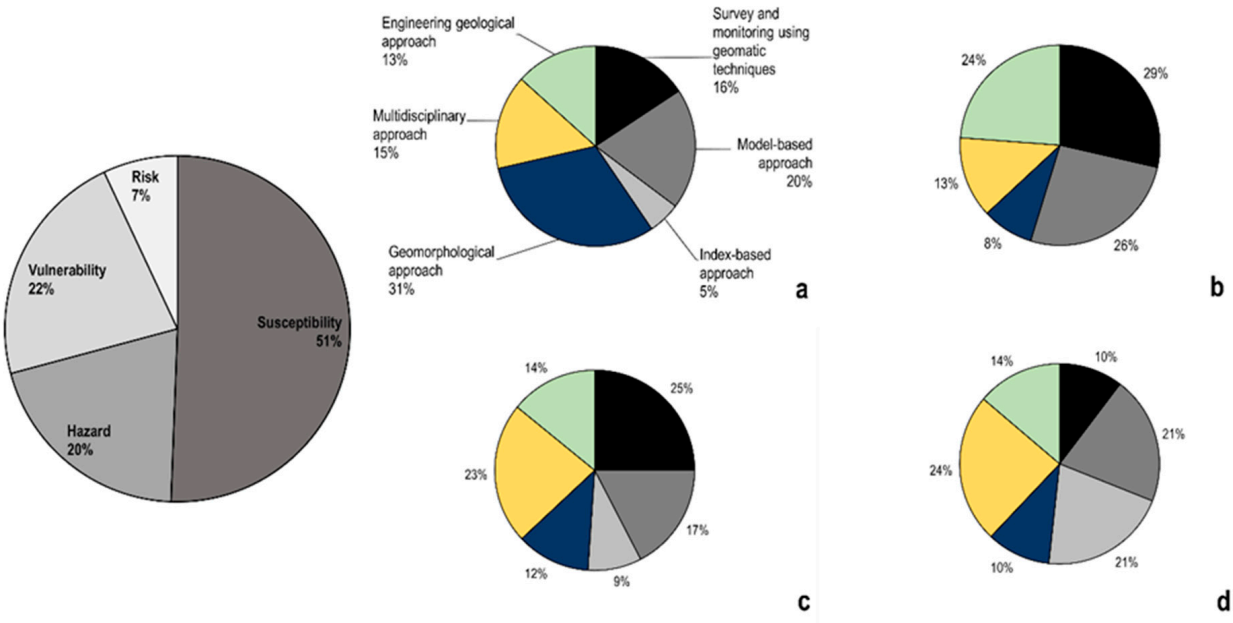


**Figure 3.** Distribution of the publications based on the study scope. Breakdown of each scope by approach-based category: (**a**) susceptibility studies; (**b**) hazard studies; (**c**) vulnerability studies; and (**d**) risk studies.

The first published papers in the database fit this category [37,38]. Those early works took advantage of GIS applications to integrate geological and geomorphological information, aiming to investigate the mechanisms and causative factors of landslides in the Tharos, Capo San Marco, and San Giovanni di Sinis areas (Sardinia, Italy) that could represent risks to the preservation of Roman and Phoenician heritage sites. This fundamental role of the geomorphological approach is also exemplified by the geomorphological investigations by Frodella et al. [39] in the High City of Antananarivo (Madagascar), a UNESCO WHL candidate site, which provided information for subsequent research deploying a multidisciplinary approach [40].

Model-based approaches (71) have shown consistent growth since 2013 (Figure 2), and studies in this category applied numerical simulations, semiquantitative analysis, and statistically and physically based models to assess the landslide susceptibility, hazard, and risk that cultural heritage can be faced with. Model-based approaches were extensively used in all study scopes, being deployed mainly for hazard (26%) assessments (Figure 3). Aiming to analyze the information contained in the Periodic Reports of the state of conservation of Europe's UNESCO WHS, Valagussa et al. [41] performed a multi-hazard assessment with the analytical hierarchy process (AHP) using detailed information on different geo-hazards from Italy. The authors indicate that the Periodic Reports are a useful starting point for hazard assessments on a continental scale, with limitations such as the underestimation of threats to cultural heritage in the specific case of landslide hazards.

Nicu [42] used three different model-based approaches (AHP, frequency ratio, and statistical index) to map the landslide susceptibility in a basin of the Moldavian Plateau (NE Romania) that hosts several Neolithic archaeological sites. Expanding this study in terms of territorial coverage and understanding of landslide threats on a site-specific scale, Nicu and Asandulesei [43] employed the same methods and LiDAR, total stations, and TLS to monitor the landslide threats and validate the models' results. They showed that nearly 70% of the sites are located in high- or very-high-susceptibility areas. Further knowledge of the landslide threats to the Neolithic sites of the Moldavian Plateau was provided by Lombardo et al. [44]. The authors employed a binomial generalized additive model to independently assess landslide and gully erosion susceptibility, applying a further procedure to create a multi-hazard map that revealed 12 sites with a high probability of the occurrence of both processes.

In Slovakia, a series of studies were performed at the Spis Castle UNESCO WHS and other cultural heritage properties [45,46]. Numerical simulations performed by Vlcko et al. [46] showed that block spreading is a significant cause of the deformations observed with instrumentation and field surveys at the Spis Castle, resulting in a modeling approach with minimal intervention on the property's structure that can be used in stabilization plans. Among others, examples of model-based approaches are provided by studies at the Rupestrian Churches of Matera (Italy) [47,48], the Zelve Open-Air Museum (Türkiye) [49], the Chinese heritage sites of the Fortified Manors of Yongtai [50] and Mogao Caves [51], Alhambra [52], and 12 churches considered Assets of Cultural Interest of Spain [53].

Survey and monitoring using geomatic techniques (59) display a sharp increase in the number of landslide studies in cultural heritage sites after 2014 (Figure 2), being the most selected approach for hazard (29%) and vulnerability studies (25%) (Figure 3). The increase in publications that fit this approach can be related to the growing availability and affordability of geomatic survey technologies in the last decade, such as synthetic aperture radars (SAR) [54], uncrewed aerial vehicles (UAVs) [55], terrestrial laser scanners (TLS) [56], and other instruments that allow for accurate representation of slopes and buildings, aiming to identify the instability mechanisms and model the response of the endangered heritage.

We highlight the growing use of SAR technologies to monitor the interaction of landslides and cultural heritage. Under the framework of the PROTection of European Heritage from GeO-hazards (PROTEGHO) project, Themistocleous et al. [57,58] used UAV surveys and Interferometric SAR data (InSAR) to monitor landslides, presenting case studies on UNESCO WHS in different countries (United Kingdom, Spain, Italy, and Cyprus) and establishing a low-impact monitoring methodology whose application is feasible to the totality of the European UNESCO properties. Also employing InSAR techniques, Pastonchi et al. [59] presented a fast and simple regional-scale procedure with Sentinel-1 data to assess deformations caused by slow-moving landslides on the UNESCO WHS in the Tuscany region (Italy) that can be replicated on cultural heritage sites worldwide.

Combining InSAR and direct monitoring techniques in the Siq of Petra (Jordan), Delmonaco et al. [60] contributed to the establishment of a risk mitigation strategy and highlighted that the wireless network of automated crack gauges was the most reliable of the tested techniques. Other studies in this category were also performed in cultural heritage sites in Greater London (United Kingdom) [61], for the Choirokoitia UNESCO WHS (Cyprus) [62], and in Greece at the site of Delphi [63] and the Kipinas Monastery in Epirus [64], among others.

Multidisciplinary approaches (51) (Figure 2) encompass strategies to assess risk and potential damages to cultural heritage sites due to landslides, combining different scientific knowledge fields. This approach was most frequently applied to assess vulnerability (23%) and risk (24%) (Figure 3), which can be related to the necessity of assessing both the physical and social aspects to properly estimate landslide risk. The combination of different questionnaire survey techniques and geomorphological knowledge [65,66], geomorphological and geomatic information with crowdsourcing to engage the general public for cultural heritage preservation [67], and dendrogeomorphological and traditional monitoring techniques [68] are examples of the necessity to integrate several scientific disciplines to assess landslide threats on cultural heritage sites.

Combining survey techniques and crowdsourcing, Marra et al. [67] showed the potential of engaging the public and managers of cultural heritage sites at the Samnite complex of Pietrabbondante (Molise, Italy). The proposal of the SUNDAE 1.0 catalog integrates national document databases, geological and geomorphological information, and cloud-based photos and videos collected by the public that can be used to update virtual models of the sites to assess the heritage's state of conservation while engaging the public on the preservation efforts.

Using questionnaires, Santoro et al. [66] investigated the landscape perception of two social groups (residents/workers, and farmers) about diverse threats (including hydrogeological risks) in the Islands, Cinque Terre, and Porto Venere UNESCO WHS (Italy). Land abandonment is reported by both groups as the most relevant landscape change, while landslides are frequently indicated by residents as one of the major problems. Both risk perceptions are intertwined since the lack of maintenance of terraced landscapes due to land abandonment can lead to the development of landslides [69].

Landslides are also a threat to the conservation of the Honghe Hani rice terraces (China), where crop losses are growing among local farmers [65]. In this area, farmers have a high perception of landslide risk but low levels of preparedness to deal with the effects of a landslide event such as the one triggered in 2018. The authors suggest that a stronger information dissemination strategy should be deployed to engage the local communities since they have high trust in the effectiveness of disaster risk prevention and mitigation strategies, as shown by the survey results. In a multidisciplinary study at the region of the Monte Olivetto Maggiore Abbey (Tuscany, Italy), Bollati et al. [68] combined meteorological information, monitoring data on erosion rates and landslides, and dendrochronology to understand the badlands relief morphology evolution, providing a survey that can be useful for the identification of critical areas for the installation of monitoring stations.

In the engineering geological (50 papers) category were included papers that used geophysical methods, traditional geotechnical monitoring instrumentation (piezometers, inclinometers, extensometers, etc.), geotechnical mapping, and other engineering geological methods. For example, Margottini [70] presented an in-depth geotechnical characterization of the siltstones and conglomerates of the Buddha niches in the Great Valley of Bamiyan (Afghanistan), whose giant statues were demolished by the Taliban in 2001, thus subsidizing the stabilization works described by Margottini [71].

Marinos and Tsiambaos [72] proposed a set of protective measures to mitigate rock fall hazards at the hills of Skyros Castle on the homonymous Greek island through geotechnical surveys and a model of the rock fragments probable trajectories. At the Selmun Promontory (Malta), where the Ghajn Hadid Tower ruins stand, Ianucci et al. [73] performed a detailed engineering geological field survey to characterize the joint network of the rock mass, combining this information with the results of a geophysical survey of seismic noise measurements. The results allowed to delimitate zones with different levels of instability due to the ongoing lateral spreading that threatens the stability of the tower ruins. Combining field investigations, geomechanical characterization of joint aperture and persistence, and kinematical analyses, Bozdag [74] was able to identify the zones most prone to rock falls and rock topples at the ancient site of Kilistra (Central Anatolia, Türkiye), suggesting a set of geotechnical remedial measures to improve the stability of the rock slopes.

Papers included in the index-based category (20) (Figure 2) combined data on landslide conditioning and triggering factors using different expert-based weighting strategies. This category is the least applied in all study scopes, with higher contributions to risk studies (21%) (Figure 3). In this category, some studies have analyzed the susceptibility and vulnerability of cultural heritage to multiple natural and man-made hazards. Valagussa et al. [75] applied the UNESCO Risk Index to the European UNESCO WHS properties, presenting a continental-scale multi-risk analysis. Their approach explores the available natural hazard data on the continent, providing guidelines to prioritize areas for more in-depth assessments.

Through a GIS-based approach, Brimblecombe et al. [76] presented cultural heritage susceptibility maps to different natural threats (heavy rainfall, typhoons, floods, landslides, fires, and earthquakes) under a changing climate in the Tokyo Region (Japan) and provide an evaluation of the impacts on the tourists' experience at the cultural heritage sites. The authors indicate that 11 cultural heritage properties can be faced with negative effects from debris flows and slope failures, recommending slope maintenance and early warning systems to managers and decision-makers. Lollino and Audisio [77] provided an application example of a GIS-based empirical approach to assess cultural heritage site susceptibility to landslides and floods, presenting two case studies on the Val Germanasca Valley (Piedmont, Italy) and Crespi d'Adda (Lombardy, Italy). Their results showed the applicability of this approach for preliminary studies aiming to define priority areas for hazard assessment and monitoring.

An example of a vulnerability study using an index-based approach is brought forward by Bertolin and Sesana [78] for the 28 remaining Norwegian stave churches. Apart from traditional variables considered in vulnerability studies (building material, maintenance condition, number of floors, age, etc.), the authors also considered the susceptibility of the indoor cultural heritage (both movable and immovable) and assessed the exposure based on topographic and building variables. Their study provided an in-depth and innovative vulnerability assessment of the immovable and movable cultural heritage of the stave churches.

### *3.2. Case Studies Geographical Distribution, Climatic Context and Landslide Types*

Some publications have presented more than one case study in areas occasionally located in different UNESCO regional groups, countries, and climatic contexts. Therefore, the percentages reported in this section are relative to the total number of case studies and not to the total number of publications. Overall, the majority of case studies were

performed in the Europe and North America group and the Asia and the Pacific group, while the Africa group and the Latin America and the Caribbean group had a smaller fraction of case studies (Figure 4). One publication was performed on a global scale [20]. Pavlova et al. [20] presented a worldwide overview of geological hazards exposure in over 900 UNESCO WHS, concluding that approximately 60% of the properties are exposed to at least one type of geological hazard. Pavlova et al. [20] showed that the most vulnerable regions are Asia and the Pacific and Latin America and the Caribbean, indicating that the most frequent hazards are earthquakes and landslides.

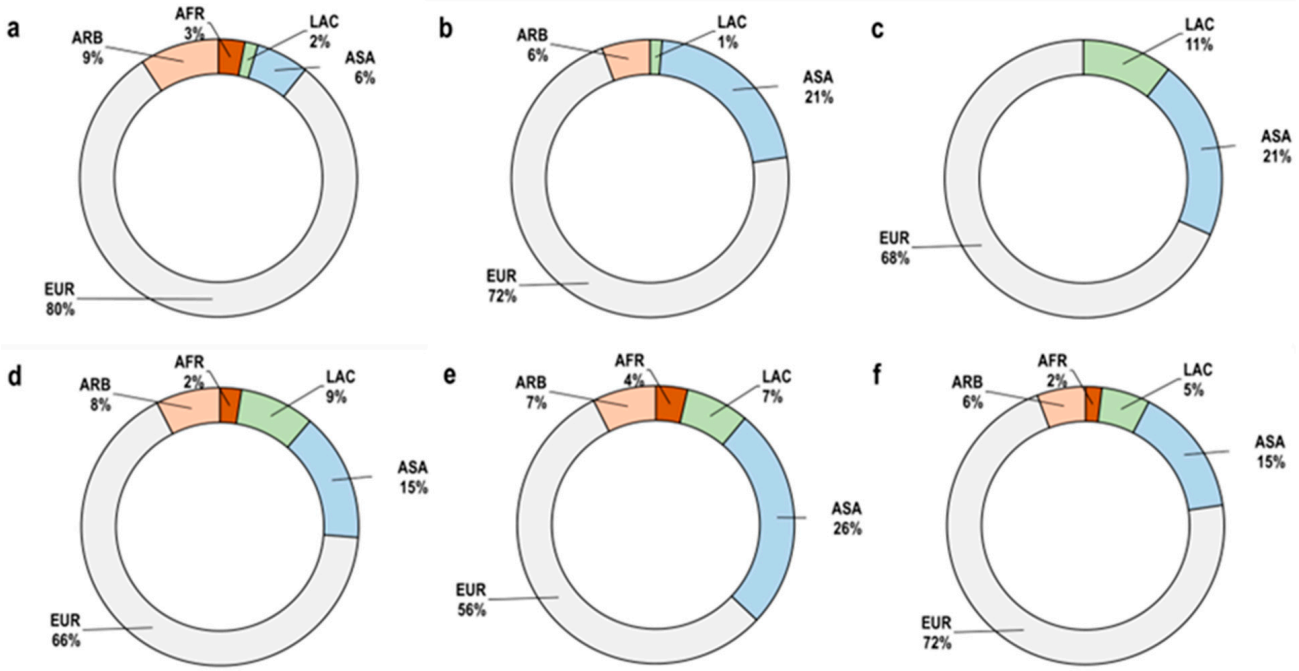


**Figure 4.** Case studies sorted by approach-based category and UNESCO Region of the study areas. (**a**) Survey and monitoring using geomatic techniques; (**b**) model-based approach; (**c**) index-based approach; (**d**) geomorphological approach; (**e**) engineering geological approach; (**f**) multidisciplinary approach. Abbreviations: AFR—Africa; ARB—Arab States; ASA—Asia and the Pacific; EUR—Europe and North America; LAC—Latin America and the Caribbean.

Italy is the leading country in all approach-based categories with 112 case studies (Figure 5), being the main contributor to the high number of case studies in the Europe and North America regional group. Italy is also the country with the highest diversity of study sites, with several case studies aimed at assessing landslide threats both in UNESCO WHS sites and in Italian heritage sites that are not inscribed in the WHL [79–84]. This result suggests a higher awareness among the Italian scientific community of the potential threats to sites of cultural significance on a national level. Romania (16 papers), Greece (16), the United Kingdom (10 papers), Cyprus (9 papers), and Spain (8 papers) have a significant contribution to the higher number of publications in the Europe and North America regional group (Figure 5).

In the Asia and the Pacific regional group, the majority of case studies are from China (25) and Japan (12), with contributions from Afghanistan (8), India (4), and Iran (3) (Figure 5). China is the second country with the most properties inscribed in the UNESCO WHL (57) and also ranks second in the number of case studies in this review. China is one the countries with the highest numbers of papers and study areas where statistically based landslide susceptibility models have been deployed, as shown by Reichenbach et al. [85] in their review of landslide susceptibility using data-driven models. This can be also explicative of both the number of Chinese case studies and the diversity of studied cultural heritage sites. In Japan, the concern with the interaction between landslides and cultural

heritage can be a consequence of the strong legal framework for landslide risk mitigation in general, for example, the 2001 Sediment Disaster Prevention Law, the Landslide Prevention Law, and the Law for Prevention of Steep Slope Failure Disaster [86].

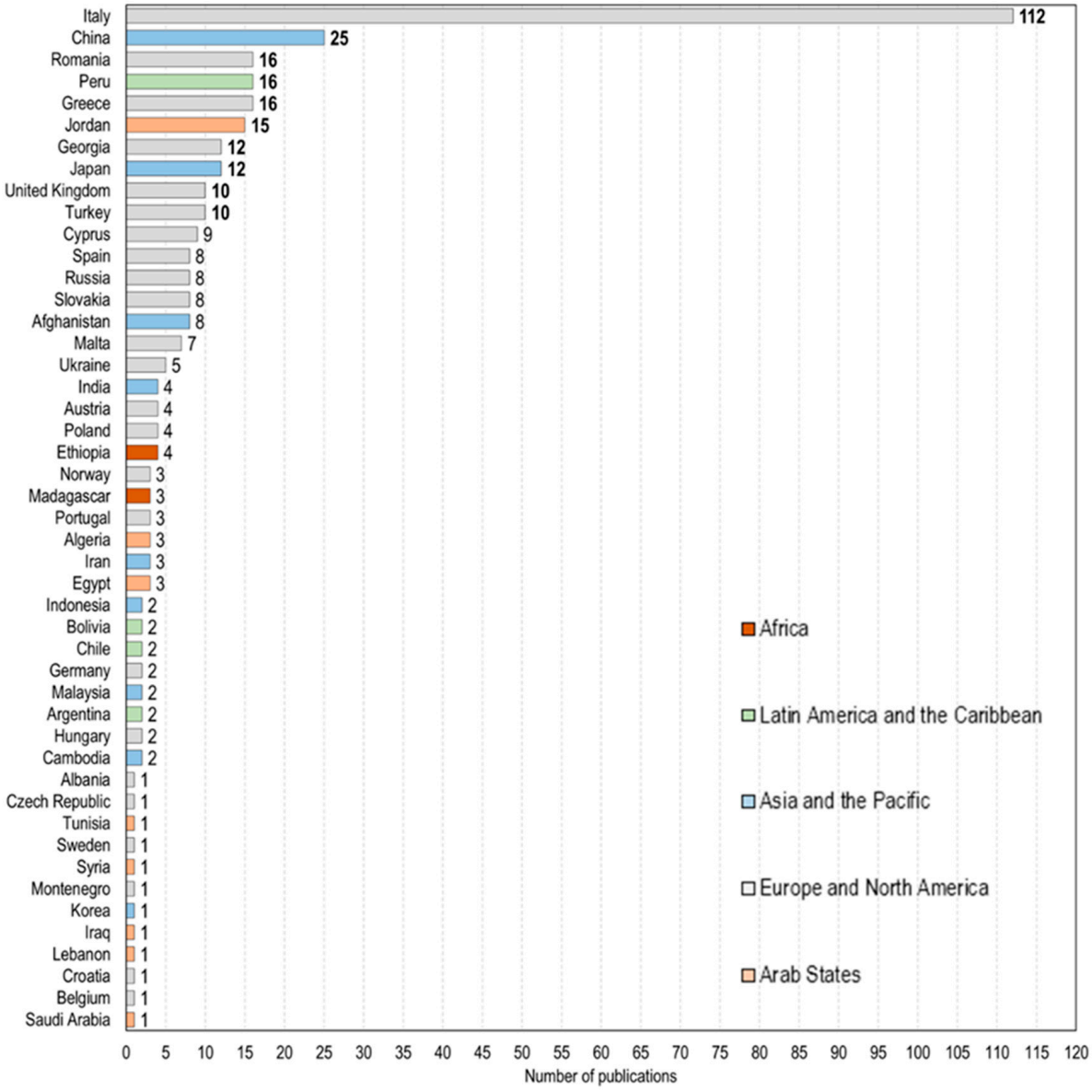


**Figure 5.** Case studies distribution by country.

The Arab States regional group ranks third with eight countries (Jordan, Algeria, Egypt, Tunisia, Syria, Iraq, Lebanon, and Saudi Arabia), with the majority of case studies from Jordan (15), Algeria (3), and Egypt (3). Only two countries from the Africa group (Ethiopia and Madagascar) and four from Latin America and the Caribbean group (Peru, Chile, Argentina, and Bolivia) have landslide case studies in cultural heritage sites (Figure 5).

Four of the top 10 countries with the most case studies (Figure 5) are not located in the Europe and North America Group (China, Peru, Jordan, and Japan). This result should be analyzed carefully, given that a high number of publications does not necessarily mean a diversity of study areas. Except for China and Japan, most of the studies on the abovementioned countries were conducted on the same heritage sites: Machu Picchu in Peru (15 out of 16 case studies), and the Siq of Petra in Jordan (all case studies in Jordan). This concentration of case studies on the same heritage property can be perceived in other areas, such as the Buddha niches of the Bamiyan Valley UNESCO WHS in Afghanistan (7 of

the 8 case studies), Katskhi Pillar and Vardzia Monasteries in Georgia (11 out of 12 case studies), and the High City of Antananarivo in Madagascar (all case studies).

Regarding the climatic context, the category "Not Applicable" (Figure 6) refers to case studies carried out on global, continental, national, or regional scales that do not allow the definition of one single climatic type under the Köppen–Geiger classification. The majority of the reviewed case studies were performed in hot-summer Mediterranean and temperate oceanic climates (23.63% and 18.13%, respectively) (Figure 6). Humid subtropical (14.01%), warm-summer humid continental (9.62%), and warm-summer Mediterranean (7.14%) climates accounted for a relevant share of the amount of landslide case studies in cultural heritage sites. Tropical, arctic, and monsoon-influenced climates figure among the less studied climatic contexts (Figure 6). Only six case studies were performed in areas under a tropical climate and 14 in monsoon-influenced contexts.

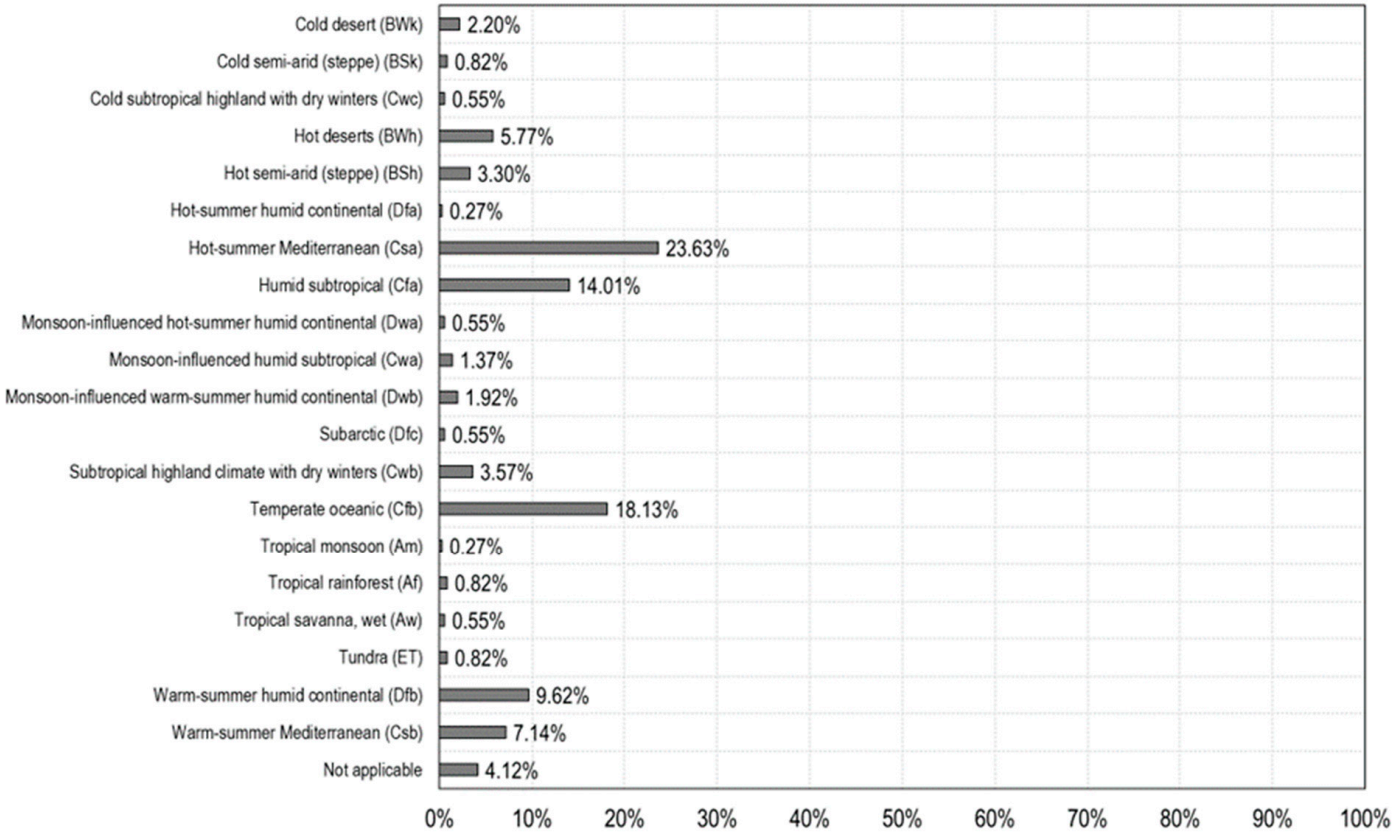


**Figure 6.** Case studies distribution by study area Köppen–Geiger climate zone.

For the landslide types, the "Not applicable" class encompasses studies performed at continental and global scales that do not allow for the differentiation of landslide type (Figure 7). A total of 6.8% of the case studies did not indicate the landslide type using common and accepted taxonomies (Figure 7). Case studies that did not indicate the landslide type most frequently deployed a model-based approach.

Translational slide and fall are the most studied types of mass movement in cultural heritage sites (28.9% and 21.8%, respectively) (Figure 7). More specifically, the majority of case studies analyzed the potential threats from block slides, earth slides, and rock falls. The selected methods for assessing translational slide and fall threats to heritage sites were similar, mainly the geomorphological approach and survey and monitoring using geomatic techniques (Figure 7). Examples of selected methods are detailed geomorphological mapping, extensive field campaigns, UAV digital photogrammetry, and TLS surveys to investigate the landslide mechanisms and potential damage to heritage sites [64,87–93]. A minority of case studies opted for index-based methods.

A total of 12.1% of the case studies were dedicated to debris flow and earth flow, usually assessed by a geomorphological approach and a multidisciplinary approach (Figure 7). Different from other landslide types, several papers aimed to reconstruct past flow events using the abovementioned approaches to understand the reactivation regime and the mobilized material source areas [52,94–96].

Soil and rock spreading and deep-seated gravitational slope deformation (DGSD) were analyzed in fewer case studies in comparison to other landslide types (Figure 7). Rock spreading and DGSD have a similar pattern of selected methods, which is associated with the slow to very slow velocity rates of those processes. This characteristic of lateral spreading and DGSD allows scientists to deploy a diversity of monitoring instrumentation, such as inclinometers and piezometers, GNSS networks, and different types of SAR data analysis [62,97–100].

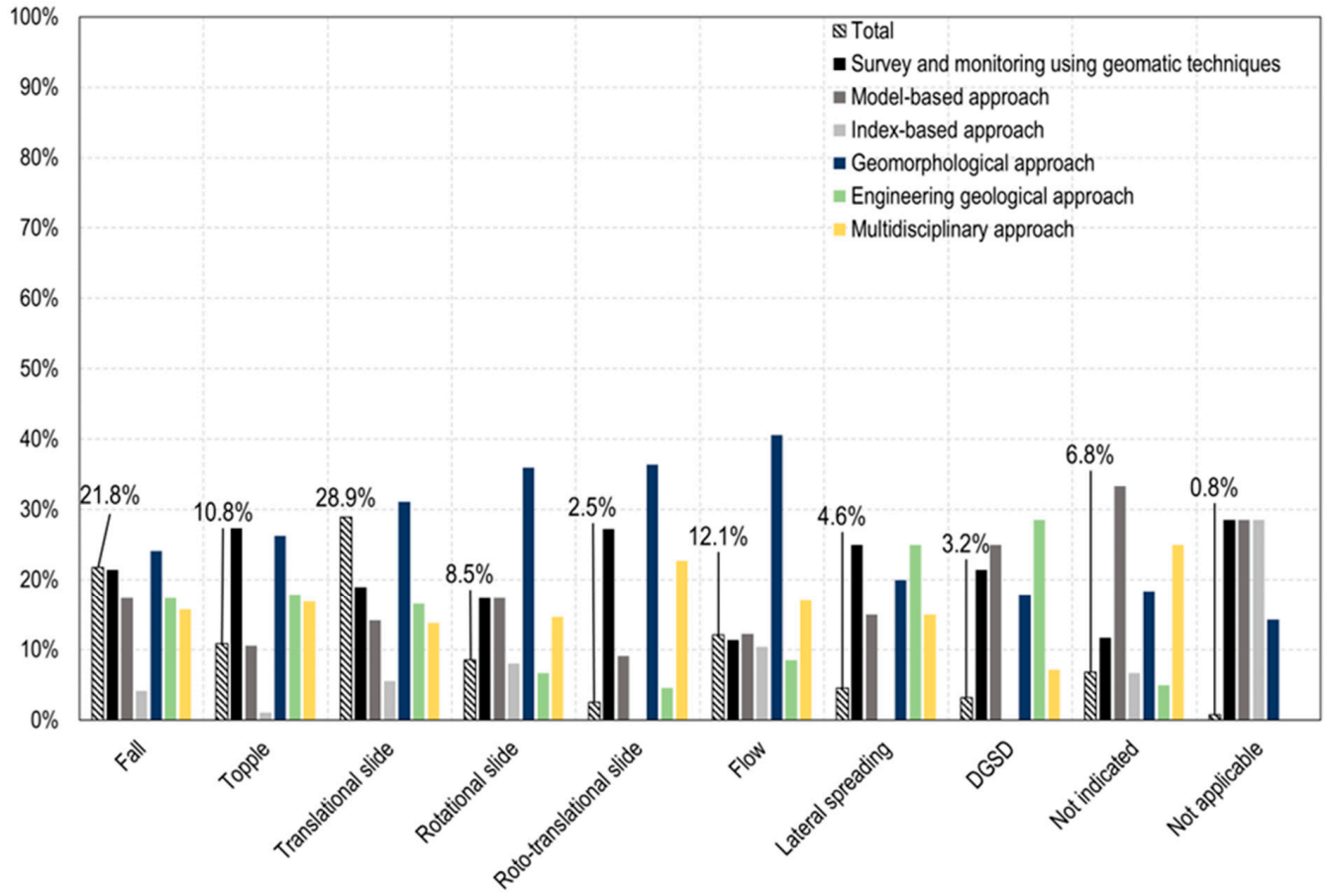


**Figure 7.** Distribution of landslide case studies in cultural heritage sites by landslide type and approach-based category. DGSD stands for "deep-seated gravitational slope deformation".

## 4. Discussion

Based on the results of the review process, we highlight that important progress has been made in the last few decades, aiming to understand the hazard and vulnerability components of landslide risk in cultural heritage sites. The challenge seems to be the translation of scientific knowledge into public policies to safeguard cultural heritage sites. Engaging the populations that are economically and socially dependent on the conservation of cultural heritage value, tourists, and other stakeholders in the preservation efforts can be a viable option to raise society's awareness and may reflect in political action.

Concerning the selected methods and approaches, we note an expansion of the use of geomatic survey and monitoring techniques in the last decade, mainly the use of UAV digital photogrammetry, laser survey techniques, and SAR-based methods. However, most

of this kind of research is restricted to the more studied countries located in Europe and North America and the Asia and Pacific regional groups. Future studies could benefit from the use of those methods in the least studied regional groups, especially in less favored countries that usually lack an updated environmental database at adequate scales for the analysis of landslide exposure to cultural heritage sites. The method selection and study design should take into consideration the regional context of each cultural heritage site, which kind of landslide is under analysis, the scale and objectives of the landslide assessment, and the financial resources available for the project. Considering the heterogeneity of geomorphological and climatic contexts and the diversity of cultural heritage sites in the selected publications, it is not feasible to suggest a need for one specific approach. Instead, it is necessary to tailor the methods deployed according to the type of cultural heritage under threat and the expertise of each group of scientists.

The leading role of the Europe and North America group can be associated with transnational cooperation projects aimed at safeguarding cultural assets, of which PROTEGHO, HORIZONS, ARCHYTAS, PANOPTIS, HYPERION, and INFRASTRESS projects are examples. Those initiatives resulted in several publications and solid know-how on the geomatic survey, model-based approaches, vulnerability, and risk assessments, as well as strengthening public policies to safeguard the European cultural heritage. The strong transnational cooperation in the European Union to safeguard cultural heritage assets may be explicative of the fact that national- and continental-scale landslide studies were only identified for Europe [24,41,75,101,102].

We note a gap for landslide studies in cultural heritage sites in Africa, Latin America, and the Caribbean, the Arab States UNESCO group of countries, and in areas with tropical and monsoon-dominated climates. Despite the number of case studies in the Arab States regional group, most of the research was aimed at assessing rock-fall threats in the Siq of Petra (Jordan), implying a gap in knowledge of landslide threats to other heritage sites of the Arab States. This scarcity of research in Africa and Latin America and the Caribbean was also noted by Fatorić and Seekamp [25], Sesana et al. [16], and Orr et al. [26] in their reviews on the effects of climate change on cultural heritage sites.

The geological context of the investigated areas was not taken into consideration due to the diversity of study scales and scopes in the reviewed papers. During the study design process, we actually considered the inclusion of the geological and tectonic contexts in the list of determinants to be extracted from each publication. However, it proved very difficult to ascertain the geological context of the study areas due to the highly heterogeneous form in which this information was reported by the authors of the selected articles. Moreover, due to the disparity in the study scale between publications (from single cultural heritage properties up to global-scale studies), reporting a simplified geological context for each case study could have been potentially misleading. The same applies to the tectonic context. In fact, it could have been misleading to provide a differentiation between active tectonic regions and stable platform contexts, especially for areas where both rainfall events and earthquakes can trigger (and have triggered in the past) landslides, such as in the Mediterranean region (the area with the most landslide studies in cultural heritage sites in our review). Nevertheless, we believe that the classification of studies by landslide type presented in the review can provide readers with insights into the most and least studied geological contexts.

A restricted number of studies in our database analyzed the possible impact on cultural heritage sites due to multiple-occurrence regional landslide events (MORLE) [103], none of them in humid tropical environments where MORLE is relatively frequent. Furthermore, high-energy landslides with a long runout, such as debris flow and earth flow, were analyzed in a restricted number of case studies in comparison with rock falls and translational slides, which we associate with the scarcity of studies in cultural heritage sites under tropical and monsoon-dominated climatic contexts.

From the analysis of the results, we note that international cooperation has advanced the understanding of landslide threats to cultural heritage sites located in the less-studied UNESCO regional groups. Therefore, international cooperation between scientists from less favored countries with their pairs based on the more studied countries can be a promising route to overcome the knowledge gap about the threats posed by landslides to cultural heritage sites in less favored countries. Several case studies in the Africa and Arab States regional groups resulted from international cooperation projects with teams from more favored countries. The studies performed on the Lalibela Rock-Hewn Churches UNESCO WHS in Ethiopia [104–107] and in Tunisia (the Dougga/Thugga site) [108] benefited from the cooperation of local experts with Italian ones under the framework of interdisciplinary projects, mainly coordinated by UNESCO.

The same applies to the publications about the High City of Antananarivo, which benefited from the cooperation between experts from different countries in the framework of the "Project for Enrollment of the High City of Antananarivo in the UNESCO World Heritage Site" of the UNESCO chair on Prevention and Sustainable Management of Geo-Hydrological Hazards [39,40,109]. In Latin America and the Caribbean, international cooperation under the framework of the International Consortium on Landslides and the International Programme on Landslides C101-1 resulted in the already mentioned case studies in the Inca citadel of Machu Picchu [110–113], involving Peruvian, Japanese, Czechoslovakian, and Italian experts [114].

## 5. Conclusions

This research was focused on the review of publications dealing with cultural heritage sites affected by landslides worldwide. The analysis of the bibliographical database allowed us to outline the most studied regions and climatic contexts, the most frequently selected methods, and the most analyzed landslide types. The highest number of studies have been carried out in Europe, North America, Asia, and the Pacific—Italy and China being the topmost—while the least studied areas are located in Africa and Latin America and the Caribbean UNESCO regional groups of countries, a picture already depicted by previous reviews. Moreover, we highlight a gap in studies aimed at assessing the potential landslide threat to cultural heritage under tropical and monsoon-dominated climatic contexts. Most of the research conducted in Africa, the Arab States, and in Latin America and the Caribbean groups has the same cultural heritage property as the study area. Therefore, it is necessary to broaden the range of studied properties to properly identify the real landslide exposure of the cultural heritage in Africa, Latin America and the Caribbean, and the Arab States groups. The diversification of study sites may also contribute to understanding how different landslide dynamics can impact cultural heritage, a piece of information that could be useful for adaptation strategies in the more studied regions.

We highlight that the cooperation between scientists from countries with different socioeconomic and academic contexts has already resulted in papers that have provided important contributions to the understanding of landslide threats to heritage sites. As indicated in the United Nations SDG #17, a promising route to overcome the gaps presented in this review may be the strengthening of international cooperation between scientists from less-favored countries and excellence centers in the most studied countries, including the indigenous communities and knowledge in the prevention and adaptation strategies. It should be underlined that the use of virtual technologies (for example, https://www.geovt.eu/, accessed on 28 September 2023) would also be beneficial in enhancing the above-mentioned cooperation by providing the means for virtual field activities and for the training of a new generation of scientists dealing with the potential impact of geohazards on cultural heritage.

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## References

1. Crozier, M.J. Landslide Geomorphology: An Argument for Recognition, with Examples from New Zealand. *Geomorphology* **2010**, *120*, 3–15. [CrossRef]
2. Cruden, D.M.; Varnes, D.J. Landslide Types and Processes. In *Landslides and Engineering Practice*; Turner, A.K., Schuster, R.L., Eds.; Special Report, 247, 36–75; Transportation Research Board, US National Academy of Sciences: Washington, DC, USA, 1996; Volume 24, pp. 20–47. ISBN 0-309-06208-X.
3. Crozier, M.J.; Glade, T. Landslide Hazard and Risk: Issues, Concepts and Approach. In *Landslide Hazard and Risk*; Glade, T., Anderson, M., Crozier, M.J., Eds.; Wiley: Hoboken, NJ, USA, 2005; pp. 1–40. ISBN 978-0-471-48663-3.
4. Borgatti, L.; Soldati, M. Landslides and Climatic Change. In *Geomorphological Hazards and Disaster Prevention*; Alcántara-Ayala, I., Goudie, A.S., Eds.; Cambridge University Press: Cambridge, MA, USA, 2010; pp. 87–95. ISBN 978-0-521-76925-9.
5. Froude, M.J.; Petley, D.N. Global Fatal Landslide Occurrence 2004 to 2016. *Nat. Hazards Earth Syst. Sci. Discuss.* **2018**, *8*, 1–44. [CrossRef]
6. Micu, M.; Micu, D.; Soldati, M. Mass Movements in Changing Mountainous Environments. In *Treatise on Geomorphology*; Shroder, J.F., Ed.; Academic Press: Cambridge, MA, USA, 2022; pp. 371–388. ISBN 978-0-08-088522-3.
7. Corominas, J.; van Westen, C.; Frattini, P.; Cascini, L.; Malet, J.-P.; Fotopoulou, S.; Catani, F.; Van Den Eeckhaut, M.; Mavrouli, O.; Agliardi, F.; et al. Recommendations for the Quantitative Analysis of Landslide Risk. *Bull. Eng. Geol. Environ.* **2014**, *73*, 209–263. [CrossRef]
8. Masson-Delmonte, V.; Zhai, P.; Pirani, A.; Connors, S.L.; Péan, C.; Berger, S.; Caud, N.; Chen, Y.; Goldfarb, L.; Gomis, M.I.; et al. *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, 1st ed.; Cambridge University Press: Cambridge, United Kingdom; New York, NY, USA, 2021.
9. Nicu, I.C. Natural Hazards—A Threat for Immovable Cultural Heritage. A Review. *Int. J. Conserv. Sci.* **2017**, *8*, 375–388.
10. UNESCO. *Convention Concerning the Protection of the World Cultural and Natural Heritage*; UNESCO World Heritage Centre: Paris, France, 1972.
11. UNESCO; ICCROM; ICOMOS; IUCN. *Managing Disaster Risks for World Heritage*; UNESCO: Paris, France, 2010.
12. UNESCO World Heritage Centre. *Climate Change and World Heritage: Report on Predicting and Managing the Impacts of Climate Change on World Heritage and Strategy to Assist States Parties to Implement Appropriate Management Responses*; World Heritage Reports: Paris, France, 2007.
13. UNESCO Convention Concerning the Protection of the World Cultural and Natural Heritage. *Thirty-Third Session of the World Heritage Committee*; UNESCO World Heritage Centre: Paris, France, 2009.

14. United Nations. *Transforming Our World: The 2030 Agenda for Sustainable Development A/RES/70/1*; United Nations: New York, NY, USA, 2015.
15. Bertolin, C. Preservation of Cultural Heritage and Resources Threatened by Climate Change. *Geosciences* **2019**, *9*, 250. [CrossRef]
16. Sesana, E.; Gagnon, A.S.; Ciantelli, C.; Cassar, J.; Hughes, J.J. Climate Change Impacts on Cultural Heritage: A Literature Review. *Wiley Interdiscip. Rev.-Clim. Change* **2021**, *12*, e710. [CrossRef]
17. ICOMOS, International Council on Monuments and Sites. *World Report 2000 on Monuments and Sites in Danger*; ICOMOS: Berlin, Germany, 2000.
18. ICOMOS, Climate Change and Cultural Heritage Working Group. *The Future of Our Pasts: Engaging Cultural Heritage in Climate Action*; ICOMOS: Paris, France, 2019.
19. ICOMOS International Council on Monuments and Sites. *Heritage at Risk: World Report 2016–2019 on Monuments and Sites in Danger*; Hendrik Bäßler Verlag: Berlin, Germany, 2020; ISBN 978-3-945880-67-8.
20. Pavlova, I.; Makarigakis, A.; Depret, T.; Jomelli, V. Global Overview of the Geological Hazard Exposure and Disaster Risk Awareness at World Heritage Sites. *J. Cult. Herit.* **2017**, *28*, 151–157. [CrossRef]
21. UNESCO, World Heritage Centre Policy Document on the Impacts of Climate Change on World Heritage Properties. *Document WHC-07/16.GA/10 Adopted by the 16th General Assembly of State Parties to the World Heritage Convention (October 2007)*; UNESCO World Heritage Centre: Paris, France, 2008.
22. Daly, C. Climate Change and the Conservation of Archaeological Sites: A Review of Impacts Theory. *Conserv. Manag. Archaeol. Sites* **2011**, *13*, 293–310. [CrossRef]
23. Zhou, W.; Chen, F.; Guo, H. Differential Radar Interferometry for Structural and Ground Deformation Monitoring: A New Tool for the Conservation and Sustainability of Cultural Heritage Sites. *Sustainability* **2015**, *7*, 1712–1729. [CrossRef]
24. Cigna, F.; Tapete, D.; Lee, K. Geological Hazards in the UNESCO World Heritage Sites of the UK: From the Global to the Local Scale Perspective. *Earth-Sci. Rev.* **2018**, *176*, 166–194. [CrossRef]
25. Fatorić, S.; Seekamp, E. Are Cultural Heritage and Resources Threatened by Climate Change? A Systematic Literature Review. *Clim. Change* **2017**, *142*, 227–254. [CrossRef]
26. Orr, S.A.; Richards, J.; Fatorić, S. Climate Change and Cultural Heritage: A Systematic Literature Review (2016–2020). *Hist. Environ. Policy Pract.* **2021**, *12*, 434–477. [CrossRef]
27. Quesada-Ganuza, L.; Garmendia, L.; Roji, E.; Gandini, A. Do We Know How Urban Heritage Is Being Endangered by Climate Change? A Systematic and Critical Review. *Int. J. Disaster Risk Reduct.* **2021**, *65*, 102551. [CrossRef]
28. Seuring, S.; Gold, S. Conducting Content-analysis Based Literature Reviews in Supply Chain Management. *Supply Chain Manag. Int. J.* **2012**, *17*, 544–555. [CrossRef]
29. Sarkar, N.; Rizzo, A.; Vandelli, V.; Soldati, M. A Literature Review of Climate-Related Coastal Risks in the Mediterranean, a Climate Change Hotspot. *Sustainability* **2022**, *14*, 15994. [CrossRef]
30. Brabb, E.E. Innovative Approaches to Landslide Hazard Mapping. In Proceedings of the 4th International Symposium on Landslides, Toronto, ON, Canada, 16–21 September 1984; pp. 307–324.
31. Guzzetti, F.; Carrara, A.; Cardinali, M.; Reichenbach, P. Landslide Hazard Evaluation: A Review of Current Techniques and Their Application in a Multi-Scale Study, Central Italy. *Geomorphology* **1999**, *31*, 181–216. [CrossRef]
32. Hervás, J.; Bobrowsky, P. Mapping: Inventories, Susceptibility, Hazard and Risk. In *Landslides—Disaster Risk Reduction*; Sassa, K., Canuti, P., Eds.; Springer: Berlin/Heidelberg, Germany, 2005; pp. 321–349. ISBN 978-3-540-69966-8.
33. Hartlen, J.; Viberg, L. General Report: Evaluation of Land- Slide Hazard. In Proceedings of the V International Symposium on Landslides, Lausanne, Switzerland, 10–15 July 1988; pp. 1037–1057.
34. Soeters, R.; van Westen, C.J. Slope Instability Recognition, Analysis, and Zonation. *Landslides Investig. Mitig.* **1996**, 129–177.
35. Van Westen, C.J.; van Asch, T.W.J.; Soeters, R. Landslide Hazard and Risk Zonation—Why Is It Still so Difficult? *Bull. Eng. Geol. Environ.* **2006**, *65*, 167–184. [CrossRef]
36. Soldati, M. Deep-Seated Gravitational Slope Deformation. In *Encyclopedia of Natural Hazards*; Bobrowsky, P.T., Ed.; Encyclopedia of Earth Sciences Series; Springer: Dordrecht, Germany; New York, NY, USA, 2013; pp. 151–155. ISBN 978-90-481-8699-0.
37. Canuti, P.; Casagli, N.; Catani, F.; Fanti, R. Hydrogeological Hazard and Risk in Archaeological Sites: Some Case Studies in Italy. *J. Cult. Herit.* **2000**, *1*, 117–125. [CrossRef]
38. Fanti, R. Geomorphological Hazard in the Tharros Archaeological Area (Western Sardinia, Italy). In Proceedings of the Geoarchaeology of the Landscapes of Classical Antiquity, Ghent, Belgium, 23–24 October 1998; Peeters Vermeulen, F., De Dapper, M., Eds.; Peeters Publishers: Leuven, Belgium, 2000; pp. 85–95.
39. Frodella, W.; Spizzichino, D.; Andrea, C.; Claudio, M.; Nicola, C. Hydrography and Geomorphology of Antananarivo High City (Madagascar). *J. Maps* **2021**, *17*, 215–226. [CrossRef]
40. Frodella, W.; Rosi, A.; Spizzichino, D.; Nocentini, M.; Lombardi, L.; Ciampalini, A.; Vannocci, P.; Ramboason, N.; Margottini, C.; Tofani, V.; et al. Integrated Approach for Landslide Hazard Assessment in the High City of Antananarivo, Madagascar (UNESCO Tentative Site). *Landslides* **2022**, *19*, 2685–2709. [CrossRef]
41. Valagussa, A.; Frattini, P.; Crosta, G.B.; Spizzichino, D.; Leoni, G.; Margottini, C. Hazard Ranking of the UNESCO World Heritage Sites (WHSs) in Europe by Multicriteria Analysis. *J. Cult. Herit. Manag. Sustain. Dev.* **2020**, *10*, 359–374. [CrossRef]

42. Nicu, I.C. Application of Analytic Hierarchy Process, Frequency Ratio, and Statistical Index to Landslide Susceptibility: An Approach to Endangered Cultural Heritage. *Environ. Earth Sci.* **2018**, *77*, 79. [CrossRef]
43. Nicu, I.C.; Asandulesei, A. GIS-Based Evaluation of Diagnostic Areas in Landslide Susceptibility Analysis of Bahluiet River Basin (Moldavian Plateau, NE Romania). Are Neolithic Sites in Danger? *Geomorphology* **2018**, *314*, 27–41. [CrossRef]
44. Lombardo, L.; Tanyas, H.; Nicu, I.C. Spatial Modeling of Multi-Hazard Threat to Cultural Heritage Sites. *Eng. Geol.* **2020**, *277*, 105776. [CrossRef]
45. Greif, V.; Drotar, T. Static and Pseudo Static Stability Analysis of the Medieval Castle Rock Slopes in Slovakia. In *Landslide Science and Practice*; Margottini, C., Canuti, P., Sassa, K., Eds.; Springer: Berlin/Heidelberg, Germany, 2013; pp. 435–440. ISBN 978-3-642-31318-9.
46. Vlcko, J.; Greif, V.; Grof, V.; Jezny, M.; Petro, L.; Brcek, M. Rock Displacement and Thermal Expansion Study at Historic Heritage Sites in Slovakia. *Environ. Geol.* **2009**, *58*, 1727–1740. [CrossRef]
47. Pascale, S.; Pastore, V.; Sdao, F.; Sole, A. Landslide Susceptibility in Archaeological and Natural Historic Park of Rupestrian Churches. In *Proceedings of the Landslide Science and Practice: Risk Assessment, Management and Mitigation 2013*; Springer: Berlin/Heidelberg, Germany, 2013; Volume 6, pp. 715–722.
48. Sdao, F.; Lioi, D.S.; Pascale, S.; Caniani, D.; Mancini, I.M. Landslide Susceptibility Assessment by Using a Neuro-Fuzzy Model: A Case Study in the Rupestrian Heritage Rich Area of Matera. *Nat. Hazards Earth Syst. Sci.* **2013**, *13*, 395–407. [CrossRef]
49. Kasmer, O.; Ulusay, R.; Genis, M. Assessments on the Stability of Natural Slopes Prone to Toe Erosion, and Man-Made Historical Semi-Underground Openings Carved in Soft Tuffs at Zelve Open-Air Museum (Cappadocia, Turkey). *Eng. Geol.* **2013**, *158*, 135–158. [CrossRef]
50. Yang, J.; You, Y.; Ye, X.; Lin, J. Cultural Heritage Sites Risk Assessment Based on RS and GIS—Takes the Fortified Manors of Yongtai as an Example. *Int. J. Disaster Risk Reduct.* **2023**, *88*, 103593. [CrossRef]
51. Zhang, L.; Wang, Y.; Zhang, J.; Zhang, S.; Guo, Q. Rockfall Hazard Assessment of the Slope of Mogao Grottoes, China Based on AHP, F-AHP and AHP-TOPSIS. *Environ. Earth Sci.* **2022**, *81*, 377. [CrossRef]
52. Fernandez-Merodo, J.A.; Mateos, R.M.; Azañon, J.M.; Ezquerro, P.; García-Davalillo, J.C.; Bejar, M.; Herrera, G.; Novo, C.; Bee, E.; Themistocleous, K.; et al. *Multiscale Analysis of Geo-Hazards Affecting the Alhambra Cultural Heritage*; Springer: Heidelberg, Germany, 2023; pp. 47–61. [CrossRef]
53. Moreno, M.; Ortiz, R.; Cagigas-Muñiz, D.; Becerra, J.; Martin, J.M.; Prieto, A.J.; Garrido-Vizuete, M.A.; Macías-Bernal, J.M.; Chávez, M.J.; Ortiz, P. ART-RISK 3.0 a Fuzzy—Based Platform That Combine GIS and Expert Assessments for Conservation Strategies in Cultural Heritage. *J. Cult. Herit.* **2022**, *55*, 263–276. [CrossRef]
54. Mondini, A.C.; Guzzetti, F.; Chang, K.-T.; Monserrat, O.; Martha, T.R.; Manconi, A. Landslide Failures Detection and Mapping Using Synthetic Aperture Radar: Past, Present and Future. *Earth-Sci. Rev.* **2021**, *216*, 103574. [CrossRef]
55. Colomina, I.; Molina, P. Unmanned Aerial Systems for Photogrammetry and Remote Sensing: A Review. *ISPRS J. Photogramm. Remote Sens.* **2014**, *92*, 79–97. [CrossRef]
56. Telling, J.; Lyda, A.; Hartzell, P.; Glennie, C. Review of Earth Science Research Using Terrestrial Laser Scanning. *Earth-Sci. Rev.* **2017**, *169*, 35–68. [CrossRef]
57. Themistocleous, K.; Cuca, B.; Agapiou, A.; Lysandrou, V.; Tzouvaras, M.; Hadjimitsis, D.G.; Kyriakides, P.; Kouhartsiouk, D.; Margottini, C.; Spizzichino, D.; et al. The Protection of Cultural Heritage Sites from Geo-Hazards: The PROTHEGO Project. *Lect. Notes Comput. Sci.* **2016**, *10059 LNCS*, 91–98. [CrossRef]
58. Themistocleous, K.; Danezis, C.; Mendonidis, E.; Lymperopoulou, E. Monitoring Ground Deformation of Cultural Heritage Sites Using UAVs and Geodetic Techniques: The Case Study of Choirokoitia, JPI PROTHEGO Project. In Proceedings of the Earth Resources and Environmental Remote Sensing/GIS Applications VIII, Warsaw, Poland, 12–14 September 2017; Michel, U., Schulz, K., Nikolakopoulos, K., Civco, D., Eds.; Curran Associates: Red Hook, NY, USA, 2017; Volume 10428.
59. Pastonchi, L.; Barra, A.; Monserrat, O.; Luzi, G.; Solari, L.; Tofani, V. Satellite Data to Improve the Knowledge of Geohazards in World Heritage Sites. *Remote Sens.* **2018**, *10*, 992. [CrossRef]
60. Delmonaco, G.; Brini, M.; Cesaro, G. Advanced monitoring systems for landslide risk reduction in the 'Siq' of Petra (Jordan). In Proceedings of the ICOMOS/ISPRS International Scientific Committee on Heritage Documentation (CIPA) 26TH International CIPA Symposium—Digital Workflows for Heritage Conservation, Ottawa, ON, Canada, 28 August–1 September 2017; Hayes, J., Ouimet, C., Quintero, M., Fai, S., Smith, L., Eds.; UNESCO: Paris, France, 2017; Volume 42-2, pp. 163–169.
61. Cigna, F.; Jordan, H.; Bateson, L.; McCormack, H.; Roberts, C. Natural and Anthropogenic Geohazards in Greater London Observed from Geological and ERS-1/2 and ENVISAT Persistent Scatterers Ground Motion Data: Results from the EC FP7-SPACE PanGeo Project. *Pure Appl. Geophys.* **2015**, *172*, 2965–2995. [CrossRef]
62. Themistocleous, K.; Danezis, C.; Gikas, V. Monitoring Ground Deformation of Cultural Heritage Sites Using SAR and Geodetic Techniques: The Case Study of Choirokoitia, Cyprus. *Appl. Geomat.* **2021**, *13*, 37–49. [CrossRef]
63. Devlioti, K.; Christaras, B.; Marinos, V.; Vouvalidis, K.; Giannakopoulos, N. Kinematic Analysis of Rock Instability in the Archaeological Site of Delphi Using Innovative Techniques. In *Transdisciplinary Multispectral Modeling and Cooperation for the Preservation of Cultural Heritage*; Moropoulou, A., Korres, M., Georgopoulos, A., Spyrakos, C., Mouzakis, C., Eds.; Springer International Publishing: Cham, Switzerland, 2019; Volume 962, pp. 407–418. ISBN 978-3-030-12959-0.

64. Konstantinidis, I.; Marinos, V.; Papathanassiou, G. UAV-Based Evaluation of Rockfall Hazard in the Cultural Heritage Area of Kipinas Monastery, Greece. *Appl. Sci.* **2021**, *11*, 8946. [CrossRef]
65. Gao, X.; Roder, G.; Jiao, Y.; Ding, Y.; Liu, Z.; Tarolli, P. Farmers' Landslide Risk Perceptions and Willingness for Restoration and Conservation of World Heritage Site of Honghe Hani Rice Terraces, China. *Landslides* **2020**, *17*, 1915–1924. [CrossRef]
66. Santoro, A.; Venturi, M.; Agnoletti, M. Landscape Perception and Public Participation for the Conservation and Valorization of Cultural Landscapes: The Case of the Cinque Terre and Porto Venere UNESCO Site. *Land* **2021**, *10*, 93. [CrossRef]
67. Marra, A.; Fabbrocino, G.; Fabbrocino, S. Conservation and Enhancement of the Pietrabbondante Archaeological Site between History, Geology and Emerging Crowd-Based Digital Technologies. *Heritage* **2022**, *5*, 1504–1528. [CrossRef]
68. Bollati, I.; Della Seta, M.; Pelfini, M.; Del Monte, M.; Fredi, P.; Lupia Palmieri, E. Dendrochronological and Geomorphological Investigations to Assess Water Erosion and Mass Wasting Processes in the Apennines of Southern Tuscany (Italy). *Catena* **2012**, *90*, 1–17. [CrossRef]
69. Tarolli, P.; Preti, F.; Romano, N. Terraced Landscapes: From an Old Best Practice to a Potential Hazard for Soil Degradation Due to Land Abandonment. *Anthropocene* **2014**, *6*, 10–25. [CrossRef]
70. Margottini, C. Instability and Geotechnical Problems of the Buddha Niches and Surrounding Cliff in Bamiyan Valley, Central Afghanistan. *Landslides* **2004**, *1*, 41–51. [CrossRef]
71. Margottini, C. Recovery of the Buddha's Niches and Cliff in Bamiyan (Central Afghanistan) after the Taliban Destruction of 2001. In Proceedings of the Landslides—Disaster Risk Reduction; Springer: Berlin/Heidelberg, Germany, 2009; pp. 191–210.
72. Marinos, P.; Tsiambaos, G. Earthquake Triggering Rockfalls Affecting Historic Monuments and a Traditional Settlement in Skyros Island, Greece. In *Proceedings of the International Symposium on Landslide Risk Mitigation and Protection of Cultural and Natural Heritage*; UNESCO, ICL: Kyoto, Japan, 2002.
73. Iannucci, R.; Martino, S.; Paciello, A.; D'Amico, S. Rock Mass Characterization Coupled with Seismic Noise Measurements to Analyze the Unstable Cliff Slope of the Selmun Promontory (Malta). *Proced. Eng.* **2017**, *191*, 263–269. [CrossRef]
74. Bozdag, A. Rockfall Hazard Assessment in a Natural and Historical Site: The Case of Ancient Kilistra Settlement (Konya), Turkey. *J. Mt. Sci.* **2022**, *19*, 151–166. [CrossRef]
75. Valagussa, A.; Frattini, P.; Crosta, G.; Spizzichino, D.; Leoni, G.; Margottini, C. Multi-Risk Analysis on European Cultural and Natural UNESCO Heritage Sites. *Nat. Hazards* **2021**, *105*, 2659–2676. [CrossRef]
76. Brimblecombe, P.; Hayashi, M.; Futagami, Y. Mapping Climate Change, Natural Hazards and Tokyo's Built Heritage. *Atmosphere* **2020**, *11*, 680. [CrossRef]
77. Lollino, G.; Audisio, C. UNESCO World Heritage Sites in Italy Affected by Geological Problems, Specifically Landslide and Flood Hazard. *Landslides* **2006**, *3*, 311–321. [CrossRef]
78. Bertolin, C.; Sesana, E. Natural Hazards Affecting Cultural Heritage: Assessment of Flood and Landslide Risk for the 28 Existing Norwegian Stave Churches. *Int. J. Build. Pathol. Adapt.* **2023**. [CrossRef]
79. Berardi, R.; Cambiaggi, L. Prediction of Slope Movement Effects on Churches for the Development of a Fragility Curve Approach. *Lect. Notes Civ. Eng.* **2020**, *40*, 82–91. [CrossRef]
80. Cambiaggi, L.; Ferrero, C.; Berardi, R.; Calderini, C.; Vecchiattini, R. Effect of slow-moving landslides on churches in the Liguria region: A geotechnical approach. In Proceedings of the 12th International Conference on Structural Analysis of Historical Constructions (SAHC 2021), Online, 29 September–1 October 2021; Roca, P., Pela, L., Molins, C., Eds.; pp. 1074–1085.
81. Colucci, E. Mountain Hamlet Heritage Between Risk and Enhancement. *Lect. Notes Netw. Syst.* **2022**, *482 LNNS*, 2575–2586. [CrossRef]
82. Lazzari, M.; Geraldi, E.; Lapenna, V.; Loperte, A. Natural Hazards vs Human Impact: An Integrated Methodological Approach in Geomorphological Risk Assessment on the Tursi Historical Site, Southern Italy. *Landslides* **2006**, *3*, 275–287. [CrossRef]
83. Marchetti, D.; Amato Avanzi, G.D.; Sciarra, N.; Calista, M.; Mazzanti, G. Numerical Modeling Applied to a Cultural Heritage Site Threatened by Rock Falls in Tuscany (Italy). In Proceedings of the Rock Mechanics in Civil and Environmental Engineering—Proceedings of the European Rock Mechanics Symposium, EUROCK 2010, Lausanne, Switzerland, 19 May 2010; pp. 647–650. [CrossRef]
84. Margottini, C. Low Environmental Impact Consolidation Works in the Rock Cliff of Civita Di Bagnoregio (Central Italy). In *Proceedings of the Landslide Science and Practice: Risk Assessment, Management and Mitigation 2013*; Springer: Berlin/Heidelberg, Germany; Volume 6, pp. 647–654.
85. Reichenbach, P.; Rossi, M.; Malamud, B.D.; Mihir, M.; Guzzetti, F. A Review of Statistically-Based Landslide Susceptibility Models. *Earth-Sci. Rev.* **2018**, *180*, 60–91. [CrossRef]
86. Yoshimatsu, H.; Abe, S. A Review of Landslide Hazards in Japan and Assessment of Their Susceptibility Using an Analytical Hierarchic Process (AHP) Method. *Landslides* **2006**, *3*, 149–158. [CrossRef]
87. Frodella, W.; Elashvili, M.; Spizzichino, D.; Gigli, G.; Nadaraia, A.; Kirkitadze, G.; Adikashvili, L.; Margottini, C.; Antidze, N.; Casagli, N. Applying Close Range Non-Destructive Techniques for the Detection of Conservation Problems in Rock-Carved Cultural Heritage Sites. *Remote Sens.* **2021**, *13*, 1040. [CrossRef]
88. Grunert, J.; Hess, S. The Upper Middle Rhine Valley as a Risk Area. *Nat. Hazards* **2010**, *55*, 577–597. [CrossRef]

89. Melelli, L.; Cencetti, C.; Cecconi, M.; Faralli, L.; Vecchietti, A.; Pane, V. The Hermitage of Cerbaiolo (Tuscany, Italy): Stability Conditions and Geomorphological Characterization. *Environ. Earth Sci.* **2016**, *75*, 322. [CrossRef]
90. Rohn, J.; Ehret, D.; Moser, M.; Czurda, K. Prehistoric and Recent Mass Movements of the World Cultural Heritage Site Hallstatt, Austria. *Environ. Geol.* **2005**, *47*, 702–714. [CrossRef]
91. Fanti, R.; Gigli, G.; Lombardi, L.; Tapete, D.; Canuti, P. Terrestrial Laser Scanning for Rockfall Stability Analysis in the Cultural Heritage Site of Pitigliano (Italy). *Landslides* **2013**, *10*, 409–420. [CrossRef]
92. Kyriou, A.; Nikolakopoulos, K.; Koukouvelas, I. Synergistic Use of UAV and TLS Data for Precise Rockfall Monitoring over a Hanging Monastery. In Proceedings of the Earth Resources and Environmental Remote Sensing/GIS Applications XIII, Berlin, Germany, 5–7 September 2022; Schulz, K., Michel, U., Nikolakopoulos, K., Eds.; Springer: Berlin/Heidelberg, Germany, 2022; Volume 12268.
93. Lazzari, M.; Gioia, D. UAV Images and Historical Aerial-Photos for Geomorphological Analysis and Hillslope Evolution of the Uggiano Medieval Archaeological Site (Basilicata, Southern Italy). *Geomat. Nat. Hazards Risk* **2017**, *8*, 104–119. [CrossRef]
94. Benedetti, G.; Bernardi, M.; Bonaga, G.; Borgatti, L.; Continelli, F.; Ghirotti, M.; Guerra, C.; Landuzzi, A.; Lucente, C.C.; Marchi, G. San Leo: Centuries of Coexistence with Landslides. In *Proceedings of the Landslide Science and Practice: Risk Assessment, Management and Mitigation*; Springer: Berlin/Heidelberg, Germany, 2013; Volume 6, pp. 529–537.
95. Faccini, F.; Piccazzo, M.; Robbiano, A. Environmental Geological Maps of San Fruttuoso Bay (Portofino Park, Italy). *J. Maps* **2008**, *4*, 431–443. [CrossRef]
96. Gizzi, F.T.; Bentivenga, M.; Lasaponara, R.; Danese, M.; Potenza, M.R.; Sileo, M.; Masini, N. Natural Hazards, Human Factors, and "Ghost Towns": A Multi-Level Approach. *Geoheritage* **2019**, *11*, 1533–1565. [CrossRef]
97. Fanti, R. Slope Instability of San Miniato Hill (Florence, Italy): Possible Deformation Patterns. *Landslides* **2006**, *3*, 323–330. [CrossRef]
98. Gigli, G.; Frodella, W.; Mugnai, F.; Tapete, D.; Cigna, F.; Fanti, R.; Intrieri, E.; Lombardi, L. Instability Mechanisms Affecting Cultural Heritage Sites in the Maltese Archipelago. *Nat. Hazards Earth Syst. Sci.* **2012**, *12*, 1883–1903. [CrossRef]
99. Mateos, R.M.; Ezquerro, P.; Azañón, J.M.; Gelabert, B.; Herrera, G.; Fernández-Merodo, J.A.; Spizzichino, D.; Sarro, R.; García-Moreno, I.; Béjar-Pizarro, M. Coastal Lateral Spreading in the World Heritage Site of the Tramuntana Range (Majorca, Spain). The Use of PSInSAR Monitoring to Identify Vulnerability. *Landslides* **2018**, *15*, 797–809. [CrossRef]
100. Reale, D.; Noviello, C.; Verde, S.; Cascini, L.; Terracciano, G.; Arena, L. A Multi-Disciplinary Approach for the Damage Analysis of Cultural Heritage: The Case Study of the St. Gerlando Cathedral in Agrigento. *Remote Sens. Environ.* **2019**, *235*, 111464. [CrossRef]
101. Mileto, C.; Vegas, F.; Cristini, V.; García-Soriano, L. The research project "Earthen architecture in the Iberian peninsula: Study of natural, social and anthropic risks and strategies to improve resilience (RISK-TERRA)". Objectives and first methodology. *Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci.* **2020**, *XLIV-M-1–2020*, 871–876. [CrossRef]
102. Vamvatsikos, D.; Chatzidaki, A. The HAPI Sensor-Aware Framework for Infrastructure Risk and Resilience Assessment. In Proceedings of the International Conference on Natural Hazards and Infrastructure, Athens, Greece, 5–7 July 2022.
103. Crozier, M.J. Multiple-Occurrence Regional Landslide Events in New Zealand: Hazard Management Issues. *Landslides* **2005**, *2*, 247–256. [CrossRef]
104. Delmonaco, G.; Margottini, C.; Spizzichino, D. Weathering Processes, Structural Degradation and Slope-Structure Stability of Rock-Hewn Churches of Lalibela (Ethiopia). *Geol. Soc. Eng. Geol. Spec. Publ.* **2010**, *23*, 131–147. [CrossRef]
105. Margottini, C.; Bobrowsky, P.; Gigli, G.; Ruther, H.; Spizzichino, D.; Vlcko, J. Rupestrian World Heritage Sites: Instability Investigation and Sustainable Mitigation. In *Advancing Culture of Living with Landslides*; Sassa, K., Mikoš, M., Yin, Y., Eds.; Springer International Publishing: Cham, Switzerland, 2017; pp. 23–50. ISBN 978-3-319-53500-5.
106. Margottini, C.; Gigli, G.; Ruther, H.; Spizzichino, D. Advances in Geotechnical Investigations and Monitoring in Rupestrian Settlements Inscribed in the UNESCO's World Heritage List. In Proceedings of the Fourth Italian Workshop on Landslides, Naples, Italy, 23–25 November 2015; Picarelli, L., Greco, R., Urciuoli, G., Eds.; Volume 16, pp. 35–51.
107. Margottini, C.; Gigli, G.; Ruther, H.; Spizzichino, D. Advances in Sustainable Conservation Practices in Rupestrian Settlements Inscribed in the UNESCO's World Heritage List. In Proceedings of the Fourth Italian Workshop on Landslides, Naples, Italy, 23–25 November 2015; Picarelli, L., Greco, R., Urciuoli, G., Eds.; Volume 16, pp. 52–60.
108. Lazzari, M.; Lazzari, S. Geological and Geomorphological Hazard in Historical and Archaeological Sites of the Mediterranean Area: Knowledge, Forecasting and Mitigation. *Disaster Adv.* **2012**, *5*, 63–71.
109. Ciampalini, A.; Frodella, W.; Margottini, C.; Casagli, N. Rapid Assessment of Geo-Hydrological Hazards in Antananarivo (Madagascar) Historical Centre for Damage Prevention. *Geomat. Nat. Hazards Risk* **2019**, *10*, 1102–1124. [CrossRef]
110. Casagli, N.; Fanti, R.; Nocentini, M.; Righini, G. Assessing the Capabilities of VHR Satellite Data for Debris Flow Mapping in the Machu Picchu Area (C101-1). In Proceedings of the LandSlides: Risk Analysis and Sustainable Disaster Management; Sassa, K., Fukuoka, H., Wang, F., Wang, G., Eds.; Springer: Berlin/Heidelberg, Germany, 2005; pp. 61–70.
111. Klimes, J. Landslide Temporal Analysis and Susceptibility Assessment as Bases for Landslide Mitigation, Machu Picchu, Peru. *Environ. Earth Sci.* **2013**, *70*, 913–925. [CrossRef]
112. Rodriguez-Pascua, M.A.; Benavente Escobar, C.; Rosell Guevara, L.; Grutzner, C.; Audin, L.; Walker, R.; Garcia, B.; Aguirre, E. Did Earthquakes Strike Machu Picchu? *J. Seismol.* **2020**, *24*, 883–895. [CrossRef]

113. Spizzichino, D.; Margottini, C.; Puzzilli, L.M. Landslide Risk Assessment and Management in the Archaeological Site of Machu Picchu (Peru). In Proceedings of the Geotechnical Engineering for the Preservation of Monuments and Historic Sites; Bilotta, E., Flora, A., Lirer, S., Viggiani, C., Eds.; Taylor & Francis Group: Abingdon, UK, 2013; pp. 697–707.
114. Sassa, K.; Fukuoka, H.; Carreno, R. Landslide Investigation and Capacity Building in the Machu Picchu—Aguas Calientes Area (IPL C101-1). In *Landslides—Disaster Risk Reduction*; Sassa, K., Canuti, P., Eds.; Springer: Berlin/Heidelberg, Germany, 2009; p. 229.

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# Climate Change and Pilgrimage to Shrines in Ethiopia

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**Abstract:** Pilgrimages are an important part of our intangible heritage. These long journeys, often on foot, can be sensitive to weather, so this study sees pilgrimages as providing an opportunity to look at the way in which changes in climate affect intangible heritage. It examines two important Ethiopian pilgrimages that involve hundreds of thousands who travel each year to Dirre Sheikh Hussein, seen as the country's Mecca, and Lalibela, its Jerusalem. These journeys in the cold season (December–February) often exceed 1000 km in length and expose pilgrims to low temperatures in mountain areas. Our analysis uses daily output data from ERA-5 and CHIRPS for rainfall and temperature across the recent past (1984–2014) and an ensemble of climate models (CMIP6) for the periods 1984–2014 and 2035–2065, to explore changes in nighttime low temperature, daytime high temperature and the potential increase in days of heavy rain in mountain areas. Additionally, we examine the increasing number of very hot days affecting travel to and from Dirre Sheikh Hussein. The pilgrims experience weather events and not long-term average conditions, so extremes and spells of inclement weather can affect their experience. Management plans for the regions have yet to address likely changes to climate at these religious sites, or consider how strategic planning might mitigate their impact on pilgrims.

**Keywords:** intangible heritage; Dirre Sheikh Hussein; Lalibela; religious tourism; hot days; cold spells; rainfall



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## 1. Introduction

Climate change is a threat to cultural heritage. In coastal areas, sea level rise can lead to damaging water levels, while inland floods frequently inundate heritage sites [1,2]. Slow and cumulative damage can arise from changing humidity and freeze–thaw cycles, while deterioration can accrue from exposure to solar radiation or air pollution [3]. The effect of changing weather and climate on our material heritage has been well recognised for several decades, along with the importance of tuning climate parameters, so they are relevant to heritage [4,5]. Despite a wealth of research output, it is only recently that the IPCC has incorporated heritage. It now appears in the *Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, which expresses the need for more work on how climate change will affect cultural heritage [6]. Although much research has been carried out in Europe and later North America, the Global South remains under-represented [7].

Studies of the effects of climate change on intangible heritage are also recognised [8] in terms of its effect on artistic or religious practices [9]. However, such studies have been more interested in the broad notion of climate change rather than the attribution of effects on intangible heritage to specific climate factors [10], and there has typically been a focus on "standard political and welfare economic calculus of climate change policy and science

[p. 2]", which can undervalue localised material and symbolic values [11]. The threat to intangible heritage is of understandable concern, as Higgins [9] argues that intangible cultural heritage is disproportionately affected by climate change because of the spiritual connection between indigenous people and their surroundings. Practices and customs may vanish if populations have to alter their lifestyles or leave their traditional surroundings. For example, a changing climate means that festivals with set dates can occur at the wrong time; the Yayoi Festival in Nikko, Japan, now comes too late to use cherry blossoms, so now parade vehicles are decorated with artificial flowers [12]; or winterscapes associated with Santa Claus and Christmas may no longer be snow-covered, even in boreal climates [13,14]. Furthermore, Harrison [15] has analysed the impacts of climate change on indigenous music, arguing that even though the issue may be recognized, it is "often without material references or inclinations [p. 28]". The breadth of climate impacts of society are likely to make it difficult to represent the effects of individual meteorological parameters on intangible heritage; in fact, this subtlety can even complicate representing climate effects on tangible heritage [4,5].

Pilgrimage is an element of our intangible heritage that is vulnerable to climate change [16,17]. Studies show that heat-related risks to pilgrims on the Hajj in Saudi Arabia are increasing with rising temperatures [17–20]. The iconic journey pilgrims undertake, along the Way of St. James, to the cathedral at Santiago de Compostela in Galicia in northwestern Spain, is affected by the changing frequency of precipitation and heat waves. This is likely to require careful management of the route [16]. In Ethiopia, two popular places for pilgrimage are Dirre Sheikh Hussein as its Mecca and Lalibela as its Jerusalem (Figure 1). These journeys are undertaken to celebrate Sheikh Hussein's birthday, the festival of Zara, at Dirre Sheikh Hussein and Genna (Christmas) at Lalibela. They take place in the cold season (Bega, i.e., December–February), and as shown in Figure 1a, pilgrims may need to cross central mountains, where the weather can be cold.

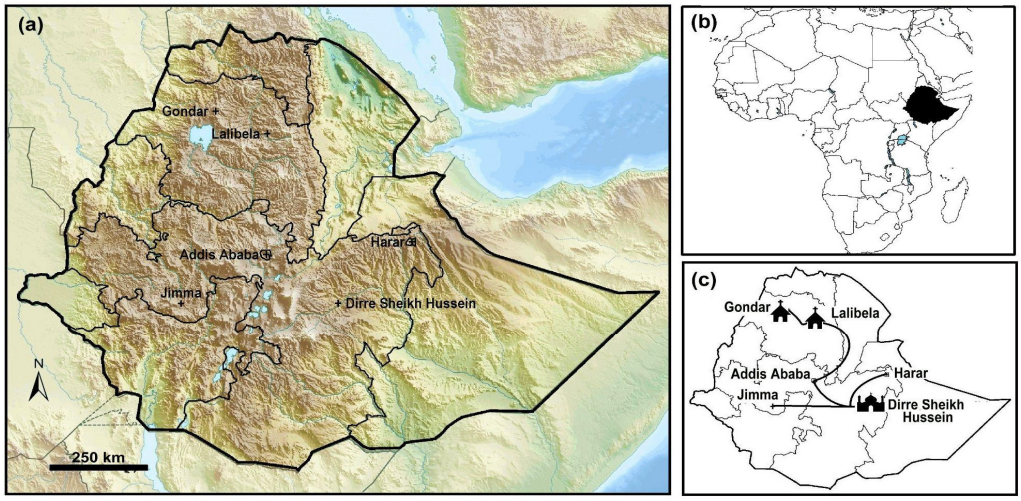


**Figure 1.** (**a**) Map of Ethiopia showing topography with locations mentioned in the text. (**b**) Africa with Ethiopia marked in black. (**c**) Major pilgrimage routes to Dirre Sheikh Hussein from Jimma, Addis Ababa (and nearby Adama) and Harar. Route from Addis Ababa to Lalibela and on to Gondar. Notes: (**a**) Basemap https://en.populationdata.net/maps/ethiopia-topographic/ (accessed on 5 November 2023).

Pilgrimage takes place during short time windows (i.e., often a few months), which makes the climates related to pilgrimages amenable to study using many of the classic tools of climatology that have been applied to examining the impact of climate change on agriculture [21], ecosystems [22], disease [23] and cultural landscapes and heritage [3].

### *1.1. Pilgrimage to Dirre Sheikh Hussein*

The Dirre Sheikh Hussein heritage site [24] is set in semi-arid lowlands in a remote part of the East Bale Zone of the Oromia region ~610 km from Addis Ababa. The sanctuary (Figure 1a) was established in the 10–12th century by the Islamic saint Sheikh Nur Hussein. He founded this important religious complex as part of his crucial role as a Muslim missionary, spreading Islam among the Arsi Oromo people of southern Ethiopia. The site has an area >19,000 ha, with an inner core of 880 ha. There are 11 historic structures and 12 gates in the white stone walls and fences of the compound [25]. The oldest building is the Zuqtum Mosque, built by Nur Sheikh Hussein and his students. In addition, there are five major tombs and some substantial mosques (18th–19th century), along with festive places and ceremonial courtyards, and water harvesting ponds including the largest, Haru Luku, built by Sheikh Hussein. About 5 km distant is Ayinagegn, a sacred cave, once a dwelling place of Sheikh Hussein. Dirre Sheikh Hussein has long been associated with Islamic learning and the religious culture of southern Ethiopia, a place where people can express a mixture of Islamic and traditional beliefs (Muda), particularly during the annual religious festivals. As such, it has become the destination for many pilgrims.

The pilgrimage to the shrine at Dirre Sheikh Hussein is a notable Islamic journey, sometimes seen to be almost as significant as the Hajj to Mecca. Devotees of Sheikh Hussein go on pilgrimages to his shrine as frequently as they can. The religious importance of the shrine has made it a place of pilgrimage, especially to celebrate the birthday of Sheikh Hussein (Zara) in January. A further celebration occurs at the end of the Muslim year with a great feast, of which the date changes each year depending on the lunar calendar.

The pilgrimage was especially popular during the period of Emperor Haile Selassie (1930s–mid-1970s) and was undertaken by about 100,000 people in 1971 [26]. It was less popular because of restrictions during the Derg regime (Provisional Military Government of Socialist Ethiopia) from 1974 to 1987, but gradually grew to an estimated 500,000 people in 2007. Over the last decade, although the number of tourists has increased, the number of pilgrims declined due to the changing influence of religious tolerance [27–29], recent civil conflict, drought, decline in livestock and crop production [30]. Times of improved agricultural economy generally see the regional community with more disposable income to finance transport and contribute to other related costs associated with the pilgrimage. The number of pilgrims was estimated at 200,000 in 2018.

Like many great pilgrimages, the journey to Dirre Sheikh Hussein is long and arduous. Travel distances of 1600 km are not unusual, and in many cases, pilgrims are on foot or ride mules, horses, donkeys or camels. In the 1970s, travel could take up to six months, with communities along the routes providing hospitality to the pilgrims as they passed through different localities. The pilgrims carry a range of cultural objects, such as the *Ulee Sheikh Hussein* (Y-shaped sticks) that identify them, so they remain unmolested even during times of war. Additionally, the *Qulu*, a cup made from a gourd, is often carried along with the *Dibbee*, a musical instrument made from a local tree.

Recently, the number of pilgrims who travel by foot has decreased due to the availability of public transport, but some pilgrims still choose to walk to Dirre Sheikh Hussein (Figure 2a,b), as is the case with other iconic pilgrimages [31]. Wealthier or international travellers can make their way from Haile Selassie Airport (Addis Ababa) through to Dirre Sheikh Hussein via Robe Airport, although it is more than 100 km to the southwest. Infrastructure that might encourage tourism to the shrine tends to be poor [32], and the airport at Dirre Sheikh Hussein was damaged during the Ethiopian-Somali war (1977–1978) so it is no longer functioning, although there has occasionally been talk of reconstructing it.


**Figure 2.** (**a**) Interior of the shrine compound at Dirre Sheikh Hussein. (**b**) Pilgrims on the main road from Robi to Addis Ababa in August 2022. They were returning to their home in Butajira town in southern Ethiopia on foot, a journey of more than 500 km. Note that they carry Ulee Sheikh Hussein (Y-shaped sticks). (**c**) Biete Ghiorgis, the rock-hewn House of St. George. (**d**) Christmas vigil at Lalibela, with prayers at Emmanuel Church in honour of the Virgin. Photograph: (**a**,**b**) author H.G.T., (**c**) author J.R., and (**d**) Tanjagari–CC BY-SA 4.0.

### *1.2. Pilgrimage to Lalibela*

Lalibela is in the Western Highlands of Ethiopia, and is famous for its 11 churches carved from the rock, a unique approach to construction. This, along with the historical significance of the site, led to the ensemble being recognised as a UNESCO World Heritage Site in 1978. Traditionally, the churches were thought to be built under the direction of King Gebre Mesqel Lalibela who reigned from 1181 to 1221, although legend has it that angels helped build the churches at night, which adds to a sense of divine intervention and mystery. Biete Giorgis (House of St. George) is the best known and most recent of the structures (Figure 2c). The town of Lalibela has an important religious significance for the Ethiopian Orthodox Church and bears an aura of devotion and spirituality, making it a unique and sacred destination. The churches are believed to possess miraculous healing powers, so they are visited by many pilgrims who seek their blessing. Pilgrims travel to Lalibela from within Ethiopia and neighbouring countries. It is a growing destination for religious heritage tourists interested in experiencing the religious and historical significance of the site. Although popular throughout the year, the key celebrations at Lalibela are Christmas or Genna, celebrated on 7 January, Timket (Epiphany), which takes place in January, and Meskel (Finding of the True Cross) in September. At these times, large numbers gather in Lalibela to attend the festivities and religious services.

Traders line the road from the town to the churches. The traditional ceremonies involve a vigil through Christmas Eve (Figure 2d). At sunrise on 7 January, Christmas celebrations centre around Bete Maryam (House of Mary) with 2–3 h of hymns and chanting. There are many weddings on Ethiopian Christmas Day in Lalibela, when couples become married to God. Lalibela is also known for its holy water that is believed to help spouses conceive their first child. By Christmas afternoon, while some pilgrims sleep or continue to celebrate, many have already started their journey home. Epiphany or Timket, which celebrates the baptism of Jesus, can occur at an artificial River Jordan in Lalibela, although

Gondar (~350 km by road to the northwest) is perhaps the most important location for this ceremony, where it takes place at Fasilides' Bath on 19 January.

The pilgrimage to Lalibela takes place for major festivals, with locals claiming that around a million people arrive at Christmas. Official figures focus on tourists, so these figures are smaller, suggesting 20,000–50,000 believers during major celebrations [33]. The total number of domestic tourist arrivals (as distinct from pilgrims) showed an increase from 6784 to 15,492 in the five year period 2008–2012. The number of international tourist arrivals also reflected a tangible increase from 21,641 in 2008 to 35,437 in 2012 [34]. In 2022, Lalibela was also a site of civil unrest, and since COVID-19, tourism has suffered [35].

### *1.3. Weather*

The climate of Ethiopia [36] covers a wide range of Köppen classes (Figure 3a), with weather in mountainous regions presenting a challenge to pilgrims, particularly for those pilgrims who come from lowland areas, and must cross the Highlands. Many pilgrims from the Jimma Region must travel near Bale Mountains National Park (Mt. Tullu Dimtu is 4377 m). Here, temperatures vary widely, and on the plateau, daytime temperatures are usually around 10 °C with strong winds. At higher elevations, frosts are common at night. The challenging climate is evident in the faces of elderly pilgrims in the mountains (Figure 1b). The timing and duration of pilgrimages will be location- and site-specific, but depends on the distance pilgrims must travel and the mode of transport, which might be on foot, by donkey, car or plane. The climate conditions can make the journey arduous for the pilgrims; high temperatures can cause heat stress for those without access to shade, persistent rain can make mountain roads vulnerable to landslides, and intense thunderstorms can affect air traffic.

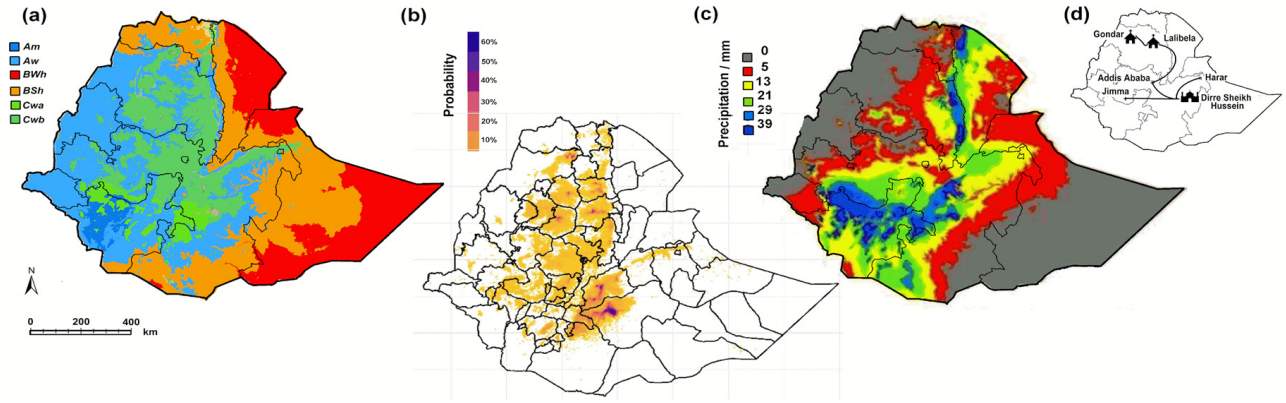


**Figure 3.** (**a**) Köppen climate map of Ethiopia, adapted from Adam Peterson's map of Ethiopia. (**b**) December frost probability [37]. (**c**) January rainfall map [38]. (**d**) Key pilgrimage routes.

The classic routes to Dirre Sheikh Hussein take pilgrims from Addis Ababa (or nearby Adama) and may proceed through Robi or Seru. Routes from Harar in the north proceed via Daro Labu to the shrine. Although both these routes might mean that pilgrims face a chance of frost at night, it is the popular route from Jimma in the west that takes pilgrims over mountains with a high probability of frost and rain, which makes travel difficult, as shown in Figure 2b. The routes to Lalibela can take pilgrims north along the Awash Valley, but winter conditions are generally milder as they move away from Addis Ababa and north beyond Debre Birhan, the coldest city of Ethiopia (~120 km northeast of Addis Ababa).

### *1.4. Aims and Hypothesis*

The tangible heritage at Dirre Sheikh Hussein is in a region susceptible to environmental change [24], so it has been the focus of some recent conservation efforts. The churches at Lalibela are better known internationally and have also been addressed in conservation programmes. Sadly, some of the restoration efforts have had undesired effects and

led to difficulties between funders, conservation professionals and the local stakeholders [39]. The expanding religious and eco-tourist market and problems in achieving this sustainably [34,39] have also added to risk at the sites. Although there are some studies of climate effects at Dirre Sheikh Hussein, which is in a region susceptible to environmental change [24], and Lalibela [40], these remain limited. However, this study focuses on the pilgrims rather than the material heritage, so it considers the effect of a changing climate on their travels and experiences at these sacred sites. Significantly, the pilgrimages to Dirre Sheikh Hussein and Lalibela both take place at the coldest time of year, which hitherto has provoked less interest among those studying the effects of climate in pilgrimages, that are typically summer occurrences [17,18,20].

## 2. Materials and Methods

Meteorological parameters were chosen to capture the challenges that pilgrims may face in terms of extremes in temperature and rainfall: low temperatures makes sleeping at night difficult, while high temperatures can mean that walking during the day is exhausting. Rainfall events can hinder both pilgrims travelling by foot and by car, as paths and roads are muddy, and in extreme cases, impassable. To capture these challenging conditions, we use two temperature parameters and one rainfall parameter:

(i) Minimum daily temperature (°C), the averaged (mean) minimum daily temperature for a given period;
(ii) Maximum daily temperature (°C), the averaged (mean) maximum daily temperature for a given period;
(iii) Rain days above 1 mm, the number of days where rainfall exceeds 1 mm per 30 days.

Furthermore, as pilgrims do not experience an average climate, but rather the particular weather that occurs during their travels, the persistence of conditions is investigated. It may be that days of persistent rain or successive wet or hot or cold days will be especially troublesome. This has been examined by determining the weather on successive days.

### *2.1. Meteorological Observations*

The parameters were calculated using the hourly 2 m surface temperature from ERA-5 reanalysis and the total daily rainfall from Climate Hazards Group InfraRed Precipitation with station data (CHIRPS) Version 2 [41], to capture observed meteorological conditions across Ethiopia. Both datasets were interpolated onto a common $0.25^\circ \times 0.25^\circ$ grid. Additional analysis was undertaken for the three climate parameters for the nine ($3 \times 3$) grid cells centred on the locations of Addis Ababa, Lalibela and Dirre Sheikh Hussein (Figure 3d).

### *2.2. Modelled Data*

In many fields, such as climate and environmental sciences, climate models provide a useful tool for assessing future scenarios. Climate models are likely to provide (i) lengthy datasets without gaps that can frequently occur in manual observational records [42], and can provide (ii) raw climate data that can be used to construct parameters that relate to heritage impacts [5].

Successfully representing Ethiopian climate conditions using GCMs can be challenging, due to issues with capturing precipitation processes and the effect of complex orography on GCMs [43,44]. Richards and Brimblecombe [45] found that an ensemble of three CMIP6 GCMs (CMCC-ESM2, HadGEM3-GC31-MM and NorESM2-MM [46]) are effective in reproducing three parameters: minimum daily temperature, maximum daily temperature and rain days above 1 mm for the period 1984–2014 by comparing the parameters generated using the ERA5 and CHIRPS to the CMIP6 datasets for this period. Therefore, the parameters were also calculated using CMIP6 GCMs [47] to explore the effect of future climate scenarios on pilgrimage. The Centre for Environmental Data Analysis (CEDA) archive was used to obtain daily 2 m surface temperature and precipitation data for the historical

period (CMIP experiment) and future projections. The results were calculated using the CMCC-ESM2, HadGEM3-GC31-MM and NorESM2-MM CMIP6 models [47], using only model runs of the variant r1i1p1f*. All models were interpolated to a common $1^\circ \times 1^\circ$ grid to facilitate model comparison.

We calculated the three climate parameters for the Bega season in the recent past, 1984–2014, and mid-century, 2035–2065, to assess the extent of change under a high emission (SSP585) scenario. The time frame of 1984–2014 is chosen to align with the climate model experimental year runs and is the most recent 30-year period included in the historic model experiments. The SSP585 scenario was chosen to illustrate a worst-case scenario for climate change impacts on pilgrimage in Ethiopia. The parameters were calculated for the period 1 December to 15 February to cover the various durations of pilgrimages that might be undertaken during the Bega season. We also calculated results for the shorter period of 14 days from 1 to 14 January, but as little significant difference was found between the results over different durations, these are included in the Supplementary Material (Figure S1). The HadGEM3 model operates on a 360-day annual timescale, but results from both this study and earlier work [45] show that this difference does not significantly affect the results. For each 30-year period, the mean and the 10th (minimum daily temperature) or 90th percentile (maximum daily temperature and rain days above 1 mm) were calculated. We use percentiles to illustrate climate extremes that pilgrims may experience.

### *2.3. Statistics*

In our statistical analysis of the meteorological data, we have often adopted non-parametric methods, as distributions are often skewed. Box-and-whisker plots represent the central tendency and range. The boxes show the lower and upper quartiles, with the median denoted by the central line in the box and a cross to represent the arithmetic mean. The whiskers show the range of all other points, except those that are deemed as outliers. An outlier is considered any value that lies over 1.5 times the interquartile range below and above the quartiles. The Kendall $\tau$ statistic was used to express rank correlation in bivariate data sets.

## 3. Results and Discussion

### *3.1. Current Climate*

The weather during Bega has some characteristics that make pilgrimages convenient. It is a relatively cool and dry season. The output from the observed data for the minimum and maximum daily temperatures and precipitation is plotted in Figure 4. The three climate parameters showed no significant trend with time over the 30-year period in Addis Ababa, Lalibela or Dirre Sheikh Hussein (Kendall $\tau$, $p > 0.05$). The area around Addis Ababa has the lowest temperatures with occasional values falling to nighttime minima below zero. The average nighttime temperatures in Addis Ababa are 6.61 °C, with a 10-percentile value of 3.78 °C (Figure 4). Furthermore, in Addis Ababa, the 30-day periods during Bega have some 16 days when temperatures are likely to be <5 °C and a day of similarly low temperatures immediately adjacent.

The area around Debre Birhan (elevation 2840 m), about 110 km northeast of Addis Ababa, is the coldest of Ethiopian cities. It lies on the route from the capital to Lalibela, and nights with sub-zero temperatures are not uncommon; over the past decade, temperatures as low as −7.8 °C have been recorded (7 January 2017) [48]. The analysis of the observed data from the grid cell immediately to the southwest of Debre Birhan shows an average nighttime 6.22 °C and a 90-percentile of 3.48 °C across the 77 days for the period 1984–2014. Here, there are likely to be as many as 22 days in a month where temperatures are <5 °C. Such cold spells are likely to be especially troublesome for pilgrims trying to find adequate shelter at night.

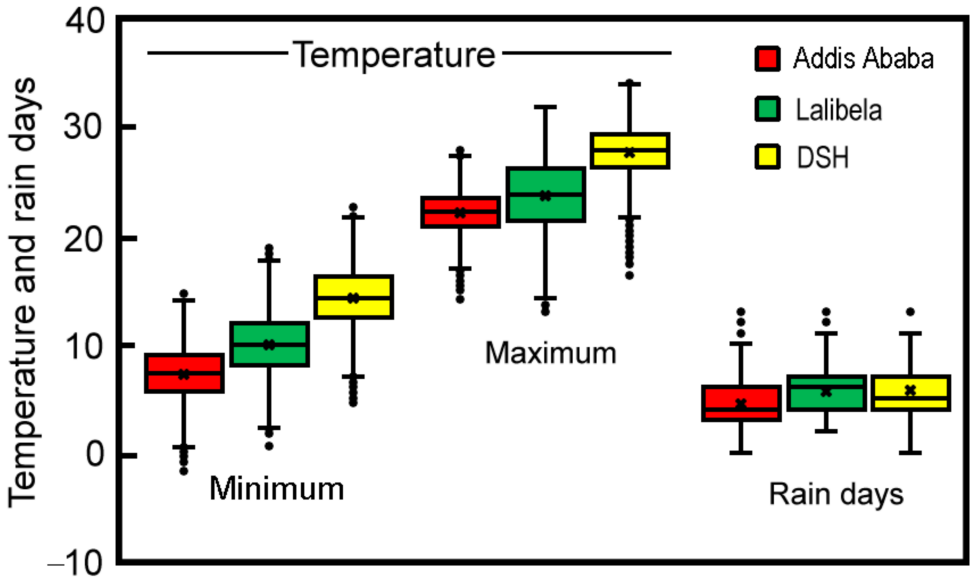


**Figure 4.** Box-and-whisker plots of the minimum daily temperatures, maximum daily temperatures and the number of rainy days (>1 mm) for the 77-day period in the Bega season for the areas around Addis Ababa, Lalibela and Dirre Sheikh Hussem, for the period 1984–2014.

Although Lalibela is not as cold, nighttime temperatures to the southeast of Lalibela are low, with an average of 7.1 °C (Figure 4). Dirre Sheikh Hussein has the highest maximum temperatures in the Bega season, with an average of 29.1 °C for the 77 days, with a 90-percentile of 31.4 °C (Figure 4)—temperatures uncomfortably hot for walking. Spells of hot weather are likely at Dirre Sheikh Hussein, where in a month, there may be 15 days with daytime temperatures > 30 °C and also a day with similarly high temperatures immediately adjacent.

The observed data also show rainfall in Addis Ababa that averages at 52.6 mm for the Bega season between 1984 and 2014. Wet weather is likely to be persistent in the area around Addis Ababa, despite Bega being the dry season. About two spells (two or more days) of days of rain in excess of 1 mm are likely in the 77-day Bega season used in our analysis. This could make the pilgrims' journeys uncomfortably wet, particularly if the rain days are consecutive. This would also be true for the mountains (Figure 3c) to the southeast, which are traversed by pilgrims making their way from Addis Ababa to Dirre Sheikh Hussein, or from Jimma to Dirre Sheikh Hussein (another very popular route). While the Bega season is generally dry, there are occasional heavy falls of rain; notable was a very wet day with 75.2 mm of rain on 11 October 2022 in Dilais, a market town in southern Ethiopia [49].

### *3.2. Future Projections*

Figure 5a shows the average minimum temperature each day for the recent past over the years 1984–2014 and for the middle of this century, 2035–2065. The minimum daily temperatures are lowest in the highland regions and higher in the southeastern areas. Minimum daily temperatures are projected to increase by the middle of the century, with the greatest increase in the northeastern region (Figure 5b,c). The highland regions of Ethiopia are projected to no longer experience average minimum temperatures of below 10 °C mid-century. This will mean that for sites such as Lalibela, cold nights will become increasingly rare during the Bega season. Even in the extreme cold years (the coldest 10% of years), average temperatures show a warming trend with minimum temperatures, even in the highlands, which are unlikely to fall below 10 °C (Supplementary Materials, Figure S2). As these are average temperatures, temperatures on individual nights may be notably lower than the average values, but this indicates that cold nights and frost events are likely to become less common in the future.

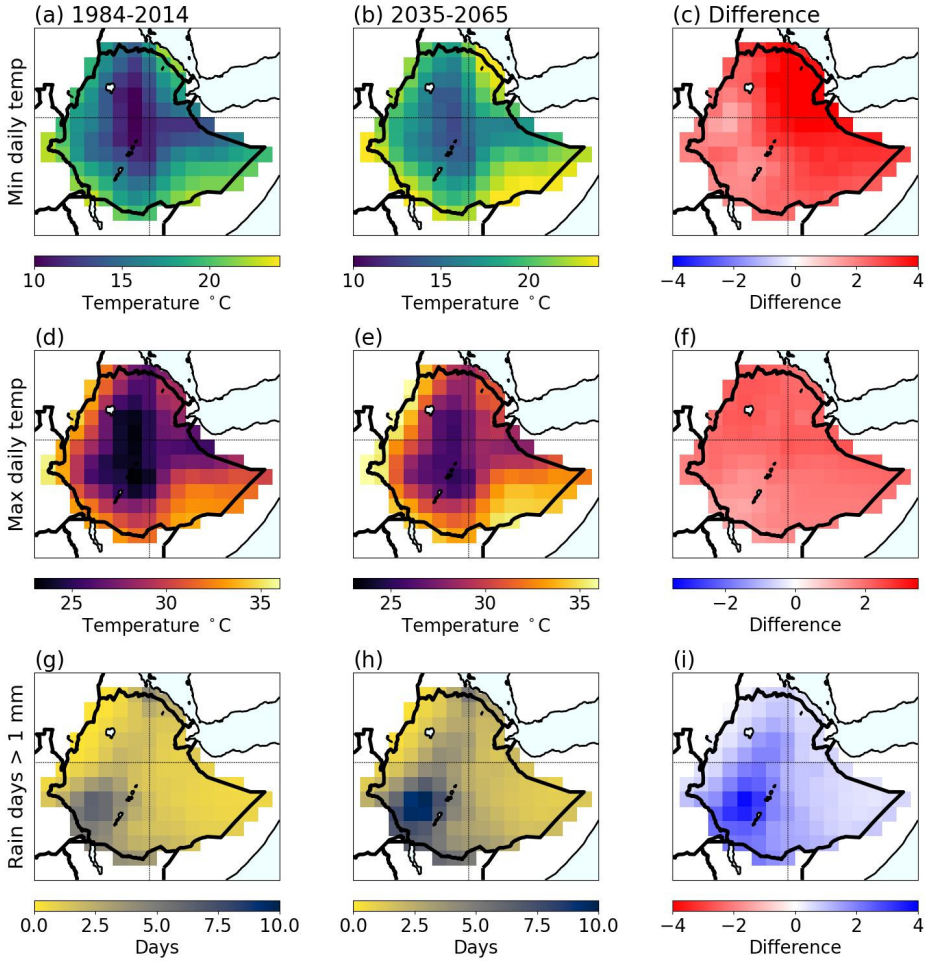


**Figure 5.** The mean modelled outputs for (**a**–**c**) minimum daily temperature (°C), (**d**–**f**) maximum daily temperature (°C) and (**g**–**i**) rain days >1 mm for (**a**,**d**,**g**) the recent past: 1984–2014, (**b**,**e**,**h**) mid-century: 2035–2065 and (**c**,**f**,**i**) the difference between the future and past scenarios. All parameters are calculated for the period 1 December to 15 February.

Figure 5d shows the average maximum daily temperature for the recent past (1984–2014), with the highest temperatures in the east and lower maximum temperatures in the Highlands. In line with the trend in minimum daily temperatures, future maximum daily temperatures are projected to increase across all of Ethiopia in the near future, 2035–2065, with an almost homogenous increase of 2 °C across the whole country (Figure 5e,f). The extremes are also projected to increase. In the recent past, extreme hot years (90th-percentile) were between 0.25 and 0.75 °C warmer than the average year. However, by mid-century, these hot years are likely to be more than 1 °C above the average year. This suggests that in the future, pilgrims are likely to experience some unpleasantly hot days when walking to sites in the eastern regions, such as on the Dirre Sheikh Hussein pilgrimage.

Figure 5g shows the average number of days with more than 1 mm of rain for the recent past over the years 1984–2014. The number of these rain days is greatest in the southwest of the country and is projected to increase by four days in the middle of the century (Figure 5h,i). There is a general increase in wet weather across the country, which could make conditions unpleasant for pilgrims, particularly if rain days were consecutive. The difference in years with an extreme number of rain days is also projected to increase mid-century, with extreme wet years in the southwest seeing more than four extra rain days per month than on average (Supplementary Materials, Figure S2).

The current rainfall in the area around Addis Ababa during the 77-day pilgrimage period is ~50 mm, with about ~7 rain days each year (~3 rain days in a month). Over the

77-day period, there are typically three spells where rainfall comes on consecutive days. In the future, the number of such rainy spells is likely to double. This will also increase in the near future in the area to the southeast of Addis Ababa. Such increases will also be felt on the route from Jimma to Dirre Sheikh Hussein, and suggest that the travellers here will have to face more persistently wet days.

## 4. Conclusions

This study was able to use climate variables to assess changing pressures on pilgrimages as intangible heritage. However, weather experienced by the pilgrims is not the average, and travel difficulties are more likely to be affected by extreme conditions or spells of consistently hot or cold weather. Thus, well-tuned parameters need to be considered when evaluating the effects on intangible heritage, which has some parallels of heritage climates developed for material heritage. General increases in temperature make the occurrence of frosts and cold weather less likely; in particular, the mountain passes will have more temperate conditions. However, the number of hot days (>30 °C) may make travel around Dirre Sheikh Hussein less pleasant for pilgrims, who will need to rest or seek shade and carry more water. The long-term management of religious tourism will need to consider the wetter climates in the southern Highlands. Also, more thought will be needed over providing shelters and accommodation at Dirre Sheikh Hussein that has to account for the higher temperatures likely to occur mid-century. Future research (i) will hopefully be able to make use of modelled outputs at higher resolution, and especially rainfall projections, to account for a varying topography and convection processes; (ii) will further assess the robustness of projections by model inter-comparison; and (iii) could consider the comfort levels experienced by pilgrims in a changing climate. As social practices are increasingly at risk in a changing environment, it is important that climate impacts on intangible heritage can be properly evaluated.

**Supplementary Materials:** The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/heritage7010004/s1, Figure S1: The mean modelled outputs for (a–c) minimum daily temperature (°C), (d–f) maximum daily temperature (°C)and (g–i) rain days >1 mm for (a,d,g) the recent past: 1984–2014, (b,e,h) mid-century: 2035–2065 and (c,f,i) the difference between the future and past scenarios. All parameters are calculated for the period 1 to 15 January. Figure S2. The extreme modelled outputs for (a–c) minimum daily temperature (°C), (d–f) maximum daily temperature (°C) and (g–i) rain days >1 mm for (a,d,g) the recent past: 1984–2014, (b,e,h) mid-century: 2035–2065 and (c,f,i) the difference between the future and past scenarios. All parameters are calculated for the period 1 December to 15 February. (a–c) uses the 10th percentile and (d–i) uses the 90th percentile.

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## References

1. Cacciotti, R.; Kaiser, A.; Sardella, A.; De Nuntiis, P.; Drdácký, M.; Hanus, C.; Bonazza, A. Climate Change-Induced Disasters and Cultural Heritage: Optimizing Management Strategies in Central Europe. *Clim. Risk Manag.* **2021**, *32*, 100301. [CrossRef]
2. Sardella, A.; Palazzi, E.; von Hardenberg, J.; Del Grande, C.; De Nuntiis, P.D.; Sabbioni, C.; Bonazza, A. Risk Mapping for the Sustainable Protection of Cultural Heritage in Extreme Changing Environments. *Atmosphere* **2020**, *11*, 700. [CrossRef]
3. Sabbioni, C.; Cassar, M.; Brimblecombe, P.; Tidblad, J.; Kozlowski, R.; Drdácký, M.; Sáiz-Jiménez, C.; Grøntoft, T.; Wainwright, I.; Ariño, X. Global Climate Change Impact on Built Heritage and Cultural Landscapes. In Proceedings of the International Conference on Heritage, Weathering and Conservation (HWC 2006), Madrid, Spain, 21–24 June 2006; pp. 395–401.

4. Brimblecombe, P. Climate Myths. In *Climate Change and Cultural Heritage*; Lefevre, R.-A., Sabbioni, C., Eds.; Edipuglia: Bari, Italy, 2010; pp. 207–209.
5. Richards, J.; Brimblecombe, P. Tuning and Effectiveness in Heritage Models. *Heritage* **2023**, *6*, 5516–5523. [CrossRef]
6. Pörtner, H.-O.; Roberts, D.C.; Adams, H.; Adelekan, I.; Adler, C.; Adrian, R.; Aldunce, P.; Ali, E.; Ara Begum, R.; BednarFriedl, B.; et al. Technical Summary. In *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*; Pörtner, H.-O., Roberts, D.C., Tignor, M., Poloczanska, E.S., Mintenbeck, K., Alegría, A., Craig, M., Langsdorf, S., Löschke, S., Möller, V., et al., Eds.; Cambridge University Press: Cambridge, UK; New York, NY, USA, 2022; pp. 37–118.
7. Simpson, N.P.; Clarke, J.; Orr, S.A.; Cundill, G.; Orlove, B.; Fatorić, S.; Sabour, S.; Khalaf, N.; Rockman, M.; Pinho, P.; et al. Decolonizing Climate Change–Heritage Research. *Nat. Clim. Chang.* **2022**, *12*, 210–213. [CrossRef]
8. Dembedza, V.P.; Chopera, P.; Mapara, J.; Macheka, L. Impact of Climate Change-Induced Natural Disasters on Intangible Cultural Heritage Related to Food: A Review. *J. Ethn. Foods* **2022**, *9*, 32. [CrossRef]
9. Higgins, N. Changing Climate; Changing Life—Climate Change and Indigenous Intangible Cultural Heritage. *Laws* **2022**, *11*, 47. [CrossRef]
10. Orr, S.A.; Richards, J.; Fatorić, S. Climate Change and Cultural Heritage: A Systematic Literature Review (2016–2020). *Hist. Environ. Policy Pract.* **2021**, *12*, 434–477. [CrossRef]
11. Adger, W.N.; Barnett, J.; Chapin, F.S.; Ellemor, H. This Must Be the Place: Underrepresentation of Identity and Meaning in Climate Change Decision-Making. *Glob. Environ. Polit.* **2011**, *11*, 1–25. [CrossRef]
12. Brimblecombe, P.; Hayashi, M. Pressures from Long Term Environmental Change at the Shrines and Temples of Nikkō. *Herit. Sci.* **2018**, *6*, 27. [CrossRef]
13. Brimblecombe, P.; Hayashi, M.; Futagami, Y. Mapping Climate Change, Natural Hazards and Tokyo's Built Heritage. *Atmosphere* **2020**, *11*, 680. [CrossRef]
14. Hall, C.M. Will Climate Change Kill Santa Claus? Climate Change and High-Latitude Christmas Place Branding. *Scand. J. Hosp. Tour.* **2014**, *14*, 23–40. [CrossRef]
15. Harrison, K. Indigenous Music Sustainability during Climate Change. *Curr. Opin. Environ. Sustain.* **2020**, *43*, 28–34. [CrossRef]
16. Tomatis, F. Analysis of Possible Repercussions of Climate Change on the Camino de Santiago Francés ("French Way") as It Passes Throught Castilla y León (Spain). *Rev. Interam. Ambiente Tur.* **2020**, *16*, 202–216. [CrossRef]
17. Yezli, S.; Khan, A.; Bouchama, A. Summer Hajj Pilgrimage in the Era of Global Warming: A Call for Vigilance and Better Understanding of the Risks. *J. Travel. Med.* **2019**, *26*, taz069. [CrossRef] [PubMed]
18. Aleeban, M.; Mackey, T.K. Global Health and Visa Policy Reform to Address Dangers of Hajj during Summer Seasons. *Front. Public Health* **2016**, *4*, 242106. [CrossRef] [PubMed]
19. Singaraj, M.A.A.; Phil, M.; Awasthi, D.K.; India, U.P.; Bhoi, T. Thermal Anomaly and Heat Index during Mecca Pilgrimage (1982–2010). *EPRA Int. J. Res. Dev.* **2018**, *3*, 1.
20. Saeed, F.; Schleussner, C.F.; Almazroui, M. From Paris to Makkah: Heat Stress Risks for Muslim Pilgrims at 1.5 °C and 2 °C. *Environ. Res. Lett.* **2021**, *16*, 024037. [CrossRef]
21. Nelson, G.C.; van der Mensbrugghe, D.; Ahammad, H.; Blanc, E.; Calvin, K.; Hasegawa, T.; Havlik, P.; Heyhoe, E.; Kyle, P.; Lotze-Campen, H.; et al. Agriculture and Climate Change in Global Scenarios: Why Don't the Models Agree. *Agric. Econ.* **2014**, *45*, 85–101. [CrossRef]
22. Scholze, M.; Knorr, W.; Arnell, N.W.; Prentice, I.C. A Climate-Change Risk Analysis for World Ecosystems. *Proc. Natl. Acad. Sci. USA* **2006**, *103*, 13116–13120. [CrossRef]
23. Rohr, J.R.; Dobson, A.P.; Johnson, P.T.J.; Kilpatrick, A.M.; Paull, S.H.; Raffel, T.R.; Ruiz-Moreno, D.; Thomas, M.B. Frontiers in Climate Change–Disease Research. *Trends Ecol. Evol.* **2011**, *26*, 270–277. [CrossRef]
24. Tola, H.G.; Brimblecombe, P. Environmental Pressures at Dirre Sheikh Hussein Sanctuary. *Heritage* **2022**, *5*, 2661–2672. [CrossRef]
25. UNESCO Inscription UNESCO. Dirre Sheik Hussein Religious, Cultural and Historical Site. Available online: https://whc.unesco.org/en/tentativelists/5649 (accessed on 3 November 2023).
26. Braukamper, U. Historicizing Sacrificial and Initiatory Systems in Ethiopia Initiating Change in Highland Ethiopia: Causes and Consequences of Cultural Transformation. By Dena Freeman. *J. Afr. Hist.* **2004**, *45*, 173–174. [CrossRef]
27. Semu, K.T. Dynamics of the Cult of Sheik Hussein of Bale, Ethiopia: Its Course and Curse of the Extremists, a Historical Perspective. *Ethiop. J. Soc. Sci. Humanit.* **2016**, *12*, 63–101.
28. Semu, K.T. The Culture of Accommodating Diversity Embedded in the Sufi Saint Cult of Bale, Ethiopia: A Historical Overview. *J. Equity Sci. Sustain. Dev.* **2022**, *5*, 29–45.
29. Ta'a, T. Religious Beliefs among the Oromo: Waaqeffannaa, Christianity and Islam in the Context of Ethnic Identity, Citizenship and Integration. *Ethiop. J. Soc. Sci. Humanit.* **2012**, *8*, 87–111.
30. Tesfaye, K.; Assefa, M. Climate Change, Climate Variability and Adaptation in Ethiopia. Available online: http://repository.smuc.edu.et/handle/123456789/2834 (accessed on 16 November 2023).
31. Downie, D. *Paris to the Pyrenees: A Skeptic Pilgrim Walks the Way of Saint James*; Simon & Schuster: New York, NY, USA, 2013.
32. Aman, A.; Mama, K. Potentials and Pitfalls of Dirre Sheik Hussein Religious and Cultural Site in Tourism Development, Ethiopia. *J. Tour. Hosp.* **2019**, *8*, 2167. [CrossRef]

33. Jarzombek, M. Lalibela and Libanos, the King and the Hydro-Engineer of 13th-Century Ethiopia. *Thresholds* **2007**, *34*, 78–81. [CrossRef]
34. Bayih, B.E. Potentials and Challenges of Religious Tourism Development in Lalibela, Ethiopia. *Afr. J. Hosp. Tour. Leis.* **2018**, *7*, 1–17.
35. BBC. Ethiopia's Lalibela Struggles as War and COVID-19 Keep Tourists Away. Available online: https://www.bbc.com/news/av/world-africa-61196572 (accessed on 20 November 2023).
36. Fazzini, M.; Bisci, C.; Billi, P. The Climate of Ethiopia. In *Landscapes and Landforms of Ethiopia*; World Geomorphological Landscapes; Springer: Dordrecht, The Netherlands, 2015; pp. 65–87. [CrossRef]
37. Takele, R. *Frost Hazard Map of Ethiopia*; Ultimate Solutions Consultancy PLC: Addis Ababa, Ethiopia, 2019.
38. Newby, W.; Amrouni, K. Morphometric Analysis of Ethiopia Water Drainage Basins. Available online: http://gisedu.colostate.edu/webcontent/nr505/ethiopia2009/nr505_fall09_team13_Amrouni_Newby/index.html (accessed on 16 November 2023).
39. Aseres, S.A. Key Stakeholders Roles and Tourism Development in Bale Zone. *Int. J. Bus. Manag. Adm.* **2016**, *1*, 2–4.
40. Taye, B.; Viles, H.; Orr, S.A. Seasonality in Moisture Dynamics in the Walls of the Rock-Cut Churches in Lalibela, Ethiopia: Implications for Weathering. *Int. J. Archit. Herit.* **2022**. [CrossRef]
41. Funk, C.; Peterson, P.; Landsfeld, M.; Pedreros, D.; Verdin, J.; Shukla, S.; Husak, G.; Rowland, J.; Harrison, L.; Hoell, A.; et al. The Climate Hazards Infrared Precipitation with Stations—A New Environmental Record for Monitoring Extremes. *Sci. Data* **2015**, *2*, 150066. [CrossRef] [PubMed]
42. Brimblecombe, P.; Richards, J. Moisture as a Driver of Long-Term Threats to Timber Heritage—Part II: Risks Imposed on Structures at Local Sites. *Heritage* **2022**, *5*, 2966–2986. [CrossRef]
43. Dosio, A.; Jones, R.G.; Jack, C.; Lennard, C.; Nikulin, G.; Hewitson, B. What Can We Know about Future Precipitation in Africa? Robustness, Significance and Added Value of Projections from a Large Ensemble of Regional Climate Models. *Clim. Dyn.* **2019**, *53*, 5833–5858. [CrossRef]
44. Richards, J.; Brimblecombe, P.; Engelstaedter, S. Modelling Temperature-Precipitation Pressures on African Timber Heritage. *Int. J. Climatol.* **2023**, *43*, 7447–7462. [CrossRef]
45. Richards, J.; Brimblecombe, P. Ability of GCMs to Represent Climate during Pilgrimages in Ethiopia. *Res. Sq.* **2023**. [CrossRef]
46. Choi, Y.W.; Campbell, D.J.; Eltahir, E.A.B. Near-Term Regional Climate Change in East Africa. *Clim. Dyn.* **2022**, *61*, 961–978. [CrossRef]
47. Eyring, V.; Bony, S.; Meehl, G.A.; Senior, C.A.; Stevens, B.; Stouffer, R.J.; Taylor, K.E. Overview of the Coupled Model Intercomparison Project Phase 6 (CMIP6) Experimental Design and Organization. *Geosci. Model. Dev.* **2016**, *9*, 1937–1958. [CrossRef]
48. Addis Ababa National Meteorological Agency. NMS Annual Climate Bulletin for the Year 2017. Available online: http://213.55.84.78/bulletins/seasonal_climatic_bulletins (accessed on 16 November 2023).
49. Ministry of Water and Energy. Addis Ababa MWE Annual Climate Bulletin for the Year 2022. Available online: http://213.55.84.78/daily_weather (accessed on 16 November 2023).

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*Review*

# A Historical Landscape under Threat: Contestation and Preservation of Malta's Pastoral Droveways

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**Abstract:** Landscapes have been shaped and reshaped by humans to meet the changing needs of shifting subsistence strategies and demographic patterns. In the Mediterranean region, a widespread subsistence strategy that has left a major imprint is pastoralism, often tied with transhumance. Pastoralism and the associated tensions between pastoralists and settled agriculturalists have political and legal dimensions which are sometimes overlooked in mainstream accounts of national "patrimony". The rapid transformations of subsistence strategies witnessed in the twentieth century have changed pastoral landscapes in diverse ways. This paper focusses on the central Mediterranean archipelago of Malta to explore how the values and management of such landscapes require holistic assessment, taking into account the intangible practices and embedded legal rights and obligations that maintained these systems. While in Malta pastoralism has practically disappeared, its physical imprint persists in the form of a network of droveways, which was once a carefully regulated form of commons. Burgeoning demographic growth is erasing large tracts of the historic environment. Against this backdrop of contestation, this paper draws on interdisciplinary approaches to interrogate the shifting legal and historical narratives through which pastoral landscapes have been managed, in the process revealing how dominant epistemological and legal frameworks are also implicated in the erasure of these landscapes.

**Keywords:** landscape; pastoralism; commons; droveways; rights of way



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## 1. Introduction

The recognition of the importance of landscapes for our wellbeing has grown hand in hand with the unprecedented pressures and threats that they face today. Since the 1990s, the literature on the sustainable stewardship of landscapes has grown exponentially. A key theme underpinning this literature is the shift from a focus on sites and monuments, to a recognition of the need to safeguard their context in the wider landscape. A second paradigm shift has been the recognition of the inseparability of tangible and intangible aspects of cultural heritage resources [1]. A third paradigm shift has been the widespread recognition that landscapes are not simply the environments that we inhabit, but are embedded in human experience. The most influential articulation of this paradigm shift is the European Landscape Convention [2], which places human experience and quality of life at the heart of the rationale and purpose of landscape stewardship [3]. This succinct articulation of principle is in turn informed by a long tradition of cross-disciplinary research that has increasingly paid attention to the intricate social construction of space, place, and scale [4]. This rapid widening of the scope and range of approaches to the study of heritage and of landscapes has also highlighted the need for increasingly interdisciplinary approaches to cover the blind spots of different disciplines. All these considerations have informed the approach taken here.

This paper focuses on a threatened element of the cultural landscape of Malta (Figure 1). This consists of a network of droveways developed across the island to permit movement of flocks of goats and sheep for grazing (Figure 2). Pastoralism was an important pillar of the island's economy well into the twentieth century. With the decline of pastoralism, many of these pastoral foraging routes have fallen into disuse. A significant proportion has been obliterated by modern buildings. Others are simply being erased as the land they occupy is taken up for other uses.


**Figure 1.** Location of the Maltese archipelago in the central Mediterranean.

**Figure 2.** Sheep being led down a steep droveway along the Bajda Ridge in northern Malta, 2005 (photograph N.C.V.).

The reasons for choosing to focus on these droveways are fourfold. First, they are a good example of a feature that does not fit the traditional definition of a monument or site. They are unassuming in appearance but represent a sustained and massive investment of effort and organization in their creation.

Second, the droveways are also a good example of a material record of the efforts of many generations of largely anonymous and marginalized members of society, who have for the most part been forgotten in historical narratives. The study of the droveways allows us some glimpse of these "people without history" [5].

Third, they are a good example of how systems of intangible rights and duties may be embedded in material remains. The droveways were carefully created to permit rights of way and use for grazing across the landscape, in symbiosis with crop cultivation. In spite of the disappearance of pastoralism, the access rights (and potential property rights) vested in these pastoral routes are still extremely relevant today. Malta has one of the highest population densities in the world, and the highest building density in Europe [6]. Space is extremely contested. The existence of a historic system of public rights of way, possibly associated with a forgotten form of "the commons", is therefore a significant legacy with important implications for the enjoyment of public space today, which in turn has important consequences for wellbeing.

Fourth, the case of the droveways is an excellent example of the necessity of interdisciplinary approaches. Without a sound understanding of their historic evolution and of the legal rights that may be embedded within them, it is impossible to safeguard these rights, or even to comprehend the value and importance of preserving the droveways that embody them. In this respect, the droveways are therefore a sobering example of how inadequate knowledge may constitute a serious threat to cultural heritage.

## 2. Pastoral Routes in Mediterranean Landscapes

Archaeologists have long sought to study the impact that the development of animal husbandry has had on the landscape. For the Mediterranean region, interest has shifted from a Braudelian view that seeks continuities in the use of space over many generations of rural life, to traditions of landscape study that puts humans before physical geography, considering people's perceptions of the constraints and opportunities offered by different ecological niches [7]. Pastoralism is seen as a complex form of economy, a practice that often requires dovetailing with a broader schedule of subsistence activities. The quantity of archaeological and documentary information that can be rallied towards an understanding of landscape history sets the Mediterranean apart from other regions of the world. Over the last fifty years, archaeologists have used multidisciplinary regional studies to investigate how the roles of people, climate, and topography have changed Mediterranean landscapes over time [8,9]. Ethnographic data have also provided useful insights into the apparently irrational ways in which decisions are sometimes made by the herder or the farmer, highlighting the different forms of environmental exploitation of ecologies that can offer comparably long spectra of productive choice. The kinds of conflicts that arise between transhumant herders and settled farmers, and the consequent need of the former to establish durable ties with powerful patrons who can mediate their interactions with the latter, is the central theme of John Campbell's anthropological monograph on institutions and moral values in a Greek mountain community [10]. His study, which was based upon long-term ethnographic research among the Sarakatsani shepherds of continental Greece, is still regarded as a classic founding text of the anthropology of the Mediterranean.

Although it may be argued that pastoral activities entail few tools in comparison with agricultural ones, their material traces in the landscape can be abundant. In the history of some of the large European agro-pastoral societies, where groups of specialized herdsmen emerged, the migration of huge flocks over long distances left its marks on the land. Transhumance routes have been identified in various regions of Italy—Sardinian *utturi* [11] (p. 200), Sicilian *trazzere* [12], and Apulian *tratturi* [13]—but also in Spain (*cañadas*) [14], where droveways were often laid out according to clear legal provisions

and edicts regulating the rights of access to common grazing grounds [15]. This tradition of seasonal droving of animals was recognized by UNESCO in 2023 and proclaimed as Intangible Cultural Heritage of Humanity for several European countries, including Albania, Andorra, Croatia, France, Italy, Luxembourg, Romania, and Spain [16].

Movement of livestock has also been a common practice at local scales, not least on the smaller Mediterranean islands, where transhumance of small herds allowed people to move herbivores away from the cultivated fields and to exploit marginal areas for grazing (e.g., Antikythera) [17]. In such cases—and Malta would certainly not be an exception [18,19]—pastoralism and agriculture functioned in symbiosis rather than isolation. The ecological niche exploited for rough grazing often fell under the definition of what nineteenth-century British cartographers referred to as "waste" (or "wasteland"). This is a "weasel word", as it has been called by Tarlow,

> for the land in question was not unused as the word suggests; what the eighteenth and nineteenth-century reformers [in Britian] called "waste" was often productive, although non-agricultural, land [20] (pp. 45–46).

## 3. Pastoral Foraging Routes in Malta: The Ethnographic and Material Record

A ubiquitous feature of the Maltese landscape is the maze of dry-stone walled tracks and minor roads that can be found throughout the two main islands. The nature of the network has long been thought to be conditioned by geomorphology and the interplay of human settlement and agriculture over time [21] (p. 185). Such minor roads and connecting tracks are the human imprint on the land's surface of a communication strategy intended for the passage of human and animal traffic before the advent of motor-driven transport.

Photographs from last century reveal that such pathways also acted as droveways (Figure 3), allowing herders to move flocks of goats from pens to rough grazing or to bring them into the capital city and adjacent towns when it was still possible to sell milk doing the rounds of houses before the advent of pasteurization in 1938 [22] (Figure 4). This practice has been confirmed through interviews with a number of farmers who recalled specific strategies from the 1950s, by which herds of goats (and some sheep) were taken out to graze and to exercise in areas identified as wasteland—Maltese: *xagħra* and *moxa*—in the cartographic record amounting to just under 5000 acres or 6.3% of Malta's total surface area at the time [19,23,24]. A sample survey of the feeding of goats and sheep conducted in 1956 showed that 80 per cent of herders relied on wasteland grazing to supply forage [24].

**Figure 3.** Roadside grazing by a herd of goats below Malta's old capital, Mdina, 1901 (reproduced by courtesy of Royal Collection Trust/© His Majesty King Charles III, 2024).

**Figure 4.** Goats in a street in Malta's capital city Valletta, photographed by Geo Fűrst in the early 1930s (reproduced by courtesy of Giovanni Bonello).

These droveways appear to have evolved more or less informally over the centuries in tandem with field systems. The earliest type of cartographic record that reveals fields enclosed with walls goes back to post-Medieval times, in the first quarter of the seventeenth century. It concerns access to contested lands in northern Malta consisting of arable fields spread across a valley basin at Miżieb ir-Riħ, bordered by rising ground used mainly for rough grazing (Figure 5).


**Figure 5.** (**A**) Modern orthophoto of northern Malta (2012, Planning Authority), compared to (**B**) plan of large field enclosures at Miżieb ir-Riħ in northern Malta, c. 1620s (reproduced by courtesy of Cathedral Archives, Mdina, Malta). Area of Plan B corresponds to white frame in A.

The lands effectively crossed the entire breadth of the island at this point. A reconstruction of the entire territory using cadastral maps of land belonging to the Church and to the Knights of the Order of St John that ruled Malta at the time, reveals that such tracts of enclosed land were often bordered by a "public road" (*strada pubblica*), which allowed

human and animal traffic to move north and south. Some of these roads were wide enough to allow the actual pathway to be flanked by verges of common land, denoted by the cartographers as a "public space" (*spazio pubblico*).

The funnel-shaped entrances that characterize many of these walled tracks facilitated the droving of livestock (Figure 6), as has been argued for similar set-ups elsewhere [25] (p. 21). Their design stands in sharp contrast to a post-1850 field pattern of rectilinear fields, roads, and service tracks, which developed on non-Church land in the same area. This relates to a systematic attempt by the British colonial government to bring under cultivation marginal and poor terrain, inherited from the Knights of the Order of St John, by granting rectangular parcels of land demarcated by dry-stone rubble walls in emphyteusis to farmers [26].

**Figure 6.** Droveway with funnel-shaped entrance along the Bajda Ridge in northern Malta (photograph N.C.V.).

## 4. Towards a Social History of Maltese Pastoralism

The interdisciplinary approach adopted here, starting from the ethnographic and material record, builds on the extensive work already carried out by historians on archival sources. A range of documentary sources may be drawn upon in the study of the Maltese landscape [27].

As noted by historian Charles Dalli [28] (p. 80), one of the earliest written references to grazing on Malta was recorded by the twelfth-century geographer al-Idrisi, who observed that the island had an abundance of grazing land. Dalli suggests this may indicate that land that had been enclosed for crop cultivation by the later Middle Ages was still unenclosed grazing land in the twelfth century.

From the mid-seventeenth century, an increase may be noted in the efforts to document land ownership through detailed land surveys in terriers or cabrei [2] (pp. 21–23).

Historical guide-books and descriptions of Malta allow us some further glimpses into the management and enclosure of grazing land. A mid-seventeenth-century account astutely notes how the different characteristics of different areas of Malta were suited to different productive activities, loosely translated here:

> Animals pasture on the rocky ground, which produces grasses that are suitable to feed and fatten them. From the same place, thorns are gathered for burning in ovens when wood is lacking. . . on the plains, wheat, barley and other fodder is sown, while in the valleys there are gardens and orchards watered by copious springs [29] (p. 131).

A late eighteenth-century revised edition of the same work provides further insight into how grazing lands were being enclosed to help feed the growing population:

> The fertility of this island has presently been increased because many public spaces (*spazj pubblici*) and lands that in the past had not been cultivated, have now been brought under cultivation. Food has become somewhat more expensive, because the population has increased a lot [30] (translated from p. 406).

The pioneering work of the medieval historian Godfrey Wettinger has documented the widespread designation of tracts of land as common land for grazing across late medieval and early modern Malta, such as the "*spacium puplicum*" recorded near the medieval hamlet of Ħal Millieri [31] (p. 51). Wettinger has also brought to light a number of specific references to contestations over grazing and access rights, stretching at least as far back as the Late Middle Ages. From the early fifteenth century onwards, when surviving written records become more abundant, numerous instances are recorded of popular protests against the enclosure of land that had previously been available for pasture, which in some cases secured the revocation of such grants of public land [32] (p. 269); [33] (pp. 31–32).

Miżieb ir-Riħ features amongst cases concerning such grievances. In 1458, complaints were made against a powerful landlord, Antoniu Desguanes, from the capital, Mdina, who was accused of capturing extensive portions of common land at Miżieb ir-Riħ by appropriation and enclosure to the detriment of the community, with the King's permission [33] (p. 33); [34] (pp. 42–43). Herders complained that these lands ran across the route to barren lands that had been the property of all the people of Malta for as far back as anyone could remember, and that these lands extending towards the district of Mellieħa provided rough grazing for animals and were a useful source of brushwood for fuel. People were afraid that if animals strayed into the fields owned by Desguanes they would be held liable for damages by the *baiulo*—the official responsible for imposing fines commensurate with the damage inflicted on crops. It was agreed by the Council of Mdina and the jurats that Desguanes would be able to keep a part of the land, but that he would need to enclose the area with a wall to stop animals from straying there. He was also required to not block public passageways and to not restrict access to the springs in the area. Although pictorial representations of this area do not exist from this period, it is probable that one of the roads shown on the early-seventeenth-century cadastral map referred to earlier (Figure 5) is one of the droveways that allowed passage through the valley basin, towards a spring (*fontana*) and the commons beyond.

Wettinger has noted several other instances, throughout the fifteenth century and across Malta and Gozo, of individuals obtaining grants of common "waste" land, which until then had been available for pasture, in order to turn it into arable fields. The cultivation of cotton, traditionally the principal cash crop of the Maltese islands, often motivated such grants [33] (pp. 10–11).

The herders' objections that the King was permitting the expropriation of common lands acquire deeper significance when considered in the light of the medieval legal hybridity which characterized Maltese law in this period [35,36]. At the time, local customary law was considered to be an important source of law throughout Europe [36] (p. 377), alongside the *Ius Comune* (incorporating the Roman Law together with Canon law and doctrinal commentary) and feudal laws [37] (pp. 32–33, 37); [35] (pp. 178–180). In the herders' complaints, communally owned property is presented as based upon ancient Maltese customs, which provide a normative buffer against land appropriation through feudal hierarchies legitimized by Sicilian feudal law. A retrospective reading that assumes the existence of a unitary legal logic governing this conflict misses the point that this is not only about a power struggle between herders and powerful barons. This is also a clash between distinct and incommensurable normative systems, corresponding to two different modes of production and the associated social structures; and this at a time when plural and incompatible normative systems were more the rule than the exception. As Brian Tamanaha observes:

> The mid-to-late medieval period was characterised by a remarkable jumble of different sorts of law and institutions, occupying the same space, sometimes conflicting, sometimes complementary, and typically lacking any overarching hierarchy or organisation [38] (p. 377).

During the late medieval period, the principal representative and administrative body on the island of Malta was the Council or *Università*, based in Mdina [39]. The *Università* of Mdina played a critical mediating role, functioning as a node of articulation between diverging normative systems. In a scholarly study of this Council as an example of a medieval communal organization, Dalli notes that while on the one hand this Council "channeled and regulated political relationships in the public sphere and derived its legitimacy as the representative and executive body from its official recognition by the Crown" [40] (p. 1), on the other hand, in 1410 the Council was still invoking "certain ancient unwritten customs and conventions", quoted by Dalli [40] (p. 8). Its intervention in the 1458 Miżieb ir-Riħ case shows how this institution was considered to possess the authority to regulate how Baron Desguanes could exercise the powers of land appropriation that he had been granted by royal permission. Dalli observes how, nearly a decade earlier, the Council had already intervened in an attempt to prevent Baron Desguanes from committing very similar encroachments:

> In 1449, following serious accusations from the town council that Desguanes, as mayor, was encroaching on public lands administered by it, like Mizieb ir-Rih, it was demanded that a Sicilian, with no Maltese connections, be appointed captain. The Crown agreed on condition that the town-council redeemed that office [40] (p. 9).

Its regulatory function was thus part and parcel of the role this Council played in administering what the herders had described as "common lands which had belonged to all the people from time immemorial". This expression is echoed in the claims made by the Council itself in the later Middle Ages that "it had enjoyed rights over common lands for the past three centuries" [28] (p. 124). In letters sent to the Crown in 1466, this Council described itself as "a mother who must procure a peaceful life for her people and children" [40] (p. 9). Even the fact that this Council was known as "the *Università*" reflects its role as administrator of commonly owned land, whether this was understood as a reference to the "totality of the people" (a *universitas personarum* in Roman law [41], or to "a totality of objects treated in one or more respects as a whole in law" (a *universitas rerum* in Roman law) [42]. To say that land belonged to the *Università* may simply have been another way of saying that the land was owned in common by the people of Malta and administered by the Mdina Council. This did not necessarily imply that such land was owned by the Mdina Council.

Bartolomeo dal Pozzo, a seventeenth-century chronicler, records similar contestations during the early years of the rule of the Knights of the Order of Saint John in Malta (1530–1798). The Knights and their Grand Master were accused of infringing the rights of the Maltese population. Dal Pozzo records how, following the death of Grand Master Verdala (1582–1595), a Chapter General of the Council of the Order was convened, which ordered, among other things, that

> . . . all the public spaces, or lands, belonging to the commons of the Island of Malta, which past Grand Masters, and particularly by Cardinal Verdala had granted to private individuals; upon which public protests had been made; must be returned once again to the commons [43] (translated from p. 366), [32] (p. 269).

Similar tensions are again recorded in the early seventeenth century, in an anonymous account preserved in two manuscript copies in different archives in Malta, and which Wettinger [32] (p. 257) has dated to between 1633 and 1636 and attributed to Don Filippo Borgia, rector of the parish of the village of Birkirkara and champion of the local population against abuses of their traditional rights. According to the author of this account, Grand

Master de Paule (1623–1636) again made encroachments on public spaces, notwithstanding the resolutions that had been made following Verdala's death [32] (pp. 269, 277–278).

The terminology used to describe the land being contested, and how the contestation changes over time, deserves particular attention. As astutely observed by Wettinger, in the fifteenth century it was not only the wealthy and powerful that received grants to enclose land, but also individuals from across all classes of society [33] (p. 10). In the seventeenth-century account attributed to Don Filippo Borgia, the enclosure of grazing land is presented as a struggle between the poor and the powerful. Enclosed lands are described as "*spatii publici levati al povero*" (public spaces taken from the poor) [32] (p. 277). The chronicler Dal Pozzo, as noted above, is even more explicit, referring to "*spatii publici o sia terreni del commune dell'Isola di Malta. . . di nuovo ritornar dovessero in commune*" (public spaces, that is lands belonging to the commons of the Island of Malta. . . must be returned to the commons) [43] (p. 366).

Wettinger observes, in a paragraph that deserves to be quoted in full:

> One sore point was the common land frequently allotted in severalty to individuals: such grants removed the land from the use of the poor who depended more than anyone else on their grazing rights and the right to gather fire-wood or thistles from such places. After Verdala's death these lands were returned to public ownership not only by the will of the Council of the Order but also by decree of Pope Clement. Don Filippo claimed that he had persuaded the Grand Master not to make similar grants without the consent of the Pope, but had to overcome the influence of 'the good ministers who stood around him and who are more often the cause that Princes do not do what they should', so that at his next meeting the Grand Master told him: You have informed me that I cannot do it without the consent of the Pope; and I tell you that my counsellors say that the Pope does not come into the matter. I want to do it because I am master [32] (p. 269).

This seventeenth-century clash between Don Filippo Borgia and Grand Master de Paule echoes the fifteenth-century conflicts between herders and barons. Significant discontinuities with these earlier conflicts can also be observed, signaling a movement towards an early modern legality. The Grand Master's words reveal an aspiration towards complete sovereign control of all the public lands in Malta. The *Università* (*qua* Mdina Council) is no longer mentioned as having *any* administrative role in regard to such lands, and the customary rights of common land ownership of the people of Malta are not permitted to restrain the exercise by the Grand Masters of their power to appropriate and dispose of these lands.

In his attempt to erase Maltese customary rights and to side-line both the Pope and the *Università*, Grand Master de Paule's actions conform to those of other early modern princes. As Tamanaha [38] observes, such princes sought to eliminate medieval legal hybridity in their quest for exclusive sovereign control over "their" increasingly centralized legal systems. In this process of constructing a unitary legality, customary law was "taken over by legal professionals" and "lost its primary ties with its social base" [38] (p. 380). Moreover: "It was also essential for sovereigns to establish their autonomy from the Church" [38] (p. 379).

The success of this strategy is revealed also by the absence of any reference to the *Università* in Don Filippo's reported defense of these lands. He prefers instead to invoke the patronage of the hierarchically organized Catholic Church, represented by the Papacy, as the protector of the rights of the poor to access and utilize public lands. By the seventeenth century, Maltese pastoralists found that they could no longer rely upon the *Università* to mediate and resist the state appropriation of public lands. Indeed, since 1530 the *Università* had been progressively emasculated as a result of the Order's constant policy to "ensure that the effective Government of Malta should be located in Valletta and that Imdina should host a local Government deprived of all powers that were not absolutely residual" [44] (p. 143); see also [45].

Since the Grand Masters themselves headed a Catholic Religious Order, the universal Catholic Church could not be marginalized as easily as the Maltese *Università* had been. This explains why the Catholic Church was to replace the *Università* as a source of political patronage to Maltese herders and villagers. Wettinger notes that Dun Filippo Borgia's account reflects this political transition, which would lead the Church to become the chief mediator between the rural Maltese and the governors of Malta until the end of the period of the Knights' rule and throughout that of British rule:

> It marks the complete eclipse, much to the satisfaction of Don Filippo and, no doubt, of Don Francesco, another lawyer priest, of the medieval political set-up, with the fading away of the local 'nobility' and the rise of the clergy to a status of influence. . . In the past, clergymen had been for hundreds of years all-powerful as churchmen. From now onwards for three centuries they would be extremely influential as politicians [32] (p. 270).

In the latter half of the eighteenth century, this alliance between the rural Maltese and the Church came increasingly to the fore. As the Order's prestige and relevance began to decline, the rural Maltese, often led by priests, started to protest and agitate for their rights. Chief among these was their right to access and use their common lands and droveways, which were being enclosed and appropriated by the Order. Thus, the imposition of new restrictions on rabbit hunting on his estates and the consequent eviction of herders from grazing land by Grand Master Ximenes seems to have sparked the so-called "Priests' Revolt" of 1775 [46], and the resentment by the rural Maltese at the loss of their communal rights seems also to explain their reluctance to fight for the Order against the French invasion of Malta in 1798 [47] (p. 26). Finally, the defense of their communally owned property not only explains *why* the rural Maltese were so ready to rebel against the French Republican army, but it also explains *how* they managed to fight them so successfully. Stephen Spiteri observes:

> The (Maltese) inhabitants knew that they had neither the men nor the resources to lay siege to the formidable and well-armed harbour fortifications and so all their efforts were aimed at making a French excursion out of the harbour enclave as difficult as possible. Here, they ingeniously exploited the nature of the rural landscape surrounding the fortifications which, divided into innumerable stone-walled fields, provided a readymade system of entrenchments. All that the inhabitants had to do was to link the field walls together, plugging in country lanes, roads, and valleys, and in so doing create an extensive and continuous form of circumvallation. They then stiffened this with a number of camps, batteries, and sentry-posts placed at strategic intervals [48] (p. 13).

During the following century and a half of British colonial rule (1814–1964), further encroachment and enclosure took place on land that had formerly been available for grazing. Substantial tracts of the shoreline, as well as inland areas, were taken over for military purposes as the island was turned into Britain's kingpin in the defense of the "Mediterranean Corridor" to India, particularly after the opening of the Suez Canal in 1869. Meanwhile the growing population also led to mounting pressure to increase agricultural productivity. The looming threat of starvation during the Napoleonic wars left a deep impression on the island's administration. The paradigm of agricultural improvement, widely embraced in Britain [20], was also brought to bear in its colonial possessions, and Malta was no exception. A statement of income of the government of Malta for the fiscal year 1835–1836 refers to the "sale of waste ground" for 24 pounds sterling [49], suggesting that grazing land was being sold to private individuals.

During the period of British colonial administration, the concept of a native commons, as opposed to property of the Crown, appears to have been obfuscated and forgotten. The designation of pasture as "wasteland" not only underplayed the important economic role played by this land, but also helped obliterate the history of public rights that had been so carefully defended in the preceding centuries. The assumption that grazing grounds were

government property, and in the gift of the colonial government to lease or sell, does not appear to have been questioned.

This shift in the way common grazing land was perceived may be better understood in the context of the wider paradigms that informed and justified British colonial projects and worldviews during the nineteenth century. In his perceptive historical anthropology of colonialism in the area of South Africa occupied by the pastoralist Tswana people, John Comaroff [50] explored the strategies utilized by colonial administrators to facilitate and legitimize their appropriation of Tswana lands. He observes that these strategies involved the strategic deployment and management of the opposition between Western notions of exclusive individual ownership rights—which aligned with settled farming practices—and traditional Tswana communal land management practices—which reflected their pastoralist economy. With specific reference to the Bechuanaland Land Commission, Comaroff argues that this Commission "negated the collective capacity of a community and its leaders to remake their own world by due process" [50] (p. 230).

Although the context of British Malta was very different, certain patterns and consequences stemming from similar colonial tactics may nevertheless be recognized. Maltese grazing land was subjected to a direct frontal assault early on in the period of British rule, when the first British Governor of Malta, Sir Thomas Maitland, abolished the *Università* in 1818 [51]. As noted above, the loss of the institution that traditionally safeguarded common rights to grazing land through communal governance was followed by the implementation of government policies that set out to enclose grazing land, convert it into agricultural land, and alienate it. A critical role in this process of privatization was played by cadastral surveys, through which the colonial government formalized its hold on such land by mapping it and redefining it as government-owned wasteland (Figure 7). As the colonial government developed ever more sophisticated tools for legally categorizing and appropriating these grazing lands and pathways, the devolution of these lands to the colonial government was to be almost unchallenged.


**Figure 7.** (**A**): Early twentieth-century survey sheet showing location of a section of pastoral route network between villages of Mosta and Naxxar. Area framed in red corresponds to insets (B) and (C). (**B**): Annotated survey sheet showing the same network, highlighted in yellow and labelled as "Waste Land". Mid-twentieth century (NAM PWD—Project House, Government Property Survey Sheets, No. 50). (**C**): The same area in 2018, drastically altered by quarrying and building activity (SintegraM orthophotos (2018), Developing Spatial Integration for the Maltese Islands, Planning Authority).

A late nineteenth-century court case can provide us with a glimpse into the legal reasoning through which the appropriation of Malta communal lands was made possible under British rule. The case of Emmanuele Luigi Galizia v. Emmanuele Scicluna made possible the privatization of part of the Maltese coastline in the area now known as the Dragonara Casino zone in Saint Julian's [52]. This case arose out of the aspirations of Emmanuele Scicluna, a leading Maltese banker, who had acquired the landholdings of the Spinola Foundation, to create a feudal domain of his own. He therefore built a palace on this land and sought to enclose the coastal promontory on which this palace is located—including substantial tracts of grazing land—with a wall on the landward side. This wall effectively prevented the government and the public from accessing either this promontory or the coastline surrounding it. The Superintendent of Public Works, Emmanuele Luigi Galizia, filed a possessory action to prevent the building of the wall and to allow unimpeded access by the government to the military fortifications on this land and by the public to the coast. On 30 April 1886, the Court of Appeal delivered its judgment. In this case the court held that government's property rights only extended to the footprint of the land upon which its military fortifications had been constructed. The court concluded that, notwithstanding that the remainder of the land belonged to Scicluna and he had therefore the right to enclose it with a wall, he still had no right to prevent access by the public to the coast or by the government to the entrenchment. Consequently, the court held that Scicluna had to leave the arched gateway he had constructed in the wall of his estate permanently open, allowing the government to have continual access to its military property and allowing the fishermen and "salt-gatherers" continual access to the sea and the saltpans.

What is striking about this judgment is the complete absence of any reference to the grazing land contained within Scicluna's enclosed promontory (Figure 8). This in turn facilitates a judicial overlooking of the possibility that the government's claim to possess public land within this enclosure could have a different basis than its ownership of the military entrenchment within it and its role as guardian of the Maltese public's rights to access the coast. In the process—and even though it would have been in its interest to do so—the colonial government had completely abandoned any claim to possess the grazing lands used by the Maltese herders and to administer them in their name. It is only the coastal land, and not the grazing land, which, as a *res extra commercium*, the government continues to administer in the interests of the public, and the only right granted to the members of the public over the grazing land is to access the coast by traversing it. This case clearly shows how, by the end of the nineteenth century, Maltese pastoralists' communal property rights had dwindled into mere rights of access.

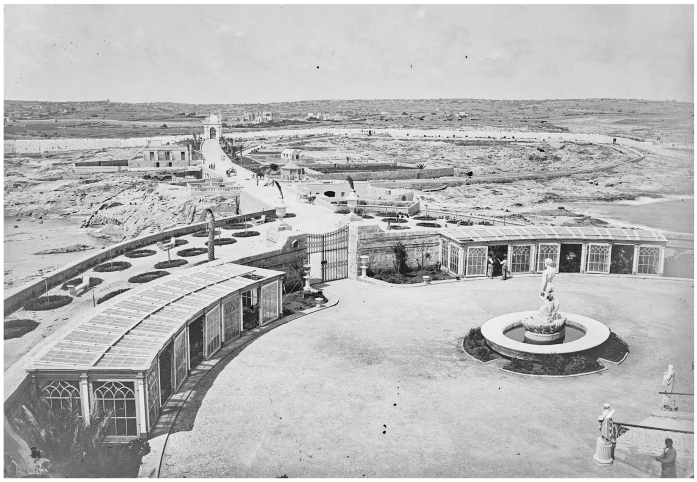

**Figure 8.** Photograph by Richard Ellis showing the access gate (top left) in the wall that enclosed the Dragonara Palace and the surrounding garigue grazing land. Late 19th century (reproduced by courtesy of the Richard Ellis Archive—Malta. M52-02).

The documentary evidence for the twentieth century is particularly detailed, making it possible to date and trace the more recent history of enclosure of former grazing land even more closely than in earlier periods. During the early twentieth century, particularly during and following the First World War, areas of former "wasteland" were systematically leased out or sold for agricultural purposes and for building. A series of plans preserved in Roll 73A at the Records and Archives Section of the Public Works Department provides detailed insight into how this policy was implemented. Unenclosed land was surveyed, and new enclosures defined and plotted onto these areas. When carving out a new enclosure, care was taken not to obstruct existing roads, and to leave narrow corridors that still allowed movement across the landscape, albeit through much more restricted spaces (Figure 9).

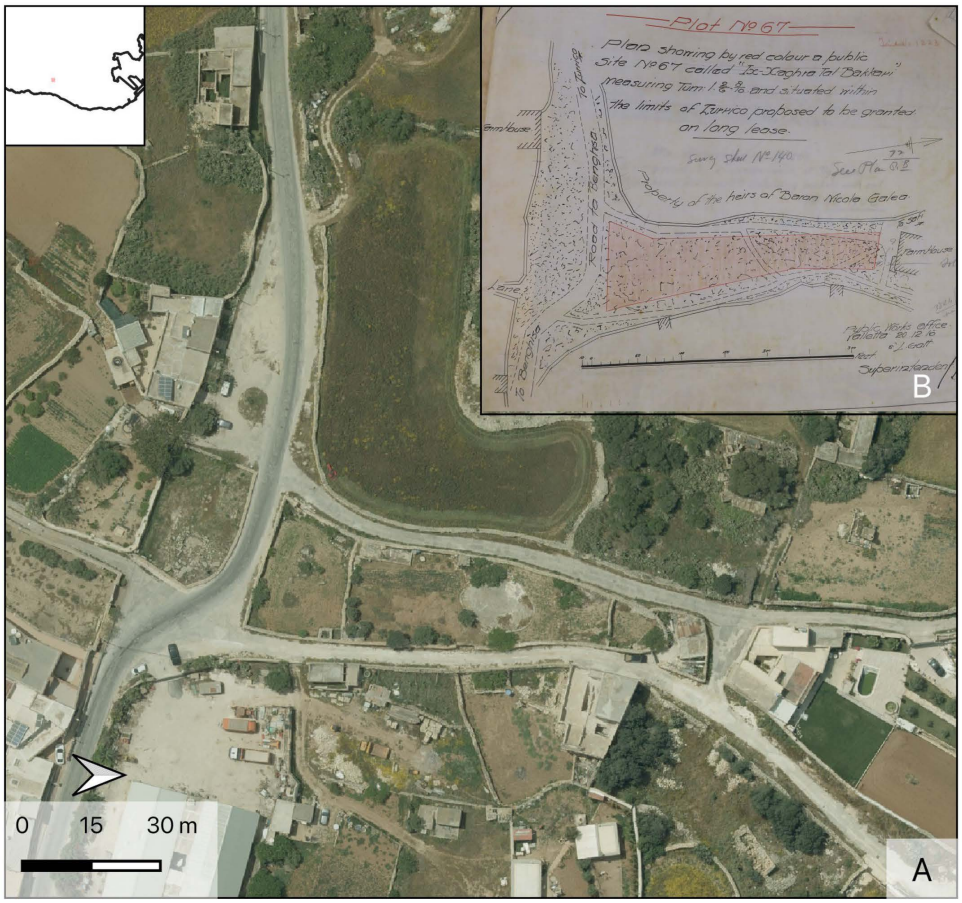


**Figure 9.** (**A**): Enclosed field formed by taking over part of a droveway at Tal-Bakkari, l.o. Żurrieq (SintegraM orthophotos (2018), Developing Spatial Integration for the Maltese Islands, Planning Authority). (**B**): Plan dated 20 December 1916 showing the demarcation of the same area in red, when it was designated for enclosure and lease (Roll 73A, 7A. Records and Archives Section within the Public Works Department).

The early 1930s were marked by a flurry of debate and legislation intended to safeguard and improve the productivity of the islands' scarce resources. The Government's efforts in this period to increase the productivity of "wasteland" were not driven purely by economic viability, but also by political and ideological considerations. In a debate in the Senate on 26 October 1932, the Leader of the Opposition, Gerald Strickland, pointed out that:

> . . . Ministers should be careful with public money. Money and reports were lavished upon dynamite to break up the rocky ground. The dynamite cost much more than any produce of crops raised on those lands [53] (p. 50).

During a debate in the Legislative Assembly on 22 November 1932, the Minister of Agriculture stated that government was considering legal provisions to preserve the soil from areas that were being taken up by building, and rather than let it get buried under building, to use it to improve rocky terrain to make it viable for crop cultivation [54] (p. 385). Progress with enacting these measures appears to have been slow.

The outbreak of the Abyssinia Crisis in early December 1934 renewed the prospect of war, and may have given a fresh impetus to the need to safeguard agricultural productivity and food security in Malta. A series of ordnances were issued barely a month later, in January 1935. Ordnance I was intended "To facilitate the preparation of Agricultural Statistics". Ordnance II, published the same day, was "To provide for the preservation of fertile soil" [55].

Ordnance II of 1935 was complemented by a "List of lands on which fertile soil may be deposited. . .", published on 26 January 1935 [56] (p. 80). Over 50 "wasteland" sites across the main island of Malta are numbered and listed, with measures on how to facilitate the deposition of soil that had been removed from building sites across the island.

An interesting exception to the leasing and selling of former grazing land for other purposes appears to have been made for areas that were considered to be archaeologically significant. The ordnance of 1935 came a decade after the enactment of the Antiquities Protection Act, which gave the state extensive powers and responsibilities to identify and protect archaeological sites [57]. As a result, areas of unenclosed "wasteland" in public ownership that were considered to be of archaeological significance, and which were included in the list of protected ancient monuments published in 1927 [58], were not included in the 1935 list of sites that could be covered in soil.

Since the second half of the twentieth century, successive building booms have continued to take up more land area for residential, commercial, and infrastructural building activity, making Malta the most built-up country in the European Union in 2018 [6]. This intensification in built-up areas has also had an impact on the former pastoral landscape. The redesignation of pastoral routes for building, which was already being practiced in the first half of the twentieth century, continued apace. Meanwhile, the feeding regimes used by sheep farmers were also changing. By 2021, the most widespread method had become the use of dried hay as fodder [59] (p. 102).

Transformation of co-owned rights into mere rights of access found its latest expression in the planning policies of Malta's Planning Authority, which seek to safeguard traditional and historical country pathways and their character [60] (Policy 1.2I). The same guidance document states that the term "country pathway" must be interpreted in a very broad sense to include, inter alia, rights of way, defined as informal tracks, normally unsurfaced, passing through arable fields and providing access to farmers or land managers having no direct access to their land from country roads or lanes, and informal pathways, which are described as those normally established on natural sites and characterized by compacted ground as a result of continuous trampling and erosion.

## 5. Transformation, Contestation, and Recovery: Five Examples

The extensive transformations of the Maltese landscape outlined above have resulted in the partial or total obliteration of a high proportion of the network of pastoral land and foraging routes that once extended across the archipelago. This transformation has been driven by different factors, which will be illustrated by the following examples. These factors may be observed alone or in concert. The following examples are intended only to illustrate their impact, and not as a comprehensive inventory of all the possible scenarios.

### *5.1. Absorption into the Road Network*

Pastoral routes developed organically as an integral part of the road network that allowed movement across the island. As noted earlier, public roads were often flanked by a wide verge, allowing the same corridor to serve for the passage of flocks of grazing sheep and goats, as well as other traffic. In many cases, these thoroughfares have been retained

and absorbed in the present-day road network. These typically have metalled roads to accommodate modern traffic, but often preserve the unmetalled verges, in whole or in part. In plan, the distinctive planimetry of the network is often preserved largely intact, as are many of the dry-stone walls that demarcate their boundaries. Examples of this process that are especially recognizable include several of the abandoned medieval settlements originally identified and studied by Blouet [61] and Wettinger [62]. Examples include Ħal Millieri, Ħax-Xluq, Ħal Mann, and Ħlantun (Figure 10). All these examples preserve a distinctive node where different country lanes converge in a wide, open space [19]. Evidence of their past use for pastoral activity is preserved in their planimetry, as well as several of their toponyms. As noted earlier, their planimetry is characterized by the distinctive funnel-shaped junctions that connect the wider open spaces with the more linear corridors. The toponymastic evidence preserves several references to a "*misraħ*", a term for which the most widely accepted translation is an open space for grazing [63]. In some instances, the toponyms associated with these nodes make even more explicit references to grazing, as at San Niklaw tal-Merħliet, literally "Saint Nicholas of the Flocks".

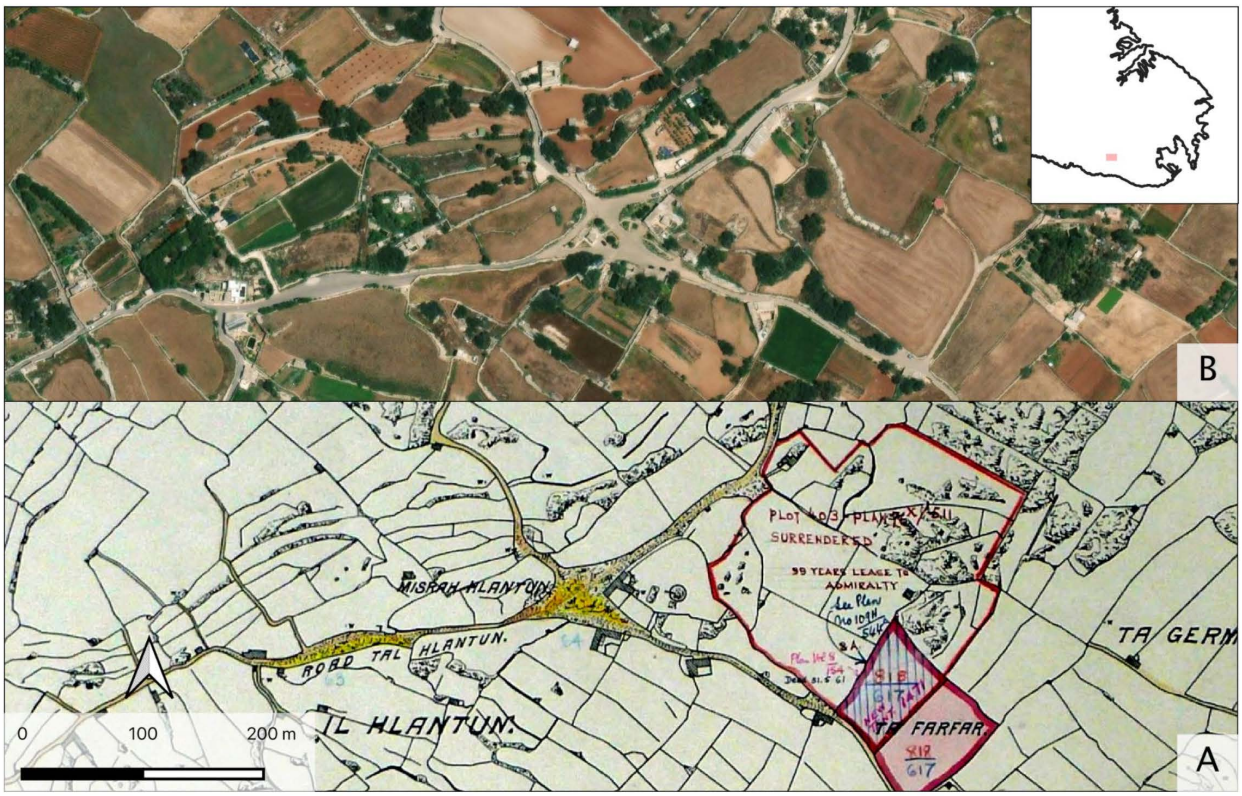


**Figure 10.** (**A**): Detail of annotated survey sheet showing droveway network, highlighted in yellow, at Ħlantun, l.o. Żurrieq. Note the toponym "Misraħ Ħlantun". Mid-twentieth century (NAM PWD—Project House, Government Property Survey Sheets, No. 140). (**B**): The same network in 2018 (SintegraM orthophotos (2018), Developing Spatial Integration for the Maltese Islands, Planning Authority).

### *5.2. Enclosure for Crop Cultivation*

The historical record reviewed earlier documents numerous instances of enclosure of common grazing grounds to create fields for crop cultivation, ranging in date across half a millennium, from when surviving written records become more abundant in the fifteenth century, well into the twentieth. In some instances, a stratification of successive enclosures may be made out, encroaching progressively further onto former grazing land, using the evidence of the morphology of the fields themselves, as well as the cartographic and archival record (Figure 11).

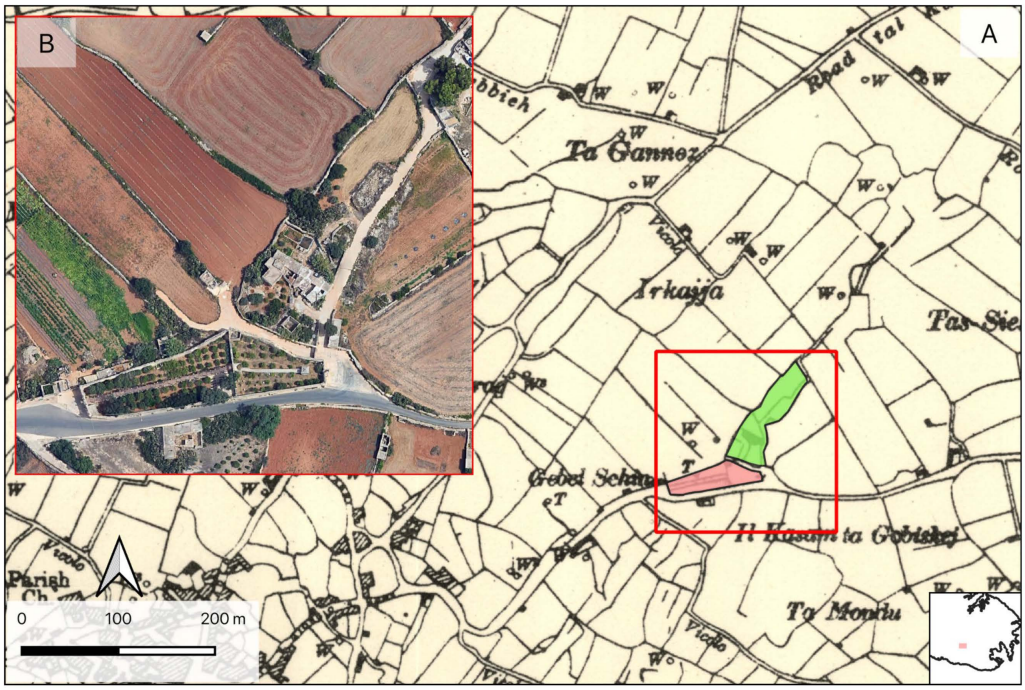


**Figure 11.** (**A**): Detail of early twentieth-century survey sheet showing successive enclosures of parts of a former grazing land near Safi. Area highlighted in red shows the extent of a garden created by the government in 1804. Area highlighted in green shows another enclosed part of the former grazing ground, probably enclosed at an earlier date. (**B**): The same area in 2018 (SintegraM orthophotos (2018), Developing Spatial Integration for the Maltese Islands, Planning Authority).

### *5.3. Urbanisation*

The exceptionally high density of building on the Maltese archipelago, which, as already noted, has the highest proportion of artificial ground cover in Europe, has also accounted for the erasure or absorption of a large area of former grazing grounds. The replacement of grazing grounds with artificially built surfaces may take several forms. The buildings of airfields alone necessitated the erasure of several square kilometers of the pre-existing cultural landscape. Four airfields were built on the island of Malta during the first half of the twentieth century. The largest of these, which still functions as the country's airport today, alone accounts for over 1% of the land surface area of the entire archipelago. Industrial activity and residential building have also taken up large areas of the former agricultural landscape. In some cases, new road layouts have erased all visible traces of past configurations of land management and use. In other cases, the imprint of these past uses, including grazing, still persists in a form that may, to varying extents, be read from the material and the archival record.

A widely attested, but to date little-studied, phenomenon is the influence of pastoral routes and the surrounding field enclosures on the urban form of settlements that developed in the early modern period. Historic village cores that took shape between the sixteenth and the eighteenth centuries are largely the result of successive building interventions by single individuals, which more often than not were added organically, without a master plan. As a result, these historic urban cores often respected and preserved the layout of existing road networks and property boundaries, and of course the boundary between private and public property. A direct corollary is that these urban cores may today still preserve a fossil imprint of the delineation of long-lost pastoral routes. This may help explain the distinctive street plan of early modern village cores, which is characterized by funnel-shaped open spaces where streets converge (Figure 12); these are morphologically very similar to the patterns observed in pastoral routes preserved in a rural context.

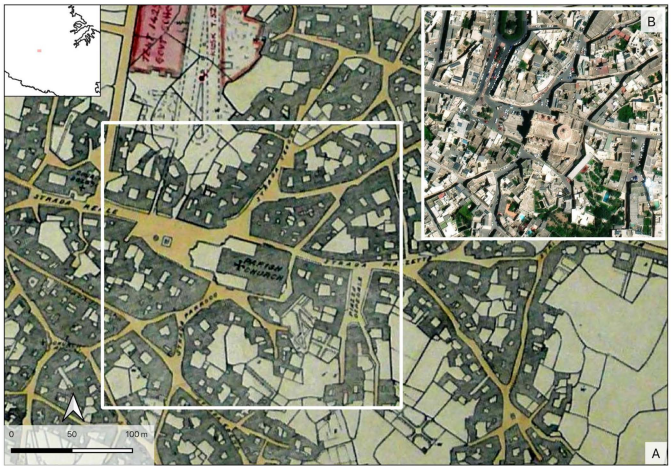


**Figure 12.** (**A**): Detail from annotated survey sheet showing street layout in the village core of Ħaż-Żebbuġ. Early to mid-twentieth century (NAM PWD—Project House, Government Property Survey Sheets, No. 89). (**B**): The area framed in white in (A) as it appeared in 2018 (SintegraM orthophotos (2018), Developing Spatial Integration for the Maltese Islands, Planning Authority).

The urbanization of former grazing lands took a very different form in the British colonial period, which in some ways was an inversion of the early modern pattern of urbanization along and around pastoral routes. By the early twentieth century, former pastoral routes had been largely appropriated by the colonial government, and in some cases were being allocated for building within their footprint. In the village of Mellieħa, for instance, which grew considerably in the nineteenth and early twentieth century, a former pastoral route was one of the first areas to be given over for building, long before urban expansion spilled over into the enclosed lands on either side of it (Figure 13). A short distance to the south of Miżieb ir-Riħ, the present-day hamlet of Manikata provides another good example. During the 1930s, a corridor that until then was used for grazing, was divided into plots for building. The area once occupied by former pastoral routes accounts for a significant proportion of the built-up area of Manikata today (Figure 14).

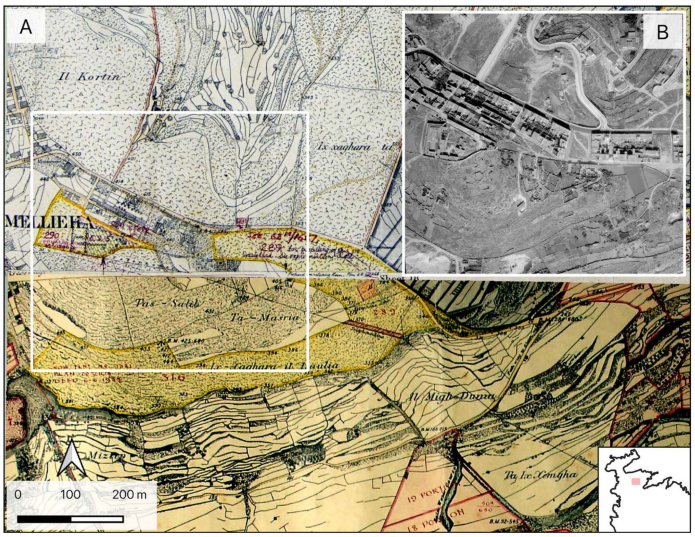


**Figure 13.** (**A**): Detail of annotated survey sheet showing the droveway network, partly shaded in darker yellow, at Mellieħa. Early to mid-twentieth century (NAM PWD—Project House, Government Property Survey Sheets, Nos. 13, 18). (**B**): The same area in 1967. Note the late nineteenth- and early twentieth-century buildings visible within the droveway on the survey sheet, and further increases in built-up area within the droveway by 1967 (National Collection of Aerial Photography, Historic Environment Scotland NCAP_SAL_HSL_MALTA_67_0004_0785).

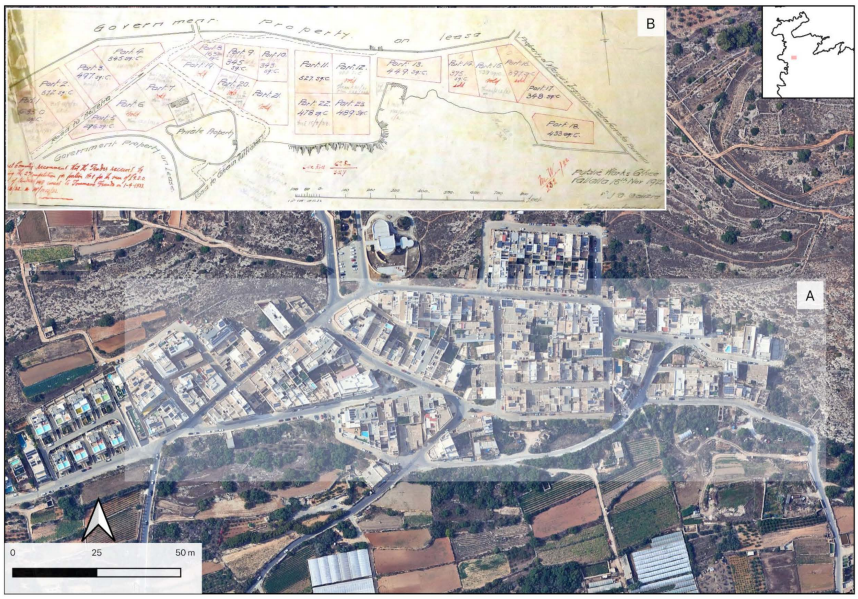


**Figure 14.** (**A**): Twentieth-century building development in Manikata hamlet. (SintegraM orthophotos (2018), Developing Spatial Integration for the Maltese Islands, Planning Authority). (**B**): Plan dated 15.11.1922 showing parceling of the former pastoral route in the same area into building plots (Roll 73A, 13A. Records and Archives Section within the Public Works Department).

### *5.4. Destruction by Quarrying*

The characterization of grazing land as "wasteland" rendered it vulnerable to another, even more destructive, reassignment to a different purpose. Grazing land on coralline limestone outcrops, where enclosure and agricultural improvement for crop cultivation may be particularly challenging, was in several cases leased or sold by the state for the quarrying of hardstone gravel (Figure 15). Lower Coralline Limestone outcrops were particularly prized for this purpose, and, as a result, during the course of the twentieth century they were largely destroyed across the archipelago, together with any trace of earlier use.

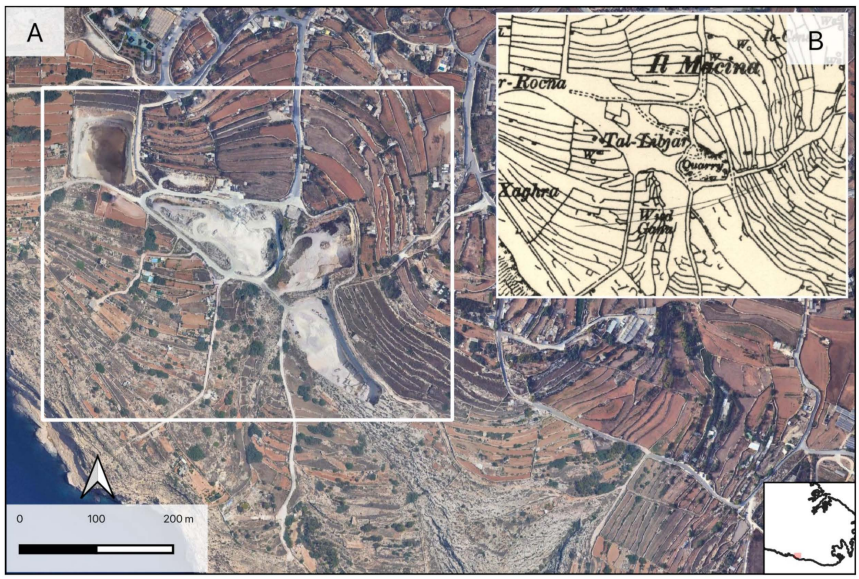


**Figure 15.** (**A**): Extensive quarrying within the footprint of a former droveway near Nigret, limits of Żurrieq (SintegraM orthophotos (2018), Developing Spatial Integration for the Maltese Islands, Planning Authority). (**B**): Detail of early twentieth-century survey sheet showing the same droveway. Note the toponym 'Tal-Ibjar' ([the place] of the [rainwater] cisterns).

### *5.5. Preservation and Scheduling*

Against this background of drastic adaptation, transformation, and erasure, the preservation of pastoral foraging routes in a relatively unaltered state is the exception rather than the rule. There are, however, several such notable exceptions. In a number of cases, they fall within areas that have been preserved and scheduled in national registers of protected assets, usually because of their recognition as Areas of Ecological Importance or Areas of Archaeological Importance. One example is the area around the former troglodyte settlement of Għar il-Kbir, and the cart ruts in the immediate vicinity, near the southwest coast of Malta. Both these sites were included in the list of protected ancient monuments published soon after the enactment of the 1925 Antiquities Protection Act [58] (p. 25). In 1998, an extensive area of karstland around these features was scheduled as an Area of Archaeological Importance, effectively also protecting the traces of pastoral foraging routes that fall within the same area. Another area of karstland at Tal-Wej was scheduled in 2011 with recognition of both an Area of Archaeological Importance and an Area of Ecological Importance, while also noting that it represented a significant multi-period cultural landscape. Although to date pastoral foraging routes have not been expressly scheduled in their own right, in such instances they nevertheless enjoy holistic protection as part of the cultural landscape.

## 6. Discussion

The fragmentary nature of the history reviewed earlier is not accidental. The history of the droveways as a form of commons is not simply a history from the margins, it is a marginalized history. The recurrent cases of appropriation of these commons, recorded at least since the fifteenth century, rested on their obliteration in memory as well as in the material landscape. The progressive obliteration of the grazing grounds and droveways that has been traced here is another example of the much more widely attested phenomenon of enclosure of the commons across Europe and beyond [64,65]. The erosion and loss of landscape commons has been analyzed and described in Rotherham's seminal work as a form of cultural severance, in which it is not only the physical landscape that is being modified, but also the nature of human engagement with that landscape [64]. As argued by Olwig, the enclosure of commons in the landscape often came hand in hand with another form of "enclosure", this time of "Cultural Commons", which severed the traditional relationships between people and place [65] (p. 39). One of the consequences has been that over the course of the past century, the rise of globalism has fundamentally altered perceptions of land and place, which has become increasingly commoditized and turned into property [65] (p. 43).

A sound understanding of the long history of contestation between competing interests in the landscape is a prerequisite for the management of the values and significance of the same landscape today. In such settings, heritage practitioners in the stewardship of historic landscapes are not only required to be guided by interdisciplinary knowledge, but they are also required to engage with contemporary ethical concerns, and to contribute to equity and wellbeing in the society they serve, in the spirit of the European Landscape Convention [2].

The interdisciplinary exploration that took place during the writing of this paper went through several iterations, which entailed many conversations. Each iteration between the evidence and the discussion of its implications led to fresh realizations. Ethnographic observation has provided a sound point of departure to understand the key characteristics of pastoral foraging routes and their purpose. Read from the perspective of law and legal anthropology, the material and archival evidence spoke eloquently of a struggle between very different normative systems, as new power structures tried to overwrite existing ones. In turn, the legal insights into the evolution of attitudes to private and common property have allowed a more informed reading of the evolution of the material form of pastoral landscapes, while the archival evidence has shed new light on their transformation in the British colonial period.

This hybrid approach has also opened up fresh avenues for further investigation. One such avenue has been the recognition that the organic development of urban centers in the countryside during the early modern period may preserve an imprint of pastoral foraging routes and the surrounding field systems in their street layout. This is significant for at least two reasons. The first is archaeological, in that it opens another avenue of investigation into the material record of lost landscapes. The second is architectural, in that it allows new insights into the development of the urban form that give early modern villages such a distinctive planimetry, as well as adding a new and previously undiscussed layer of value and significance to these urban forms.

The preliminary study undertaken here has further demonstrated that pastoral routes in the Maltese context, which before the writing of this paper had barely received a mention in the discourse about heritage preservation, are in fact a crucial component of the Maltese cultural landscape. They not only played a central role in the subsistence strategies of past inhabitants, but also represented a remarkable framework of rights and obligations founded on a concept of commons. The separation between the more tangible, material aspects of pastoral routes, and their more intangible legal and conceptual aspects, is a demonstrably artificial and unhelpful divide. Shifting subsistence strategies and structures of power and authority have resulted in a long history of contestation and redeployment of the material landscape where pastoralism was practiced.

The successive transformations of the Maltese landscape that have been outlined, as commons first became "wastelands", and then private land, fit squarely into the wider picture of cultural severance described by Rotherham [64]. In the process, the significance of pastoral routes has also morphed considerably, presenting new challenges and opportunities in their management and use, as new values come to the fore. On the global scene, the rediscovery and reworking of traditional commons is increasingly becoming an important ingredient in innovative approaches to the sustainable management of cultural landscapes, across countries ranging from the United Kingdom [66] to Japan [67]. This potential for reworking and reinvention of the commons for the future stewardship of the landscape also holds true for Malta. Even as the practice of pastoralism has receded, the pastoral routes hold the prospect of being invested with fresh significance. Today, the burgeoning overbuilding of the archipelago is increasingly acknowledged to be eroding the quality of life of the inhabitants. Against this backdrop, the prospect of a network of open spaces that were historically a form of commons gains renewed salience and significance. Further study of this threatened heritage and of its potential contribution to quality of life today not only appears timely, but also pressing.

## 7. Conclusions

The evolution and transformation of pastoral routes in Malta, outlined in this paper, played a crucial but often neglected role in the formation of the archipelago's cultural landscape. In the introduction, four key reasons were given why they merit study, and why they are relevant to the theme of endangered heritage.

The first and second reasons were both tied to the form of heritage that they represent, and some common conclusions may be drawn for both. The pastoral routes represent a clear departure from conventional forms of heritage, in the traditional sense of monuments that are more easily delimited, yet they are also the cumulative result of the efforts of many generations of largely anonymous individuals, who reshaped landscapes but left a relatively small imprint in the written record. The tangible and intangible heritage values of pastoral routes have been widely recognized on the international scene. In the Maltese context, this has yet to happen, partly because they have fallen into disuse, and partly because their purpose and significance have been largely forgotten.

This brings us to the third reason why the pastoral routes represent an interesting form of threatened heritage. Their material imprint in the landscape is inseparable from the system of practices, rights, and obligations that regulated their use. One of the long-term impacts of their long history of transformations has been the erosion, even erasure, of

the concept of commons in the Maltese landscape. In the brief history traced above, a recurring theme is the progressive displacement and overwriting of the legal and conceptual framework that had been the basis for common grazing ground for half a millennium. The loss of this legal and conceptual framework was accompanied by the loss of public rights of access in the landscape, which in turn came hand in hand with the enclosure and repurposing of much of the land that had formerly been commons. Furthermore, as a result of the erasure of the same legal and conceptual framework, the fragments of the pastoral network that still persist in the Maltese landscape are not presently recognized as commons, but are widely held to be government property, as a legacy of the British colonial administration. This has important consequences. The reallocation of former grazing lands for building has sometimes been contested on the grounds of environmental and cultural landscape preservation. However, it has never been contested on the grounds of the public's right as the historic owner of that land. In short, the loss of memory of historic rights, and the consequent failure to exercise those rights, has paved the way for the loss of the landscape itself.

The above raises a further challenge. The living practices of pastoral activity along these routes have dwindled to the verge of extinction over the past decade, under the pressure of urbanization and increasing regulation. Surviving sections of what was once a continuous network are now divided by cultivated enclosures, busy roads, and urban areas. The intangible practices and associative values attached to the droveways are, as a result, also threatened with extinction, and to a large extent, are only being preserved through ethnographic documentation. The preservation of the material imprint of the pastoral routes on the cultural landscape is, on the other hand, a realistic and attainable goal, which has clear benefits for the citizen.

The fourth reason why pastoral routes were considered an interesting example for study was that they demonstrate how an interdisciplinary perspective is useful, even vital, to address the complexity of the challenges that they present. This paper has advocated and deployed such an interdisciplinary approach, drawing on archaeology, history, ethnography, law, and legal anthropology for a better-informed approach to understanding and managing this element of the cultural landscape today. This paper has also raised new questions for each of these disciplines that require further research, considered in the next section.

## 8. Future Directions

This paper has traced some key characteristics of the evolution of pastoral routes in Malta, outlining some issues around their management today, and will now consider some challenges for the future. Malta is one of the most densely populated, and most heavily built, territories on the entire planet. Paradoxically, although Malta was among the first countries to sign the European Landscape Convention when it was opened for signature in 2000, at the time of writing (May 2024) it had still not ratified the same Convention, to give it force of law. A plausible explanation for this inordinate delay is a hesitation to regulate the high density of competing interests that jostle over the limited land area available. The long history of contestation over land use that has been traced in this paper has arguably entered its most acute chapter to date, and ratification of the Convention is therefore a more pressing priority than ever.

In such a setting, the safeguarding of open spaces, and of the right to public access and enjoyment of those spaces, is more critical than ever, and essential for the wellbeing of the citizen and the community. The future study and management of the historical pastoral routes considered in this paper need to be informed by these needs, and by principles of equity and responsible stewardship of the landscape. This requires further interdisciplinary research, on the lines advocated in this paper, and on several fronts. The interdisciplinary efforts need to encompass an even wider range of specializations than was possible in the present contribution. Ecology and agricultural science may add vital perspectives on present-day challenges, which may be complemented and enriched by the long-term perspectives provided by paleoecology. Topography, hydrology, surface geology, and soil

are key variables that inevitably influenced the decisions that shaped the pastoral route network over time. Each of these areas offers rich scope for further interdisciplinary work. Future approaches also require a paradigm shift, on the lines advocated by Rotherham, to integrate social and economic considerations in the management of landscapes and ecology [68] (p. 439).

The consolidation of administrative and legal measures to coherently safeguard those spaces and rights of access is a high priority for the future. The legal standing of surviving pastoral routes needs to be examined and assessed case by case. Further investigation in collaboration with policy-makers would be necessary to ascertain whether it may be viable to encourage, maintain, and possibly reintroduce traditional pastoral foraging in suitable sectors of the pastoral route network that have not been impacted by urbanization. In other cases, a more viable scenario is the recognition and protection of historic pastoral routes as open spaces for public enjoyment. A Public Domain Act was enacted in Malta in 2016, but to date, implementation on the ground has been very slow. It does nevertheless provide a firm legal basis and the opportunity for the formal recognition of public rights over surviving parts of the former network of pastoral routes.

In order to achieve all the objectives that have just been outlined, and as a basis for further research, a high priority will be the comprehensive spatial mapping of the pastoral route network as recorded in the historic mapping record, and of the present state of its components, to provide a quantifiable spatial record of the various transformations they have undergone, as outlined in this paper.

The comprehensive mapping of the pastoral route network will also be invaluable for the exploration of another aspect that was partially explored in an earlier contribution [19]. This is the analysis of the spatio-temporal and topological characteristics of the network as a system of movement and connectivity. This may be taken further by considering the experiential dimensions of the rhythms and taskscapes of the pastoral activity that the network made possible, drawing on the rich seam of approaches that have bridged archaeological interpretations and ethnographic comparisons, such as Tim Ingold's work on the temporality of landscape [69], lines of connectivity and wayfaring [70] (pp. 96–103), and the experience of walking and movement across a landscape [71].

Meanwhile, more research is needed to continue to shed light on the role and significance of pastoralism in the shaping of the Maltese landscape. The timeline of the account presented above of the evolution of pastoral routes and their evolution is heavily dependent on the written record. In particular, the chronology of the original emergence of these systems in Malta remains unclear and will require extensive archaeological sampling to complement the written and ethnographic record.

A related avenue of investigation, which may also be pursued further through archaeological analysis complemented by the archival record, is the more detailed charting of the changes undergone by the pastoral routes over time, from their original formation, through the vicissitudes of successive encroachment, urbanization, and obliteration, to their survival and preservation today. A subsidiary question that warrants investigation is the relationship between the morphology of pastoral routes and that of street networks in historic urban spaces, which in some cases may have been built along and around earlier pastoral routes, and in a later period, within them, in both cases preserving their imprint in the urban street plan.

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## References

1. Rogers, A.P. Values and Relationships between Tangible and Intangible Dimensions of Heritage Places. In *Values in Heritage Management: Emerging Approaches and Research Directions*; Avrami, E., Macdonald, S., Mason, R., Myers, D., Eds.; Getty Conservation Institute: Los Angeles, CA, USA, 2019; pp. 172–185; ISBN 9781606066201.
2. Council of Europe. *European Landscape Convention*; European Treaty Series, No. 176; Council of Europe: Florence, Italy, 2000.
3. Dejeant-Pons, M. (Ed.) *Landscape Mosaics: Thoughts and Proposals for the Implementation of the Council of Europe Landscape Convention*; Council of Europe: Florence, Italy, 2022.
4. Marston, S.A. The social construction of scale. *Prog. Hum. Geogr.* **2000**, *24*, 219–242. [CrossRef]
5. Wolf, E. *Europe and the People Without History*, 2nd ed.; University of California Press: Berkeley and Los Angeles, CA, USA, 2010; ISBN 9780520268180.
6. Eurostat. *Eurostat Statistics Explained: Land Cover Statistics*. Available online: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Land_cover_statistics#Land_cover_in_the_EU_Member_States (accessed on 12 April 2024).
7. Barker, G. Agriculture, Pastoralism, and Mediterranean Landscapes in Prehistory. In *The Archaeology of Mediterranean Prehistory*; Blake, E., Knapp, A.B., Eds.; Blackwell: Oxford, UK, 2005; pp. 46–76.
8. Retamero, F.; Schjellerup, I.; Davies, A. (Eds.) *Agricultural and Pastoral Landscapes in Pre-Industrial Society: Choices, Stability and Change*; Earth 3; Oxbow: Oxford, UK, 2016.
9. Knodell, A.R.; Wilkinson, T.C.; Leppard, T.P.; Orengo, H.A. Survey archaeology in the Mediterranean world: Regional traditions and contributions to long-term history. *J. Archaeol. Res.* **2023**, *31*, 263–329. [CrossRef]
10. Campbell, J. *Honour, Family and Patronage: A Study of Institutions and Moral Values in a Greek Mountain Community*; Oxford University Press: Oxford, UK, 1964.
11. Mientjes, A.C. *Paesaggi Pastorali: Studio Ethnoarcheologico sul Pastoralismo in Sardegna*; CUEC Editrice: Cagliari, Italy, 2008; ISBN 8884674786.
12. Cinà, R.; Massaro, F.P. La transumanza e le trazzere Siciliane. *Riv. Agenzia Territ.* **2001**, *1*, 21–42.
13. Caliandro, L.P.; Loisi, R.P.; del Sasso, P. Connections between *masserie* and historical road systems in Apulia. *J. Agric. Eng.* **2014**, *45*, 15–23. [CrossRef]
14. Brunce, R.G.H.; De Aranzabal, I.; Schmitz, M.F.; Pineda, F.D. *A Review of the Role of Drove Roads (Cañadas) as Ecological Corridors*; Alterra-Rapport 1428; Alterra: Wageningen, The Netherlands, 2006. Available online: https://library.wur.nl/WebQuery/wurpubs/fulltext/22779 (accessed on 9 April 2024).
15. Mattone, A.; Simbula, P.F. (Eds.) *La Pastorizia Mediterranea: Storia e Diritto (Secoli XI-XX)*; Carocci: Rome, Italy, 2011.
16. UNESCO. Transhumance: The Seasonal Droving of Livestock along Migratory Routes in the Mediterranean and in the Alps [Online Video]. Available online: https://www.unesco.org/archives/multimedia/document-4941 (accessed on 14 April 2024).
17. Bevan, A.; Conolly, J. *Mediterranean Islands, Fragile Communities and Persistent Landscapes: Antikythera in Long-Term Perspective*; Cambridge University Press: Cambridge, UK, 2013.
18. Alberti, G.; Grima, R.; Vella, N.C. The use of geographical information system and 1860s cadastral data to model agricultural suitability before heavy mechanization. A case study from Malta. *PLoS ONE* **2018**, *13*, e0192039. [CrossRef] [PubMed]
19. Alberti, G.; Grima, R.; Vella, N.C. Locating potential pastoral foraging routes in Malta through the use of a Geographic Information System. In *Temple Landscapes: Fragility, Change and Resilience of Holocene Environments in the Maltese Islands*; French, C., Hunt, C.O., Grima, R., McLaughlin, R., Stoddart, S., Malone, C., Eds.; McDonald Institute for Archaeological Research: Cambridge, UK, 2020; pp. 267–283. [CrossRef]
20. Tarlow, S. *The Archaeology of Improvement in Britain, 1750–1850*; Cambridge University Press: Cambridge, UK, 2007.
21. Bowen-Jones, H.; Dewdney, J.C.; Fisher, W.B. (Eds.) *Malta: Background for Development*; Department of Geography, University of Durham: Durham, UK, 1961.
22. Barnes, S.F. Milk pasteurization in Malta. *Aust. J. Dairy Technol.* **1951**, *6*, 3–5.
23. Hamilton, A.P.F. *Report on a Survey of the Need for Afforestation and Water Conservation in the Waste Land of the Maltese Islands*; Government Printing Office: Marsa, Malta, 1952.
24. Charlton, W.A. Trends in the Economic Geography of Malta since 1800. Ph.D. Thesis, University of Durham, Durham, UK, 1960.
25. Rippon, S. *Historic Landscape Analysis: Deciphering the Countryside*; Practical Handbooks in Archaeology 16; Council for British Archaeology: York, UK, 2004.
26. Hunt, C.O.; Vella, N.C. A view from the countryside: Pollen from a field fill at Miżieb ir-Riħ. *Malta Archaeol. Rev.* **2008**, *7*, 61–69.
27. Vella, N.C.; Spiteri, M. Documentary Sources for a Study of the Maltese Landscape. In *Storja: 30th Anniversary Edition*; Frendo, H., Ed.; Malta University Historical Society: Marsa, Malta, 2008; pp. 19–29.

28. Dalli, C. *Malta: The Medieval Millenium*; Midsea Books: Marsa, Malta, 2006.
29. Abela, G.F. *Della Descrittione Di Malta Isola Nel Mare Siciliano Con Le Sue Antichita, Ed Altre Notitie*; P. Bonacota: Marsa, Malta, 1647.
30. Ciantar, G.A. *Malta Illustrata, Ovvero Descrizione Di Malta, Isola Del Mare Siciliano e Adriatico, Con Le Sue Antichita*; Stamperia del Palazzo di S.A.S.: Marsa, Malta, 1772.
31. Wettinger, G. The village of Ħal Millieri: 1419–1530. In *Ħal Millieri: A Maltese Casale, Its Churches and Paintings*; Luttrell, A., Ed.; Midsea Books: Marsa, Malta, 1976; pp. 36–68.
32. Wettinger, G. Early Maltese popular attitudes to the government of the Order of St John. *Melita Hist.* **1974**, *6*, 255–278.
33. Wettinger, G. Agriculture in Malta in the Late Middle Ages. In *Proceedings of History Week 1981*; Buhagiar, M., Ed.; The Historical Society: Marsa, Malta, 1981; pp. 1–48.
34. Wettinger, G. Mellieħa in the Middle Ages. In *Mellieħa Through the Tides of Time*; Catania, J., Ed.; Mellieħa Local Council: Marsa, Malta, 2002; pp. 40–47.
35. Donlan, S.P. Remembering: Legal Hybridity and Legal History. *Comp. Law Rev.* **2011**, *2*. Available online: https://ssrn.com/abstract=1874088 (accessed on 18 April 2024).
36. Donlan, S.P.; Andò, B.; Zammit, D. "A Happy Union"? Malta's Legal Hybridity. *Tulane Eur. Civ. Law Forum* **2012**, *27*, 165–208.
37. Ganado, J.M. Maltese Law. *J. Comp. Legis. Int. Law Third Ser.* **1947**, *29*, 32–39.
38. Tamanaha, B. Understanding Legal Pluralism: Past to Present, Local to Global. *Syd. Law Rev.* **2008**, *30*, 375–411.
39. Dalli, C. Governing the Islands: The Universitates of Malta and Gozo. In *Malta's Road to Autonomy: 100 Years on from the 1921 Self-Government*; Camilleri, M., Spiteri, M., Eds.; Malta Libraries: Marsa, Malta, 2023; pp. 16–29.
40. Dalli, C. Medieval Communal Organisation in an Insular Context: Approaching the Maltese Universitas. In *The Making and Unmaking of the Maltese Universitas*; A Supplement of Heritage; Midsea Books: Marsa, Malta, 1993; pp. 1–12.
41. Universitas Personarum. *Merriam-Webster.com Dictionary*. Available online: https://www.merriam-webster.com/dictionary/universitas%20personarum (accessed on 6 April 2024).
42. Universitas Rerum. *Merriam-Webster.com Dictionary*. Available online: https://www.merriam-webster.com/dictionary/universitas%20rerum (accessed on 6 April 2024).
43. Dal Pozzo, B. *Historia Della Sacra Religione Militare di S. Giouanni Gerosolimitano Detta di Malta, Volume I (1571–1636)*; Giovanni Berno: Verona, Italy, 1703.
44. Gugliuzzo, C.; Restifo, G. Una "colonia" ribelle: Malta, gli Inglesi e la peste del 1813. *Incontr. Mediterr. Numero Monogr. L'Islam Eur. Passato Futuro* **2002**, *2*, 139–160.
45. Fiorini, S. The Municipal Councils in the Maltese Islands 1530–1800. The End of the Universitas under Maitland's Regime. In *The Making and Unmaking of the Maltese Universitas*; A Supplement of Heritage; Midsea Books: Marsa, Malta, 1993; pp. 13–24.
46. Cassar, C. *Fenkata: An Emblem of Maltese Peasant Resistance?* Ministry for Youth and the Arts: Marsa, Malta, 1994.
47. Pagliaro, A.; Mancini, G. *Dizionario di Politica*; Partito Nazionale Fascista: Rome, Italy, 1940.
48. Spiteri, S. Maltese 'Siege' Batteries of the Blockade. *Arx Online J.* **2008**, *6*, 4–20. Available online: https://issuu.com/arkitettura/docs/arx-vol6-2008 (accessed on 9 April 2024).
49. Thornton, W.H. *Memoir of the Finances of Malta Under the Government of the Order of St. John of Jerusalem, During the Last Years of Its Dominion, and as Compared with Those of the Present Time*; Government Press: Marsa, Malta, 1836.
50. Comaroff, J. The Discourse of Rights in Colonial South Africa: Subjectivity, Sovereignty, Modernity. In *Identities, Politics, and Rights*; Sarat, A., Kearns, T.R., Eds.; University of Michigan Press: Ann Arbor, MI, USA, 1995; pp. 193–236.
51. Ganado, A. The End of the Universitas under Maitland's Regime. In *The Making and Unmaking of the Maltese Universitas*; A Supplement of Heritage; Midsea Books: Marsa, Malta, 1993; pp. 25–28.
52. Emmanuele Luigi Galizia Nomine vs. Banchiere Emmanuele Scicluna, Corte di Appello di Sua Maesta Aula Civile, 30 Aprile 1886. In *Collezione di Decisioni dei Tribunali Superiori Dell'isola di Malta: Emanate da Gennajo 1886 a Giugno 1888: Volume xi, 1886–1888*; Tipografia del Malta Times: Marsa, Malta, 1888.
53. Senate. *Parliamentary Debates. Official Report Volume 9. Fourth Parliament of Malta. Session 1932–1933*; Government Printing Office: Marsa, Malta, 1935.
54. Legislative Assembly. *Parliamentary Debates. Official Report Volume 21. Fourth Parliament of Malta. Session 1932–1933*; Government Printing Office: Marsa, Malta, 1935.
55. *Malta Government Gazette Supplements*; Government Printing Office: Valletta, Malta, 1935; published on 8 January 1935.
56. *Malta Government Gazette*; Government Printing Office: Valletta, Malta, 1935; published on 26 January 1935.
57. Ganado, A. The Protection of Cultural Heritage in Maltese Law. *J. Mediterr. Stud.* **1999**, *9*, 122–134. Available online: https://muse.jhu.edu/article/670247 (accessed on 9 April 2024).
58. *Malta Government Gazette*; Government Printing Office: Valletta, Malta, 1927; published on 14 January 1927.
59. Abela, J. A Preliminary Study on the Effect of Different Feeding Regimes on the Physiochemical Characteristics of Local Sheep's Milk. *MCAST J. Appl. Res. Pract.* **2022**, *6*, 99–112. [CrossRef]
60. Malta Environmental and Planning Authority. *Rural Policy and Design Guidance*; MEPA: Floriana, Malta, 2014.
61. Blouet, B. *The Story of Malta*; Faber and Faber: London, UK, 1967.
62. Wettinger, G. The Lost Villages and Hamlets of Malta. In *Medieval Malta: Studies on Malta before the Knights*; Luttrell, A., Ed.; The British School at Rome: London, UK, 1975; pp. 181–216.
63. Wettinger, G. *Place-Names of the Maltese Islands: Ca. 1300–1800*; PEG: Marsa, Malta, 2000; ISBN 9789990992496.

64. Rotherham, I.D. Cultural Severance and the End of Tradition. In *Cultural Severance and the Environment: The Ending of Traditional and Customary Practice on Commons and Landscapes Managed in Common*; Rotherham, I.D., Ed.; Springer: Berlin/Heidelberg, Germany, 2013; pp. 11–30. Available online: https://go.gale.com/ps/i.do?id=GALE%7CA360609360&sid=googleScholar&v=2.1&it=r&linkaccess=abs&issn=00094978&p=AONE&sw=w&userGroupName=anon~19b87832&aty=open-web-entry (accessed on 18 April 2024).
65. Olwig, K.R. Globalism and the Enclosure of the Landscape Commons. In *Cultural Severance and the Environment: The Ending of Traditional and Customary Practice on Commons and Landscapes Managed in Common*; Rotherham, I.D., Ed.; Springer: Berlin/Heidelberg, Germany, 2013; pp. 31–46. [CrossRef]
66. Mackay, D. New Commons for Old: Inspiring New Cultural Traditions. In *Cultural Severance and the Environment: The Ending of Traditional and Customary Practice on Commons and Landscapes Managed in Common*; Rotherham, I.D., Ed.; Springer: Berlin/Heidelberg, Germany, 2013; pp. 401–412.
67. Bolthouse, J. End of Tradition, Reworking of Custom: Re-assembling Satoyama Woodlands on Tokyo's Urban Fringe. In *Cultural Severance and the Environment: The Ending of Traditional and Customary Practice on Commons and Landscapes Managed in Common*; Rotherham, I.D., Ed.; Springer: Berlin/Heidelberg, Germany, 2013; pp. 387–400.
68. Rotherham, I.D. Concluding Thoughts on the Implications of Cultural Severance on Landscapes, Ecology and People. In *Cultural Severance and the Environment: The Ending of Traditional and Customary Practice on Commons and Landscapes Managed in Common*; Rotherham, I.D., Ed.; Springer: Berlin/Heidelberg, Germany, 2013; pp. 433–443.
69. Ingold, T. The Temporality of the Landscape. *World Archaeol.* **1993**, *25*, 152–174. [CrossRef]
70. Ingold, T. *Lines: A Brief History*; Routledge: London, UK, 2007.
71. Ingold, T. *The Life of Lines*; Routledge: London, UK, 2015.

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# Assessing the Long-COVID Impact on Heritage Organisations

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**Abstract:** The aim of this paper is to understand the long-COVID impact on cultural heritage organisations, and future research needed. COVID-19 was disruptive to cultural heritage socioeconomic activities across the world during 2020 and 2021. Whilst government intervention and changes from physical to digital engagement generally prevailed, the long-COVID impact on cultural heritage organisations, their people and users, buildings, and collections remains unknown. The extent, also, to which financing, curating, visiting, and volunteering patterns have changed is uncertain. Following the pandemic closures and associated support, cultural heritage organisations are facing continuing economic, social, political, environmental, technological, and organisational culture pressures. This research examines the existing academic literature, sector publications, annual reports and associated visitor information to understand whether cultural heritage organisations have long-COVID, whether they can survive another pandemic, and what further research is needed to be better prepared. Four case studies from the UK look at the visitor and financial impacts of COVID-19 on the British Library, the London Transport Museum, The Theatre Royal Drury Lane, and Kensington Palace. This paper contributes to heritage research by providing a deeper understanding of the impact that COVID-19 had on heritage, and how to proactively plan for similar future disruptions. The impact themes show that change did not result in a new normal but in the need for a new space, consisting of blended space (physical and digital), mixed space (indoors and outdoors), and community of practice space (isolated or cross-sector networking space). The literature highlights the significance of the sector coming together during the pandemic to share knowledge and provide support through its networks. It also highlights how important it is for such unity not to be lost but to be harnessed to support ongoing organisational sustainability and better preparedness for future crises. Finally, future research suggestions are proposed grouped into social, digital, financial, and operational research themes.

**Keywords:** COVID-19; heritage; cultural heritage; new space (physical; digital; common space); organisational sustainability; sharing knowledge; wellbeing



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## 1. Introduction

On 10 January 2020, the World Health Organisation (WHO) initiated meetings and sharing of extensive guidance on a novel coronavirus outbreak. The following day, the first death due to this coronavirus was reported, and on 11 March 2020, the WHO characterised the coronavirus disease as a pandemic [1]. Initially named 2019 novel coronavirus, the coronavirus disease (COVID-19) is caused by the virus called Severe Acute Respiratory Syndrome CoronaVirus 2 (SARS-CoV-2) [2]. At the time of writing, the latest WHO report (28 January 2024) recorded 10,902 deaths in the previous 28 days, reaching a total of 7,026,465 reported deaths worldwide. Over half a million cases have been reported in the past 28 days, and nearly 0.8 billion cases reported overall [3].

The world shielded from the pandemic with lockdowns (closure of businesses and restrictions of international flights, domestic travel, and physical contact), building up stocks of personal protective equipment (PPE) and setting up extra medical facilities [4]. The lockdowns minimised its impact until vaccines were able to change its course; however,

equitable distribution of vaccines around the world was a significant issue [5]. The 'anthropause' lockdowns [6] had significant impact on people's wellbeing due to the isolation, and damaged world and local economies. COVID-19 disrupted every aspect of life, from health provision, education, agriculture, sports, culture, and entertainment [7]. It had a significantly negative impact on employment and job security, and amplified gender and social inequality [8,9].

As we will see throughout this paper, COVID-19 affected heritage management significantly; the lockdowns limited access to heritage sites, such as museums and galleries, libraries, archives, archaeological sites and monuments, historic houses and castles, theatres, and all other cultural performing venues. It restricted travel, impacted its staff, volunteers, communities and users' health and livelihoods, changed habits in operations and communication, in buildings' security and collection care, and the overall heritage organisations' viability was threatened. Government intervention across the world prevented permanent closures, mostly, but the lockdown closures drained financial reserves, challenged people's flexibility and skills, and created conservation backlogs. The closures did not affect all types of heritage organisations the same, with size, governance type, registration/accreditation status, and more significantly indoor to outdoors spaces variation, all making a difference to the impact. On the other hand, parts of the planet witnessed reduction in pollution, and saplings of novel means for reaching out to audiences and communities spurred to significant growth.

As people are affected differently by COVID-19, and some suffer its effects long after the infection, we use long-COVID [10] as an analogy to understand what the long-term effect of COVID-19 is on the various types of heritage organisations, and how to best prepare for, or mitigate, similar future crises. Whilst the world aimed to return to normal, that normal we were used to was an imposed assortment of ongoing crises, including the cost of living, climate change, social inequality, wars and political unrest [11]. Coloniality, restitution, and structural racism, alongside COVID-19, climate change, and social and economic inequality, are highlighted as the most pressing issues in heritage management research currently [12]. Managing the 'fragmented ecosystem' of heritage operations [13] relates to questions of its cost and usefulness [14,15], especially for contributing to UNESCO's sustainable development goals [16,17]. On the effect of COVID-19 on heritage management, Graham Black asks 'Will it create a 'new normal' or simply speed up trends that were already under way—or merely be a short-term blip?' and highlights that heritage institutions 'more than ever the need to stand back from day-to-day priorities and re-think for the long term' [18] (p. 296). The literature questions the fundamental role of heritage; how can heritage organisations best prepare not only to survive (cost of heritage operations) but also to positively contribute to support 'the fragile culture' [19] of society during and after crises (usefulness of heritage)? Heritage after all is about learning from experience to benefit our present and future [20].

The aim of this paper is to deepen our understanding of the long-COVID impact on heritage organisations and the role of heritage in shaping the 'next normal' [17] as a new space (Sections 3.3 and 4), and to outline future research needed in mitigating crisis impact (Section 4). This paper contributes to heritage research by providing deeper understanding of the impact that COVID-19 had on heritage, and how to proactively plan for similar future disruptions.

## 2. Materials and Methods

This paper utilises an extensive academic literature review enhanced by case studies utilising annual reports and associated visitor number information. These methods together help to understand whether heritage organisations have long-COVID, whether they can survive another crisis, and what further research is needed to be better prepared.

### *2.1. Literature Review*

Out of 109 academic works from a SCOPUS search for ("covid" OR "post-covid") AND ("heritage" OR "cultural heritage" OR "heritage buildings" OR "heritage monuments"), the literature review utilises 79 academic papers and eleven book chapters. A total of 19 papers were rejected, mainly for the use of heritage as 'mother tongue' or generally referring to 'traditional' song, food, drink, or religion. There was one duplication (newer version) and two papers were inaccessible or of questionable quality. To the selected 90 SCOPUS papers and chapters, 4 papers were added from the recent Special Issue The Impact of COVID-19 on Cultural Heritage [1]. Six further papers were included from peer suggestions.

The 100 papers and chapters reflected 36 nations. Six studies were researching COVID-19 and heritage in multiple EU nations. Italy, UK, USA, and Greece were the countries with the most papers included but in addition to those European and North American works, Asia, Africa, South America, and Australasia also had multiple representations. A total of 51 out of the 89 academic papers included extensive empirical phases, utilising a wide spectrum of methods to collect extensive data. A total of 56 publicly accessible sector publications were also reviewed, providing detailed insight on impacts for heritage operations and teams. Notable contributions include the Arts and Humanities Research Council (AHRC) funded research by The Centre for Cultural Value, the extensive stream on COVID-19 and wellbeing from Historic England, Ulster University's UKRI research, and extensive reports by international (UNESCO, ICOMOS, ICON, EU), and UK museum organisations. The analysis started with initial thematic categorisation: effects (negative and positive); government intervention; physical and digital changes; impacts on teams, users, buildings, and collections; changes to operational patterns, best practice observed, future research. Clear themes emerged: space (physical, digital, sharing), time (planning, emergency preparation), purpose (role during and post-crisis) and rethinking the role of heritage. The initial categories and resulting themes are expanded in the results section.

### *2.2. Case Study Methodology*

Four arts and heritage sector case studies were selected for their contrasting funding regimes:

1. A library: The British Library, a Department for Digital, Culture, Media and Sport (DCMS) funded library with revenue generating powers. The British Library is an exempt charity under the Charities Act 1993.
2. A museum: The London Transport Museum is a Transport for London (TfL), Local Authority affiliated museum. London Transport Museum Limited is a registered charity (number 1123122), which was incorporated on 6 February 2008 as a subsidiary company of TfL.
3. A theatre: The Theatre Royal Drury Lane has been a site for entertainment since 1663 and the world's oldest theatre site in continuous use. Part of the Lloyd Webber (LW) Theatres Group Limited. Company number 03987955.
4. A historic house: Kensington Palace is part of Historic Royal Palaces, which is self-funded (i.e., an independent charity).

The aim of examining these case studies is to understand the long-COVID impact on diverse heritage organisations and outline future research needed in mitigating such impact. The process of examining the case studies commenced with collating organisational reports, annual accounts, archives, databases, and websites using a stripped down version of the Business Model Canvas [21]. Business models are defined as how organisations create and capture value [21]. Value is both quantitative ('e.g., price, speed of service') and qualitative ('e.g., design, customer experience') [22] (p. 23).

The Business Model Canvas is a graphic representation of why an organisation exists, what it intends to do, for whom and what is required to initiate and maintain it. A simplified version of the BM is in Table 1 below [22]:

**Table 1.** Business Model Canvas (BMC) is a graphic representation based on Ondrus and Lyytinen, 2011).

| Business Model Canvas | | |
|---|---|---|
| Infrastructure Aspects | Value Proposition | Market Aspects |
| | Financial Aspects | |

The case studies are presented in Section 3.1.7.

### *2.3. Document Structure*

Following the introduction and methodology (Sections 1 and 2), the results are presented in Section 3, followed by the discussion (Section 4) and conclusion (Section 5).

In Section 3, the long-term effects of COVID-19 on heritage are presented within six themes (Sections 3.1.1–3.1.6). The four case studies are then presented in Section 3.1.7, providing an insight on visitor and financial impacts of COVID-19 across four different types of heritage organisations: a museum, a library, a theatre, and a palace. In the next section (Section 3.2), three themes relate to calls for review of the heritage sector as found within the COVID-19 literature: a call to critically review the sector (Section 3.2.1), understanding the ethics of COVID-19 (Section 3.2.2), and to evaluate the intervention roles of the government and the heritage sector support (Section 3.2.3). Section 3.3 introduces the main theme of a new space, not a new normal. It expands on the roles of physical, digital, and blended spaces (Sections 3.1.1–3.1.3), and as shared spaces for information sharing, networking (Section 3.3.4) and by extension as wellbeing spaces (Section 3.3.5).

Section 4 discusses the effect of such findings in a fledgling sector and provides an extensive bank of future research that is needed (Section 4.1). The conclusion presents the need to understand the opportunity of a new diversified organisational space, and the capacity and power that a unified sector would possess.

## 3. Results

### *3.1. COVID-19 Effects on Heritage*

The study of previous pandemics shows that their long-term effect is unpredictable [23]. COVID-19 demonstrated how difficult it is to accurately predict the future [24]. 'It was a crisis for cultural heritage, after all, where nothing was bombed, looted, or erased' (participant comment in [24] (p. 282)).

The following long-term effects are presented in this section:

- ➢ Disruption and contribution,
- ➢ Impact variation for types of organisations,
- ➢ Impact on teams,
- ➢ Impact on users,
- ➢ Impact on buildings and collections, and
- ➢ Impact on tourism and visitor economy.

#### 3.1.1. Disruption and Contribution

The restrictions disrupted not only heritage but also supply chains for food, health and manufacturing, impacting on the local economies [25]. Based on the ICOM survey on 7 May 2020, within two months of COVID-19 being declared a pandemic, 95% of museums across 107 countries had closed [26] and had to cancel and postpone cultural activities [13,27]. The cancelations included practices such as rituals and ceremonies [28] and wider programming of events and festivals [29,30]. The disruption to physical visitation weakened the user's connections, leading to loss of authenticity [29]. The alternative of digital interaction from home crept up as unnoticed 'digital colonisation' in people's lives [31]. Heritage is now reflecting on its own contribution; evidence exists of only limited innovation by heritage organisations to contribute to the overall effort beyond following the

restrictions, towards extra activities to fight COVID-19 or its health and wellbeing impacts (Section 3.1.7).

#### 3.1.2. Impact Variation for Types of Organisations

The review shows that heritage organisations' variation by size, governance type, registration/accreditation status, and more significantly indoor to outdoors spaces, all make a difference to the impact.

Unaccredited and smaller museums are more likely to not reopen, or to take longer to reopen, compared to accredited and larger museums. Local authority museums reopen more quickly, independent charity-run museums less so, and independent private museums even less quickly [32]. Sites having UNESCO listing recovered faster [33]. Large multi-site organisations with international visitors tend to recover faster than small independent ones [34]. High-profile sites tend to attract funding easier [35]. Liu and co-authors point out the significance of timing during the year, in 'the UK, the closure of heritage sites during the peak season (i.e., Easter until September) where organizations earn up to 70% of their annual turnover, resulted in a difficult situation. . .82% of heritage organizations reported high or moderate risk to their organization's long-term viability' [36] (p. 2).

Small cinemas and independent film producers have higher impact risk [13]. Cinemas for example, operated with significantly limited capacity due to social distancing even when restrictions were loosened [37].

Broadcasting online as an alternative is not equally popular. In Italy, the public surveyed showed that '40% would pay for a pop music concert, around 30% for musical, theatre, classical music concerts and opera and only 24% for dance shows' [13] (p. 40). In Malta, cancellation of planned programming for the initial closures severely affected freelance artists [38]. The real online audience growth has been on streaming sites noting high subscriptions increases, TV for accessing information and as a source of entertainment even if limitations of creating new content fashioned an increase in repeats, radio listening, and video game downloads [13].

#### 3.1.3. Impact on Teams

The loss of life included a lineup of heritage and culture professionals [39] and affected people's mental health [34].

Heritage crises planning is usually on likely risks such as fire, flood, and terrorism, and is managed through the emergency management plan and subsequent business continuity plans, but the COVID-19 crisis was not familiar. The risk registers normally deal with isolated issues, not complete closures [40]. 'Covid is . . .completely different. It is like a war. . .there's no end to it at the moment. . .' (participant comment in [40] (p. 11)).

Naramski in his study of European tourism sites found that 14% of managers believed their site was at long-term risk of closure [41]. Strategy now looked at flexible working and associated human resource operations, partnership needs, emergency preparedness, alternative income generation and collection access means, associated information technology infrastructure, and the skills required to deliver all these [42].

Staff and volunteers found themselves wearing masks, installing signage, conducting regular disinfection, and reducing public programming [34]. It was a nervous period in which staff and volunteers wearing masks felt negatively about other members and visitors who did not wear masks [36].

As people started adjusting to working from home, job security was a major concern [43]. In a Texan study, four out of five employees were able to work remotely, and one in three organisations had staff reduction [34] while in the V&A London case study an 11% staff reduction was recorded [44]. Also in the UK, despite the government support furlough scheme, the National Trust made 1767 staff redundancies due to COVID-19 [45], Based on ICOMs worldwide museum survey, 6% of temporary contracts were terminated or not renewed, 16.1% of freelancers had their contract temporarily stopped, and 22.6% of

freelance contracts were not renewed during the pandemic. The loss of volunteer support was also highly impactful [34].

The cultural sector is a fragment ecosystem, comprised mainly of small (10–49 staff) or micro- (below 10 staff) organisations. These small and micro-organisations are extensively supported by freelance self-employed people to provide expertise and capacity. In the EU, one-third of people working in the cultural sector are self-employed, and from those with permanent contracts, only three-quarters are employed full time. Short-term temporary contracts include many artists, and the workforce is supplemented by unpaid volunteers [13].

Different artistic jobs are affected differently, as a painter can paint in isolation, but a dancer would need to be part of a group. While writers can continue to write, book launches and sales were negatively impacted. Pandemic-interrupted projects affected contract staff, for example only 1.2% of Scenographers from The German Association of Scenographers were paid for their work, as their employer companies were in financial crisis [13]. Furthermore, the loss of income can affect disproportionally people who were already at a disadvantage, such as women and disabled people, growing inequality within the sector [13]. '. . .diverse workers saw larger reductions in hours during the pandemic than their white colleagues' [43] (p. 41).

> 'We found that women, people who experience racism, disabled individuals and those without higher education qualifications appeared more likely to leave the sector during 2020. . .younger creative workers (the under-30 s) were significantly more likely to leave creative occupations than their older counterparts. . .in music, performing and visual arts' [43] (p. 41).

Before job retention schemes (furlough) kicked in, staff health and wellbeing was affected due to job and financial insecurity, especially when they had dependents on them [40]. Whilst many people understood the positive process of furlough, others often felt expendable [40] creating a division between people still working on site, and people working from home or being furloughed [43]. Digital provision is often delivered by freelancers, and internal staff had to take on those roles without the training or skills available [38,46]. During furlough, the fewer people left active in the organisation often had to take more, new roles, and learn how to deliver those but often without any training [40]. Workers not furloughed who picked up extra roles felt burned out, particularly in small teams as found in many theatres for example [43]. Depending on the quality of the communication systems utilised, working from home had both alienating, and simplification (less travel, reduced office needs) effects, creating the opportunity for a more mobile workforce. [47].

Pay in the cultural heritage sector is generally lower than other sectors, and overall the cultural sector workforce is at high risk during pandemic-like crises [13]. Even when there is growth in the sector, renumeration is not reflected equally, especially for artists [38]. In the EU culture sector, the impact on jobs was the highest out of all industries, yet the government compensation for culture did not match the compensation levels to other industries [13]. Freelances were an at-risk group and the first ones to stop getting work [46]. Freelances felt not only the financial pressures but also isolated [43]. Privately operating conservators contracted by heritage also suffered loss of work and associated income [48]. Role changes occurred, visitor-facing roles appeared to be at risk, many people moved to other industries, and fewer people entered the cultural sector [43].

### Training and Support

Heritage organisations in general were very aware of the staff and volunteer wellbeing needs [40]. However, the lack of digital skills within heritage organisations became obvious, alongside the lack of investment required to develop digital skills [19]. [In]actions in the risk register need to be matched with staff training and capacity [40]. The Institute of Conservation provided ongoing training, support, and communications, demonstrating the value of professional networks during such crises [48] although it is not clear whether those resources are still accessible. The heritage workforce itself seems to be more fo-

cused on delivering engagement rather than developing its own skills to deliver such engagement [49].

Generally, the majority of heritage organisations do not have a digital content team [42] or digital infrastructure [46] to deliver an impactful and quality digital offer. Flexibility and ability in staff to take up new roles helped to increase digital content and digital engagement [38].

High-risk groups are the temporary contracted heritage skills specialists who require financial government support to survive lockdowns [50]. Additionally, the sector needs research on the role of freelances and wider cultural workforce in the cultural sector [43].

As a snapshot of how museum teams are coping post-pandemic, English museums during 2022/23 had four volunteers for every one paid member of staff; compared to 2019/20 (pre COVID-19), volunteer hours were 14% down and volunteer numbers 5% down. Further, 3% of museums did not reopen at all. Recruitment for volunteers and seasonal staff was difficult, while permanent staff struggled financially and some left the sector for higher paid jobs [51].

#### 3.1.4. Impact on Users

> 'One of the results of COVID-19 is grief. Grief is a response to loss, especially the loss of a loved one who has died, to whom there has been a bond or affection. Grief refers to a state of loss, while sadness is a reaction to loss' [52] (p. 478).

The pandemic expedited research on the role of heritage sites in wellbeing and wider social benefit [50,53,54]. Wellbeing as an individual construct relates to how one feels and functions, and as a social construct it relates to people holistically examining their lives [53]. There is evidence that engaging in cultural activity had beneficial effect on wellbeing, and reducing stress; often, distressed families looked at heritage sites for distraction from the stress of the pandemic [43]. Heritage site visits are associated with a reduction in stress and an increase in happiness, particularly when personal levels of wellbeing were low initially. Such improvement appears to be independent of the individual's appreciation of the historic environment [54].

When site visits were possible, restrictions such as face masks and social distancing negatively impacted the visitor experience, but visitors appreciated the safety reasons [36]. However, people wanted consistent rules at different sites [34]. The restrictions also deprived school groups of the physical experience of heritage sites [34].

Closure of heritage sites brough an interest to consider one's local heritage, and reopening was associated with visitor reflection on their motivations for visiting heritage sites [27]. Upon reopening, the word COVID on social media was associated with positive emotions linked to the freedom to visit [36]. This is confirmed by a participant on the impact of heritage sites to visitors' wellbeing, "Lockdown made me realise just how important these national treasures are to our wellbeing" [53] (p. 1117). Personal feelings during the lockdown included isolation, helplessness, and anxiety about the future, alongside a reflection on personal outlook and priorities, and having more family time [53].

Heritage site visitors during the pandemic did adjust their habits; they travelled less often than intended and used a car rather than an airplane or train [55]. Heritage site visits were the safe first steps towards re-engaging with the outside physical world; however, prebooking was not always welcome [53]. Three types of heritage experiences were identified during the pandemic; seeking learning, seeking wellbeing and entertainment, and seeking participation [42,46]. Engaging with other people and experiential learning has been important to people visiting heritage sites, so much so that inability to access formal learning interpretation and materials has not been detrimental to visits during the pandemic [53]. People with membership who previously visited heritage sites regularly felt more destabilised by the restriction to their routines [53]. Older people missed their annual and regular events more than young people did [27]. Pre-pandemic regular (3–4 times a year) heritage site visitors increased their visit regularity by a further 70% post-pandemic. Meeting friends and family at heritage sites was the main reason for visit-

ing pre-lockdown (42.4% of visitors), post-lockdown re-uniting with family and friends became almost the sole reason (83.5%). The authority of, and trust towards heritage sites and larger historic, managed spaces, made people follow the guidance and overall feel safer [53]. Even during partial restrictions, people did not feel safe travelling when infection rates were low; however, they felt safer in heritage sites compared to other places, as they tended to trust the measures, and even the historic setting. This can also be observed in religious sites [56] although perhaps such blind faith could cause carelessness in following precautionary measures.

The shift to online visits and digital experiences was significant, but with limitations. Even when the majority of a population has access to the internet, as in Europe, people do not necessarily have the capacity and equitable access [57]. Already interested audiences found digital content to engage with, but less engaged audiences remained less engaged [43]. Some museum programming does not work as well online, for either technological reasons or because it is designed to work in a shared community space [58].

A final consideration on users relates to community behaviour; communities can become divisive during crises, especially when government policy is inconsistent leading to loss of public trust [34]. Cultural meanings of past injustice were reignited during the pandemic 'most notably the toppling of the statue of slaver Edward Colston into Bristol Harbour' [23] (p. 172). The fear of contracting the virus has been associated with xenophobia and ethnocentrism [59] not helped by the 'then-president Trump's cruder language, like "kung flu" and "Chinese" virus that gave tacit consent to an ongoing wave of anti-Asian violence. . .included, tragically, the killing of six people of Asian descent, eight people in total, by a white gunman in Atlanta' [35] (p. 123). The recovery of communities relied in part on the prompt recovery of heritage operations. For many people, the extended stay at home has made them look more sensitively at the ordinary parts of life and have a more thoughtful perspective on heritage [31].

Back to normal, in 2022/23 English museums have seen increase in visitation to free museums and events, and a decrease in paid programming. Schools are struggling with funding trips, particularly the travel cost [51].

#### 3.1.5. Impact on Buildings and Collections

Heritage organisations have a dual purpose; whilst their visitor element impacts the local economy and their own financial survival, they also have an ongoing conservation set of operations to deliver [34].

The lack of staff in buildings led to issues with maintenance, conservation and security [29,60]. Works that stopped had an impact on ongoing conservation and maintenance needs, including the supply of materials [61]. In Malta, for example, travel restrictions blocked specialist conservation staff getting to the island [62]. Reduced nature-sites security and monitoring have led to increase in deforestation and other natural resources' exploitation [63] including mining, poaching, and vandalism [64]. Evidence shows that extensive parts of collections were not monitored during the pandemic [65]. Due to the overall restriction in movement, theft of artefacts generally reduced although it still occurred, and vandalism increased as sites were less monitored [66]. Research in conservation and ecology was also negatively affected [67].

Buildings also suffered from loss of visitor income that funds maintenance and repairs. Most organisations used emergency funding towards building maintenance and utility bills [68] but organisations that are not formally registered or accredited were affected more due to inability to access conservation funding [69].

Digital visitor engagement is a less-disruptive visitor approach to the fabric of the buildings and collections [62]. This can also include engaging visitors in monitoring remote heritage sites through submission of photos to help conservation, particularly in periods of reduced staff such as the lockdowns. Examples include the reporting of fallen trees and other damage [70]. Whilst some conservation work was achieved remotely, many daily monitoring and conservation tasks were not compatible with staff working from home,

with additional risk from leaking pipes and failing equipment [48]. A number of outdoors conservation roles did continue to work, but with some associated health risks [61].

There was a benefit, however, on wear and tear by the reduction in visitor volumes [27] and of air pollution which causes substantial deterioration on building materials such as stone, metal, glass and concrete [71]. Reduced air, land, and sea pollution, including 'human-generated sounds. . .manifested. . .as a seismically detectable reduction in ground vibration' [25] (p. 267). In 24 cities studied around the world, there was significant reduction in pollutants (PM10, $NO_2$, and $SO_2$) [71]. In Egypt, greenhouse gas emission reduced by 30–40% alongside reduction in air and water pollution ((Mostafa et al., 2021) in [72]). The reduction in tourism contributed to a dramatic reduction in pollution in cities but also in nature and the seas [28,63,73], and provided fragile environments a 'welcome respite' [74]. It also demonstrated that policy can intervene when needed to limit damage (physical and social) by overtourism and achieve a more sustainable balance [24].

#### 3.1.6. Impact on Tourism and Visitor Economy

The pandemic restrictions caused loss of tourism income for heritage sites, tour operators, hotels, wider communities [13,29,34,64], and for many other industries that rely on tourism [75]. The tourism sector is more vulnerable than other business sectors [76] as is all physical heritage that relies on displays and events [19]. The United Nations World Travel Organisation, and the European Cultural Tourism Network amongst others, published guidance for tourism recovery [76] as communities required tourism to restart so that their local economy could recover [34]. The impact was less severe in rural tourism areas [36] and countries with lower dependency on tourism [77]. Research across 20 European countries shows that camping grounds, motorhome and trailer parks had the least negative impact, and holiday short-stay accommodation was impacted less than hotels [59]. Limited mobility encouraged domestic visitation and longer stays [77]. The extra demand for outdoors spaces, however, caused over-tourism in some nature sites, causing management problems [34].

The restrictions prompted discourse about the over-reliance on tourism [36] which especially affected places relying on international tourism such as World Heritage Sites [33]. The infection risk changed the welcoming attitude towards global tourists [36] but also tourism organisations now need to better understand traveller's concerns on health risks [78]. The pandemic highlights the need to model tourism in a sustainable manner [28,79]. The literature on heritage tourism recovery is about fast recovery to the previous tourism levels [36] rather than heritage itself recovering or finding models of tourism that cause less financial and conservation risk to heritage or to the environment. Post-pandemic tourism needs to be community centred and inclusive [28] and to demonstrate social benefits as well as the economic benefits to a community [72]. It is an opportunity not only to plan tourism growth sustainably [28,80], re-think the impact of tourism and plan better spatial distribution, but also to educate tourists about their responsibility towards more sustainable visitation [33].

Whilst the tourism industry focuses mainly on growth, a shift from quantity to quality is also proposed [81]. However, such a shift can mean that tourism will become more expensive and elitist [82]. In rural areas, tourism could better integrate with farming and agriculture as a diversified economy that reduces community risk [28] and provides diversification to tourism seasonality [83].

The management of a heritage site involves high baseline costs [84]. The visitor income loss in heritage organisations impacted employment and organisational viability [24]. 'Museums which have grown increasingly dependent on visitor numbers and self-generated income, faced a very difficult time due to COVID-19' [44] (p. 90). USA museums lost $33 million a day, leading to cost cutting and risk reduction measures [34]. Lavy and co-authors' study in Texas shows that income loss was more severe in museums compared to outdoor nature sites, and in some cases outdoor sites had an increase in income. Donations was the main income stream, and it decreased overall as visitors felt the financial strain,

but again the donations decrease was much less in outdoor sites. Loss from programming activities had to be replaced by federal funding. The overall financial impact put many sites at risk of never reopening again [34].

Absence of diversification is a significant business planning flaw [44]. With a reduction in public funding, break-even budgets rely on user income-generation streams which disappear when sites are forced to close [85], such as cancelled events [80]. Over-reliance on private funding creates vulnerability [13,38] and the financial impact has raised questions about government funding priorities [23]. Considering the sea-level rises, coastal erosion, infrastructural development around heritage sites, plus looting and vandalism, there simply is not enough money to preserve the existing cultural heritage [82].

Innovative online sales such as the Fitzwilliam artworks wearing masks create additional income (Figure 1, [46] (p. 357)); however, the financial shortfall cannot be solved simply by moving heritage operations online [23].

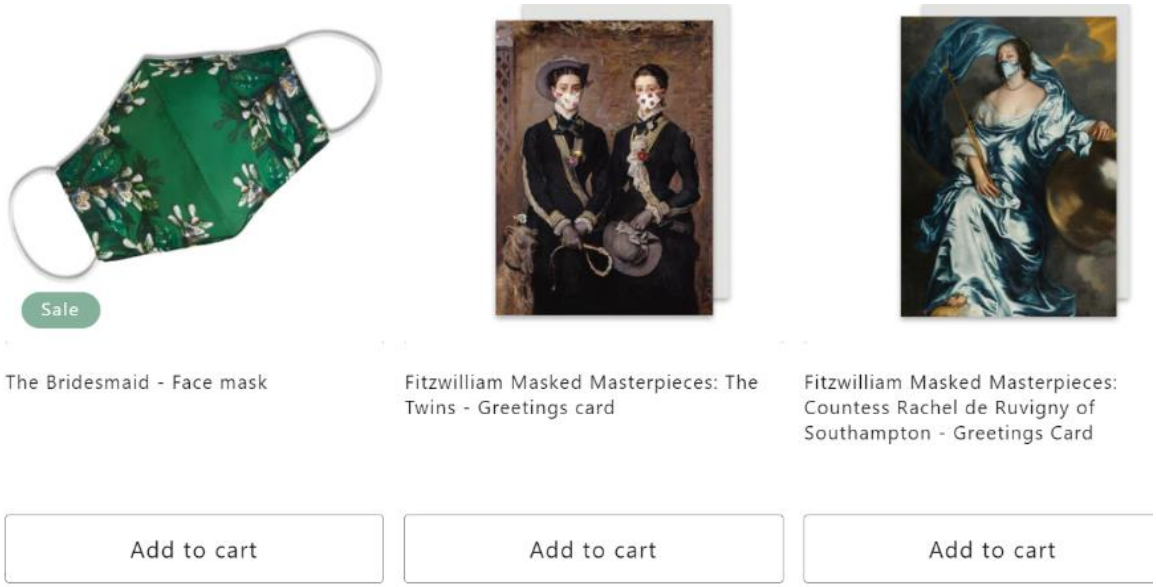


**Figure 1.** Fitzwilliam Masked Masterpieces. Image from https://curatingcambridge.co.uk/collections/fitzwilliam-masterpieces (accessed on 26 February 2024). Based on (Samaroudi, Echavarria and Perry, 2020, p. 357 Cards with artwork figures wearing masks from the Fitzwilliam Museum (Fitzwilliam Museum 2020)).

Existing financing schemes are not suitable for heritage organisations [38,50]. Instead, considering the precarious cash flow situation in heritage organisations, insurance cover against business disruption and income loss should be extensively utilised [84]. Additionally, tax reform was suggested by the Heritage Alliance as one of the government intervention measures [50]. The Heritage Alliance also pointed out that the financial impact on visitors was likely to result in a reduction in donations and memberships [50]. In the 2022/23 English museums' survey, two-thirds had higher operating costs whilst donations and admission income were down by 4% and 3%, respectively, as an indirect cost-of-living impact on museums [51]. Nearly half of the organisations surveyed in the UK had reserves to keep them going for six months or less time [49].

#### 3.1.7. Case Studies

Case Study 1: The British Library

The British Library was established through UK Government legislation via the British Library Act of 1972 (HM Government, 1972). However, there were some other important preceding laws and international agreements, which ultimately led to the British Library Act 1972.

The National Lending Library for Science and Technology, part of the British Museum, gave a gift of assets to the British Library in 1973 [86]. The new British Library was launched amid the world Oil Crisis of 1973–1974 [87] but it weathered the storm.

Forward to the year 2019, the British Library had 28.274 m total visits (1.597 m onsite visits; 26.677 m website visits), received GBP 96.9 m in government grants; GBP 8.6 m in donations and legacies; and had self-generated income of GBP 15.2 m [88]. At that time, the British Library had a strategy composed of six purposes: (1) Custodianship (conservation); (2) Research support; (3) Innovation support for Businesses and their growth; (4) Cultural engagement; (5) Inspiring Learning; (6) International Partnerships [88] (p. 7). The British Library estate change portfolio 'St Pancras Transformed', 'Boston Spa Renewed' and 'British Library North', were all in the pipeline before 2020 [88]. Additionally, the British Library had an established network of Business and Intellectual Property Centres within Local Libraries [88] (p. 5). Then came the COVID-19 Coronavirus pandemic in early 2020.

When COVID-19 struck, along with the associated lockdowns, the British Library used the six-point strategy and the estate change portfolio to manage the crisis. The British Library estate change portfolio consists of the St Pancras main Library site, the Boston Spa Newspaper Storage Building and a new British Library site in Leeds, (respectively, 'St Pancras Transformed', 'Boston Spa Renewed' and 'British Library North') [88]. Nationally significant (and nationally funded) heritage organisations, as seen in the British Library case study appear to be exceptions to the view that heritage organisations do not have a digital content team [43] or digital infrastructure [47] that is key to deliver an impactful and quality digital offer.

The British Library change portfolio uses the United Nations' Sustainable Development Goals (SDGs) to show where they could contribute towards sustainable outcomes. The SDGs adopted by 193 nations in 2015, are due to be implemented by 2030. Use of SDGs are most developed for the St Pancras Transformed and Boston Spa Renewed programmes. St Pancras Transformed clusters goals together and Boston Spa Renewed looks at individual SDGs [88] (p. 56). The 50th anniversary of the 1972 British Library Act, and the Development of the Knowledge Matters Strategy form part of this 'Change Portfolio'. The Infrastructure extension plan intends to extend the St Pancras site (which was opened by HM Queen Elizabeth II in 1998 by 100,000 square feet ('St Pancras Transformed' for culture, learning, and business [88] (p. 4)).

In 2020, additional British Library responses to COVID-19 included a rapid transformation of their model into a 'digital first' national library [88] (p. 7), via for example, the 'Heritage Made Digital' programme [88] (p. 11). This technological business management innovation would later have significant repercussions for the British Library, its visitors and staff.

With the majority of its income from the Department for Culture, Media and Sport (DCMS), in financial year 2022/23 the British Library received almost GBP 20 m more post-COVID-19 Grant in Aid from DCMS than in 2019 [89]. The annual increase in the DCMS grant, allowed the British Library to cope well during the COVID-19 crisis. However, the emphasis on technological change introduced a significant business management flaw.

The British Library suffered a major cyber-attack in October 2023 [90] (p. 1). Criminals copied and removed 600 GB of files, including staff and library users' personal data. The data were auctioned on the 'dark web' after the British Library refused to pay a ransom [90] (p. 2). Its systems and services suffered deep and extensive damage. However, following the cyber-attack the premises, exhibitions, events, and Reading Room access remained open. In the first two months (October 2023 to December 2023), the British Library research services were severely compromised and some search facilities have not returned [90].

Presumably because of COVID-19 and this cyber-attack, the British Library now has almost 2 m fewer visitors than in 2019 [89]. Total 2023 visits to the British Library (St Pancras site, Knowledge Centre and Boston Spa site and visits to the Library website, with the majority of these visits being to the website), were 26.515 m [89] (compared with 28,274 m visitors in 2019 [88]).

Case Study 2: The London Transport Museum

London Transport Museum (Figure 2) is a museum affiliated with Transport for London (TfL) and the Greater London Authority (a Local Authority). Although it receives a grant from TfL, which in 2019 was GBP 3.139 m, its trading activities raised GBP 4.445 m in the same period [91]). However, it is also reliant on other partners, including The National Lottery Heritage Fund; Arts Council England (ACE), as one of ACE's National Portfolio Organisations (NPOs) [91]; the Department for Digital Culture Media and Sport (DCMS); and HM Treasury [92] (p. 3). There were also 411,766 total visits to the London Transport Museum in 2019 [93].

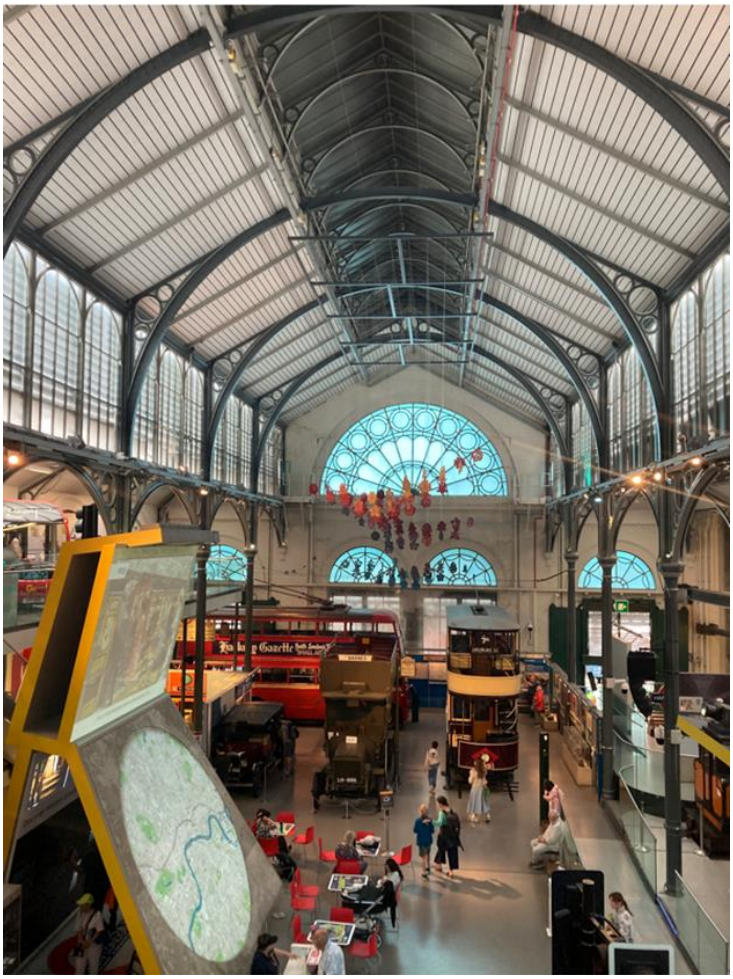

**Figure 2.** London Transport Museum Interior (Photo Courtesy of © Colin Seymour 2023).

In 2019, excepting the Audience Development Strategy, the London Transport Museum Strategy/Change Portfolio/Change Programmes were not obvious. The Audience Development Strategy and the Diversity and Inclusion (D&I) initiative, set targets to increase the diversity its visitors, prioritising ethnic diversity and socioeconomic classifications [91]. This approach changed when COVID-19 hit.

In the advent of the COVID-19 crisis, the London Transport Museum implemented a two year 'recovery' strategy, focussed on 'people, projects, and systems' [94] (p. 12). Being heavily reliant on income generated from visitors, it needed other sources of income during the lockdown periods. These income shortfalls were substituted to some extent by increases in the TfL grant, as well as in donations and legacies [94]. Evidence from the earlier literature that heritage site visitors adjusted their habits during the pandemic (i.e., travelling less often and more locally [55]) suggests changes in visitor segments, audiences,

and behaviours. A possible area for future research would be to examine how these changes impacted the London Transport Museum.

The fact that the London Transport Museum 2023's visitor numbers have exceeded the pre COVID-19 levels (respectively 435,628 and 411,766) and 2023 self-generated income is 54% higher than in 2019 (GBP 6.850 m versus GBP 4.445 m), are evidence that the recovery strategy has been very successful. The 2023 and 2019 visitor figures are from ALVA (2019) [93] and (2023) [95]. The 2019 and 2023 income figures are from LTM (2020) [91] and LTM (2023) [92]. Considering the London Transport Museum as a large museum operationally, compared to the wider museum sector, the literature suggestion that large multi-site organisations with international visitors tend to recover faster than small independent ones [36], is supported by the London Transport Museum case study.

Case Study 3: The Theatre Royal Drury Lane

The Theatre Royal Drury Lane (Figure 3) was first erected in 1663 by Thomas Killigrew under a Royal Charter from King Charles II [96]. The Theatre Royal Drury Lane is owned by LW Theatres Group Limited, which is itself owned by Really Useful Theatres Entertainment Limited. The LW Theatres Group Limited also manages the London Palladium and provides head office functions and ticketing services to other theatres within the LW Theatres group.


**Figure 3.** Theatre Royal Drury Lane—Lord of the Rings. Photo courtesy of Andy Roberts, available at: 'Theatre Royal Drury Lane—Lord of the Rings' licensed under CC BY 2.0 (accessed 18 March 2024).

However, unlike the other case studies so far, The Theatre Royal Drury Lane data (audience and financial) are amalgamated with theatres in the LW Theatres group. Separate audience and financial data for The Theatre Royal Drury Lane are not publicly available. Potentially, this absence of data suggests an area of future research.

Although The Theatre Royal Drury Lane closed from 19 January 2019 for refurbishment work, the group 2019 audience and income figures were 841,000 and GBP 34,670,000,

respectively [97]. The Annual Report and Financial Statements for this and subsequent periods, show no government 'grants' or 'donations and legacies'. So, LW Theatres Group finances are mainly based on audience attendance.

Understandably, when the COVID-19 pandemic arrived along with the associated lockdowns/theatre closures, the group finances were hit very hard. In 2020, LW Theatres Group venues closed for 15 weeks due to the pandemic [98] and made a GBP 7 m loss [98] (p. 11) audience figures of 527,000 [98]. Refurbishment work at The Theatre Royal Drury Lane cost GBP 24.7 m [99] (p. 2). In contrast to heritage organisations that used emergency funding (e.g., for building maintenance [69]), LW Theatres used some debt financing.

The following year, 2021, was even more damaging. In 2021, LW Theatres Group venues closed for 37 weeks due to COVID-19. It made a GBP 15 m loss [98] (p. 11) on audience figures of 28,000 (LW Theatres Group Limited, 2021). Continuing refurbishment work at The Theatre Royal Drury Lane cost a further GBP 18.6 m [98] (p. 2).

The Annual Report and Financial Statements for Financial Year 2022/2023 have not been submitted to Companies House yet. However, it will be very interesting to see how the LW Theatres Group has fared since the 'end' of COVID-19. The Theatre Royal Drury Lane refurbishment work was completed in July 2021 [99]. LW Theatres Group Annual Report and Financial Statements for Financial Year 2021/2022 are very promising, showing income at GBP 88 m, with associated audience figures of 1.281 m across the group [100].

Case Study 4: Kensington Palace

Historic Royal Palaces (HRP) (Figure 4), established in 1998, is a Royal Charter Body with charitable status. HRP cares for, conserves and presents to the public, the unoccupied Royal Palaces: HM Tower of London, Hampton Court Palace, Kensington Palace State Apartments, the Banqueting House at Whitehall and Kew Palace with the Royal Kitchens, Queen Charlotte's Cottage, and the Great Pagoda. HM The King owns these palaces in right of Crown. HRP, contracted by the Secretary of State for Culture, Media and Sport manages the five London palaces on behalf of the King. The current contract expires on 31 March 2028 [101].

**Figure 4.** Kensington Palace. Photo courtesy of Sergii Gulenok, available at: 'Kensington Palace' licensed under CC BY-NC 2.0 (accessed 18 March 2024).

The Kensington Palace financial data are amalgamated with HRP sites. This absence of data suggests an area of future research. Kensington Palace attendance data are available via the Association of Leading Visitor Attractions (ALVA).

In 2019, attendance at Kensington Palace was 510,304 visitors [93]), with self-generated income for all HRP sites of GBP 105.43 m. Additionally, the HRP sites received GBP 4.46 m grants and GBP 2.08 m in donations and legacies [102].

In the following year (2020), the COVID-19 pandemic and associated lockdowns reduced Kensington Palace visitor numbers tenfold, to 55,557 [103]. Although, self-generated income for HRP palaces remained high at GBP 101.81 m, along with GBP 728 k grants and GBP 2.49 m in donations and legacies [104].

While 2021 showed an increase in Kensington Palace visitor numbers to 196,355 [105], overall self-generated income for HRP palaces plummeted to GBP 32.69 m. At that time, HRP palaces benefitted from much needed GBP 20.55 m grants and GBP 509 k in donations and legacies.

Likewise, in 2022, HRP palaces received GBP 10.37 m grants and GBP 939 k in donations and legacies [106], with Kensington Palace visitor numbers at 294,043 [107].

Although Kensington Palace 2023 visitor numbers (421,697 [95]) have not returned to 2019 levels, HRP 2023 finances have bounced back, with self-generated income of GBP 102.47 m [106]. Correspondingly, in 2023 HRP received less in grants (GBP 1.42 m, [106]), with donations and legacies at GBP 1.89 m [106]. Concerning the discussion about the over-reliance on tourism [36], it seems that either HRP have diversified their post-pandemic income streams, or that they have revised their value propositions, or that there has been a change in visitor segments. Further research in this area could suggest one or more of these, or something else is responsible for the HRP financial recovery. This would provide further evidence of heritage organisations needing to diversify their business models and adapt to changing circumstances [44].

### *3.2. Calls for Review in the Sector*

The calls for review in the sector relating to COVID-19 are presented next, within three themes: a call to critically review the sector, understanding the ethics of COVID-19, and to evaluate the intervention roles of the government and the heritage sector support.

#### 3.2.1. The Call to Critically Review the Sector

During the pandemic, the heritage sector came together to share expertise [40]. It showed conviction on its cause and survival, by building partnerships to share information and expertise, based on its shared aims, and balancing out weaknesses [13]. Heritage organisations also reached out more; they researched and listened more to their local communities [43]. The pandemic forced sites to communicate to users more timely and methodically [33]. And the natural environment was able to recover [29].

But the COVID-19 pandemic also increased the political instability around the world [24] and the political discussion became a blaming game [108,109]. Previous crises such as the influenza of 1918–1920 happened in a different world, before economic, travel, and information globalisation [25]. The COVID-19 pandemic occurred over much longer timescales compared to earthquakes or floods. Yet, recovery has similar processes of focusing on public health, followed by reestablishing critical services and then rebuilding local economies [34]. The pandemic reminded everyone in heritage management that the preservation of material heritage is an enormous and potentially impossible task, especially with climatic changes; the need to rethink heritage management due to the pandemic asks how much can realistically be conserved [82] and perhaps makes it more urgent to digitally record and provide virtual access to collections. The pandemic widened the gap between sustainable development objectives and the realistic ability to deliver those objectives [72]. As such, in heritage the shock is likely to initiate 'a "reset", rather than a simple "bounce-back" or return to preCOVID-19 aspirations [110]. The physical restrictions have altered perspectives on the value and purpose of heritage [111]. As heritage was so affected by COVID-19, we must question the way it is studied, managed, and used [112].

The nation-based heritage endorsed by UNESCO perpetuates the patriarchal, nationalistic, and materialistic elements of heritage, and makes it harder to deal collectively with

complex human issues during a crisis [113]. Heritage has been used politically to reinforce a sense of the '. . .''supercitizen,'' to use Honig's term from her 2001 book Democracy and the Foreigner' which unites people against an external threat, rather than unite people towards common goals [35] (p. 124).

Criticism is being raised about the commodification of heritage to the detriment of collectively addressing common human challenges [108]. There is a need to evaluate the over-reliance of heritage as tourism for income generation [82], even parks now rely heavily on commercial income from parking, concessions, and events [114]. There is also an over-reliance on weekend events associated with short stays away from home, all happening around artefacts and spaces that are already fragile [82].

The lack or inability of planning during the pandemic was evident, in Ireland for example only 25% of museums had a recovery plan [115]. The pandemic also exposed the poor HR provision and pay levels in the sector prior to the pandemic [43,116] and the need for training and development in business and HR functions [43]. Not all staff and volunteers were kept informed and engaged, even with improved communication and expertise sharing during the pandemic [40].

In addition to timing issues in the ability to plan, space also needs rethinking. Future design of physical spaces in heritage sites needs to consider visitor volumes, displays, visitor flows, and their purpose, as 'slickly designed visitor centers are more entertainment than civic discussion' [82] (p. 474). Even city centre regeneration needs to be reevaluated post-COVID-19, as it can only preserve facades, not communities [82]. Finally, the extensive volume of heritage sites was not generally used in preventive actions during the health crisis. The limited use included some heritage sites as vaccination centres or emergency places, field hospitals (community centres and halls, exhibition centres, concert halls) and pop-up testing centres (also set up in exhibition centres, and sports stadiums, community centres, church halls and show grounds). Such testing stations often utilised event marquees and traffic control equipment that sites already had for visitor services [4].

What should the role of museums and other heritage sites be during and after a crisis? Marcia Bezerra [31] answers with the 2019 International Council of Museums definition of the museum, to '. . .contribute to human dignity and social justice, global equality and planetary wellbeing' (ICOM 2020) [31]. It is an opportunity to review inclusion relating to digital engagement, and the importance of nature to health and wellbeing [68]. To view the COVID-19 impact on heritage as a universal call not only to saving lives but also to a 'life worth living' [113]. UNESCO asks heritage to fight for a sustainable future and for a new world reflecting our shared needs and shared future [117]. Silberman asks of UNESCO to represent local and global intangible heritage such as inequality, war, and hatred, not nationalistic bounded traditions [82]. This is in accord with Butler asking a human-centred world, moving away from nationalistic approaches to managing heritage [113]. To deal with existing and future global crises, a global society will benefit from experiencing of a heritage that reflects the multiculturalism of communities, not the harmful nationalistic attitudes that nurtured imperialist and colonialist attitudes [82]. Holtorf champions '. . .Richard Sandford's (2020) contemplation whether the legacy of COVID-19 might be "a new sense of ourselves as moral actors" (p. 59) in resetting the role of heritage as the unifying and collaborative driver for a sustainable future for humanity [108].

There is a call then to stand back and rethink [18], and to make informed and long-term decisions [43]. This is an opportunity to reflect on the sector [18,36,118] refocus on sustainable development and find solutions to overtourism [82,111,119]. Heritage needs to develop a better understanding of the contribution of heritage towards physical and mental health of individuals and communities [13]. Ongoing research is needed in preventing and managing similar viral disease [120] and heritage could then help to build community awareness and planning for prevention and coping during pandemics.

UNESCO urges for a holistic approach by focusing on five key areas that feed into an inclusive, diverse, and sustainable ecosystem: policy, values propositions, technology harnessing, support provision, and informed evidencing (Figure 5) [117] (p. 49).


**Figure 5.** UNESCO COVID-19 Culture in times of COVID-19: resilience, recovery, and revival strategy, p14. Source: https://unesdoc.unesco.org/ark:/48223/pf0000381524 (accessed on 14 February 2024).

Community participation and engagement in planning and implementation are useful approaches, during and following a crisis [65]. The post-COVID-19 era should have '. . .an emphasis on processes of collective memory rather than things. Localism will be an increasing element in cultural heritage appreciation. . .cultural heritage will be where people live, not where people visit' [82] (p. 473). Rethinking heritage contribution at the local level, will also make it less vulnerable to such crises [112]. Local communities need to build their skills in sustainable development and associated infrastructure [28], and heritage organisations could be core to the community skill building. Yamada and co-authors propose that heritage organisations need to better understand their local communities, particularly the vulnerable ones, and to make a concerted effort to fully engage with young audiences [27].

There are many small changes that can also help. Archaeology is key active learning [121] and can contribute to public engagement during lockdowns with back garden digs and digital community projects [23]. Heritage can explore lesser known collections through digital [122] and by moving away from blockbuster exhibitions and better use of permanent collections for temporary exhibitions [18].

A rebalance is needed of physical and digital in all aspects of heritage management; research, planning, and operations [30]. Walmsley proposes '**regenerative modes of working. A regenerative approach would carve out time for the positive initiatives that we witnessed across the cultural sector during the pandemic:** revisioning and restrategising, professional and network development, reflection and evaluation, play and innovation' (highlighting in original [43] (p. 68)). And the sector needs to plan by keeping in mind that environmental protection, heritage, tourism, and wellbeing are interconnected [115].

The heritage service is diverse and intangible, making it difficult to change [56]. COVID-19 has taught us that the future requires creative participation in change, rather than stubborn conservation of past mistakes [82]. Heritage can develop new ways of communicating, working, and supporting other organisations in the sector [61].

### 3.2.2. The Ethics of Curating COVID-19

'The National COVID Memorial Wall outside St Thomas' Hospital in London features 150,000 hand-drawn pink and red hearts to represent those who have died after contracting the virus and stretches nearly five hundred meters between Westminster and Lambeth Bridges' (Figure 6) [35] (p. 133).

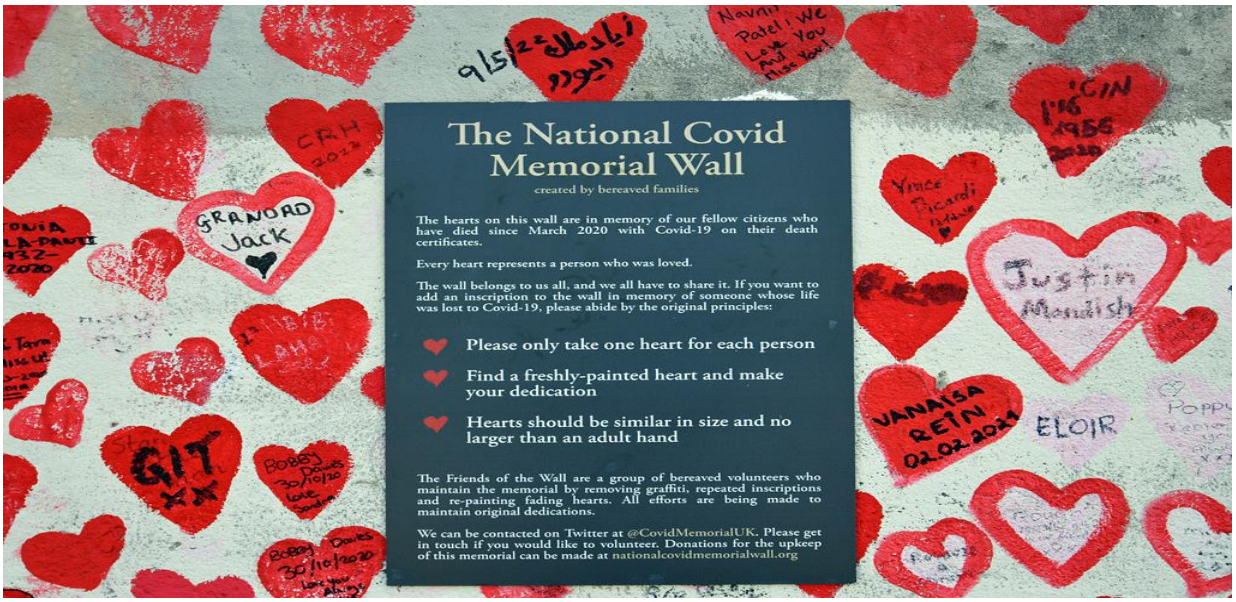


**Figure 6.** COVID Memorial Wall/2022. Image by George Rex Creative Commons https://openverse.org/image/b1b75076-86e6-436a-8f2a-92fdb1c2af03?q=covid%20Memorial%20Wall (accessed on 25 February 2024).

'A sense of urgency in the collective push to commemorate victims of COVID-19 has produced a more piecemeal, ad hoc, and hence unpredictable politics of memory. Faith leaders, politicians, and family members of victims hurry to integrate their own sense of loss into a broader, more purposeful narrative' [35] (p. 133). The New-York Historical Society, Museum of London [35] Old House Law Museum, and National Museums Scotland [4] raced to collect and reveal COVID-19, with the Irish and British Archaeologists launching the Viral Archive (2020) [108]. Spennemann 'posits that the social and economic impact of COVID-19 is so profound that the pandemic will become the focus of public exhibitions in the future' [123] (p. 29). He then builds up a picture of what the preservation of a

COVID-19 temporary structure would be; not just the physical objects but also contextual documentation about the rationale for it, its planning, staff rostering, sample collection protocols, etc., providing a more permanent representation of a temporary event [4]. Bezerra sees museums as places to reflect about the pandemic, the isolation, the masks, and the feeling of blame for neglect that caused loss of people close to us [31].

Angelo and co-authors ask how ethical is it to collect during a pandemic, the signage, masks, barriers, and other physical evidence of such a tragic event? They point out how little material, including archival record there is from past pandemics. And if one collects such evidence while it is all around us, how soon is it ethically appropriate to exhibit such reminder of human loss? [73]. Hoskins and Maddern ask further, who should be asked about being involved in such discourse? How is such quarantine affecting us and how does it relate to historic quarantine and migration sites? Will the story be about hand sanitizers and home-made masks, or about the inequitable distribution of vaccines? [35].

Are heritage organisations discussing and interpreting social changes such as our readily acceptance to be tracked in mass? [124]. Holtorf expresses disappointment that heritage engagement was mostly about respite and escapism, and not enough about discourse on the core troubles and concerns people had [108]. He further urges heritage to move on from its main use as nationalist pride and economic development, and to serve in connecting humans over a world heritage [108]. Lerario encourages museums 'to transform their collections from 'objects' into 'subjects' of communication' [26] (p. 3075). This is in accord with many museums slowly moving away from exhibiting for financial reasons and now are 'activating collections', and invite community participation and co-curation [43] (p. 64).

#### 3.2.3. Government and Sector Support Intervention

The Network of European Museum Organisations recommendations for supporting museums in respond to the pandemic were: the provision of urgent funding support, investment in digital infrastructure and skills, and making museums fit for any future crisis [38]. In the USA the Coronavirus Aid, Relief, and Economic Security Act (CARES Act) provided support during the pandemic to non-profit organisations and small businesses [34]. The UK Government Job Retention Scheme ('furlough') had positive impact on peoples job security, which affects financial security and health [40] alongside a GBP 1.57 billion emergency government funding pot to support the sector [43,68,125,126]. UNESCO recommends that 1% of government expenditure should be allocated for culture annually [127]. In the UK during 2022/2023, 0.39% of government spending was on culture (one-twelfth of what was spent on Defence), and even in 2020/21 with the provision of emergency funding, the percentage was 0.44% [128].

From across the world there is evidence of lack of government coordination [40,43]. Pressure on the UK government to reverse policy and open outdoor attractions, including zoos, was needed and was eventually successful [40]. By the time the government confirmed that parks could stay open in England, one-quarter of them had already closed [85].

The sector asked that sufficient notice for reopening is required [129]. The variation between regional and national restrictions, lack of staff and volunteers, and distancing limitations affecting capacity, meant that one-third of attractions in England did not open directly after the lockdown ended [36]. Disconnected but overlapping strategies and guidance were a common issue [67] as governments had to balance protection of the vulnerable with minimising negative economic impact [23]. Overall, the contradictory guidance impeded recovery [34]. Government guidance has to be clear, consistent, and aligned between local and national government [34].

Sector support organisations such as the American Alliance of Museums, the Museums Association in the UK, and the International Council of Museums (ICOM) looked at categorising levels of risk and prioritising responses; online access to collections was a key theme [46]. Another theme was that the high-risk group of freelances needs policy to reflect fair pay, and the sector to understand and support graduating artists [13].

### *3.3. A New Space*

The immediate effect of COVID-19 on space was emptiness; of airports, public buildings, and shop shelves due to panic buying [130]. The impact themes show that change did not result in a new normal but in the need for a new space, consisting of blended space (physical and digital), mixed space (indoors and outdoors), and community of practice space (isolated or cross-sector networking space).

#### 3.3.1. Physical Spaces

During the lockdowns, there was decreased travel and increased time spent at home, and people started seeing personal time and space from a different perspective [27].

When limited access was permitted, changes to site visits included face masks, contactless payment, sanitising all surfaces, social distancing, body temperature checks, vaccination passports [76], QR codes for registering visits to trace positive cases [124], prebooking for timed entry, plexiglass screens, removal of interactive displays, and the appearance of collection-based facemasks in the museum shops [18]. The changes raised practical issues such as 'how do you deep clean a sand pit?' [18] (p. 298).

Documentation, information leaflets, ticketing, membership subscription, and payment became contactless [13,75,124]. The lockdowns interrupted but not stopped long-term development projects [44] nor quinquennial inspections [131]. Site staff and volunteers used digital technology to work from home [42]. Break-ins, damage and theft, including of lead from church roofs, was widely reported during lockdowns [132].

Social distancing, face coverings and hygiene processes were welcome and expected in indoor sites. In outdoor sites, those actions were less relevant [36]. Visitors are generally positive about protection measures but these have to be applied consistently across sites [36]. Heritage sites need more engaging ways to communicate such measures to visitors [83,133] and when sites have implemented and communicated well the measures, they see increase in visitor confidence, satisfaction, and return visits [56,134]. Furthermore, people who visited previously are more likely to visit during a lift of restrictions [56].

Rarely disrupted events such as religious ceremonies were affected [27], which was a particular issue in areas with limited or no online alternatives to physical attendance [83]. And associated sounds were suspended, such as bell ringing in churches or the prayer broadcast from mosque minarets that changed to urged people to pray from home instead [25].

In heritage research, fieldwork was interrupted [31], particularly for research participants where extensive travel or large areas were involved, whilst back-garden and in-isolation research increased [70]. More digital research networks, however, were created [67].

Traffic in the air, on ground, and sea reduced [25]. When travel was permitted, people chose destinations near home or in neighbouring countries, often using private transport and visiting rural and outdoor destinations more [59]. The impact on community lives included the cancellation of sporting events, from football to Olympics, and of festivals, concerts, exhibitions, and annual events like Christmas markets [135]. The SARS-CoV-2 virus infection was more severe in cold weather, hence winter destinations were more impacted than summer ones [41].

The pandemic created a less physical world in which the 'hug' becomes a historic artefact [31]. Concerns were raised that public transport such as bus services could disappear in remote areas where they were already financially at risk [136]. By expanding online meetings, our personal spaces have become backgrounds in our work and study [31]. 'Cultural consumption' takes place not in the museum settings but in our homes, and competes with our daily activities [26] (p. 3074). With the restrictions during COVID-19, we have gained a new perspective about material heritage, physical access and mobility [24].

During the lockdowns and recovery following reopening, indoor sites have been affected by restrictions much more that outdoor sites [36]. After a slow return initially, parks and natural heritage sites experienced increased visitor numbers compared to preCOVID-

19 years [34]. Outdoor versus indoor provision was a factor in the ability to cope with the pandemic [34], particularly as restrictions in travel and indoor spaces prompted people to use local parks [125]. The moto 'Visit your local park, Protect the NHS, and Save Lives' demonstrates the importance that open spaces had during the pandemic [114]. Nature sites had a marked increase in visitor numbers; however, this created staff shortage issues, littering, and erosion [68,77]. It is important, therefore, for all sites to consider and calculate their visitor carrying capacity [137] including the management of visitor volumes in historic cities [138]. Existing options can be developed creatively, Vrasida proposes the extensive development of underwater observatories and diving to explore underwater natural and cultural heritage as an alternative experience that still follows restriction rules [139]. Furthermore, the increased use and appreciation of open spaces is creating an increase in open spaces' stakeholder collaboration [29]. Baggot asks that the visioning process for green spaces is 'based on principles of social equity, sustainability and public health' and enabled by collaboration [85].

The governments' restriction approach towards indoor and outdoor spaces varied [36]; therefore, heritage organisations should plan for each type differently and aim to maximise outdoor space uses during pandemics. Outdoors, however, was not the only alternative to indoors limitations. Digital space was called upon to supplement physical engagement [140]. Even before the pandemic, the vulnerability of physical heritage had called for the development of digital engagement [19]. The necessary changes made due to the pandemic in online and outdoors use can aid long-term sustainability and these need to be built in business models and to be continuously developed [34].

#### 3.3.2. Digital Space

When the pandemic was declared, there was a clear lack of digital expertise to provide online content [141]. This was particularly noticeable in developing countries which lacked the digital infrastructure and skills to provide equitable alternative engagement [46]. The pandemic found museums lagging behind in digital planning and skills as they realised they needed means to communicate, interpret collections, and raise funds [46]. Even though sites had social media before the pandemic, it was common to have no updates from the sites for months [142]. Museums had been reluctant to fully embrace digital contact until the restrictions on physical contact forced their hand [26]. Organisations with prior digital engagement experience had a clear advantage when the lockdown was implemented [43].

Heritage has not been alone in accelerating digital changes. 'One major impact of the lockdown during the COVID-19 pandemic has been to speed up online provision across the education sector, from teaching five year olds to universities' [18] (p. 156). The significant development of collections digital engagement was not initiated during but before the pandemic [44]. The physical restrictions, however, became an accelerator for digital technologies adoption [24,71,142] and opportunities for 'digitization and transmission of knowledge' [30] (p. 1).

Kużelewska and Tomaszuk discuss the sharp increase in internet users globally from 2008 to 2019, by 2.5 billion people [57]. Using recent information from Statista, we see that at the start of the pandemic, around 59% of the world population used the internet and that did not change dramatically during the pandemic, and the increase continued afterwards, reaching 66.2% (two-thirds of the world population) using the internet by January 2024 [143].

Through online meetings, websites, and apps, people brought heritage home, changing habits and perspectives. Interacting online from one's familiar space creates an openness in interaction [31]. And full of hope, people marked favourite digitally visited sites to physically visit when allowed to return [144].

Website pages saw an initial reduction in online visits when physical sites closed, as people were not looking at opening hours or similar visitor information [145]. Even then, website visits were usually a few seconds short [146]; the use of collection pages and databases, however, used for research by academics, students and general public was

higher during the pandemic compared to pre-pandemic use [145]. The online retail sales increased during the lockdowns and now could reach worldwide audiences [44].

During the pandemic, there was a significant increase in provision and use of digital offer [34] and an increase in associated public engagement [46,147]. This extended contactless access to heritage spans from ticket booking, virtual tours, virtual classes and workshops, and story times [34] to '. . .immersive reality headsets (augmented reality, virtual reality and mixed reality) and handheld devices equipped with a higher graphical computation, positional tracking sensors and rendering capability. . .' [142] (p. 204).

The online content included use of previously digitised resources (online collections and exhibitions, virtual museum tours, 360° tours, publications, performances, games), digitisation of programming during the lockdown (live and recorded broadcasting of performances and talks), increased social media activity (including use of YouTube and SoundCloud), and lockdown-related activities offering behind the scenes views of collections and heritage operations, or inviting participatory co-creation of artistic and educational activities online [42]. The American Alliance of Museums themed four types of digital experiences during the 'pandemic crisis: (i) "unique campaigns and series on social media"; (ii) "engage in real-time with live streams"; (iii) "virtual tours"; and (iv) "virtual and artificial reality" ' [42] (p. 367).

Museum social media presence had a significant increase during the pandemic [44]. A whole range of hash tags on social media such as #ClosedButOpen were used to maintain communication [42]. Users on social media engaging with cultural heritage content applied positive and reassuring terminology [36].

Funding contributed to the transfer of physical performances online, an example being the project funded by the National Lottery Heritage Fund that enabled St-Martin-in-the-Fields to keep singers in employment by delivering concerts online [68]. Theatres, music festivals, operas, and other performative arts released shows through social media and on Zoom [146]. Images and video were particularly useful content for collections and educational digital content [46].

Mainstream media have existing accessible and wide audiences. The Museums Association and the BBC demonstrated how this can be used for a successful cultural provision, through the Culture in Quarantine service that was available across radio, television, and digital platforms (Figure 7) [148].

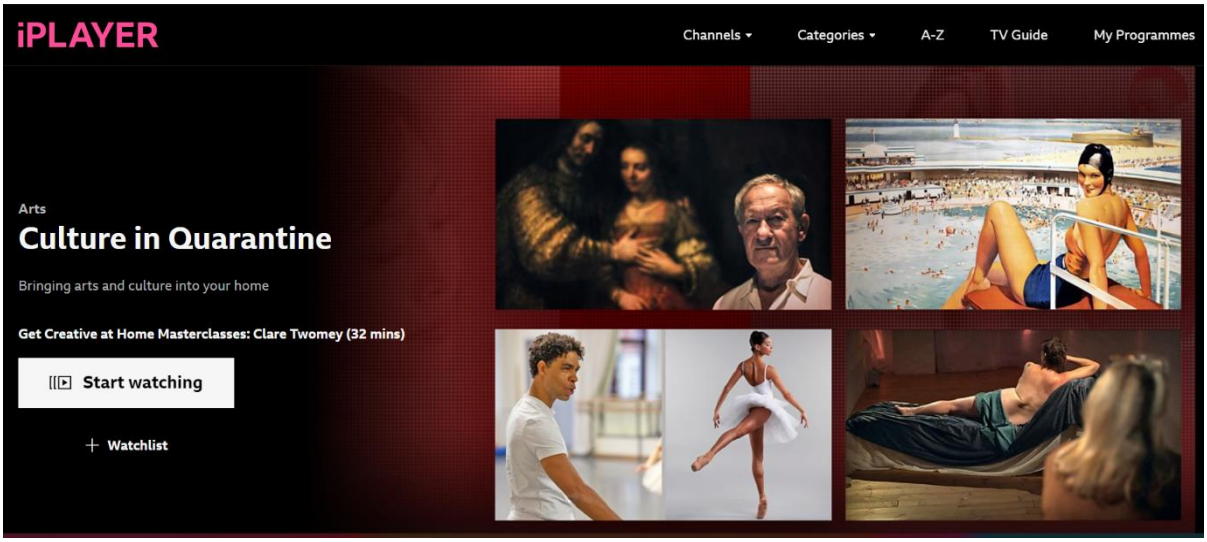


**Figure 7.** Culture in Quarantine Digital culture provision between the Museums association and the BBC. Image: https://www.bbc.co.uk/iplayer/episodes/p088hhjd/culture-in-quarantine (accessed on 26 February 2024).

A good example of extensive and quality digital presence is provided for Benaki Museum in Athens, by Boutsiouki and Damou. The Benaki Museum combined online presence utilising 'international cultural platforms, such as the Europeana and the Google Arts', website digital access to collections and archives, alongside '360° virtual tours of all galleries that are supported by an audio guide in six languages', and multimedia period and collections themed productions [42]. Google Arts is also mentioned by Tsichla for its ability to share cultural contact digitally to worldwide audiences [149].

A good example of a virtual exhibition[2] is the digital transfer of "Rembrandt and Amsterdam portraiture, 1590–1670" by the Museo Nacional Thyssen-Bornemisza, Madrid, Spain, which created a 56% uplift in online visits [38].

In European heritage sites, virtual tours were the most popular online content [41]. However, the provision of 360° virtual tours or similar experiences during the pandemic was very low, with only 2% of heritage sites in the USA and 3% in the UK offering such digital experiences [147]. The 360° tours are found at 40% of multi-site museum organisations and at only 11% of micromuseums [150].

Digital enabled heritage to maintain contact with its users to market itself, to provide online shopping, and access to online events [151]. Online calls to support heritage sites financially through donations, online shopping, memberships, and gifts, were present in most heritage organisations digital content [46]. It also provided wider learning prospects and more importantly increased 'the intention to revisit' [6] (p. 5). Digital was particularly useful to maintain engagement with schools and with local communities, and preparing those audiences to return on site once open [43]. In the UK and USA, history and art-related institutions offered more digital content than science/natural history ones, and libraries offered the least [46].

Continued digital engagement also enabled heritage organisations to discuss contemporary issues [46]. Content around wellbeing and emotional support was highlighted as a priority by international heritage organisations, yet such provision was very modest and there is little evidence of digital content serving the specific needs of vulnerable groups. A good example against this trend is from the Manchester Museum's wellbeing 'Cultural First Aid Kit' for hospitals and care centres [46] (p. 352). There are examples of heritage organisations providing critical thinking discourse through social media and wider digital content, this mainly related to sites that represent difficult heritage such as the Auschwitz Memorial, Anne Frank House, and the International Slavery Museum [152].

Government members were understandably keen to show off the vast range of heritage experiences that can be accessed 'without ever leaving your living room' [153]. User-friendly ways to access multi-site digital content is Bloomberg Connects which provides access to 'thousands of hours of content from 350+ institutions, for free' [154] and the Irish Museums Association webpage[3] showcases the digital offer of its country by listing links to a range of Virtual and 3D Tours, 360° Visual Tours, Audio/Video Tours and Podcasts, Online collections and Exhibitions, Creativity and Learning Resources [155].

But the increase in online content was not easy. The need for increased use of digital technologies faced limited digital skills and small digital budgets [77]. The urgent increase in digital services was delivered by staff having to take new responsibilities [46]. Digital content that utilised existing methods such as hashtag, minimal cost, and few skills, were utilised the most, whilst resource-heavy methods such as podcasts and live streaming were used much less. Where there was organisational capability to reallocate resources, it boosted the increase in online content provision, which in turn increased online visitors [38]. Heritage organisations urgently learned how to utilise social media as spaces of co-creation with users, and online content such as photos become cultural heritage collections that reflect the public mood and the types of technology being available [156]. By developing considerable digital content, many heritage sites from non-English speaking countries reached worldwide audiences [157]. The lack of skills and budgets was more impactful in volunteer-run museums as only one in ten offered digital educational content, and their social media and video content was also significantly lower than museums with

paid staff [150]. A total of 20% of European heritage sites studied by Naramski and co-authors did not increase their online presence, due to lack of expertise or capacity [41]. Smaller organisations and festivals did not have the capacity or resources to convert their programming to an online offer [43].

Digital technology was used to develop digital skills, from induction training [34] to webinars, podcasts, daily and weekly online briefings that were shared regularly and extensively by the sector support such as the Association of Leading Visitor Attractions, Museums Association, Association for Cultural Enterprises, Association of Independent Museums and The Heritage Alliance [40]. Furthermore, heritage organisations increased use of technology for conservation monitoring [71] and even explored AI for exhibitions [158].

Digital access was also boosted to share operational knowledge and processes about managing heritage organisations during the pandemic; the EU presents strong examples of knowledge banks for COVID-19 and cultural heritage management and research, including country reports, interview series, online initiatives, financial measure by country, reopening measures, and a wide range of other resources [159].

### Digital Development

Based on the 2020 National Lottery Heritage Fund survey, COVID-19 related restrictions created three key priorities for the use of digital technology in the UK museums: '(a) marketing, fundraising and communication purposes; followed by (b) content development; and (c) community building online' [46] (p. 340).

Social media has been upgraded from a distraction to main stream engagement [23] and overall digital media has become a necessary public communication method [34]. Haq and co-authors see digital engagement of virtual tours and online interactions as an extensive multisensory experience, an online tourism sector [75]. An increase in digital engagement is expected, for a lasting hybrid visitation [77].

There is strong public support for the development of digital technologies for the cultural heritage sector [19] and Holtorf argues for heritage to be digitally capable and relevant [108]. User technologies, however, have financial cost considerations and user limitations; they have high initial and ongoing costs especially due to fast-changing digital technology, can be difficult to use, of poor or average quality, and isolating rather than socialising [13,142,147]. Small and rural sites have found access to the technology more difficult, but as associated costs are reducing, digital technology is becoming more accessible to utilise [147]. Therefore, the costs, skills required, and benefits of digital plans need to be integral to the business plans and to be linked to the organisations' overall objectives [19].

Digital infrastructure and skills training are key in the sector's engagement with the public and for internal sharing of information [142]. Digitisation of collections is restricted by limited budget, staff capacity, Intellectual Property Rights restrictions, and unsuitable equipment. Practical considerations such as the size of the artefacts have an impact, for example natural history museums in Europe with large artefacts that are difficult to digitize, have very low (15%) percentage of their collections accessible online [26]. Digital skills and infrastructure require continued sector support [42,140]. The investment in digital should build rich content on the strength of collections [38]. The EU allocated €2.4 billion (2021–2027) for the development of digital skills and infrastructure in the cultural sector and proposed the development of a common European space online for cultural resources [42].

### Operational Usefulness

With the acceleration of digital engagement, digital content is going to be the backbone of heritage operations [6] and becomes shared value when it is created with or by the public [160]. Participatory digital interactions contribute to the value of heritage, they become part of heritage [156]. And content from previously used digital technology such as audio guides is now available through the visitor's own mobile devises [142].

The use of Sketchfab and other programmes in 3D artefact provision [46] has seen an increase in 360° virtual tours that combine a range of content and can be utilised for

virtual access, education, and conservation purposes [84]. However, in exploring collection artefacts only 1% of digital content is of 3D objects [46]. The continued digitisation of collections can help in both the conservation and engagement objectives [161,162].

Online commercial income generation was generally underutilised during the pandemic; some of the most innovative uses were the application of collection images on face masks [46] as mentioned in Section 3.1.6 (Figure 1). The digital income generation varies per size of the sites; for example digital income generation tools in the UK are used at 80% of large museums compared to 35% of micromuseums [150]. There is, therefore, opportunity and further need to monetise digital content [13].

Larger museums generally utilise digital more than small museums, and paid-staff organisations utilise digital more than volunteer-led organisations [150]. Social media and website visits have continued to grow post-pandemic, but online educational provision has decreased [150]. There is, however, a need to protect heritage organisations and users from deliberate digital misinformation campaigns [57]. And the limitations and potential of AI need to be acknowledged and further researched [158].

Digital Equality and Social Usefulness

Increased opportunities and barriers of online access due to digital technology fall within the international human rights to participation [57]. Digital technology can bring people together against a crisis, but not all people have equal digital access [156] raising the question whether the introduction of digital access has introduced new barriers to access [46]. Digital access requires digital literacy, a device to access content, and sufficient quality internet connection, but there is a disparity in such availability of all three across the world, creating barriers and a digital divide [42].

> '. . .digital distribution is not the great equaliser or diversifier that much of the sector was hoping it was and even claiming it to be. Although the **number of cultural engagements increased** during the pandemic, **the number of engagers remained stubbornly static**. . .
>
> . . .Most significantly, the digital offer inverts the age profile of audiences. Whereas **in-person engagement tends to be dominated by older people, the digital offer has a much younger (and more ethnically diverse) audience**, with a distinct preference for more interactive, immersive experiences' (highlighting not in the original) [43] (p. 68).

Furthermore, the online site visits are not social events but private, isolating, designed as a single-user experience [146].

Digital engagement, therefore, needs to digitally include excluded audiences [156]. It requires a plurality of media to reach audiences, and to reflect the plurality of art and audiences [145]. Visual content for example, can be more easily understood by most people, but needs to be supplemented to be fully inclusive [46]. Likewise, whether virtual, or visual and auditory, online experiences need to provide an authentic representation of the heritage it depicts [135].

Clini and Quattrini see digital as the means to democratise access to cultural heritage and an opportunity to develop collaborative interaction of public and organisations, and expand digital educational provision [19]. Digital also changes the role of the museum from an authoritative place to becoming a visitor, now asking to enter people's homes [26]. This creates a challenge for the website, to become 'as warm, welcoming, inclusive, and supportive as the physical site' [18] (p. 164). Online content needs to be of good quality, assessed through benchmarking, evaluation of decision-making processes, and of the resources being allocated [42].

> '. . .many museums limit themselves to simply transferring online their collections and/or disseminating their ordinary on-site activities, leaving little space for interaction and generally paying little importance to establishing a direct relation with the public. For a more skilled, informed and exigent audience, seeking for

> captivating and engaging experiences, such kind of online experience does not represent an attractive option' [26] (p. 3068). Cultural organisations therefore 'need to transform their narratives from object-centric to people-centric' [146] (p. 3).

The purpose and quality of content are questioned too. Kist asks whether online content can trigger critical thinking about ethical issues, and whether it should? Or is it just for marketing, fun and non-challenging? Is the need to be popular becoming self-censorship? [152].

Towards a Blended Space

Crooke discusses 'blended engagement' of the physical and digital offer as a more inclusive approach to positively impact wellbeing and build trust on museums as 'places of care' for collective reflection during crisis [58] (p. 13).

Conservation and interpretation of heritage artefacts and sites can be achieved through digital media, as complementary to physical visits, not instead [147]. Digital engagement can contribute to reducing the impact of physical visits [62], provide continued communication [163] and reach younger audiences [151]. By combining physical and digital, museums can improve their reach and organisational sustainability [42]. For example, short (2–5 min) videos, as used for digital access to a site during restrictions, can prompt future interest and visits [164].

A virtual multi-user pilot is the Mondrian 3d museum[4] [146], which suggests that 'In a 3d museum you can stroll around, chat with other visitors, take a guided tour, build your own exhibition and invite your private audience' [165]. There is now an opportunity to create combined physical and digital spaces for socialising '. . .to experience a joint, synchronous, social activity without requiring to be co-located in the same physical place' [146] (p. 2).

#### 3.3.3. Metadata: The Era of Cookies

Use of online users' metadata provides the ability to learn about visitor demographics for research and AI applications [19] and to provide online content to targeted audiences [6]. Digital engagement enables to understand visitor patterns such as tracking the users' position in a heritage site [19]. In this necessary and perceived as positive and dynamic approach to heritage engagement, cultural heritage is discussed as 'a product' and the users as 'cyber public' [149] (p. 675). The digital engagement being more accessible but also less tangible, is likely to be a manufactured individual experience, instead of a physical 'well-informed expression of collective and civilizational memory' [82] (p. 471). Metadata should be used thoughtfully, to create more user-friendly websites and content [145] alongside a considerate use of metadata in audience development and to inform the development of virtual reality and artificial intelligence [42].

#### 3.3.4. Common Spaces: Information Sharing and Networking

The literature consistently highlights the significance of the sector coming together during the pandemic to share knowledge and support through its networks. It also highlights how important it is for such unity not to be lost but be harnessed to support ongoing sustainability and better preparedness for future crises.

The pandemic united the fragmented heritage sector and concerted effort is needed to maintain this unity [43]. A crisis of such magnitude was beyond what the heritage sector could be prepared for and was further hampered by unclear decision making and communications of official guidance. It, therefore, had a significant impact on the sustainability of sites and on the welfare of its people. The sector, however, demonstrated the significant increase in collaboration and information sharing at national and international level [40]. The sector ecosystem has demonstrated how interdependent it is and the usefulness of networks and sector bodies 'such as the Historic Environment Forum, the Heritage Alliance, Historic Houses and Icon' to represent the diversity and requirements of the

sector [125] (p. 15). In the Historic England survey, participants asked for means of better information sharing and prevention from duplicating resources [129]. ICON provided a comprehensive bank of guidance and resources to its members during the pandemic, including a post-lockdown collections' care guide for before returning to site, upon return to site, and collection care essentials [48]. Dealing with the pandemic has been aided by inter and intra organisational information sharing in heritage, cross-sector and international sharing and alliances [76]. Sector networks have been important for sharing information and expertise [67,125], best practice, guidance sharing, and digital skills development [29]. Report and guidance encourage governments to promote cross-sector collaboration [117], and transnational collaboration is imperative during crises [38]. 'Data and knowledge sharing must be encouraged' [43] (p. 46).

It is an opportunity to continue sharing [35] knowledge and equipment cross borders as we did during the pandemic and learn to collaborate for all challenges ahead [125]. The issues of out of date policies [34] call for a resource bank with up-to-date pandemic policies. Better preparation is needed, through improved resource coordination, and open sharing of information [34], and simple templates or checklists for shutdown procedures and associated training will be useful [40]. Compendium is one such an example, it provides a very useful database with reopening measures for the cultural sector, across a number of countries in Europe (inc. the UK) [166].

#### 3.3.5. Social Equality and Heritage as Wellbeing Hybrid Spaces

'Originally described as a 'social leveller', it has become clear that the overwhelming effect of the pandemic has been to exacerbate already existing social and economic inequalities' [12] (p. 1). The pandemic caused inequality through economic, access, and social factors. Most impacted were the already marginalised and vulnerable, particularly of the south hemisphere [23], also impacted by inequality in distribution of vaccines around the world [12]. The economic impact has been highlighted more prominently than the human loss [75]. The use of digital engagement by heritage organisations increased the barrier for already disadvantaged communities [31]. And within heritage organisations '. . .the pandemic has aggravated and accelerated existing inequalities and longer-term trends across the arts and cultural sector' [43]. It also changed perceptions on civil liberties as seen by the mass public acceptance of public tracking through smart phones for COVID-19 [124].

Chiscano and Darcy [167] discuss the impact of spaces (and access to such spaces) on disability. They discourse disability as per Chatterjee's 2008 work on museum practice, not a disability of the body, but disability of a person due to socioeconomic, political, and cultural barriers to participation. Such limitation disables people from contributing to the value creation of cultural heritage, which also means that their voice is not represented in the interpretation of such cultural heritage. This creates a vicious cycle, the more vulnerable that people feel and the less represented they are, the less they engage. Chiscano and Darcy's COVID-19 recommendation to site managers is to review how socioeconomically accessible and representative their [physical and digital] sites are.

Considering physical disabilities, particularly for blind and partially sighted people, 'messages like 'stay at home' and 'social distancing' are not new' to them [168] (p. 6). In that respect, online activities have enhanced the physical access limitations. However, online content for people with disabilities needs to not only be developed with their participation [167] but also 'in a universally accessible format, accommodating users with and without disabilities' (p. 1), as inclusive additions and integrated content, rather than segregating disable from able users [169].

Heritage sites can contribute to visitors' wellbeing aspects 'including capability, social connections, ontological security, and trust' [53] (p. 1129). They can link communities with health and wellbeing agencies, co-create and provide hybrid spaces to the community, and measure the benefits of wellbeing [58]. Heritage sites can be the reflective and shared space for communities to recover and grow [58].

## 4. Discussion—A New Space, Not a New Normal

Are heritage organisations suffering from long-COVID then? In general, heritage organisations increasingly have a dual-purpose; of historic environment preservation, and the expectation of a more self-funded business model. And their role as all-knowing is being challenged, alongside their inherited patriarchal, elitist, and nationalist attitudes. Individual organisations have been struggling for decades amidst funding cuts, increasing conservation costs, and an identity crisis. The sector itself is still a relatively young one, emerging from its previous incarnation of Cultural Property to a yet un-unified sector, interchangeably called Culture (relating to values of creativity, learning and personal cultivation), or Heritage (inherited assets within which the cultural values reside[5]). The combined Cultural Heritage term can also be exclusive, as natural heritage, and intangible heritage do not feel included.

COVID-19 infected such a fledgling and already weary patient; it drained its reserves and forced it to evaluate its routines and purpose. A total of 95% of museums across the planet closed during the pandemic, and depending on their governance structures, size, role, and capacity, they reopened at very different stages and with varied levels of injuries. Their people had to learn new operational habits, and self-employed heritage professionals were seriously distressed. COVID-19 exposed the poor provision of succession and professional development planning within most heritage organisations which are managed by small teams and are volunteer dependent. Their regular users felt seriously deprived, and new audiences, including school children, missed out on cultural heritage's nurturing embrace. Vast volumes of conservation backlogs of building and collections deteriorated further, whilst digital engagement came to the rescue but with more financial costs and training requirements. The case studies show how the more diversified and prepared organisations were, the better their recovery was, but even the more developed ones fell victims; this time to different types of malicious, digital viruses. The pre-COVID-19 period was assumed as normal, but was not healthy. It was dominated by a (purposefully?) divided sector that, however, learned to communicate better in a more distanced manner. And this revealed its strength. The sector came together to share knowledge and expertise across its common objectives, and hence evened out its weaknesses.

Change, therefore, did not result in a new normal but to the need for a new space. Physical spaces can have conservation, capacity, and access limitations, but are tangible proof of the stories being told, and central to people coming together. Digital spaces can complement the physical spaces, with increasingly more sophisticated, and costly media. Heritage audiences ought to be engaged beyond being financial sources or interesting social media data being tracked by cookies; the blended spaces need to be spaces of wellbeing for users, staff, and volunteers, and common networking spaces encouraging trust to share information and learning from each other.

The case studies emphasise the benefits of diversification; financial and of belonging in a diverse group of sites. The case studies have presented a complex picture of the impact of COVID-19 and the unpredictable outcomes for the four heritage sites. On the one hand, it seems like the London Transport Museum fared best out of the case studies. Despite having the clearest strategy (especially concerning their portfolio and estates programmes) and receiving the largest grants, the British Library did not fare as well as the others, in addition to being unfortunate due to their over-reliance on information technology and the subsequent data breach. Although the LW Theatres Group Limited did not appear to receive any grant income, it did surprisingly well during and especially after COVID-19, with the Theatre Royal Drury Lane coming onstream in 2021, after heavy investment in refurbishment. Kensington Palace and HRP, which needed significant support via grants have also done relatively well, although not as well as the London Transport Museum.

The case studies suggest that some measures with regard to new blended spaces that occurred during the pandemic, were actually in the pipeline well before COVID-19 arrived. Examples are the Theatre Royal Drury Lane closure for refurbishment in 2019 and the

British Library estates change portfolio programme (which commenced before COVID-19). The wider impact of COVID-19 in the case studies was:

- An acceleration to enhance digital spaces, especially at the British Library (which led to catastrophic results for the British Library).
- A race to get grant funding, apart from the Theatre Royal Drury Lane which relied on debt financing during COVID-19.
- A massive reduction in visitor numbers and hence rapid falls in self-generated income. Only the London Transport Museum seems to have recovered (and surpassed) its pre-pandemic position.

### *4.1. Future Research*

Based on the literature and case studies, organisational areas that require further research have been grouped below in social, digital, financial, and operational themes. The extensive future research proposed, demonstrates the need for proactive preparedness rather than reactive responses; metaphorically thinking along the lines that ongoing maintenance is cheaper than major repairs. It also shows that whilst this paper is a good starting point, much more theoretical and empirical research is needed to inform the topic of proactive planning for organisational sustainability in heritage.

Social

Aligned with the work by Historic England, how can heritage contribute to wellbeing and health, and how can these be tangibly measured and valued?

From Walmsley and co-authors [43]: 'Develop more understanding of all the different contractual frameworks for artists, creatives and other workers in the CCS and propose a framework for fair practice that does not lead to precarious employment and income and ensures an equal and level playing field in comparison to standard workers'.

What has the visitation restrictions' impact been on schools?

What can we learn from the extraordinary change in the soundscape during the pandemic compared to what we have been accustomed to as normal? How can such learning be communicated to heritage audiences?

The DCMS announced a series of research through the Boundless creativity Report [170]. How is that research progressing and how can the findings be utilised?

Digital

How much of the digital engagement is still provided, and how does that complement, or not, the physical engagement provision?

The limitations and potential of AI need to be acknowledged and further researched.

What is the impact on the English language of the global digital content increase by non-English speaking nations?

Why was the use of 360° virtual tours so low during the pandemic, even in developed countries? What is due to the cost, technical skills and equipment needed, poor overall quality, or other factors?

Financial

Have financial reserves in heritage organisations diminished? How much by, do they have 3, 6, 12 months' worth?

A longitudinal study is needed to map the recovery journey of heritage organisations.

Future research is needed on insurance models against loss of income from disasters and pandemics.

How can the beneficial to wellbeing outdoor spaces be used strategically to diversify the visitor and income generating provision of heritage organisations during pandemic and 'normal' times?

The Heritage Alliance proposed tax reforms to support recovery. Have tax reforms or equivalent measures taken place, if so, what difference have those made? The 'VAT on tourism and hospitality services' report by Seely and Masala provides a starting point [171].

Operational

Are heritage organisations adding pandemic planning in their general emergency plans?

How do heritage operations and emergency planning compare in pre- and post-pandemic years?

How do the funding, resources, and training for digital development provided by the EU and nations across the world, compare?

What processes and platforms are being used to collate and share heritage management knowledge about dealing with pandemics?

Natural England stated: 'As the nation emerges from the current crisis we're [Natural England] determined to make sure that our green spaces are greener, our natural environment is stronger and the public's connection with it is deeper than ever before. The Government's environmental ambition is explicit within the 25 Year Environment Plan, and Natural England is uniquely placed to develop new ways to recover nature that integrate the management of the historic and natural environment.' [74]. Is this happening? How is this being delivered?

As streaming sites, TV, and radio saw high user increase during the pandemic, how can heritage develop significantly higher volumes of ongoing programming for streaming sites, TV, and radio, to drive engagement during normal times and reuse during pandemics?

Have the numbers of visitor memberships dropped during the pandemic? Have memberships recovered/increased since?

The cases have highlighted areas of further research, especially regarding theatres. For example, it would be interesting to examine how the LW Theatres Group Limited coped at the theatre site level and what exactly they did to manage the COVID-19 crisis so well. Likewise, an in-depth study of the London Transport Museum during this period could also reveal some interesting results and shed more light on how heritage organisations cope with crises.

## 5. Conclusions

This paper detailed the wider socioeconomic and cultural impacts of COVID-19 on the heritage sector. The idea of risk was approached through a more systematic and comprehensive way that looks beyond the material conservation and extends towards the sustainability of a heritage organisation, which heavily relies on visitor flow. This paper shows that the heritage sector was not prepared for dealing with the pandemic. As risk preparedness revolves mostly around dealing with environmental challenges such as floods, climate change, or disasters such as fires or even looting, it is essential to rethink of risk preparedness more broadly taking into account unanticipated and uncertain events, such as a pandemic and their holistic and systemic impacts.

COVID-19 was a major disruption across all aspects of life, including the economy and the need to rethink about over-reliance on tourism. It accelerated digital engagement and had a varied impact on heritage organisations, depending on their size and type of operations, governance model, and crucially their access to outdoor spaces. It impacted the teams and users of heritage sites, and the collections and buildings in those sites. It [re]ignited an interest for the role of heritage in wellbeing and equitable participation, whilst heritage still reconciles itself in relation to gender equality, colonialism, and nationalism. The literature calls for a critical review of the sector include the need to understand the ethics of COVID-19, and to evaluate the intervention roles of the government and of the heritage sector support. It is a call for quality physical and digital co-creation of a unifying heritage. It is a universal call not only to saving lives but also to a 'life worth living' [113], to behave sustainably, and imagine a new diversified (operationally and socially) space.

Organisational sustainability, and mitigation strategies against long-COVID type-crises will benefit from proactively planning a diversification of spaces (blended (physical and digital), mixed (indoors and outdoors), and community of practice space (work in isolation, or be part of a multi-site and cross-sector networking space). The literature highlights

the significance of the sector coming together during the pandemic to share knowledge and provide support through its networks. It also highlights how important it is for such unity not to be lost but to be harnessed to support ongoing organisational sustainability and better preparedness for future crises. Unity across the biocultural heritage sector (perhaps this is a more inclusive term?) is the equivalent to building healthy vaccine stocks.

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## Notes

[1] https://www.mdpi.com/journal/heritage/special_issues/covidOnCH (accessed on 31 January 2024).

[2] https://static.museothyssen.org/microsites/exposiciones/2020/vv_audioguia_rembrandt/index_sonido_in.htm?startscene=0&startactions=lookat(223.97,0.24,100,0,0) (accessed on 26 February 2024).

[3] https://irishmuseums.org/text-pages/irishmuseumsonline-content-and-resources (accessed on 26 February 2024).

[4] https://museum3d.eu (accessed 26 February 2024).

[5] See relating research at www.avculturalheritage.org (accessed on 28 May 2024).

## References

1. WHO. COVID 19 Timeline. Available online: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/interactive-timeline (accessed on 16 February 2024).
2. WHO. Naming the Coronavirus Disease (COVID-19) and the Virus that Causes It. Available online: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/technical-guidance/naming-the-coronavirus-disease-(covid-2019)-and-the-virus-that-causes-it (accessed on 16 February 2024).
3. WHO. COVID-19 Cases | WHO COVID-19 Dashboard. Datadot. Available online: https://data.who.int/dashboards/covid19/cases (accessed on 16 February 2024).
4. Spennemann, D.H.R. COVID-19 on the Ground: Managing the Heritage Sites of a Pandemic. *Heritage* **2021**, *4*, 2140–2162. [CrossRef]
5. WHO. Vaccine Equity. Available online: https://www.who.int/campaigns/vaccine-equity (accessed on 16 February 2024).
6. Belenioti, Z.-C. COVID-19 resilience via digital cultural heritage; digital life in museums and festivals during the anthropause. *Int. J. Technol. Mark.* **2022**, *16*, 403–420. [CrossRef]
7. Naseer, S.; Khalid, S.; Parveen, S.; Abbass, K.; Song, H.; Achim, M.V. COVID-19 outbreak: Impact on global economy. *Front. Public Health* **2023**, *10*, 1009393. [CrossRef]
8. WHO. Impact of COVID-19 on People's Livelihoods, Their Health and Our Food Systems. Available online: https://www.who.int/news/item/13-10-2020-impact-of-covid-19-on-people%E2%80%99s-livelihoods-their-health-and-our-food-systems (accessed on 16 February 2024).
9. Wellcome Trust. The Covid-19 Effects on Societies and Economies | News. Wellcome. Available online: https://wellcome.org/news/equality-global-poverty-how-covid-19-affecting-societies-and-economies (accessed on 16 February 2024).
10. NHS. Long-Term Effects of COVID-19 (Long COVID). nhs.uk. Available online: https://www.nhs.uk/conditions/covid-19/long-term-effects-of-covid-19-long-covid/ (accessed on 16 February 2024).
11. Andres, L. How Can Cities Learn from the Pandemic? Available online: https://bartlett-review.ucl.ac.uk/how-can-cities-learn-from-the-pandemic/ (accessed on 31 January 2024).
12. Shepherd, N. (Ed.) *Rethinking Heritage in Precarious Times: Coloniality, Climate Change, and Covid-19*; Routledge: London, UK, 2023. [CrossRef]
13. IDEA Consult; Goethe-Institut; Amann, S.; Heinsius, J. Cultural and Creative Sectors in Post COVID-19 Europe. 2021. Available online: https://www.europarl.europa.eu/RegData/etudes/STUD/2021/652242/IPOL_STU(2021)652242_EN.pdf (accessed on 14 February 2024).
14. Heritage Alliance. Heritage Alliance Annual Report. 2020. Available online: https://www.theheritagealliance.org.uk/wp-content/uploads/2020/10/Heritage-Alliance-AnnualReport_2020_Online.pdf (accessed on 19 February 2024).

15. Sagger, H.; Philips, J.; Haque, M.; DCMS. Valuing Culture and Heritage Capital: A Framework towards Informing Decision Making. GOV.UK. Available online: https://www.gov.uk/government/publications/valuing-culture-and-heritage-capital-a-framework-towards-decision-making/valuing-culture-and-heritage-capital-a-framework-towards-informing-decision-making (accessed on 19 January 2024).
16. Abidoye, B.; Felix, J.; Kapto, S.; Patterson, L. Leaving No One Behind: Impact of COVID-19 on the Sustainable Development Goals (SDGs). UNESCO. 2021. Available online: https://sdgintegration.undp.org/sites/default/files/Leaving_No_One_Behind,_COVID_impact_on_the_SDGs_second_flagship.pdf (accessed on 19 February 2024).
17. UNESCO. COVID-19 Recovery | UNESCO'. Available online: https://www.unesco.org/en/covid-19 (accessed on 19 February 2024).
18. Black, G. (Ed.) *Museums and the Challenge of Change: Old Institutions in a New World*; Routledge: Abingdon, Oxon, UK; New York, NY, USA, 2021.
19. Clini, P.; Quattrini, R. Editorial. Digital Cultural Heritage, arts reproduction and Museums systems. Languages and techniques in a Covid and post-Covid scenario for new forms of heritage against the silence of a fragile culture. *SCIRES-IT—SCIentific RESearch Inf. Technol.* **2021**, *11*, 1–10. [CrossRef]
20. UNESCO. UNESCO—Living Heritage and the COVID-19 Pandemic: Responding, Recovering and Building Back for a Better Future. 2021. Available online: https://ich.unesco.org/en/living-heritage-and-the-covid-19-pandemic-01179 (accessed on 5 February 2024).
21. Osterwalder, A.; Pigneur, Y. *Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers*; Wiley: London, UK, 2010.
22. Ondrus, J.; Lyytinen, K. Mobile Payments Market: Towards Another Clash of the Titans? In Proceedings of the 2011 10th International Conference on Mobile Business, Como, Italy, 20–21 June 2011; pp. 166–172. [CrossRef]
23. McAtackney, L. Heritage, Social Justice and Black Lives Matter in Ireland during COVID-19. In *Rethinking Heritage in Precarious Times*; Routledge: London, UK, 2023; Available online: https://www-taylorfrancis-com.libproxy.ucl.ac.uk/chapters/edit/10.4324/9781003188438-15/heritage-social-justice-black-lives-matter-ireland-covid-19-laura-mcatackney?context=ubx&refId=c4acbc0e-3d55-4681-80bb-a6c7aea38743 (accessed on 23 February 2024).
24. Winter, T. COVID-19, Black Lives Matter, and Heritage Futures. In *Rethinking Heritage in Precarious Times*; Routledge: London, UK, 2023.
25. Spennemann, D.H.R.; Parker, M. Hitting the "pause" button: What does COVID-19 tell us about the future of heritage sounds? *Noise Mapp.* **2020**, *7*, 265–275. [CrossRef]
26. Lerario, A. Languages and Context Issues of ICTs for a New Role of Museums in the COVID-19 Era. *Heritage* **2021**, *4*, 3065–3080. [CrossRef]
27. Yamada, H.; Seki, H.; Kono, T. The COVID-19 pandemic, cultural heritage, and policy in Japan: Implications of survey data. *Int. J. Cult. Policy* **2023**, 1–20. [CrossRef]
28. Giliberto, F.; Labadi, S. Re-Imagining Heritage Tourism in Post-COVID Sub-Saharan Africa: Local Stakeholders' Perspectives and Future Directions. 2023. Available online: https://www.mdpi.com/2071-1050/15/5/4339 (accessed on 18 February 2024).
29. Kono, T.; Adetunji, O.; Jurčys, P.; Niar, S.; Okahashi, J.; Rush, V. *The Impact of COVID-19 on Heritage: An Overview of Responses by ICOMOS National Committees (2020) and Paths Forward*; ICOMOS: Charenton-le-Pont, France, 2020; Available online: https://openarchive.icomos.org/id/eprint/2415/ (accessed on 5 February 2024).
30. Fava, F. Ongoing adaptive reuse: Patterns of heritage resilience before and after COVID-19. *J. Cult. Herit. Manag. Sustain. Dev.* **2022**. *ahead-of-print*. [CrossRef]
31. Bezerra, M. The Heritage Through My Window: Some Reflections on Teaching in the Brazilian Amazon During the Covid-19 Pandemic. In *Rethinking Heritage in Precarious Times*; Routledge: London, UK, 2023.
32. Liebenrood, M. Accreditation, Size, and Museum Reopening after Lockdown. Mapping Museums Lab. Available online: http://blogs.bbk.ac.uk/mapping-museums/2022/06/14/accreditation-size-and-museum-reopening-after-lockdown/ (accessed on 22 January 2024).
33. Kvítková, Z.; Petru, Z. Cultural UNESCO Heritage in COVID-19 Pandemic Times. *Acad. Turist.—Tour. Innov. J.* **2023**, *16*. Available online: https://academica.turistica.si/index.php/AT-TIJ/article/view/521 (accessed on 14 January 2024). [CrossRef]
34. Lavy, B.L.; Zavar, E.; Tamima, S. Heritage as businesses: COVID-19 disruptions to Texas museums, heritage sites, parks, and protected places, and their responses to evolving guidance. *Int. J. Geoheritage Parks* **2023**, *11*, 652–668. [CrossRef]
35. Hoskins, G.; Maddern, J. Anticipating a Covid-19 Memorial Landscape: Quarantine and Migration Heritage as a Template? *Change Over Time* **2022**, *11*, 122–139. [CrossRef]
36. Liu, Z.; Orr, S.A.; Kumar, P.; Grau-Bove, J. Measuring the impact of COVID-19 on heritage sites in the UK using social media data. *Humanit. Soc. Sci. Commun.* **2023**, *10*, 537. [CrossRef]
37. Duckett, V. Finding More than I Asked For Discussing the Impact of COVID-19 on the Film Heritage Foundation, Mumbai, and Korean Film Archive, Seoul. *Mov. Image: J. Assoc. Mov. Image Arch.* **2020**, *20*, 231–234. [CrossRef]
38. NEMO. Survey on the Impact of the COVID-19 Situation on Museums in Europe. *Final Report.* Available online: https://www.ne-mo.org/fileadmin/Dateien/public/NEMO_documents/NEMO_COVID19_Report_12.05.2020.pdf (accessed on 21 February 2024).

39. Martins, A.; Shule, V. The impact of the COVID-19 pandemic on the arts, culture, and heritage sectors in the African Union member states. *Int. J. Cult. Prop.* **2020**, *27*, 477–480. [CrossRef]
40. Mackay, R. An Abrupt and Brutal Audit: An Analysis of the Crisis Management Response of UK Museums and Heritage Attractions to the Covid-19 Pandemic. *Mus. Int.* **2021**, *73*, 8–19. [CrossRef]
41. Naramski, M.; Szromek, A.R.; Herman, K.; Polok, G. Assessment of the Activities of European Cultural Heritage Tourism Sites during the COVID-19 Pandemic. *J. Open Innov. Technol. Mark. Complex.* **2022**, *8*, 55. [CrossRef]
42. Boutsiouki, S.; Damou, M. Digital Activities as Online Getaways to Cultural Heritage: The Paradigm of Greek Museums During the COVID-19 Era. In *Tourism, Travel, and Hospitality in a Smart and Sustainable World*; Katsoni, V., Ed.; Springer Proceedings in Business and Economics; Springer Nature Switzerland: Cham, Switzerland, 2023; pp. 365–385. [CrossRef]
43. Walmsley, B.; Gilmore, A.; O'Brien, D.; Torreggiani, A.; Nightingale, A. Culture in Crisis. 2021. Available online: https://www.culturehive.co.uk/wp-content/uploads/2022/01/Culture_in_Crisis.pdf (accessed on 15 February 2024).
44. Seymour, C.; Fouseki, K.; Krystallis, I. COVID-19 a Disaster for Heritage Business Models—Victoria & Albert Museum Case Study. In *Teaching Cases in Tourism, Hospitality and Events*; Dixit, S.K., Piramanaygam, S., Eds.; CABI: Wallingford, UK, 2023; pp. 81–99. [CrossRef]
45. National Trust. Annual reports. *National Trust.* Available online: https://www.nationaltrust.org.uk/features/annual-reports (accessed on 21 January 2022).
46. Samaroudi, M.; Echavarria, K.R.; Perry, L. Heritage in lockdown: Digital provision of memory institutions in the UK and US of America during the COVID-19 pandemic. *Mus. Manag. Curatorship* **2020**, *35*, 337–361. [CrossRef]
47. Macgregor, O.J. COVID-19 induced changes in the archaeological consulting workplace. *Artefact* **2022**, *44*, 7–10.
48. Mantyniemi, A. "Waking Up" Collections: Caring for Collections in Lockdown and Preparing for Recovery | Historic England. Available online: https://historicengland.org.uk/whats-new/debate/recent/impact-of-covid-on-heritage/waking-up-collections/ (accessed on 6 February 2024).
49. UK Heritage Pulse. Heritage Sector Is Resilient to the Pandemic, Despite Economic Challenges | The National Lottery Heritage Fund. Available online: https://www.heritagefund.org.uk/about/insight/research/heritage-sector-resilient-pandemic-despite-economic-challenges (accessed on 5 February 2024).
50. The Heritage Alliance. Available online: https://www.theheritagealliance.org.uk/ (accessed on 24 January 2022).
51. AIM. Steady State? *AIM's Latest Survey Findings. AIM—Association of Independent Museums.* Available online: https://aim-museums.co.uk/steady-state-aims-latest-survey-findings/ (accessed on 1 March 2024).
52. Firouzkouhi, M.; Abdollahimohammad, A. Grief, Heritage of COVID-19. *J. Loss Trauma* **2022**, *27*, 478–480. [CrossRef]
53. Sofaer, J.; Davenport, B.; Sørensen, M.L.S.; Gallou, E.; Uzzell, D. Heritage sites, value and wellbeing: Learning from the COVID-19 pandemic in England. *Int. J. Herit. Stud.* **2021**, *27*, 1117–1132. [CrossRef]
54. Gallou, J.S. Places of Joy: The Role of Heritage during the COVID-19 Pandemic | Historic England'. Available online: https://historicengland.org.uk/whats-new/research/back-issues/places-of-joy-the-role-of-heritage-during-the-covid-19-pandemic/ (accessed on 28 January 2024).
55. Hai Nguyen and Andres Coca-Stefaniak. Impact of COVID-19 Pandemic on Cultural Heritage in Europe. 2021. Available online: https://projects2014-2020.interregeurope.eu/fileadmin/user_upload/tx_tevprojects/library/file_1632210273.pdf (accessed on 15 February 2024).
56. de Rooij, P.; van Liempt, A.; van Bendegom, C. Should we stay, or should we go? The influence of risk perceptions on revisit intentions to cultural heritage during the COVID-19 pandemic. *J. Herit. Tour.* **2022**, *17*, 431–447. [CrossRef]
57. Kużelewska, E.; Tomaszuk, M. European Human Rights Dimension of the Online Access to Cultural Heritage in Times of the COVID-19 Outbreak. *Int. J. Semiot. Law* **2022**, *35*, 1067–1079. [CrossRef]
58. Crooke, E.; Farrell-Banks, D.; Friel, B.; Hook, A.; Jackson, H.; Maguire, T.; McDermott, P. Museums and Community Well-being. 2022. Available online: https://www.ulster.ac.uk/__data/assets/pdf_file/0015/1043205/MCC-Briefing2_Dec2021_MuseumsandCommunityWellbeing.pdf (accessed on 15 February 2024).
59. Jurlin, K. Were Culture and Heritage Important for the Resilience of Tourism in the COVID-19 Pandemic? *J. Risk Financ. Manag.* **2022**, *15*, 205. [CrossRef]
60. ICOM. Museums, Museum Professionals and COVID-19: ICOM and UNESCO Release Their Full Reports. *International Council of Museums.* Available online: https://icom.museum/en/news/museums-museum-professionals-and-covid-19-survey-results/ (accessed on 30 October 2023).
61. Historic England. Heritage Online Debate #10: The Impact of Covid-19 on the Heritage Sector | Historic England. Available online: https://historicengland.org.uk/whats-new/debate/recent/impact-of-covid-on-heritage/ (accessed on 5 February 2024).
62. Caruana, J.; Debono, E.; Stroud, K.; Zammit, M. The impact of COVID-19 closures on the Megalithic Temples of Malta UNESCO world heritage site. *J. Cult. Herit. Manag. Sustain. Dev.* **2021**, *13*, 15–27. [CrossRef]
63. Gani, H.R.; Osman, M.; Das, S.; Faroque, A.R.; Osman, M. Impacts of COVID-19 Pandemic on Ecosystem Services at UNESCO World Heritage Site, Sundarbans: A Viewpoint on India and Bangladesh. In *Management of Tourism Ecosystem Services in a Post Pandemic Context*; Routledge: London, UK, 2022.
64. UNESCO World Heritage Centre. Impacts of COVID-19 on World Heritage to Continue for Years, according to Report. *UNESCO World Heritage Centre.* Available online: https://whc.unesco.org/en/news/2298/ (accessed on 5 February 2024).

65. Ambaw, Z.G.; Nigatu, T.F.; Masrie, F.A. Multidimensional Impacts of COVID-19 Pandemic on Cultural Heritage Management (CHM) and Conservation Practices in North-Central Ethiopia. *GTG* **2022**, *45*, 1552–1557. [CrossRef]
66. Jakubowski, O. Zagrożenie dziedzictwa kulturowego przestępczością—*Analiza* wydarzeń w 2020 roku (początek pandemii COVID-19). *Santander Art Cult. Law Rev.* **2022**, *2022*, 133–152. [CrossRef]
67. López-Urbaneja, A.; Escribano-Ruiz, S.; Cortés-Avizanda, A.; Gutierrez Ilabaca, Á.; Aramburu Lasa, J.J.; Garai Lopez, M.; Castro Ortiz de Pinedo, K.; García Porras, A.; Azkarate Garai-Olaun, A. Comparative analysis of responses to COVID-19 in UNESCO Landscapes and World Heritage sites from Southern Europe and America. *J. Cult. Herit. Manag. Sustain. Dev.* **2023**. *ahead-of-print*. [CrossRef]
68. National Lottery Heritage Fund. Our New Report Uncovers Impact of COVID-19 Crisis on Heritage | The National Lottery Heritage Fund'. Available online: https://www.heritagefund.org.uk/news/our-new-report-uncovers-impact-covid-19-crisis-heritage (accessed on 5 February 2024).
69. Astruc, S.J. Deterioration of heritage shophouses turned into hostels in phuket old town, thailand, during the covid-19 pandemic. *Sustain. Dev. Plan.* **2022**, *258*, 405–415. [CrossRef]
70. Brigham, R.; Orr, S.A.; Wilson, L.; Frost, A.; Strlič, M.; Grau-Bové, J. Using Citizen Heritage Science to Monitor Remote Sites Before and During the First COVID-19 Lockdown: A Comparison of Two Methods. *Conserv. Manag. Archaeol. Sites* **2022**, *24*, 127–142. [CrossRef]
71. Broomandi, P.; Tleuken, A.; Zhaxylykov, S.; Nikfal, A.; Kim, J.R.; Karaca, F. Assessment of potential benefits of traffic and urban mobility reductions during COVID-19 lockdowns: Dose-response calculations for material corrosions on built cultural heritage. *Env. Sci Pollut Res* **2022**, *29*, 6491–6510. [CrossRef]
72. Sadki Aba, A.S. Intangible Cultural Heritage, Sustainability, and the COVID-19 in Marrakech. In *Intangible Cultural Heritage and Sustainable Development*; Routledge: London, UK, 2023.
73. Angelo, D.; Britt, K.M.; Brown, M.L.; Camp, S.L. Collecting and Curating COVID-19 Heritage: Challenges of Conservation and Management. *Conserv. Manag. Archaeol. Sites* **2023**, *24*, 160–181. [CrossRef]
74. Willett, E. Natural England and Covid-19 | Historic England. Available online: https://historicengland.org.uk/whats-new/debate/recent/impact-of-covid-on-heritage/natural-england-and-covid-19/ (accessed on 19 February 2024).
75. Haq, F.; Yasin, N.; Nair, G. Envisioning the Future of Heritage Tourism in the Creative Industries in Dubai: An Exploratory Study of Post COVID-19 Strategies for Sustainable Recovery. *Heritage* **2023**, *6*, 4557–4572. [CrossRef]
76. Ostrowska-Tryzno, A.; Ostrowska-Tryzno, A.; Pawlikowska-Piechotka, A.; Pawlikowska-Piechotka, A. Historic Sports Architecture in the COVID-19 Pandemic Time (UNESCO World Heritage Sites). Main Library of the Jan Dlugosz University in Czestochowa; 2021. Available online: http://dlibra.bg.ajd.czest.pl:8080/dlibra/docmetadata?id=6441 (accessed on 28 January 2024).
77. Tuzová, K.; Vaishar, A.; Šťastná, M.; Urbanová, M. The Impacts of COVID-19 on the Visitor Attendance of Cultural and Natural Heritage: A Case Study of the South Moravian Region. *Sustainability* **2023**, *15*, 14081. [CrossRef]
78. Nasir, M.B.M.; Azinuddin, M.; Hanafiah, M.H.M.; Shariffuddin, N.S.M. Shifts in heritage tourists' health risk and travel sentiments following COVID-19 pandemic: Evidence from Georgetown UNESCO World Heritage Site. *Anatolia* **2023**, *34*, 448–451. [CrossRef]
79. Koliopoulos, T.K.; Kouloumbis, P.; Ciarkowska, K.; Antonkiewicz, J.; Gambus, F. Antonkiewicz, J.; Gambus, F. A Roadmap for Integrated Green Health EcoTourism Infrastructures, Safe Cultural Heritage Experience and AgriTourism Destinations in the Post Covid-19 Pandemic Era. In *Advances in Tourism, Technology and Systems*; de Carvalho, J.V., Rocha, Á., Liberato, P., Peña, A., Eds.; Smart Innovation, Systems and Technologies; Springer: Singapore, 2021; pp. 108–119. [CrossRef]
80. Roigé, X.; Arrieta-Urtizberea, I.; Seguí, J. The Sustainability of Intangible Heritage in the COVID-19 Era—Resilience, Reinvention, and Challenges in Spain. *Sustainability* **2021**, *13*, 5796. [CrossRef]
81. UN Tourism. Cultural tourism & COVID19 | UN Tourism'. Available online: https://www.unwto.org/cultural-tourism-covid-19 (accessed on 5 February 2024).
82. Silberman, N.A. Good-bye to all that: COVID-19 and the transformations of cultural heritage. *Int. J. Cult. Prop.* **2020**, *27*, 467–475. [CrossRef]
83. Nega, D.; Baye, B.; Kindu, A. COVID-19 and The Holy Land of Lalibela World Heritage Site, Ethiopia. *Int. J. Relig. Tour. Pilgr.* **2022**, *10*, 27–37. [CrossRef]
84. Pagano, A.J.; Romagnoli, F.; Vannucci, E. Non-Incomes Risk Mitigation Mechanisms for Cultural Heritage: Role of Insurances Facing Covid-19 in the Italian Context. *Environ. Clim. Technol.* **2022**, *26*, 871–882. [CrossRef]
85. Baggott, I. Parks, People and a Pandemic | Historic England. Available online: https://historicengland.org.uk/whats-new/debate/recent/impact-of-covid-on-heritage/parks-people-pandemic/ (accessed on 6 February 2024).
86. His Majesty's Government. *Appropriation Accounts*; s.l; HMSO: London, UK, 1973.
87. His Majesty's Government. *Appropriation Accounts*; s.l; HMSO: London, UK, 1974.
88. British Library. *British Library Annual Report and Accounts 2019/20*; s.l; HMSO: London, UK, 2020.
89. British Library. *British Library Annual Report and Accounts 2022/23*; s.l; British Library: London, UK, 2023.
90. British Library. *Learning Lessons from the Cyber-Attack, British Library Cyber Incident Review*; s.l; British Library: London, UK, 2024.
91. London Transport Museum. *Annual Report 2019–2020*; s.l; London Transport Museum: London, UK, 2020.
92. London Transport Museum. *London Transport Museum Limited: Annual Report and Financial Statements 2022/23*; s.l; London Transport Museum: London, UK, 2023.

93. Association of Leading Visitor Attractions. *ALVA'*; Association of Leading Visitor Attractions: London, UK, 2019.
94. London Transport Museum. *London Transport Museum: Annual Report 2020/21*; s.l; London Transport Museum: London, UK, 2021.
95. Association of Leading Visitor Attractions. *ALVA'*; Association of Leading Visitor Attractions: London, UK, 2023.
96. LW Theatres. *LW Theatres'*; LW Theatres: London, UK, 2023.
97. LW Theatres Group Limited. *Annual Report and Financial Statements for the Period Ended 28*; s.l; LW Theatres Group Limited: London, UK, 2020.
98. LW Theatres Group Limited. *Annual Report and Financial Statements for the Period Ended 3*; s.l; LW Theatres Group Limited: London, UK, 2021.
99. Desai, H. First Look: Theatre Royal Drury Lane Reopens following £60 Million Refurbishment. 2021. [WWW Document]. Official London Theatre. Available online: https://officiallondontheatre.com/news/first-look-theatre-royal-drury-lane-reopens-following-60-million-refurbishment/ (accessed on 18 March 2024).
100. LW Theatres Group Limited. *Annual Report and Financial Statements for the Period Ended 3*; s.l; LW Theatres Group Limited: London, UK, 2022.
101. Historic Royal Palaces. Official Site. *Historic Royal Palaces.* Available online: https://www.hrp.org.uk/ (accessed on 27 January 2022).
102. Historic Royal Palaces. *Historic Royal Palaces: Trustees' Report and Financial Statements For the Year Ended 31*; s.l; Historic Royal Palaces: London, UK, 2020.
103. Association of Leading Visitor Attractions. *ALVA'*; Association of Leading Visitor Attractions: London, UK, 2020.
104. Historic Royal Palaces. *Historic Royal Palaces: Trustees' Report and Financial Statements For the Year Ended 31*; s.l; Historic Royal Palaces: London, UK, 2021.
105. Association of Leading Visitor Attractions. *ALVA'*; Association of Leading Visitor Attractions: London, UK, 2021.
106. Association of Leading Visitor Attractions. ALVA | Association of Leading Visitor Attractions'. Available online: https://www.alva.org.uk/details.cfm?p=423 (accessed on 21 December 2021).
107. Historic Royal Palaces. *Historic Royal Palaces: Trustees' Report and Financial Statements for the Year Ended 31*; s.l; Historic Royal Palace: London, UK, 2023.
108. Holtorf, C. Archaeology and cultural heritage beyond quarantine: Reflections from Sweden on COVID-19 and its consequences. *Rev. De Arqueol.* **2022**, *35*, 53–68. [CrossRef]
109. Trono, A. Natural Heritage and Cultural Routes as an Engine for Post-COVID-19 Regeneration: Changes and Challenges. In *Tourism Recovery from COVID-19*; Managing Cultural Tourism: A Sustainability Approach; World Scientific: Singapore, 2022; Volume 2, pp. 123–143. [CrossRef]
110. UNESCO. World Heritage in the Face of COVID-19. 2021. Available online: https://unesdoc.unesco.org/ark:/48223/pf0000377667 (accessed on 25 February 2024).
111. Dewi, C.; Rofe, M.; Nichols, J.; Izziah, I. Heritage and the COVID-19 pandemic: The meaning of visitation. *Built Heritage* **2023**, *7*, 11. [CrossRef]
112. Mataga, J. COVID-19 and Heritage in Southern Africa: Precariousness, Resilience, and the Future of Heritage. In *Rethinking Heritage in Precarious Times*; Routledge: London, UK, 2023.
113. Butler, B. Covid Heritage Imperatives as New Pharmacologies of Care: Revelations of "Heritage Beyond Power" and "What Makes Life Worth Living". In *Rethinking Heritage in Precarious Times*; Routledge: London, UK, 2023.
114. Monger, H. Visit Your Local Park, Protect the NHS, Save Lives | Historic England. Available online: https://historicengland.org.uk/whats-new/debate/recent/impact-of-covid-on-heritage/visit-your-local-park/ (accessed on 20 February 2024).
115. Heritage Council. Covid-19 Heritage Sector Survey. *The Heritage Council.* Available online: https://www.heritagecouncil.ie/projects/covid-19-heritage-sector-survey (accessed on 5 February 2024).
116. The University of Sheffield. The Economic Impact of Covid-19 on the Culture, Arts and Heritage (CAH) Sector in South Yorkshire and comparator regions. 2021 [WWW Document]. Available online: https://www.sheffield.ac.uk/city-region/enhancing-cultural-vibrancy/covid-research-0 (accessed on 12 May 2021).
117. UNESCO. Culture in Times of COVID-19: Resilience, Recovery and Revival—UNESCO Digital Library. Available online: https://unesdoc.unesco.org/ark:/48223/pf0000381524 (accessed on 14 February 2024).
118. Smith, C.S.; The Pandemic Is an Opportunity for Museums to Reinvent Themselves. Museums Association. Available online: https://www.museumsassociation.org/museums-journal/opinion/2021/05/the-pandemic-is-an-opportunity-for-museums-to-reinvent-themselves/ (accessed on 5 January 2024).
119. Ioannides, D.; Gyimóthy, S. The COVID-19 crisis as an opportunity for escaping the unsustainable global tourism path. *Tour. Geogr.* **2020**, *22*, 624–632. [CrossRef]
120. Curtis, C.; Stillman, J.; Remmel, M.; Pierce, J.C.; Lovrich, N.P., Jr.; Adams-Curtis, L.E. Partisan polarization, historical heritage, and public health: Exploring COVID-19 outcomes. *World Med. Health Policy* **2023**, *15*, 163–178. [CrossRef]
121. Wright, D. Laboratories in the lounge room: Archaeological field methods training during the COVID-19 pandemic. *Artefact* **2021**, *44*, 16–21.
122. Crooke, E.; Farrell-Banks, D.; Friel, B.; Jackson, H.; Hook, A.; Maguire, T.; McDermott, P. Museums and the Pandemic: Revisiting Purposes and Priorities. 2022. Available online: https://pure.ulster.ac.uk/en/publications/museums-and-the-pandemic-revisiting-purposes-and-priorities-a-rep (accessed on 15 February 2024).

123. Spennemann, D.H.R. Curating the Contemporary: A Case for National and Local COVID-19 Collections. *Curator Mus. J.* **2022**, *65*, 27–42. [CrossRef]
124. Spennemann, D.H.R. The Digital Heritage of the Battle to Contain COVID-19 in Australia and Its Implications for Heritage Studies. *Heritage* **2023**, *6*, 3864–3884. [CrossRef]
125. Guest, K. Heritage and the Pandemic: An Early Response to the Restrictions of COVID-19 by the Heritage Sector in England. *Hist. Environ. Policy Pract.* **2021**, *12*, 4–18. [CrossRef]
126. Culture Recovery Board. Culture Recovery Fund. GOV.UK. Available online: https://www.gov.uk/government/groups/culture-recovery-board (accessed on 5 February 2024).
127. Human Rights Council. *Promotion and Protection of All Human Rights, Civil, Political, Economic, Social and Cultural Rights, Including the Right to Development*'; Brill Publishers: Leiden, The Netherlands, 2021. [CrossRef]
128. Statista. uk budget for culture—Αναζήτηση Google'. Available online: https://www.google.com/search?q=uk+budget+for+culture&rlz=1C1CHZO_enGB914GB914&oq=uk+budget+for+culture&gs_lcrp=EgZjaHJvbWUyBggAEEUYOTIGCAEQRRhA0gEJNzE4MGowajE1qAIAsAIA&sourceid=chrome&ie=UTF-8 (accessed on 14 February 2024).
129. Historic England. Join the Debate: What You Told Us About the Impact of COVID-19 on the Heritage Sector | Historic England. Available online: https://historicengland.org.uk/whats-new/debate/recent/impact-of-covid-on-heritage/join-the-debate/ (accessed on 6 February 2024).
130. Spennemann, D.H. COVID-19 has been good to me. *Artefact* **2022**, *44*, 10–16.
131. Blackman, R. The Impact of Covid-19 on Rural Churches, Contractors and Professional Advisers | Historic England. Available online: https://historicengland.org.uk/whats-new/debate/recent/impact-of-covid-on-heritage/rural-churches-contractors-and-professional-advisers/ (accessed on 20 February 2024).
132. Cary, S. Virtual Heritage, Lockdown and Opportunities: A View From Enfield Council | Historic England. Available online: https://historicengland.org.uk/whats-new/debate/recent/impact-of-covid-on-heritage/virtual-heritage-lockdown-and-opportunities/ (accessed on 20 February 2024).
133. Longhi-Heredia, S.A.; Marcotte, P. The Attractiveness of Quebec's Heritage Sites in The Era of Covid-19. *Vis. Rev. Int. Vis. Cult. Rev./Rev. Int. De Cult. Vis.* **2021**, *8*, 151–165. [CrossRef]
134. Huete-Alcocer, N.; Navajas-Romero, V.; Rojas, R.D.H. Analysis of the measures of COVID-19 (SARSCoV-2) in the image, satisfaction and loyalty of visitors to a world heritage city. *J. Policy Res. Tour. Leis. Events* **2022**, 1–17. [CrossRef]
135. Parker, M.; Spennemann, D.H.R. Stille Nacht: COVID and the Ghost of Christmas 2020. *Heritage* **2021**, *4*, 3081–3097. [CrossRef]
136. Powers, M. Changing Behaviour Under Covid-19 | Historic England. Available online: https://historicengland.org.uk/whats-new/debate/recent/impact-of-covid-on-heritage/changing-behaviour-under-covid-19/ (accessed on 6 February 2024).
137. Elgammal, I.; Refaat, H. Heritage Tourism and COVID-19: Turning the Crisis into Opportunity within the Egyptian Context. In *Tourism Destination Management in a Post-Pandemic Context*; Gowreesunkar, V.G.B., Maingi, S.W., Roy, H., Micera, R., Eds.; Tourism Security-Safety and Post Conflict Destinations; Emerald Publishing Limited: Bradford, UK, 2021; pp. 37–48. [CrossRef]
138. Dastgerdi, A.S.; De Luca, G.; Francini, C. Reforming Housing Policies for the Sustainability of Historic Cities in the Post-COVID Time: Insights from the Atlas World Heritage. *Sustainability* **2020**, *13*, 174. [CrossRef]
139. Vrasida, M. Underwater Cultural Heritage Tourism and Diving Tourism Alternatives in the COVID-19 Era. In *Strategic Innovative Marketing and Tourism in the COVID-19 Era*; Kavoura, A., Havlovic, S.J., Totskaya, N., Eds.; Springer Proceedings in Business and Economics; Springer International Publishing: Cham, Switzerland, 2021; pp. 171–177. [CrossRef]
140. Crooke, E. Museums and Digital Media: Innovation, Engagement and Practice: A Report of the Museums, Crisis and Covid-19 Project. *2022*. Available online: https://pure.ulster.ac.uk/en/publications/museums-and-digital-media-innovation-engagement-and-practice-a-re (accessed on 15 February 2024).
141. World Intellectual Property Organization. The Impact of the COVID-19 Pandemic on Cultural and Creative Industries. 2022. Available online: https://www.wipo.int/edocs/mdocs/copyright/en/wipo_cr_covid_19_ge_22/wipo_cr_covid_19_ge_22_study.pdf (accessed on 15 February 2024).
142. Varriale, L.; Volpe, T.; Noviello, V. Enhancing Cultural Heritage at the Time of the COVID-19 Outbreak: An Overview of the ICT Strategies Adopted by Museums in the Campania Region of Italy. In *Tourism Destination Management in a Post-Pandemic Context*; Gowreesunkar, V.G., Maingi, S.W., Roy, H., Micera, R., Eds.; Emerald Publishing Limited: Bradford, UK, 2021; pp. 201–218. [CrossRef]
143. Statista. Global internet user penetration 2024. *Statista.* Available online: https://www.statista.com/statistics/325706/global-internet-user-penetration/ (accessed on 21 February 2024).
144. Bassa, L. (Ed.) *Combining Modern Communication Methods with Heritage Education*; Advances in Linguistics and Communication Studies (ALCS) Book Series; IGI Global: Hershey, PA, USA, 2023.
145. Gibson, R.C.; Chowdhury, S.; Chowdhury, G. User versus institutional perspectives of metadata and searching: An investigation of online access to cultural heritage content during the COVID-19 pandemic. *Int J Digit Libr* **2023**, *25*, 105–121. [CrossRef]
146. Vayanou, M.; Chrysanthi, A.; Katifori, A.; Antoniou, A. Cultural heritage and social experiences in the times of COVID 19. *CEUR Workshop Proc.* **2020**, *2687*, Code 163354.
147. Domínguez-Jiménez, J.L.; Castilla-Agredano, B.; González-Nieto, M.; Moreno-Alcaide, M.; Monterroso-Checa, A. Preparing rural heritage for another kind of Covid pandemic: Heritage digitalization strategies in the Alto Guadiato Valley and Subbetica of Cordoba, Spain. *SCIRES-IT—SCIentific RESearch Inf. Technol.* **2021**, *11*, 195–208. [CrossRef]

148. Atkinson, R. How Can Digital Platforms Help Museums Connect to Audiences during COVID-19 Emergency? *Museums Association.* Available online: https://www.museumsassociation.org/museums-journal/news/2020/03/19032020-how-digital-platforms-be-used-to-support-musems-during-covid-19-crisis/ (accessed on 2 February 2024).
149. Tsichla, M.-E. Covid-19 and Greek Museums. Digitality as a Mean of Promoting Cultural Heritage During the Coronavirus Period. New Ways of Expression. In *Digital Heritage. Progress in Cultural Heritage: Documentation, Preservation, and Protection*; Ioannides, M., Fink, E., Cantoni, L., Champion, E., Eds.; Lecture Notes in Computer Science; Springer International Publishing: Cham, Switzerland, 2021; pp. 675–682. [CrossRef]
150. Institute for Government Analysis. Timeline of UK Government Coronavirus Lockdowns and Restrictions. *Institute for Government.* Available online: https://www.instituteforgovernment.org.uk/data-visualisation/timeline-coronavirus-lockdowns (accessed on 17 November 2023).
151. Ng, W.-K.; Hsu, F.-T.; Chen, C.-L. The Impacts of Digital Technology on Service Design and Experience Innovation: Case Study of Taiwan's Cultural Heritage under the COVID-19 Pandemic. *Systems* **2022**, *10*, 184–201. [CrossRef]
152. Kist, C. Museums, Challenging Heritage and Social Media During COVID-19. *Mus. Soc.* **2020**, *18*, 345–348. [CrossRef]
153. Huddleston, N. Working Together to Weather the Storm | Historic England. Available online: https://historicengland.org.uk/whats-new/debate/recent/impact-of-covid-on-heritage/working-together-to-weather-the-storm/ (accessed on 6 February 2024).
154. Bloomberg Connects. *Bloomberg Connects.* Available online: https://www.bloombergconnects.org/google/ (accessed on 23 February 2024).
155. Irish Museums Association. Online—Ima. *Irish Museums Association.* Available online: https://irishmuseums.org/text-pages/irishmuseumsonline-content-and-resources (accessed on 14 February 2024).
156. Ginzarly, M.; Srour, F.J. Cultural heritage through the lens of COVID-19. *Poetics* **2022**, *92*, 101622. [CrossRef] [PubMed]
157. Jumino, J.; Wasisto, J.; Krismayani, I. The Use of English Dictions in Promoting Various Cultural Heritage of The Indonesian Archipelago during The Covid-19 Pandemic. *E3S Web Conf.* **2021**, *317*, 02002. [CrossRef]
158. Spennemann, D.H.R. Exhibiting the Heritage of COVID-19—A Conversation with ChatGPT. *Heritage* **2023**, *6*, 5732–5749. [CrossRef]
159. Compendium of Cultural Policies & Trends. COVID-19 | Compendium of Cultural Policies & Trends. Available online: https://www.culturalpolicies.net/covid-19/ (accessed on 14 February 2024).
160. Righettini, M.S.; Ibba, M. Cultural Heritage Digitalisation Policy as a Co-creation of Public Value. Evaluation of the Participatory Digital Public Service of Uffizi Galleries in Italy During the COVID-19. In *New Metropolitan Perspectives*; Calabrò, F., Della Spina, L., Mantiñán, M.J.P., Eds.; Lecture Notes in Networks and Systems; Springer International Publishing: Cham, Switzerland, 2022; pp. 257–267. [CrossRef]
161. Ren, W.; Chen, X. Evaluation of an Online 360° Virtual Reality World Heritage Site During COVID-19. *Open Archaeol.* **2021**, *7*, 1192–1215. [CrossRef]
162. Yossef, R.; Abdallah, M.R.; Nour, W.A. Digitize the Architectural Heritage in Egypt to Overcome the Repercussions of COVID-19. *Civ. Eng. Archit.* **2023**, *11*, 51–63. [CrossRef]
163. Conforti, M.E.; Polino, C.; Fernández-Lomana, J.C.D. Science Communication During the COVID-19 Pandemic Crisis: Archaeology and Archaeological Heritage in Atapuerca, Spain. *Conserv. Manag. Archaeol. Sites* **2023**, *24*, 1–17. [CrossRef]
164. Liyushiana; Sibarani, R.; Purwoko, A.; Emrizal. Cultural-Heritage Virtual Tour for Tourism Recovery Post COVID-19: A Design and Evaluation. *IJDNE* **2022**, *17*, 447–451. [CrossRef]
165. Museum3D. Available online: https://museum3d.eu/ (accessed on 25 February 2024).
166. Compendium of Cultural Policies & Trends. Reopening measures | Compendium of Cultural Policies & Trends. Available online: https://www.culturalpolicies.net/covid-19/comparative-overview-reopening/ (accessed on 14 February 2024).
167. Chiscano, M.C.; Darcy, S. Making Cultural and Tourist Attractions Accessible and Inclusive for People with Disability through Value Co-Creation Amidst COVID-19: A Critical Discourse Analysis. Google Docs. Available online: https://drive.google.com/file/d/1NyFuFir0P4avtO57GMNek3D5YvHNThgZ/view?usp=embed_facebook (accessed on 20 May 2024).
168. Cecilia, R.R. COVID-19 Pandemic: Threat or Opportunity for Blind and Partially Sighted Museum Visitors? *J. Conserv. Mus. Stud.* **2021**, *19*, 5. [CrossRef]
169. Lee, J.-W. The Future of Online Barrier-Free Open Space Cultural Experiences for People with Disabilities in the Post-COVID-19 Era. *Land* **2024**, *13*, 33. [CrossRef]
170. UKRI, AHRC, and DCMS, 'Boundless Creativity report', 2021. Available online: https://www.gov.uk/government/publications/boundless-creativity-report (accessed on 26 February 2024).
171. Seely, A.; Masala, F. 'VAT on Tourism and Hospitality Services', February 2024. Available online: https://commonslibrary.parliament.uk/research-briefings/sn06812/ (accessed on 24 February 2024).

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# Overheating in Historic Buildings in the UK: An Exploratory Study of Overheating Risks, Building Performance, and Thermal Comfort

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**Abstract:** A study reviewing overheating in historic buildings in the context of extant climate change. Due to global warming, more research is required when considering summertime thermal comfort in the UK, which is a more significant topic of conversation due to the heatwave in 2022. With a large demographic of the UK population residing in dwellings with historic value, this paper aimed to contribute findings that review their specific traits with respect to overheating. This was achieved by monitoring and analysing internal (and external environmental data) in three case studies in the south-east. Upon examination of the literature, many buildings in the UK are consistently subject to temperatures that exceed overheating. It was found that many properties of historic buildings lend themselves to summertime cooling such as higher thermal mass, better ventilation (without the use of mechanical or active systems), and less insulation. This, however, could come at the cost of winter thermal comfort. In all three case studies, the surveyed buildings passed the CIBRE criteria, but users still commented on being 'too hot'. The high recorded RH levels in all properties, coupled with the inadequate overheating criteria, were deemed the cause. There are new regulations in place to minimise overheating in new buildings but no support for those that are already existing.

**Keywords:** historic buildings; climate change; thermal comfort; overheating; risk assessment



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## 1. Introduction

It is widely agreed that urgency is now required in responding to climate change given the accelerated pace at which our planet is heating up, as outlined in the recent 26th United Nations Climate Change Conference (COP26) [1]. As a result, the UK government made a commitment to guarantee that greenhouse gas emissions will be cut by 100% from levels found in 1990 by the year 2050. This target is legally binding, as per the Climate Change Act 2008 Order 2019 [2], which stemmed from a recommendation by the Climate Change Committee (CCC) in 2019 [3]. These radical imperatives have been enacted to arrest climate change due to the severe associated consequences to human health, the environment, and global economy, all of which are already being felt around the UK [4]. According to the Met Office [5], average temperatures in the UK have increased by 0.5 °C in the last decade and are a further 1.1 °C warmer than between 1961 and 1990. There is also an increasing number of extreme weather events, most notably, hotter summers, which, as a result of global warming, are now 30 times more likely to occur. The previous record temperature of 38.7 °C (July 2019) was topped in July 2022 when temperatures in excess of 40 °C were felt for the first time in the UK, as recorded by five weather stations from London to Lincolnshire, with a level 4 heatwave warning being initiated for the first time [6]. It is forecast that under a higher emissions scenario, by the end of the century, temperatures could exceed 40 °C every three years [7]. These extreme changes to our climate are linked to serious health risks and excess mortality rates. According to the Office for National Statistics [8], between 17 and 20 July 2022, 1012 excess deaths were recorded and attributed

to the heatwave (253 excess deaths per day, excluding COVID-19). It is forecast that by 2050, 7040 heat-related deaths in the UK could occur per year [9].

With the average adult in the UK spending 87% of their time indoors [10] (a percentage that is likely to have increased since the COVID-19 pandemic), the role buildings play in keeping us cool in an increasingly hotter climate, as well as the associated impact this has on carbon usage, cannot be understated. With the demand for cooling increasing, mechanical means of cooling are being most commonly relied upon in the UK (i.e., fans, HVAC). With new builds accounting for less than 1–2% of the overall building stock each year, most of the demand for cooling is attributed to those residing in existing buildings [11]. Many of these existing buildings in the UK would be categorised as 'historic', as the UK is home to some of the oldest building stock in the world, with 4.3 million buildings being built before 1944 and a further 5.9 million prior to 1919 (20.6%) [12]. Due to the importance of preserving heritage buildings, adaptations utilised by their modern counterparts are not always feasible [13]. However, the pressure to ensure dwellings are environmentally efficient is increasingly important due to the reasons already stated, coupled with the ever-changing government legislation that could leave historic properties behind the curve.

Much of the existing building stock found in the UK has been designed and adapted to manage cold weather by retaining heat [14,15]. Furthermore, tensions have been documented between energy efficiency and historic preservation, leading to extensive research in conservation-compatible retrofit solutions [16]. Given the sudden change prompted by climate change, traditional building design and retrofit measures are now potentially leading to discomfort and health implications for users of heritage buildings amid more frequent heatwaves and hotter summers, as discussed above. Mitigating these changes is far from straightforward due to the accompanying legislative limitations and technical challenges [17].

Understanding thermal comfort and its drivers within the context of historic buildings is an under-researched topic. There is little existing literature that relates specifically to overheating in historic buildings. Moreover, the overheating standards are very simplistic (see Section 1.1.1) and based on historic climatic data and research. This illustrates the need for a more nuanced methodology to understand factors that influence overheating in historic buildings. Most of the present studies focus on winter thermal comfort and retrofitting [18]. The studies that specifically target overheating allude to the fact that modern building design is the main contributing factor behind the overheating crisis [19]. While this narrative is supported by several research papers [14,20], there is little research on how overheating impacts historic fabrics and their users. Aiming to bridge this gap, this study is an initial exploration to achieve a better understanding of the following:

1. how historic buildings' unique properties impact the likelihood of overheating.
2. the historic building's ability to regulate a consistent internal temperature and relative humidity when compared to recorded external conditions.
3. how the occupants/users of historic buildings react and behave in accordance with fluctuating temperatures and relative humidity.

Prior to investigating various cooling methods, it is important to understand the unique properties of historic or traditional buildings that can impact overheating, as well as their ability to accommodate changes. The research has shown that developing an overheating profile for each building should be unique, as there is a large list of contributing factors [21,22]. To this end, we developed an overheating risk assessment for historic buildings based on the literature review. We implement this risk assessment in three historic properties in the UK. We also monitored the properties to evaluate their performance and interviewed the residents/users to assess their comfort levels. Overheating not only concerns users' thermal comfort but also their health and well-being [23,24]. It also could affect the usability of the building. The primary risk that we explored in this paper concerns indoor environmental quality. Other risks associated with overheating in historic buildings include risks to the building fabric and objects. While this is an important area to be

investigated, the impact of overheating on heritage buildings and artefacts is beyond the scope of this paper.

The paper is structured in six consecutive parts. Section 2 describes the methodology adopted for this research. Section 4 describes the results. Section 5 discusses the implications of this research. The paper concludes with possibilities for future work.

### *1.1. Key Concepts*

#### 1.1.1. Overheating and Thermal Comfort

We acknowledge that there is no robust and universally accepted definition of overheating [25]. It is largely a subjective term, lacking a formal definition, although it can be loosely described as when an individual experiences discomfort as a result of an increase in internal temperature [26]. In this research, we adopt the Chartered Institution of Building Services Engineers (CIBSE) criteria [27]. Based on these criteria, for residential buildings, the indoor temperature should not exceed 26 °C for bedrooms for 1% of the annual occupied hours. For living rooms, it should not exceed 28 °C for 1% of the annual occupied hours. For schools and office buildings, the indoor temperature should not exceed 28 °C for 1% of the annual occupied hours. While managing indoor microclimate risk in museums is out of scope for this research, the authors refer readers to the book 'Environmental management: guidelines for museums and galleries' [28]. High temperatures can induce 'heat stress', which can prove fatal (when the human core temperature exceeds 37 °C). The American Society of Heating and Air-Conditioning Engineers [29] states that an indoor temperature of above 35 °C is the heat stress 'danger line', with the danger line temperature decreasing by as much as several degrees in higher humidity levels. The authors note that this guidance is not yet specified in building regulations or health and safety guidelines in the UK. Increased humidity affects human health as it is directly related to thermal comfort, as it increases the difficulty the body experiences when removing heat via sweat evaporation [30].

#### 1.1.2. Defining Historic Buildings

Historic buildings are defined by a building's age, special features, or designation in planning regulations. This research adopts the definition by English Heritage, which defines historic or traditionally constructed buildings as "nearly all buildings constructed prior to 1919, as well as a significant proportion of those built before 1945" [31].

## 2. Materials and Methods

A methodology has been devised that includes three different methods, including

1. developing overheating risk assessment that relates to historic buildings using a literature review
2. case study selection to test and validate risk assessment
3. risk assessment of the case studies based on the model developed
4. collection of environmental data (temperature and humidity) for case studies
5. semi-structured interviews with those who occupy the properties
6. validation of risk assessment using interview data and environmental data

A combination of qualitative and quantitative methods was chosen to address the issues holistically. Combining these methods is expected to neutralise any limitations of either in use alone and also build on both their strengths [32,33].

The details of the three methods are provided in Sections 2.1–2.3.

A total of three historic buildings were assessed for their ability to remain cool in the summer months. The case studies were selected to test and evaluate the methodology to assess overheating and its impact on buildings users. The selected case studies are located in the south-east of the UK as this area will be disproportionately impacted by global warming. In fact, during the 2022 heatwave, southern areas achieved significantly higher temperatures, with London being the worst affected, as mapped by scientists at the National Centre for Earth Observation [34].

One of the three properties is located in a rural area outside of London, and the other two were in central London (zones 1–2, highly urbanised environment). The spread of locations offers further scope for understanding any variables exhibited between the two environments and how this, in turn, impacts overheating. Both areas are home to a large historic building stock, as evidenced by the data from the Office for National Statistics [35]. The details of the case studies are provided in Section 3. Table 1 provides an overview of the data collected.

**Table 1.** Data Collected.

| | **Case Study 1** | **Case Study 2** | **Case Study 3** |
|---|---|---|---|
| Location | Marden, Kent | Islington, London | The House Mill London |
| Environmental Data Collection Period | 56 days (28 June 2023–24 August 2023) | 56 days (28 June 2023–24 August 2023) | 415 days (1 June 2022–21 July 2023) |
| Number of internal data loggers | 2 | 2 | 1 * |
| Location of internal data loggers | Living room and bedroom | Living room and bedroom | First floor, close to south-facing window |
| Number of external data loggers | 1 | 1 | 1 |
| Interviews | one resident | one resident | one user |
| Risk Assessment | conducted during July 2023 | conducted during July 2023 | conducted during July 2023 |

* A data logger was also located on the ground floor, but the data were corrupted so could not be used for the purposes of this study.

### *2.1. Risk Assessment*

There are a wide variety of factors that contribute to overheating in buildings, such as solar gains transferred through fabric, solar gains transferred through openings/windows, external air temperature, and internal heat gains [22,36]. All these considerations are relevant to historic buildings, however, the areas are broken down within the risk assessment model we developed. The overheating risk assessment models available are not applicable to historic buildings. To this end, the authors developed a risk assessment to be tailored for use in historic buildings, incorporating the findings from the literature review. This will act as a means of cross-referencing the data recorded through the loggers and interviews.

The risk assessment we developed builds upon the Good Homes Alliance tool [37], which is designed to be a 'first filter' risk assessment and assists with establishing a risk category (low, medium, and high) for the likelihood of a dwelling overheating in the UK. The guidance encourages a reduced reliance on mechanical means of cooling, but much of the advice on means of mitigating overheating involves deeper retrofit strategies that do not apply to historic buildings. The Good Home Alliance assessment contains questions that fall into the following categories: regional and local context, site characteristics, occupancy characteristics, key characteristics of the building, solar heat gains and shading, infiltration, ventilation and effectiveness of openings, and energy efficiency characteristics. We followed the same structure of the assessment. We included the same scoring system as it has undergone revisions over the years with the help of case studies [38]. We added factors specific to historic buildings under site characteristics and key characteristics of the building. In key characteristics of the building specifically, we added three factors likely to increase overheating risks, including the floor area of occupied rooms, the condition of the property, and the listed status. We also added a factor likely to mitigate overheating risks, i.e., building construction. In site characteristics, we have added orientation as a factor likely to increase overheating risk. We have expanded the scope of risk assessment tools to include historic public buildings to be able to assess a wider variety of buildings. In this, we have added the number of occupants for public buildings. Furthermore, we have simplified the assessment for non-experts to use easily. In this, we have simplified regional and local context to only refer to the location of the building, i.e., urban or rural context. In this research, we focus on naturally ventilated buildings as they form a large majority of UK's

historic buildings, and therefore, we have removed any references to mechanical ventilation from the assessment.

The risk assessment we developed comprises 23 questions and is tailored for assessing historic buildings. Each question has guidance notes to assist the person carrying out the review of the key considerations when scoring, as there are several scoring options for each question. Factors that are likely to increase overheating risk are numbers equal to or higher than zero. In this, the higher the score, the more risk. Factors that are likely to mitigate overheating are numbers less than zero. In this, the lower the score, the lower the risk, which will reduce the total score. When all the scores are entered into the spreadsheet, a total score is calculated, which is categorised into one of the three risk groups; high risk > 32, medium risk 22–31, low risk < 21. The score categories have been calculated through averages of previously worked case studies in a wide variety of dwellings. It is the intention that this will provide the authors with the factors that are most likely to increase the risk of overheating. The list of considerations in the developed assessment is as follows:

**Regional and local context**. The location of historic buildings is an important factor in assessing the risk of overheating. Areas located in highly urban districts such as central London are dominated by hard surfaces. These surfaces increase the average air temperature as they absorb heat during the day and release it at night [37]. Table 2 illustrates the risk assessment for regional and local context. The buildings located in towns or cities, due to the 'urban heat island effect', where heat is stored in pavements, roads, and buildings, is further compounded by a lack of trees when compared with the countryside [39,40]. The presence of green spaces and large water bodies in the context can help mitigate the effects of overheating [41].

**Table 2.** Regional and local context.

| | Explanation | Options | Score |
|---|---|---|---|
| Where is the building situated? | Heat urban island effect increases the likelihood of overheating | Central/high heat risk London | 6 |
| | | Towns Cities | 4 |
| | | Suburban areas | 2 |
| | | Rural Areas | 0 |
| Is there significant blue/green infrastructure in the surrounding area? | How close is the property to green spaces/large water bodies? | Yes: As guidance, score 2 mitigation points for at least 50% of surroundings within a 100 m radius to be blue/green or a site in a coastal area. | −2 |

**Occupancy characteristics** Overheating risks are also dependent on the length of occupancy [42]. The more time spent indoors, the warmer the internal environment is likely to be. On the other hand, under-occupied properties pose less risk of overheating. In public buildings, the higher the number of users per day, the warmer the internal environment is likely to be [43]. How the occupants use the buildings could also add to overheating risks [44]; however, we have not considered it in our initial exploration. Table 3 illustrates the risk assessment in relation to occupancy characteristics.

**Site characteristics**. The characteristics of a site can influence the overheating risks. In this, we consider the orientation of the property and the opening of windows. South-facing buildings receive the most amount of solar gains. Therefore, these buildings are most likely to be subjected to overheating. The surroundings of a historic property also dictate whether the windows can be opened without any risks such as pollution, noise, and security [45]. If such risks exist, the property may be more at risk of overheating due to lack of ventilation. The overheating risks can be mitigated if there are tall trees or buildings that can shade the solar-exposed areas [46]. Moreover, pale or blue/green surroundings can further reduce overheating risks. Please see Table 4.

**Table 3.** Occupancy characteristics.

| | Explanation | Options | Score |
|---|---|---|---|
| Length of occupancy (dwelling) | The more time spent, the warmer the internal environment is likely to be | Long occupancy hours: score 3 per adult at home most of the day (excluding the first adult), e.g., score 0 for 1 adult with long occupancy hours, 3 for 2 adults with long occupancy hours, etc. | 3X |
| | | High occupancy density, i.e., more than 2 people per bedroom: count the total number of bedrooms (including the main room in a studio), multiply by 2, and score 3 per occupant over that "2-per-bedroom total" | 3X |
| Number of of occupants (public buildings) | The higher the number of users, the warmer the internal environment is likely to be | More than 100 people | 4X |
| | | Between 50–100 people | 2X |
| | | less than 50 people | 0X |
| Are the homes under-occupied or likely to be? | "Under occupancy" is taken here as less than 1 person per bedroom, based on the total number of occupants and bedrooms—whether or not occupants share a bedroom, bedrooms are used as offices etc. | Low occupancy density: count the total number of bedrooms (including the main room in a studio), and score 2 per occupant under that total number of bedrooms. e.g., score 0 for 2 occupants in a 2-bed flat; 2 for 1 occupant in a 2-bed flat; 4 for 2 occupants in a 4-bed | −2x |

**Table 4.** Site characteristics.

| | Explanation | Options | Score |
|---|---|---|---|
| Orientation | Buildings that are south facing (with the majority of facing windows) receive the most amount of solar gains | South-facing | 4 |
| | | Other | 0 |
| Window Opening | Can windows be opened without risk? Risks could include acoustic risks, poor air quality, e.g., near factory, car park, or very busy road; security risks; adjacent to heat rejection plant | Day time—considerable restrictions on opening windows | 16 |
| | | Day time—some restrictions on opening windows | 8 |
| | | Day time—few restrictions on opening windows windows | 4 |
| | | Night time—considerable restrictions on opening windows windows | 16 |
| | | Night time—considerable restrictions on opening windows windows | 16 |
| | | Night time—some restrictions on opening windows | 8 |
| | | Night time—few restrictions on opening windows | 4 |
| Are immediate surrounding surfaces in majority pale in colour, or blue/green? | All surfaces within 10 m of the property | Yes, the large majority of surfaces | −2 |
| | | Yes, approximately half of the surfaces | −1 |
| | | No | 0 |

**Table 4.** *Cont.*

| | Explanation | Options | Score |
|---|---|---|---|
| Are there existing tall trees or buildings that shade solar-exposed glazed areas? | | Yes, to all or a majority of solar-exposed areas | −2 |
| | | Yes, but only to some of the solar-exposed areas (only score this when considering individual dwellings: do not score for a whole apartment block if some apartments are shaded but not others, except if scoring specifically these shaded apartments rather than the whole block) | −1 |

**Key characteristics of the building**. Table 5 illustrates the risk assessment in relation to key characteristics of the building. Identifying a building's age is key to the process of identifying its innate characteristics and, in turn, the efficiency of its fabric. Despite the challenging nature of identifying a building's age, it is made possible by recognising the major changes to techniques that were used in constructing them. Pre-1919 dwellings range from mass-built solid-wall stock to exemplary individual buildings. In the UK, traditional buildings typically comprise solid load-bearing masonry walls, with pitched rooves and timber framed windows [13]. This building envelope is characterised by its high thermal mass, due to the materials' dense and heavy nature. A building that obtains a high thermal mass (or 'thermal inertia') is associated with being efficient at absorbing external thermal gains while not exhibiting considerable changes to ambient temperature, remaining thermally stable. Heavy materials such as brick or masonry act as a buffer by absorbing energy, which is, in turn, released slowly, hence, why churches are often cool in the summer [47]. Exposed thermal mass refers to thermal mass without appropriate ventilation that gradually releases the heat in occupied rooms and contributes to overheating. High exposed thermal mass can contribute to mitigating overheating when it is combined with night ventilation. A lack of safety and noise have been identified as the main barriers to ventilation. We also acknowledge that occupants' awareness of the importance of night ventilation is a key factor in mitigation.

While we considered high thermal mass in combination with night ventilation a mitigation point, we must acknowledge that with the increased likelihood of 'tropical nights' in the UK, a high thermal mass can be an issue. When the temperature is high throughout the night (rather than historically cool) and materials with a high thermal mass radiate heat rather than absorbing it, the indoor environment is more likely to be impacted [48]. This is further exacerbated for buildings located in towns or cities due to the 'urban heat island effect', where heat is stored in pavements, roads, and buildings and further compounded by a lack of trees when compared with the countryside [39].

A literature review of investigations into the overheating of homes carried out by Departments for Communities and Local Government [49] summarised that the scale of the problem for existing buildings was considerable (as highlighted by several monitoring studies). The studies informed that the areas that were most at risk from large variations in internal temperatures during heatwaves were top floor flats, end terraces, and purpose-built dwellings, with bedrooms being the greatest cause for concern [50,51].

Older buildings that have been left in a state of disrepair can face severe overheating as negative solar gains are absorbed though any openings. which are then, in turn, transferred into the living spaces.

Historic buildings are also protected by law through forms of designation. When applying these restrictions to changes that could be made to historic buildings to better cope with overheating, there is currently a fragmented approach to the approval of retrofit schemes. This is largely down to the associated variety in size, operation mode, and local cultures of the NGO's advising on the designations, as well as the local authorities. This,

in turn, leads to the guidance and advice that is provided not always being consistent or compatible [52]. There are several studies that highlight these inconsistencies (See for example, [53–55]).

**Table 5.** Key characteristics of the buildings.

| | Explanation | Options | Score |
|---|---|---|---|
| Are the buildings a higher-risk typology? | Flats and bungalows often combine risk factors such as dwelling size and heat gains from surrounding areas or the roof | Flats | 6 |
| | | Bungalows | 4 |
| | | Mid-terrace, end terrace | 1 |
| | | Detached/semi-detached | 0 |
| What is the aspect of the building? | Dual aspect buildings make effective ventilation easier and more likely. | Single aspect | 6 |
| | | Corner aspect or dual aspect with convoluted air path | 3 |
| | | Dual aspect | 0 |
| Floor Area of occupied rooms | Smaller surface to floor area (SA/FA) increases overheating risk | small | 3 |
| | | medium | 2 |
| | | large | 1 |
| Condition of the property | Buildings that are poorly maintained have an increased risk | Poorly maintained | 6 |
| | | Adequately maintained | 3 |
| | | Well maintained | 0 |
| Listed status | Buildings that are listed are less likely to be able to accommodate changes | Listed | 4 |
| | | unlisted | 0 |
| Do buildings have high exposed thermal mass and a means for secure and quiet night ventilation? | Medium and heavyweight construction materials can be effective in reducing overheating risks in combination with night-time ventilation. Relying on night-time ventilation must take account of occupants' awareness and security | Yes | −2 |
| | | No | 0 |
| Building Construction | Correlation between construction types and overheating | Solid masonry | −2 |
| | | Cavity wall | −1 |
| | | Timber frame | 0 |

Well-insulated buildings are increasingly likely to experience overheating [25]. The same can be said for windows that have secondary glazing units installed [26]. When considering overheating in historic buildings, there are three main considerations, forming a 'trilema': energy performance, practical usability, and heritage preservation.

The 'heritage preservation' is a uniquely specific factor of the overheating trilemma that applies to the UK. There are two key areas where legislation is directly involved when carrying out any adaptations to an historic building, building regulations and planning consent or approval [56]. The approved documents that specifically apply to historic buildings are Part L-Conservation of Fuel and Power and Part F–Ventilation. Part L aims to achieve the conservation of fuel and power by regulating the efficiencies of mechanical systems (i.e., cooling and heating), as well as by enforcing fabric performance standards [56]. Part F is intrinsically linked to Part L, with both needing to be viewed together when enacting any change on a building. As alluded previously, the difference in imposed standards is far more relaxed when reviewing the existing buildings. Many of the considerations found within the approved documents are generic, so expecting the same standards for both new

and old buildings is unrealistic due to the extent of the differences in their make-up and the way they perform [57]. Overheating is directly addressed in building regulations part O [58] but only applies to newly constructed domestic buildings.

Capuano et al. [59] make the case that most conventional methods of passive cooling have design implications (or utilise unsustainable methods), which, in turn, conflict with the heritage preservation philosophy. These methods range from; new windows (reduce glazing areas and g-value, modern draft strips, solar control films), external shading (awnings, shutters, and canopies), urban redesign (increasing green spaces, shade landscaping), altering roof form and introducing vents, solar reflective paint, and external insulation. However, there are methods that can be incorporated by historic buildings without legislative restriction for the most part; cross ventilation (strategic window opening across aspects), internal insulation (pipes, roof spaces, with particular materials as to not exacerbate the issue), modify interior design (lighter, less thick materials), and solar window films [60–62].

**Solar heat gains and shading**. Considering solar heat gains from glazing exposed to solar radiation is necessary for risk assessment as it increases the likelihood of overheating [63]. The more glazing exposed, the higher the likelihood of overheating [37]. In this, there are five categories to consider, depending on the proportion of exposed glazing. We acknowledge that in historic buildings in the UK, the proportion of higher glazing, i.e., more than 50%, is a highly unlikely scenario. However, this factor is relevant for historic buildings with highly glazed features such as conservatories. While we acknowledge that the type of glazing can also impact overheating risk [63], for our initial exploration, we used only the ratio of glazing to surface criteria. Refer to Table 6.

**Table 6.** Solar heat gains and shading.

| | Explanation | Options | Score |
|---|---|---|---|
| What is the solar-exposed glazing ratio for the buildings? | The more glazing that is exposed increases the likelihood of overheating. | Solar exposed glazing-to-facade > 65%. | 20 |
| | | Solar exposed glazing-to-facade > 50%. | 12 |
| | | Solar exposed glazing-to-facade > 35%. | 8 |
| | | Solar exposed glazing-to-facade < 35%. | 4 |
| | | Highly glazed feature, e.g., conservatory, enclosed glazed balcony | 14 |

**Infiltration, ventilation, and effectiveness of openings**. Internal air tightness leads to an increased risk of overheating. High energy standard retrofitted buildings, as well as internally heavyweight structures, have an increased likelihood of severe overheating [25], with buildings in the south of the UK facing the largest risk.A very leaky building is less likely to be at risk of overheating. On the other hand, airtight buildings are more likely to be overheated. Internal airtightness can be mitigated by effective ventilation. Cross ventilation is an effective means of cooling a building. In this, we consider the positioning of windows in historic buildings. Single aspect refers to openable windows on one wall. Dual aspect refers to buildings with openable windows on two or more walls, whereas corner aspect means two sides that are exterior walls. As airtightness regulations refer to new buildings only, in historic buildings, more of a qualitative approach is adopted due to the unique characteristics and different typologies of heritage buildings. In energy efficiency research, airtightness is assessed through hydrothermal simulations and blower door tests. For these risk assessment tools, the level of airtightness is following the criteria: presence or not of window and door draughtproofing, wall insulation, loft insulation, and floor insulation. The main sources of the air leakage points [64,65] that can be detected in historic buildings are

- Fenestration, in the wall joints and the joints in the frame, especially in mobile parts.
- Apertures across the envelope to let ducts or conduits go inside (fresh water, waste water, gas, and/or ventilation)
- Electrical devices (switchboards, plugs, switches, lighting)
- Large cracks caused by ground settlement or cavities in wooden structure.
- Baseboards and in tongue and groove joints of the floor boards.

Refer to Table 7.

**Table 7.** Infiltration, ventilation, and effectiveness of openings.

| | Explanation | Options | Score |
|---|---|---|---|
| Air tightness | As per the Historic England (2021) study, air tightness increases likelihood of overheating | Very leaky building, e.g., at least 3 "high leak features" If test available: >12 $m^3/m^2/h$ at 50 Pa | 0 |
| | | Average or very airtight building but with suitable background ventilation provision. | 1 |
| | | Average airtightness, WITHOUT suitable background ventilation provision. | 1 |
| | | Very airtight building, WITHOUT suitable background ventilation provision. | 1 |
| Do windows and openings support effective ventilation? | Cross ventilation is an effective means of cooling a building | Single aspect | −4 |
| | | Corner aspect | −5 |
| | | Dual aspect | −6 |

**Energy efficiency**. Certain measures that are put in place to increase the performance or efficiency of a building could increase the likelihood of overheating risk [66]. In this, we consider the heating systems, roof and loft insulation, and type of window glazing as factors that could increase risks of overheating. The heating systems are divided into two types: (1) communal/district heating and (2) individual heating and hot water systems. For evaluating risks due to heating systems in communal heating, if there is not much information available on the scheme, we suggest taking scoring route 1. Scoring route 2 should be taken if information is available on the scheme. Roof coverings can aid in heat gains. Properties with no or minimal insulation are more likely to be at risk. Lastly, the type of windows should be considered when evaluating risks. Buildings with single-glazed windows are least at risk. We consider the ground-floor insulation as a mitigating factor. Un-insulated suspended floors mitigate the risks to a great extent. Please refer to Table 8.

### *2.2. Environmental Data*

Environmental monitoring is a reliable way to assess historic building performance in a changing climate. In order to have a quantifiable measure of the internal gains of a property, capturing temperature and relative humidity (RH) data in each of the three properties was a necessity. Of the three properties, the authors set up two data loggers in two of the buildings, with the other property having already been capturing the data prior to this study being conducted. Table 1 illustrates the data collection period. Tinytag Ultra 2 Temperature Loggers (TGU-4017) were utilised, as they are most suited to monitor internal environments where there is little moisture. The loggers recorded temperature and RH every hour, 24 h a day. The loggers were placed in two different locations due to the differing overheating thresholds, as per the CIBRE criteria. External environmental data were also collected in the three different locations 24 h a day for the same time periods that the internal loggers were recording.

**Table 8.** Energy efficiency.

| | Explanation | Options | Score |
|---|---|---|---|
| Does the heating system create a risk of high internal heat gains? | Community/district heating can create a risk due to hot pipework operating during the summer, especially if it runs across internal areas (e.g., corridors), leading to heat gains and higher temperatures in these areas and ultimately into adjacent dwellings. Individual heating systems can create a risk too | Communal/district heating: Scoring route 1: not much information on the scheme/early design stage: Score 7 for scheme details unknown or unlikely to be best practice OR Score 2 for best practice, e.g., following CIBSE CP1 2020 "Best Practice", or ambient loop, and no store in apartments. Scoring route 2: information on the scheme is available: Score 2 if long corridors with no or limited ventilation, Score 1 if corridors with effective ventilation to limit overheating, Score 0 if corridors with running pipework are very short or there are no internal corridors, or the communal heating scheme is at low temperature distribution PLUS Score 3 if poorly insulated store inside the dwelling, 1 if well insulated store inside the dwelling, and 0 if no store inside the dwelling PLUS Score 1 if poorly insulated distribution. | Up to 7 |
| | | Individual heating and hot water systems: Score 3 for poorly insulated store, 1 for well insulated store, and 0 for no store PLUS Score 1 for poorly insulated/long distribution, 0 for insulated/efficient | Up to 5 |
| Roof and loft insulation | Significant heat gains can be generated from roof coverings | Houses, bungalows, top floor flats: No or minimal (<50 mm) insulation: 2 points | 2 or 3 |
| | | Houses, bungalows, top floor flats: Some insulation (>100 mm): 1 point PLUS 1 point if roof covering likely to get hot | 1 or 2 |
| | | Houses, bungalows, top floor flats: New build levels of insulation e.g., new loft roof, exemplar retrofit. All flats except top floor flats | 0 |
| Windows | Window U-Value | Single glazed | 0 |
| | | Existing double glazed or single + secondary | 2 |
| | | Similar to new build standards | 3 |
| Ground floor insulation | Ground temperature is relatively constant throughout the year, and this can provide beneficial cooling in the summer, particularly in the case of suspended floors. | Houses, bungalows, ground floor flats: Un-insulated suspended floor, ventilated | −2 |
| | | Un-insulated slab, or minimal insulation | −1 |
| | | Insulated slab, or insulated suspended floor. All upper floor flats. | 0 |

The readings were also analysed by working them into the overheating criteria to record whether the buildings were subject to overheating, as per the CIBRE metrics. Where applicable, heatwave and winter data were also reviewed to provide a comparison.

### *2.3. Interviews*

An occupier of each property was interviewed to assess their experience in the property, as well as a discussion regarding other variables that lend themselves to overheating. In other words, the interviews were used to inform the risk assessment, particularly the section on occupancy characteristics. There was a total of 19 questions, which attempted to obtain information that cannot be captured through the data loggers or risk assessment methods. Interviews were also used to validate the results of the risk assessment model according to the thermal comfort perceptions. The topics of conversation were as follows:

1. Occupant characteristics/patterns
2. Defining unique relationship with overheating
3. Satisfaction with the environmental performance of the building and its impacts
4. Understanding areas and features of the building that impact overheating risk
5. User behaviour in hot weather when occupying the building
6. Ability to make alterations/adaptations to improve cooling capacity
7. Awareness of support/incentives to improve building performance/efficiency

All three interviews took place face-to-face at the property in question, along with the risk assessment taking place immediately before or after the interview. Once they were completed, the authors analysed any similarities in the answers given across the various properties.

## 3. Case Studies

Three case studies were selected to test and evaluate the methodology to assess overheating in historic buildings. The details of the case studies are provided in Table 2. The case studies are selected for their different attributes. They include residential and public historic buildings in rural and urban contexts. The buildings were constructed in different periods and employed different construction techniques and materials, as evident from Table 2. Two out of three cases are listed buildings.

### *3.1. Marden, Kent*

The first property selected is a semi-detached 3-story Farmhouse located in Marden, Kent. The district authority is Maidstone, located within the Collier Street Parish. Marden is a highly rural area, with this property being situated in a farm, ten minutes away from the village, so there are many trees and large bodies of water near the house. This dwelling was originally constructed in 1662, with the western section being constructed later to extend the property There are several grade II listed buildings within the immediate area, although this building does not obtain listed status. This is a 6-bedroom family home that is only regularly occupied by two individuals. The first data logger was set up in the ground floor sitting room, and the second in bedroom 2 on the second floor Both rooms that the loggers were placed in are lightly used, with the windows closed for the vast majority of the duration of this study (Table 9).

**Table 9.** Case studies.

| | **Case Study 1** | **Case Study 2** | **Case Study 3** |
|---|---|---|---|
| Location | Marden, Kent | Islington, London | Bromley-By-Bow, London |
| Type | Semi-detached 3 story Farmhouse, 6 Bedroom | Mid-terrace, Georgian Maisonette, 2-bedrooms | Tidal mill |
| Context | Highly rural area | Highly developed area | Highly developed area, situated on the River Lea |
| Built in | 1662, subsequent retrofits | 1828–1829 | 1776 |
| Listed status | Un-listed | Grade II listed, conservation area | Grade I listed |
| Construction | Timber framed, weatherboarded | Solid masonry wall, London stock bricks with stucco bands | Solid masonry wall, timber-boarded rear elevation, stock brick front elevation |
| Windows | Double glazed, hinged | Double glazed sash | Single glazed sash |
| Orientation | Corner aspect | North-facing | South-facing |
| Aspect | South-facing | Dual aspect | Dual aspect |
| Usage | Residential | Residential | Industrial |
| Occupants | Regularly occupied by two individuals | Lightly occupied by two young professionals who both work away from home | Open to the public on Sundays where tours take place over the course of five hours |
| EPC | D | C | N/A |

### *3.2. Islington, London*

The second property is a grade II listed Georgian Maisonette situated within a conservation area in the London Borough of Islington. The flat is located on the second and third floors of a terraced house, built circa 1828–1829 by William Chadwell Mylne, Surveyor for the New River Estate. Islington is a highly developed area in central London (zone 1), so this property is likely to be significantly affected by the urban heat island effect. The envelope consists of yellow stock brick set in Flemish bond with a banded stucco ground floor and stucco dressings The windows are double glazed timber sashes, with the downstairs windows being very large, spanning most of the height of the room (3 m). The roof is dual-pitched with turnit slates with an asphalt gully running through the center. The property is lightly occupied by two young professionals who both work away from home. The flat is dual aspect, and there is little risk to opening windows as the flat is situated on the upper floors. As with the first property, the loggers were placed on a high shelf in the downstairs living room and second-floor master bedroom by a north-facing window.

### *3.3. House Mill, Bromley-by-Bow, London*

The third property being studied is House Mill in Bromley-By-Bow, London. It is also known as Tide Mill. It is a grade I listed building located in the borough of Newham, constructed in 1776 The building is only open to the public on Sundays, when tours take place over the course of five hours. Bromley-By-Bow is a highly urbanised area and surrounded by River Lea, from the Thames. Internally, much of the exposed timber is painted with a white lime wash, which was intended to reduce internal temperatures. This was carried out so as to limit the chance of fires breaking out. There are many open cavities in the walls and floor A data logger was placed on a beam by a south-facing window on the first floor (the grinding floor). A data logger was also located on the ground floor, but the data were corrupted so could not be used for this study.

## 4. Results

In this section, we present the results of the overheating risk assessment of three case studies, results of the environmental data monitoring, and interviews.

### *4.1. Risk Assessment*

Table 10 illustrates the results of the risk assessment. House Mill was found to be least at risk, while the properties in Marden and Islington were found to be at medium risk. Regional and local context seemed to be one of the most important factors in the risk assessment. Comparatively, the property in Islington scored the highest in the risk assessment model among the three properties. This is not surprising as the property is in central London and exposed to the 'urban heat island effect'. However, in this, we also see the importance of mitigation measures. Without any mitigation points, the risks due to context are higher in Islington, whereas the presence of mitigation factors in House Mill lowers the risk, as it is also exposed to the 'urban heat island effect'.

Site characteristics such as the ability to open windows and site orientation can also influence overheating risks significantly. South-facing House Mill with restrictions on opening windows during the day as well as night led the property to score higher in risk assessment compared to other case studies. In terms of mitigation, we see that Marden scored higher than the other case studies because of the presence of trees that limit direct solar exposure and the presence of pale/blue-green colours in the immediate surrounding surfaces.

Occupancy characteristics that could add to overheating risks are dependent on how the occupants use the buildings [44]. In our study, the occupants seem to be working actively on mitigating overheating risks with their behaviour. While the occupancy density was low in all three cases, this may not be true for other cases, particularly in London where the housing crisis is a documented problem.

**Table 10.** Risk Assessment.

| Factors | Increase Points | Mitigation Points | Total |
|---|---|---|---|
| **Marden, Kent** | | | |
| Regional and local context | 0 | 2 | −2 |
| Site characteristics | 12 | 4 | 8 |
| Occupancy characteristics | 3 | 6 | −3 |
| Key characteristics of the dwelling | 9 | 4 | 5 |
| Solar heat gains and shading | 4 | - | 4 |
| Infiltration, ventilation, and effectiveness of openings | 2 | 4 | −2 |
| Energy efficiency | 13 | 1 | 12 |
| Total | | | 22 (medium risk) |
| **Islington, London** | | | |
| Regional and local context | 6 | 0 | 6 |
| Site characteristics | 8 | 1 | 7 |
| Occupancy characteristics | 0 | 4 | −4 |
| Key characteristics of the dwelling | 15 | 4 | 11 |
| Solar heat gains and shading | 4 | - | 4 |
| Infiltration, ventilation, and effectiveness of openings | 1 | 6 | −5 |
| Energy efficiency | 7 | 0 | 7 |
| Total | | | 26 (medium risk) |
| **House Mill, London** | | | |
| Regional and local context | 6 | 2 | 4 |
| Site characteristics | 20 | 2 | 18 |
| Occupancy characteristics | 0 | 8 | −8 |
| Key characteristics of the dwelling | 11 | 2 | 9 |
| Solar heat gains and shading | 4 | - | 4 |
| Infiltration, ventilation, and effectiveness of openings | 0 | 6 | −6 |
| Energy efficiency | 2 | 2 | 0 |
| Total | | | 21 (low risk) |

Key characteristics of the dwelling also contribute significantly to the overheating risks. The fact that Islington is a list-property (thereby, limiting active adaptation possibilities) and a flat adds significantly to the increase points in this property. All the case studies are constructed in solid wall masonry, thereby mitigating the overheating risk to some extent.

Solar heat gains and shading were the same for all three study cases as a contributing factor. The absence of shading in the historic environment in the UK is already mentioned in the introduction as one factor for overheating in historic buildings.

Infiltration, ventilation, and effectiveness of openings can also influence the overheating risk of a historic building. Low airtightness in House Mill seems to be contributing to low risk in overheating. In Islington, the effectiveness of window openings is an important mitigation factor. Interestingly, in House Mill, even if there is a restriction on opening the windows, the building is very leaky, which lowers the risk for overheating.

Lastly, the energy efficiency seems to be an important parameter influencing risk for overheating, especially regarding the Marden study case. As a house with no loft insulation and existing double glaze windows, there is the possibility that significant heat gains can be generated from roof and window coverings. On the contrary, House Mill, which was found with no floor insulation, contributed to mitigation points. As the ground temperature is relatively constant throughout the year, a beneficial cooling effect can be provided during the summer.

The combination of all the above factors created in each study case a unique overheating risk profile. Even though two of the studied buildings fall into the medium risk band,

each building has its own risk points and limitations but also adaptation possibilities to be considered.

### *4.2. Environmental Data Analysis*

In Table 11, we can see the environmental monitoring period in the case studies, the number of days spent monitoring the internal and external environments. In each study case, the internal temperatures and relative humidity are compared with the measured external temperatures, which were monitored as well for the same period. The average temperature is noticed to be relative stable between the different floors for the monitored period. For the first two case study buildings, the indoor temperature is higher in comparison with the external temperature, in the scale of 5 °C. This is not noticed in House Mill, where the indoor average temperature is only 1 °C higher than the external average.

In the Marden building, there is a little difference between the monitored floors (0.15 °C). The average temperature in the ground floor is 22.2 °C and 22.4 °C upstairs. On the contrary, according to the Table 11, there is a rise in the average relative humidity by 3.15% from the ground floor to the bedroom, which can cause a different feeling for the same absolute room temperature.

In the Islington building, there is a slight difference between the average temperature on the living room (on the lower floor) and the master bedroom (0.87 °C). The average relative humidity is also relative stable on the two floors. According to Table 11, both buildings pass the CIBRE criteria for overheating. However, the risk assessment indicated both study cases had medium risk.

**Table 11.** Environmental data analysis.

| **Marden, Kent** | **Sitting Room, Downstairs CP08** | **Bedroom 2, Upstairs CP05** | **External** |
|---|---|---|---|
| Recording period | 28 June 2023–24 August 2023 | 28 June 2023–24 August 2023 | 28 June 2023–24 August 2023 |
| No. of days | 56 days | 56 days | 56 days |
| Average temperature (°C) | 22.23 | 22.38 | 17.25 |
| Average RH (%) | 59.8 | 62.95 | 78.21 |
| CIBRE Criteria | PASS, 0% of recorded hours above 28 °C | PASS, 0.024% of recorded hours above 26 °C | N/A |
| **Islington, London** | **Living Room, Downstairs CP03** | **Master Bedroom, Upstairs CP04** | **External** |
| Recording period | 28 June 2023–24 August 2023 | 28 June 2023–24 August 2023 | 28 June 2023–24 August 2023 |
| No. of days | 56 days | 56 days | 56 days |
| Average temperature (°C) | 22.71 | 23.58 | 18.21 |
| Average RH (%) | 61.36 | 62.04 | 71.21 |
| CIBRE Criteria | PASS, 0% of recorded hours above 28 °C | PASS, 0.024% of recorded hours above 26 °C | N/A |
| **House Mill, London** | | **1st Floor (Internal)** | **External** |
| Recording period | | 1 June 2022–21 July 2023, | 1 June 2022–21 July 2023 |
| No. of days | | 415 days | 415 days |
| Average temperature (°C) | | 14.13 | 13.26 |
| Average RH (%) | | 73.85 | 73.38 |
| CIBRE Criteria | | 0.00048% of recorded hours above 28 °C | N/A |

Figures 1–3 present the monitoring data from air temperature and relative humidity in each of the study cases for the monitored period. Figure 4 shows the results of monitoring in the House Mill during the heatwave period of 2022.

In Figure 1, we notice that the temperature measured inside the house has lower limits 20 °C and peaks can reach 30 °C. The external temperature is documented with higher fluctuations, the lower external temperature in the documented period is 10 °C and the higher external temperature is 28 °C. In general, the peaks in indoor temperature follow the peaks of external temperature. While there is a higher external temperature, there is a higher temperature indoors. However, there is an instance in the graph where external temperature rose above the indoor (7 July 2023). In the end of the monitored period, 15–24 August, low external temperature spikes seemed to cause higher internal temperatures. Regarding the relative humidity, it is important to point out that indoor relative humidity min level is 45 and the max level is 65%. These fluctuations are inside the human comfort scale for non-air-conditioned buildings.

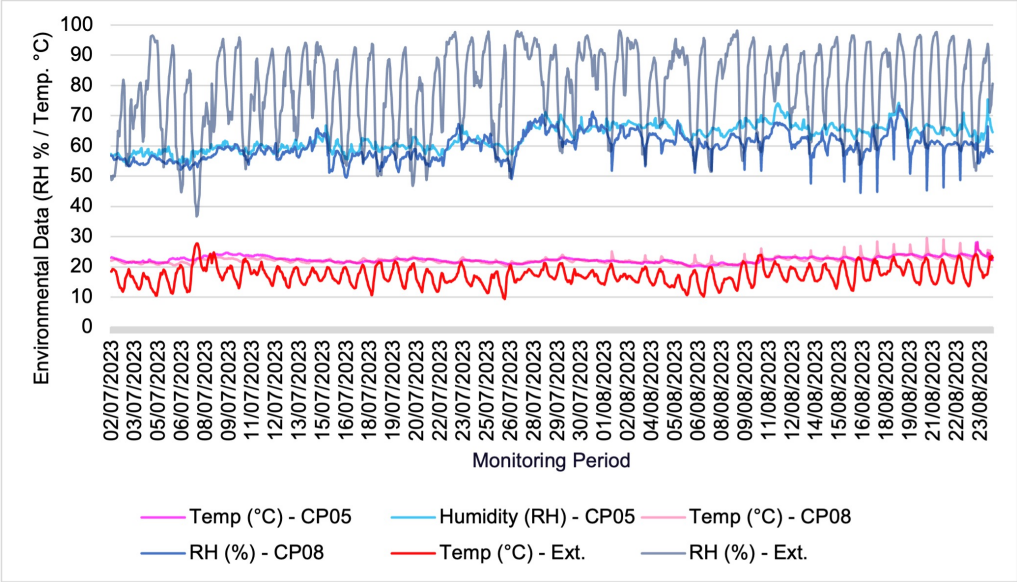


**Figure 1.** Temperature and relative humidity in Marden, Kent.

In Figure 2, we notice that the temperature measured inside the house has lower limits 20 °C and peaks can reach 28 °C in the beginning of the monitoring period. The external temperature is documented with higher fluctuations, the lower external temperature in the documented period is 10 °C, and the higher external temperature is 30 °C. There are approximately six instances in the graph where external temperature rises above the indoor. Regarding the relative humidity data, it is important to point out that indoor relative humidity min level is 42 and the max level is 73%. Relative humidity is, in a few instances, outside the human comfort levels for non-air-conditioned buildings.

In House Mill, the environmental monitoring devices were placed for over a year. We also have data from the heatwave period of 2022 in which UK was most affected. From Figure 3, we see that the pattern of indoor temperature and relative humidity follows the external conditions. During the coldest period, i.e., December 2022, where the external temperature was below 0 °C, the indoor temperature was above 0 °C. The indoor temperature during the coldest period was approximately 4 degrees higher than the external.

Figure 4 illustrates the results of environmental monitoring during the heatwave period of 2022. We see a trend of the building heating up during the day but cooling off at night. Nevertheless, the building is significantly cooler (about 10 °C) during two days of extreme weather conditions.

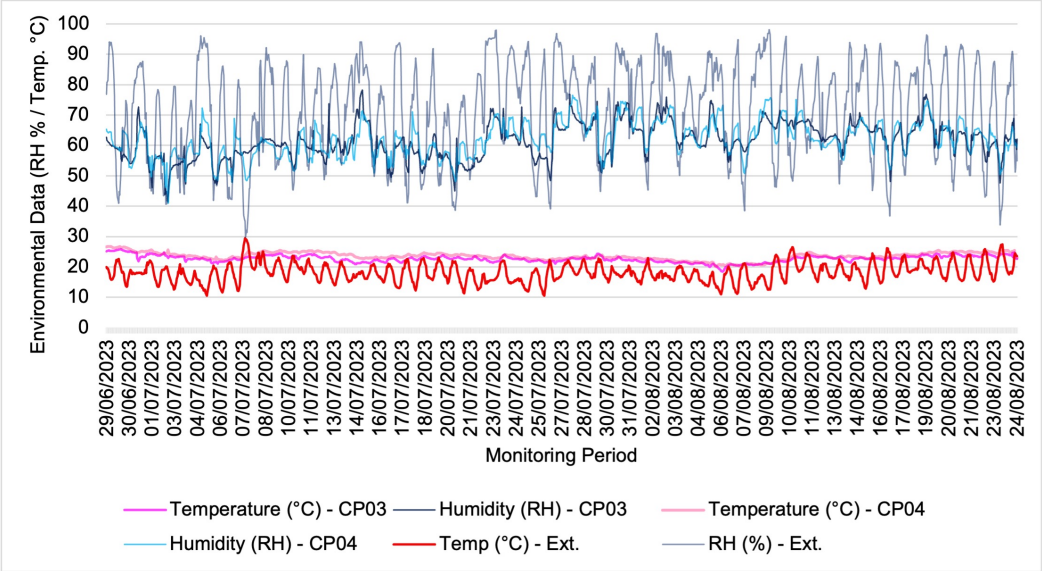


**Figure 2.** Temperature and relative humidity in Islington, London.

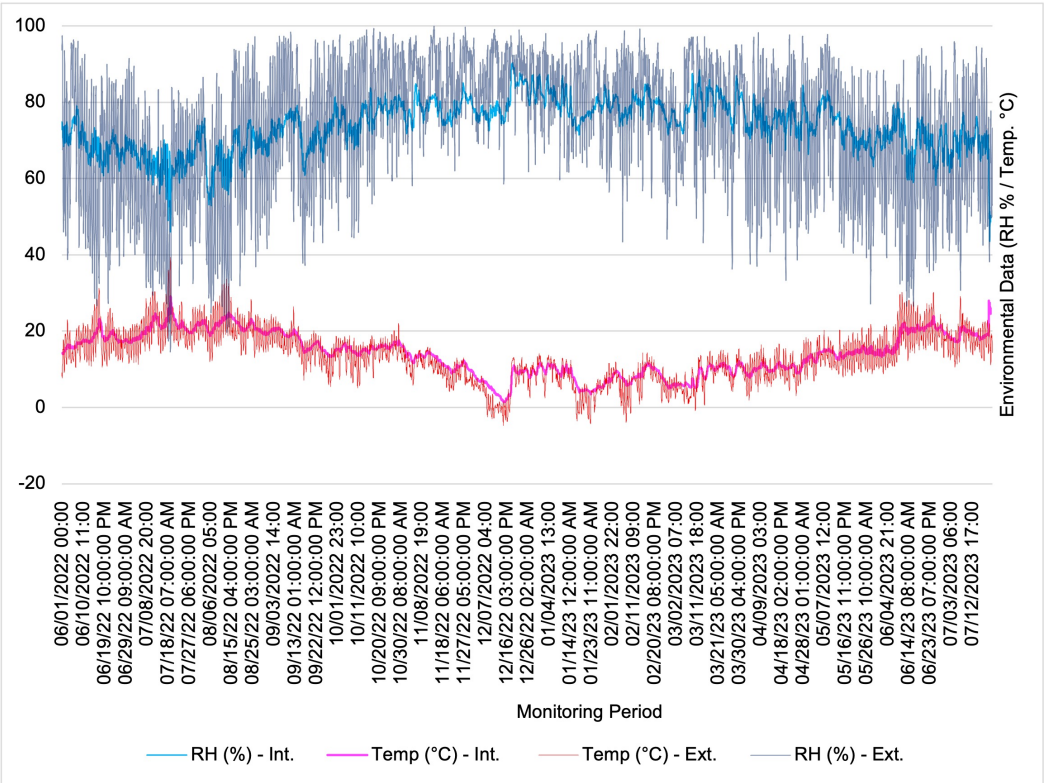


**Figure 3.** Temperatureand relative humidity in House Mill, London.

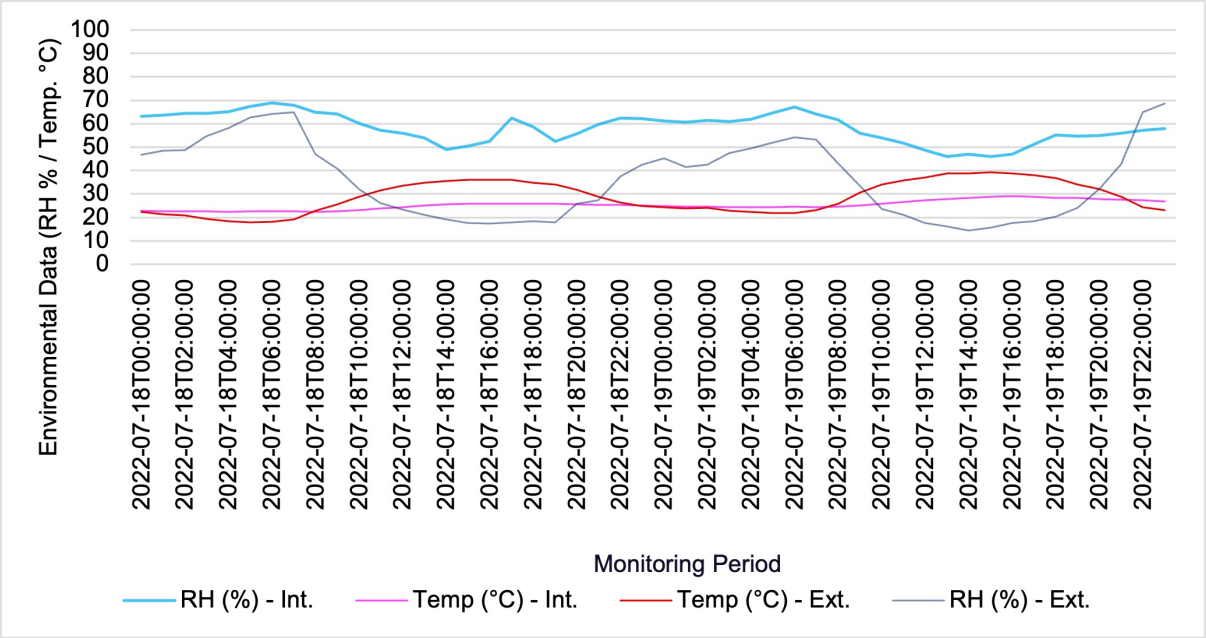


**Figure 4.** Temperature and relative humidity during heatwave in House Mill.

### *4.3. Interview*

In Marden, an interview was carried out with one of the two occupants of the property. The occupant stated an overall satisfaction with the indoor environmental conditions in their home in all seasons. However, during the summer, there is documented a strong thermal discomfort in parts of the residence. In the summer, the second floor gets 'extremely' hot, as they describe it. We do not have environmental data for the second floor, but on the first floor, the documented temperature rises up to 30 °C, although the lower floors, especially the ground floor, manage to stay cooler. To make themselves more comfortable during the summer, the occupants are aware and already using some common adaptive strategies, such as the use of curtains to keep the direct sunlight out of the room and opening of the windows and doors in the ground floor. They also mention a different use of the house rooms during the summer months, by avoiding the bedrooms on the top floor and sleeping on the lower floors to stay cool. This may be disturbing for the occupants in the long term, but as the rooms are used periodically, this is not a permanent change for the main occupants. Regarding active cooling, they use a fan, as they state, 'but in the absence of an airconditing, they are prepared as best they could' for future heatwaves. It is important to note that despite the overheating experience, the wood and brick construction of the house (wooden Kentish weatherboarding) is recognised as a contributing factor to the ability of the house to stay cool in the summer and to retain the heat in the winter. Regarding winter comfort specifically, the occupant was, in general, satisfied with the indoor conditions; they comment that the building 'isn't too draughty' and has double glazed windows, and additionally, there were no damp/condensation problems either. To make themselves more comfortable in the winter, the occupants use central heating and also log fires. For the energy efficiency of the building, the interviewee was only aware of incentives offered for insulation, as well as for certain heating boilers.

In Islington, the interview was carried out with the individual who was renting the property at the time. During the summer, the occupant is generally satisfied, but in high temperatures, they experience overheating. They also stated that the hot weather is unlikely to directly impact productivity in this case as they work away from home; however, the heat does impact sleep quality, which, in turn, does have an effect on their productivity. In particular, the upstairs, i.e., the bedroom, was described as 'noticeably worse than downstairs'. This causes a different use of the rooms because of thermal discomfort and a disruption of sleep, as the user stated that they need to sleep 'on the sofa downstairs'. To

make themselves more comfortable during summer, they use passive adaptive techniques like closing their shutters in the day, keeping their windows open. They already use a fan to stay cool. To prepare for possible future heatwaves, the occupant has bought a new fan, as they have recognised that it helped previously, but still they feel unprepared. Historic characteristics of the building such as high ceilings and large slash windows were recognised as factors that influence the indoor environmental conditions by the interviewee. The occupant was experiencing poor comfort conditions during winter as well. The reasons for poor winter thermal comfort were stated as building characteristics such as high ceilings and an older boiler. These cause the flat to remain cold throughout the season. Regarding energy efficiency, there was no awareness of incentives or initiatives relating to overheating or retrofitting by the interviewee, but there is the feeling that it is going to be more difficult to make adaptations due to the age of the building.

An interesting point raised from both interviews was that the occupants needed to change their everyday routines and use of their rooms during the summer due to overheating and not during winter thermal discomfort. Even though, in one case, they were satisfied with the indoor conditions and the other was not during winter. Both of them were informed about overheating and have already been using a fan. They both are also aware how the historic characteristics of their building (construction technique, high ceilings, small/large windows) influence the indoor environment. Another key takeaway was that both interviewees indicated a lack of knowledge of what could and could not be changed in their property due to its heritage properties or an awareness of any initiatives regarding overheating and regarding retrofitting.

At House Mill, there was no formal interview conducted; rather, a few questions relating to the buildings' thermal comfort were asked during the guided tour. Regarding the indoor environmental conditions during summer, the guide stated that the building remained cool without the need to open windows. The interviewee gave a reason for this: a large body of water surrounding the mill and the open areas of the structure due to age and viewing areas for historic mechanisms. Regarding the winter environmental conditions, they described how cold the building would be. There is no heating system, according to the guide in the building. The interviewee recognised that the factors that attributed to poor thermal conditions in the winter were contributing to the building's ability to keep cool during the summer months.

There is a difference between the three interviews regarding the experiences of overheating, where occupants of Marden and Islington have stated discomfort during summers. The use of the building, as well as the building type and direct external environment, can be possible reasons for this. According to the risk assessment, House Mill is categorised as low risk for overheating. This is confirmed by the interview.

## 5. Discussion and Conclusions

It is important to discuss the extent of overheating as an issue in the UK. Many perceive the UK to be mild, which is true for the most part of the year. Due to extant climate change, our summers are warmer, and heatwaves are more frequent and longer. This can lead to health concerns, and even deaths are becoming more common [67]. Studies have shown the cognitive impact of heat. In this, researchers claim that global warming trends may be correlated to increasing violent crime rates [68]. Furthermore, hotter temperatures have also been reported to impact productivity. Our research has demonstrated that productivity is related to quality of sleep, which is affected during hot summer days. A study on the impact of hotter temperatures on productivity found that productivity is decreased by 76% when operational temperatures of 40 °C are experienced [69]. Most of these concerns are caused by internal heat. Overheating can cause a disturbance to everyday human activities such as eating, hydration, and sleeping [70,71]. This was also evident in our research in two residential case studies: Marden and Islington. The occupants were forced to change the use of the rooms to comfortably carry out their everyday activity. With 20 to 30% of buildings in the UK obtaining heritage value [72], a significant demographic reside in them.

If the 'most aggressive' 4–5 °C temperature rises are realised, many of the homes we occupy would be uninhabitable. Despite this not yet being a reality, temperatures in the UK are on the rise, meaning that more needs to happen to be proactive and not allow historic buildings to be left behind. A reliance on active cooling is not feasible to mitigate this reality due to active cooling systems contributing to the cause, as well as hurdles that limit their installation. Despite it being understandable that the application of building regulations to existing properties is not as feasible, the creation of Buildings Regulations part O [58] is evidence that the government recognise this issue. It does not affect newer buildings in isolation, and therefore, more research needs to be carried out to understand the issues in-depth, devise mitigation strategies, and inform policies.

The second is that the unique properties of historic buildings, for the most part, are better equipped to deal with hotter weather conditions. Due to their design and construction materials, they take longer to heat up and have better ventilation (due to lack of air tightness, a largely unintended benefit). This is often at the cost of winter thermal comfort. In more extreme weather events, e.g., the 2022 heatwave, and with the need to prepare for regular 40 °C plus temperatures in the future, it was found that there are many obstacles that prevent adaptation in older buildings. Low-cost building materials that inherently have lower thermal mass seem to contribute the most towards modern buildings' poor performance, which is now being mitigated through updates to Building Regulations Part O, with no such regulations applying to existing buildings. Moreover, the tension between energy efficiency and historic preservation has an impact in the way adaptive opportunities can be approached in historic buildings. More research is required to understand whether overheating considerations can further add to or relax the already existing tensions.

When reviewing the data, the first observation would be that all three properties passed the CIBRE criteria when considering the entire recorded period, where each scored well below the 1% threshold for both the upstairs and downstairs criteria. This could largely be due to the weather conditions exhibited in 2023. According to the Met Office [73], summer 2023 was warmer and wetter than average. Even so, despite the CIBRE criteria not being exceeded in any of the properties for the recorded period, interviewees in Islington and Marden claimed that the upper floors of their dwellings were 'unbearably hot'. Through a detailed analysis of the monitoring data and not only based on the CIBRE criteria, there were documented several instances of higher than 28 °C temperatures indoors in both buildings. There is still an open research question about how often and for how long occupants can tolerate overheating indoor conditions. Nevertheless, the proposed risk assessment indicated that Marden and Islington were under a medium risk for overheating, as was confirmed from the users through interviews. The proposed risk assessment model was also validated in the third study case in House Mill as it indicated the house to be subjected to lower overheating risk, as was confirmed by the interview. Researchers [66] believe that the threshold of 26 °C for bedrooms is outdated and propose a new overheating criterion due to changes in summertime bedding and bedwear that have occurred since the original guidance was published. The World Health Organisation [74] have also qualified in their guidance for thermal comfort that temperatures in excess of 24 °C can lead to discomfort and potential harm for those who are more vulnerable. It is important to recognise that standards are a way to ensure equality and consistency; therefore, the values and even methodologies described in the standards do not ensure prediction of reality. Concurrently, this could also highlight the ambiguity and cultural differences toward the way overheating is interpreted as illustrated by researchers [66]. These definitions are also limited by the fact that there are many variables when determining what temperatures are comfortable or safe for an individual in particular vulnerable populations.

In the academic community, the urban heat island effect has been a prominent discussion point in overheating research. Comparing the cases of Marden and Islington, we see that even though Marden is not subjected to the urban heat island effect, the overall risk profile of the property is the same as Islington, i.e., both of them were found to be

in medium risk. We also see that the temperatures in Marden were higher indoors in more occasions than in Islington. This study also highlights the importance of mitigation points in the historic properties that can lower the overheating risks, even if the building is subjected to the urban heat island effect.

The buildings could feel hotter than they are due to the high RH levels. Higher RH levels are linked to overheating as sweat cannot evaporate at the same rate [75]. While the average RH in all case studies are between the recommended range of 60–80% [76], it fluctuates above 80% in all case studies, thereby adding to the discomfort of the occupants. Guidance from the Health and Safety Executive (HSE) [77] differs, saying that a healthy range for relative humidity should be within the range of 40–70%. This is then qualified by the need for the RH to be at the lower end of this range at higher temperatures. Islington was considerably in excess of this threshold, and in the case of House Mill, well above even the HSE maximum of 70%. Relative humidity was found to be excessive in all three properties, which could be further raising the overheating risk. Upper floors were also found to be marginally warmer that ground floor levels, although the perception of heat is greater when we are trying to sleep [14]. The effect of RH is under-studied and we cannot conclude with certainty that elevated RH had a significant effect on thermal comfort perception.

When reviewing the data for House Mill during the heatwave period of summer 2022 (Refer to Figure 4), the building failed the CIBRE assessment, as 12.5% of the recorded temperature data were above the threshold. The highest recorded temperature externally at House Mill during the heatwave was 39.4 °C, where at the same time internally, it was 29.2 °C. Given the unprecedented nature of this weather event, for the building to remain more than 10 °C cooler when no 'active cooling' measures were present would be considered a revelation to most. While this research did not investigate the cause of this, it could be attributed to many factors including context, orientation of the building, construction, and so on.

For the most part, the results are in alignment with the existing research. As mentioned by Historic England [78], increased ventilation, small windows, and larger floor to surface area all increase the likelihood of a building remaining cooler in the summer months. The most noteworthy example of this is House Mill, where all these features are present. The building is lightly occupied and situated above a large body of water, which is also proven to reduce overheating [25,36]. There were also notable differences between the case studies in Islington and Marden, where the property in Islington had a higher average temperature. Despite the Marden property being occupied for less of the time and being south facing, the urban heat island effect and being situated on the top two floors meant the property in Islington performed worse during the monitored period. The very high relative humidity reading for House Mill is likely a result of the building's location near a large water source with many openings in the floor where moisture can permeate.

Despite the CIBRE guidance [27] stating that bedrooms require lower temperatures to achieve thermal comfort, the case studies that had loggers on multiple floors both displayed higher temperature in the bedrooms than in the living rooms. It is well documented that heat rises, so it is expected that this would be the case as bedrooms in both case studies were located upstairs. This could also be likely due to sporadic interactions and behaviors. For example, in Marden, the occupants use the room in which the ground floor logger was placed in the evening and often make use of a log fire during colder spells, including in the summer. It was also noted that the occupier of the Islington property left the upstairs windows open for most of the time to 'air out' the room, even when the home was unoccupied. Such behaviour is not surprising as researchers have demonstrated the buildings we occupy have systems in place to warm a property but less can be done to cool it [79].

### *5.1. Reflection on the Overheating Risk Assessment*

In this research, we developed an overheating risk assessment tailored for historic buildings. The risk-based approach can support current retrofit approaches. Overheating standards at the moment are applied in a way that focuses on temperature limits and occupancy hours. However, this may be outdated, unfitting in historic contexts. The risk-based approach gives the opportunity to create a unique overheating risk profile for each building. The risk assessment includes both factors that are likely to increase overheating and factors that are likely to mitigate overheating risks. When reviewing the results of risk assessment against environmental monitoring and interview data, the results remained consistent with one another. As the hottest building, Islington had the highest average temperature recorded, the highest score on the risk assessment, and the user raised the highest levels of concern regarding overheating factors during the interview. Equally, House Mill had the lowest average temperature and lowest risk assessment score, as well as comments made by the guide highlighting the low internal temperatures. This demonstrates the applicability of risk assessment in historic buildings in the UK.

One must consider that the risk assessment was developed for historic buildings in the UK. The three case studies used to demonstrate the applicability of the risk assessment are located in the south of the UK. More case studies from different regions of the UK should be used to further test and develop the risk assessment. This risk assessment may not be useful for countries in different climatic zones than the UK. However, it can be used as a baseline to develop overheating risk assessments for different climatic zones. The risk assessment we developed gives a generic understanding of how likely it is for a historic property to be overheated. It does not, however, give any specific indication for those who might be more at risk. In other words, the overheating risk assessment is a good tool when used in combination with a good understanding of vulnerabilities. Lastly, the risk assessment is the first iteration that is meant to empower people who are not trained professionals to assess the overheating risks posed by a property in their working or residential environments. For professionals, more details could be added regarding traditional building characteristics.

#### 5.1.1. Limitations

There are a few limitations to this study. The first being the loss of data from the logger on the ground floor of House Mill. This meant that an analysis of the differences in environmental data could not be established. Ideally, a larger sample of buildings would have been assessed, which would have provided a more comprehensive overview of the issue of overheating. It is also important to note that despite the UK summer of 2022, according to the Met Office [73], 'of ten of the warmest summers on record by mean temperature, summer 2023 is the wettest'. It was also stated that July was the 'UK's sixth wettest July on record'. Despite the summer season of 2023 being 0.8 °C warmer than the average, the majority of the 'dry days of warm summer sunshine', brought about by high pressure, occurred in June. Wet and windy conditions then proceeded due to low-pressure systems for much of July and August, i.e., during the period of data collection for this research. These irregular weather conditions are likely to skew the collected data as recording for this study, for two of the three case studies did not begin until 28 June 2023, with all but a few days falling within the overcast second half of the season. This meant that a like for like comparison could not be achieved, although this does not detract from the valuable data that were collected. The overheating risks not only concern their thermal comfort but also their health and well-being when using the building. It also could affect the usability of the building. The primary risks that we explored in this paper are risks concerning indoor environmental quality. There are other risks associated with overheating in historic buildings, including risks to the building fabric and objects. The impact of overheating on heritage buildings and artefacts is beyond the scope of this paper.

#### 5.1.2. Further Research

This study has drawn attention to several areas that require further research. The first is reassessing the overheating criteria. As highlighted, there are numerous overheating criteria, all of which tell a different story. Any temperature that is below the 35 °C threshold for human health is largely based on conjecture. More research is required to flesh out the existing models to account for more variables (e.g., age). Future studies should incorporate a wide pool of buildings with varying typographies, grouped and analysed based on the factors that cause overheating, as discussed.

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## References

1. United Nations. COP26 The Glasgow Climate Pact; United Nations Climate Change Conference. 2021. Available online: https://unfccc.int/sites/default/files/resource/cma2021_10_add1_adv.pdf (accessed on 1 June 2024).
2. Climate Change Committee. CCC Insights Briefing The UK Climate Change Act; Climate Change Committee. 2020. Available online: https://www.theccc.org.uk/wp-content/uploads/2020/10/CCC-Insights-Briefing-1-The-UK-Climate-Change-Act.pdf (accessed on 19 September 2023).
3. Brader, C. Mission Zero: Independent Review of Net Zero, UK Parliament. 2023. Available online: https://lordslibrary.parliament.uk/mission-zero-independent-review-of-net-zero/ (accessed on 24 May 2024).
4. Kendon, M.; McCarthy, M.; Jevrejeva, S.; Matthews, A.; Sparks, T.; Garforth, J. State of the UK Climate 2020. *Int. J. Climatol.* **2021**, *41*, 1–76. [CrossRef]
5. Office, M. Climate Change Continues to Be Evident across UK; Met Office. 2021. Available online: https://www.metoffice.gov.uk/about-us/press-office/news/weather-and-climate/2021/climate-change-continues-to-be-evident-across-uk (accessed on 19 August 2024).
6. Mayor of London. Mayor Urges Extreme Caution during Heatwave; Mayor of London. 2022. Available online: https://www.london.gov.uk/press-releases/mayoral/heatwave-presents-serious-risk-to-life (accessed on 19 August 2024).
7. Met Office. Summer 2022: A Historic Season for Northern Hemisphere Heatwaves; Met Office. 2022. Available online: https://blog.metoffice.gov.uk/2022/07/19/summer-2022-a-historic-season-for-northern-hemisphere-heatwaves/ (accessed on 13 June 2023).
8. Office for National Statistics. Excess Mortality during Heat-Periods: 1 June to 31 August 2022; Office for National Statistics. 2022. Available online: https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/articles/excessmortalityduringheatperiods/englandandwales1juneto31august2022 (accessed on 6 July 2023).
9. Kovats, S.; Brisley, R. *Health, Communities and the Built Environment*; Climate Change Committee: London, UK, 2021.
10. Roberts, T. We Spend 90% of Our Time Indoors. Says Who? 2016. Available online: https://www.buildinggreen.com/blog/we-spend-90-our-time-indoors-says-who (accessed on 28 August 2023).
11. Eames, M.; Marvin, S.; Hodson, M.; Dixon, T.J.; Guthrie, P.; Lannon, S. Briefing: Re-engineering the city 2020–2050–urban foresight and transition management. *Proc. Inst. Civ.-Eng.-Urban Des. Plan.* **2014**, *167*, 1–4. [CrossRef]
12. Piddington, J.; Nicol, S.; Garrett, H.; Custard, M. The Housing Stock of the United Kingdom. 2020. Available online: https://files.bregroup.com/bretrust/The-Housing-Stock-of-the-United-Kingdom_Report_BRE-Trust.pdf (accessed on 1 March 2024).
13. Prizeman, O. *Sustainable Building Conservation: Theory and Practice of Responsive Design in the Heritage Environment*; Routledge: London, UK, 2019.
14. Peacock, A.; Jenkins, D.; Kane, D. Investigating the potential of overheating in UK dwellings as a consequence of extant climate change. *Energy Policy* **2010**, *38*, 3277–3288. [CrossRef]
15. Lomas, K.J. Summertime overheating in dwellings in temperate climates. *Build. Cities* **2021**, *2*, 487–494. [CrossRef]
16. Buda, A.; de Place Hansen, E.J.; Alexander, R.; Giancola, E.; Pracchi, V.N.; Mauri, S.; Marincioni, V.; Gori, V.; Fouseki, K.; López, C.S.; et al. Conservation-compatible retrofit solutions in historic buildings: An integrated approach. *Sustainability* **2021**, *13*, 2927. [CrossRef]
17. Hacker, J.; Belcher, S.; Connell, R. *Beating the Heat: Keeping UK Buildings Cool in a Warming Climate*; UKCIP: Oxford, UK, 2005.

18. Hao, L.; Herrera-Avellanosa, D.; Del Pero, C.; Troi, A. Overheating risks and adaptation strategies of energy retrofitted historic buildings under the impact of climate change: Case studies in Alpine region. *Appl. Sci.* **2022**, *12*, 7162. [CrossRef]
19. Jenkins, D.; Ingram, V.; Simpson, S.; Patidar, S. Methods for assessing domestic overheating for future building regulation compliance. *Energy Policy* **2013**, *56*, 684–692. [CrossRef]
20. Ibrahim, A.; Pelsmakers, S.L. Low-energy housing retrofit in North England: Overheating risks and possible mitigation strategies. *Build. Serv. Eng. Res. Technol.* **2018**, *39*, 161–172. [CrossRef]
21. Overheating and Historic Buildings; Historic England. 2020. Available online: https://historicengland.org.uk/advice/technical-advice/retrofit-and-energy-efficiency-in-historic-buildings/overheating-historic-buldings/ (accessed on 8 December 2023).
22. Alrasheed, M.; Mourshed, M. Domestic overheating risks and mitigation strategies: The state-of-the-art and directions for future research. *Indoor Built Environ.* **2023**, *32*, 1057–1077. [CrossRef]
23. Mavrogianni, A.; Tsoulou, I.; Heaviside, C.; Oikonomou, E.; Petrou, G.; Symonds, P.; Davies, M.; Taylor, J.; Milojevic, A.; Wilkinson, P. Urban Overheating and Impact on Health: An Introduction. In *Urban Overheating: Heat Mitigation and the Impact on Health*; Springer: Singapore, 2022; pp. 1–20. [CrossRef]
24. Barlett, C.P.; DeWitt, C.C.; Madison, C.S.; Heath, J.B.; Maronna, B.; Kirkpatrick, S.M. Hot temperatures and even hotter tempers: Sociological mediators in the relationship between global climate change and homicide. *Psychol. Violence* **2020**, *10*, 1–7. [CrossRef]
25. Lomas, K.J.; Porritt, S.M. Overheating in buildings: Lessons from research. *Build. Res. Inf.* **2017**, *45*, 1–18. [CrossRef]
26. Historic England. Webinar on Climate Change Adaption: Assessing Future Summertime Overheating Risk in Historic Buildings; Historic England. 2021. Available online: https://historicengland.org.uk/content/docs/consultations/evidence-on-heat-resilience-and-sustainable-cooling-by-historic-england-aug23/ (accessed on 1 August 2024).
27. CIBSE. *Guide A. Environmental Design*, 8th ed.; Chartered Institution of Building Services Engineers: London, UK, 2015.
28. Cassar, M. *Environmental Management: Guidelines for Museums and Galleries*; Routledge: London, UK, 2013.
29. ASHRAE. ASHRAE Handbook; American Society of Heating, Refrigeration and Airconditioning Engineers. 2001. Available online: https://www.ashrae.org/technical-resources/ashrae-handbook (accessed on 1 March 2023).
30. Met Office. Why Is Humidity Important? Met Office. 2023. Available online: https://www.metoffice.gov.uk/weather/learn-about/weather/types-of-weather/humidity/effects (accessed on 6 July 2022).
31. English Heritage. *Conservation Principles, Policies and Guidance*; English Heritage: London, UK, 2008.
32. Pole, K. Mixed method designs: A review of strategies for blending quantitative and qualitative methodologies. *Mid-West. Educ. Res.* **2007**, *20*, 35–38.
33. Costa-Carrapiço, I.; González, J.N.; Raslan, R.; Sánchez-Guevara, C.; Marrero, M.D.R. Understanding thermal comfort in vernacular dwellings in Alentejo, Portugal: A mixed-methods adaptive comfort approach. *Build. Environ.* **2022**, *217*, 109084. [CrossRef]
34. National Centre for Earth Observation. Heathrow Breaks UK's Land Surface Temperature Record; National Centre for Earth Observation. 2022. Available online: https://www.nceo.ac.uk/article/heathrow-breaks-uks-land-surface-temperature-record/ (accessed on 27 June 2023).
35. Office for National Statistics. Data and Analysis from Census 2021, Age of the Property Is the Biggest Single Factor in Energy Efficient Homes; Office for National Statistics. 2022. Available online: https://www.ons.gov.uk/peoplepopulationandcommunity/housing/articles/ageofthepropertyisthebiggestsinglefactorinenergyefficiencyofhomes/2021-11-01 (accessed on 6 April 2023).
36. Gupta, R.; Gregg, M. Assessing the magnitude and likely causes of summertime overheating in modern flats in UK. *Energies* **2020**, *13*, 5202. [CrossRef]
37. Good Homes Alliance. Overheating in Retrofit and Existing Homes: Tool and Guidance to Identify and Mitigate Overheating Risks in Retrofit and Exisiting Homes; Good Homes Alliance. 2022. Available online: https://kb.goodhomes.org.uk/wp-content/uploads/2022/03/202112-GHA-Retrofit-Existing-GUIDANCE-LAUNCH-VERSION.pdf (accessed on 1 August 2023).
38. Good Home Alliance. Overheating in Retrofit and Existing Homes–Tool and Guidance; Good Home Alliance. 2022. Available online: https://kb.goodhomes.org.uk/tool/overheating-retrofit/ (accessed on 19 August 2024).
39. Capon, R.; Hacker, J. *Modelling Climate Change Adaptation Measures to Reduce Overheating Risk in Existing Dwellings*; Building and Environment: Glasgow, UK, 2009.
40. Santamouris, M. Recent progress on urban overheating and heat island research. Integrated assessment of the energy, environmental, vulnerability and health impact. Synergies with the global climate change. *Energy Build.* **2020**, *207*, 109482. [CrossRef]
41. Leal Filho, W.; Wolf, F.; Castro-Díaz, R.; Li, C.; Ojeh, V.N.; Gutiérrez, N.; Nagy, G.J.; Savić, S.; Natenzon, C.E.; Quasem Al-Amin, A.; et al. Addressing the urban heat islands effect: A cross-country assessment of the role of green infrastructure. *Sustainability* **2021**, *13*, 753. [CrossRef]
42. Mavrogianni, A.; Davies, M.; Taylor, J.; Chalabi, Z.; Biddulph, P.; Oikonomou, E.; Das, P.; Jones, B. The impact of occupancy patterns, occupant-controlled ventilation and shading on indoor overheating risk in domestic environments. *Build. Environ.* **2014**, *78*, 183–198. [CrossRef]
43. Ferdyn-Grygierek, J.; Kaczmarczyk, J.; Blaszczok, M.; Lubina, P.; Koper, P.; Bulińska, A. Hygrothermal risk in museum buildings located in moderate climate. *Energies* **2020**, *13*, 344. [CrossRef]
44. Baborska-Narożny, M.; Stevenson, F.; Grudzińska, M. Overheating in retrofitted flats: Occupant practices, learning and interventions. *Build. Res. Inf.* **2017**, *45*, 40–59. [CrossRef]

45. Heydarian, A.; McIlvennie, C.; Arpan, L.; Yousefi, S.; Syndicus, M.; Schweiker, M.; Jazizadeh, F.; Rissetto, R.; Pisello, A.L.; Piselli, C.; et al. What drives our behaviors in buildings? A review on occupant interactions with building systems from the lens of behavioral theories. *Build. Environ.* **2020**, *179*, 106928. [CrossRef]
46. Gherri, B. The Role of Urban Vegetation in Counteracting Overheating in Different Urban Textures. *Land* **2023**, *12*, 2100. [CrossRef]
47. Padfield, T. The Role of Absorbent Building Materials in Moderating Changes. 1998. Available online: https://conservationphysics.org/phd/ch1a.pdf (accessed on 27 February 2024).
48. Gagliano, A.; Nocera, F.; Patania, F.; Moschella, A.; Detommaso, M.; Evola, G. Synergic effects of thermal mass and natural ventilation on the thermal behaviour of traditional massive buildings. *Int. J. Sustain. Energy* **2016**, *35*, 411–428. [CrossRef]
49. Department for Communities and Local Government. Investigation into Overheating in Homes: Literature Review. 2012. Available online: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/7604/2185850.pdf (accessed on 19 August 2024).
50. Drury, P.; Watson, S.; Lomas, K.J. Summertime overheating in UK homes: Is there a safe haven? *Build. Cities* **2021**, *2*, 970–990. [CrossRef]
51. Lomas, K.; Morgan, K.; Haines, V.; Hartescu, I.; Beizaee, A.; Barnes, J.; Zambelli, Z.; Ravikumar, M.; Rossi, V. Homes Heat Health protocol: An observational cohort study measuring the effect of summer temperatures on sleep quality. *BMJ Open* **2024**, *14*, e086797. [CrossRef]
52. Jahed, N.; Aktaş, Y.D.; Rickaby, P.; Bilgin Altınöz, A.G. Policy framework for energy retrofitting of built heritage: A critical comparison of UK and Turkey. *Atmosphere* **2020**, *11*, 674. [CrossRef]
53. Historic England. Traditional Windows: Their Care, Repair and Upgradings. 2017. Available online: https://historicengland.org.uk/images-books/publications/traditional-windows-care-repair-upgrading/heag039-traditional-windows-revfeb17/ (accessed on 20 February 2023).
54. Ginks, N.; Painter, B. Energy retrofit interventions in historic buildings: Exploring guidance and attitudes of conservation professionals to slim double glazing in the UK. *Energy Build.* **2017**, *149*, 391–399. [CrossRef]
55. Friedman, K.; Cooke, A. Is UK Planning a barrier to energy efficient heritage retrofit: A comparative analysis of a selection of London Boroughs. In Proceedings of the Retrofit 2012 Conference, Salford, UK, 24–26 January 2012.
56. HM Government. Planning Permission: England & Wales. 2023. Available online: https://www.gov.uk/planning-permission-england-wales (accessed on 10 June 2022).
57. Williamson, A.; Finnegan, S. Sustainability in heritage buildings: Can we improve the sustainable development of existing buildings under approved document L? *Sustainability* **2021**, *13*, 3620. [CrossRef]
58. HM Government. *Statutory Guidance Overheating: Approved Document O*; HM Government: London, UK, 2021.
59. Capuano, L.; Laurini, E.; De Berardinis, P. Passive cooling in the restoration of historic buildings. *Eco-Archit. VI Harmon. Archit. Nat.* **2016**, *161*, 215.
60. Martínez-Molina, A.; Tort-Ausina, I.; Cho, S.; Vivancos, J.L. Energy efficiency and thermal comfort in historic buildings: A review. *Renew. Sustain. Energy Rev.* **2016**, *61*, 70–85. [CrossRef]
61. Vitale, V.; Salerno, G. A numerical prediction of the passive cooling effects on thermal comfort for a historical building in Rome. *Energy Build.* **2017**, *157*, 1–10. [CrossRef]
62. Liu, C.; Xie, H.; Ali, H.M.; Liu, J. Evaluation of Passive Cooling and Thermal Comfort in Historical Residential Buildings in Zanzibar. *Buildings* **2022**, *12*, 2149. [CrossRef]
63. Usta, P.; Zengin, B. An evaluation of the glazing type impact on building energy performance through a building simulation. *J. Energy Syst.* **2022**, *6*, 1–17. [CrossRef]
64. Historic England. Report: Energy Efficiency and Historic Buildings, Draught-Proofing Windows and Doors; Historic England. 2012. Available online: https://historicengland.org.uk/images-books/publications/eehb-draught-proofing-windows-doors/ (accessed on 6 August 2024).
65. Martín-Garín, A.; Millán-García, J.A.; Hidalgo-Betanzos, J.M.; Hernández-Minguillón, R.J.; Baïri, A. Airtightness analysis of the built heritage–field measurements of nineteenth century buildings through blower door tests. *Energies* **2020**, *13*, 6727. [CrossRef]
66. Lomas, K.J.; Li, M. An overheating criterion for bedrooms in temperate climates: Derivation and application. *Build. Serv. Eng. Res. Technol.* **2023**, *44*, 485–517. [CrossRef]
67. Taylor, J.; Wilkinson, P.; Davies, M.; Armstrong, B.; Chalabi, Z.; Mavrogianni, A.; Symonds, P.; Oikonomou, E.; Bohnenstengel, S.I. Mapping the effects of urban heat island, housing, and age on excess heat-related mortality in London. *Urban Clim.* **2015**, *14*, 517–528. [CrossRef]
68. Anderson, C.A. Heat and violence. *Curr. Dir. Psychol. Sci.* **2001**, *10*, 33–38. [CrossRef]
69. Smallcombe, J.W.; Foster, J.; Hodder, S.G.; Jay, O.; Flouris, A.D.; Havenith, G. Quantifying the impact of heat on human physical work capacity; part IV: Interactions between work duration and heat stress severity. *Int. J. Biometeorol.* **2022**, *66*, 2463–2476. [CrossRef]
70. Bhadra, J.; Beizaee, A.; Lomas, K.; Hartescu, I. 0219 Experimental study on thermal comfort and sleep quality of sleeping people in overheated bedroom conditions in the UK. *SLEEP* **2023**, *46*, A96–A97. [CrossRef]
71. Okamoto-Mizuno, K.; Mizuno, K. Effects of thermal environment on sleep and circadian rhythm. *J. Physiol. Anthropol.* **2012**, *31*, 14. [CrossRef]
72. Wise, F.; Moncaster, A.; Jones, D. Rethinking retrofit of residential heritage buildings. *Build. Cities* **2021**, *2*, 495–517. [CrossRef]

73. Met Office. Mixed Conditions Bring Warm and Wet Summer for the UK; Met Office. 2023. Available online: https://www.metoffice.gov.uk/about-us/news-and-media/media-centre/weather-and-climate-news/2023/summer2023ukweather (accessed on 13 June 2022).
74. Head, K.; Clarke, M.; Bailey, M.; Alicia Livinski, R.L.; Singh, A. Report of the systematic review on the effect of indoor heat on health. In *WHO Housing and Health Guidelines*; World Health Organization: Geneva, Switzerland, 2018.
75. Toftum, J.; Fanger, P.O. Air humidity requirements for human comfort. *ASHRAE Trans.* **1999**, *105*, 641.
76. Baughman, A.; Arens, E.A. *Indoor Humidity and Human Health—Part I: Literature Review of Health Effects of Humidity-Influenced Indoor Pollutants*; Center for the Built Environment: Berkeley, CA, USA, 1996. Available online: https://escholarship.org/uc/item/5kz1z9cg (accessed on 19 June 2024).
77. Health and Safety Executive. Sick Building Syndrome: Guidance for Specialist Inspectors; Health and Safety Executive. 1992. Available online: https://www.hse.gov.uk/foi/internalops/ocs/300-399/oc311_2.htm (accessed on 10 January 2023).
78. Historic England. Building Regulations, Approved Documents and Historic Buildings; Historic England. 2023. Available online: https://historicengland.org.uk/advice/technical-advice/building-regulations/ (accessed on 19 August 2024).
79. Nguyen, J.L.; Schwartz, J.; Dockery, D.W. The relationship between indoor and outdoor temperature, apparent temperature, relative humidity, and absolute humidity. *Indoor Air* **2014**, *24*, 103–112. [CrossRef] [PubMed]

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# Terrorism Risk Assessment for Historic Urban Open Areas

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**Abstract:** Making cities resilient and secure remains a central goal in urban policy strategies, where established methods, technologies, and best experiences are applied or replicated when the knowledge of a threat is already well established. The scientific community and specialized bodies are invited to comprehend and evaluate disastrous events that are still not well explored to broaden the concept of resilient cities. Among these, terrorism in the European-built environment remains an underexplored topic, despite various studies assessing its economic, social, and political dimensions, exploring the radicalist matrix, or examining the post-effects of high-impact disastrous events. Within this framework, this work presents an algorithm for the risk assessment of historic urban open areas (uOAs) in Europe, combining theories of the terrorism phenomenon, the normative experiences, and the phenomenological results of violent acts in uOAs. Specifically, the algorithm is determined by studying physical qualities/properties and elements that usually feature the uOAs, using a limited set of descriptors. The descriptors and their formulation are set starting from their qualification, in compliance with the risk determinant (Hazard, Vulnerability, and Exposure), and discussed starting from participatory methods (Delphi and AHP). The algorithm is finally applied to Italian historic squares, testing the mathematical approach, verifying theories of the phenomenon, and setting up a comprehensive three-dimensional risk matrix for both soft and hard targets. This latest constitutes an operative tool to assess the investigated built environment exposed to terrorist threats aimed at developing more detailed mitigative strategies.

**Keywords:** terrorism; risk assessment; historic built environment; soft and hard targets; matrix of risk; Italian squares



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## 1. Introduction

Two main macro-dimensions connect the "Cultural Heritage" and "terrorism threat" in cities. The first is prevalently related to the ideological–political component of the extremist movement, aimed at exalting its own cultural supremacy and promoting armed conflict [1–3]. In that sense, the main terrorist activities aim at the intentional disruption or smuggling of Cultural Heritage. The second one describes and exhibits the operative dimension of violent acts in terms of maximization of the impact, considering the number of victims and/or the potential publicity [4]. Here, the discussion focuses on the touristic attraction of places or buildings, which increases the number of potential people involved in the attack or/and the mediatic relevance of the violent act. As is clear, the issues relate, respectively, to national and local sizes, involving legislative regulations in fighting/preventing radicalism [5–7] and promoting secure cities [8], extending the issue to all nations [9,10].

When the discussion on the terrorism threat focuses on the cultural/historical sites/buildings and their users, the main issues are related to secure cities and people's safety. This trend is also a consequence of the increasing number of violent acts in less politically exposed nations, such as Europe [11]. Several national norms and guidelines have been

promoted in order to manage the threat after, during, and before the attacks. The activation of national regulations has made Germany, the United Kingdom, and France represent the most prepared European states, due to several recent hazardous events. The USA and Australia are notable worldwide for their historical background on the issue [12]. Regarding the specificity of European countries' activities, the focus is on mitigative strategies and the dissemination of good behavior for users and policy advisors in tracing suspicious individuals [13,14]. On the other hand, the UK has supported the discussion on secure cities and the invisibility of strategies as inherent argumentation for reducing the risk proneness of urban places, particularly safeguarding their image in cultural and historical sites [15–17]. This evidence was fully discussed and presented in recent works by Quagliarini et al. [12,18]. This study is appropriately focused on urban open areas, which constitute the most vulnerable areas in cities due to their minor attention to regulations and the exploitation of low levels of mitigation and prevention. In fact, the phenomenological analysis of previous events in Europe has highlighted how such places are prone to such events [18], as a consequence of the high level of likelihood and the low quality of security. Moreover, when these places are combined with the presence of strategic and cultural buildings or sites, the level of hazard is increased due to the nature of the phenomenon, which is mainly interested in maximizing the publicity of the violent act [4].

### *1.1. Previous Experience in Risk Assessment in Cities Prone to Terrorism*

When the focus is on terrorist risk assessment for the promotion of secure cities, the latest scientific studies that correlate terrorism and risk assessment in cities discuss four key themes (the studies derived from the SCOPUS database focus on the keywords "risk assessment; terrorist; terrorism; city", excluding medical and psychological research, and referring to the period 2018–2024):

- New technologies and approaches to support counterterrorism agencies by means of innovative IoT tools [19–21] or social and collaborative approaches [22].
- Risk assessment of terrorist threat focusing on specific infrastructures or cities and regions [21,23–27], with major applications referring to Asia and the USA, and very limited cases in Europe.
- Vulnerability of buildings or the security assessment of human health when exposed to specific attacks in cities [28–31].
- Risk assessment of specific classes of special cultural buildings [32,33] to protect cultural contents.

Consequently, this overview underlines the lack of a specific discussion on urban open areas; however, the importance of historical and cultural ones is emphasized by the concept that these places are not constituted only by unbuilt areas but are the result of a combination of infrastructure, buildings, and sights with a rigid and invariable shape [34,35].

At the same time, the analysis of the regulation framework determined by the European guidelines in supporting risk management and assessment [36–38] has highlighted the necessity to use a common method to measure terrorism risk in cities, favoring the focus on the local characterization of the phenomenon, which influences the weapon availability and the attack type [4]. As it is clear, the risk assessment of terrorism is a complex matter involving economic, political/religious conditions that change at national and local levels and affect people's security and (psychological) health [39–42] in different ways. However, this investigation can be supported by the individuation of a limited set of conditions and well-considered aims.

Research on promoting risk disaster comprehension has highlighted the strong relevance of three main elements of risk, called "determinant" [43–45]: Hazard is related to the nature of the study events and their frequency; Vulnerability describes the propensity or predisposition to be adversely affected; and Exposure discusses the potential effects or damages (on people, services, buildings). For the qualification of such determinants, the phenomenon requires to be parametrized coherently with features, conditions, and properties that affect single determinants. This process is widely applied for assessing and

qualifying other physical or anthropic events; moreover, the process is usually combined with participatory methods to discuss the interdependencies and single weights in the overall risk assessment [46–50]. Undoubtedly, the numerical assessment of risk allows for the quantification of any analyzed threat, offering the opportunity to re-iterate the procedure in assessing strategies or stressors that alter the starting state of observation of the phenomenon or conditions. However, the quantification of risk requires critical translation in terms of constraints and rules for its management, also taking into account suitable levels of acceptability of risk. In that sense, the use of qualitative methods for terrorism risk assessment offers the opportunity for easy re-iteration using a limited set of data and details, also limiting the goodness of quantitative results for specific analysis (e.g., economic damages, number of victims, behavioral quantification during the evacuation process) [51–54] or more complex goals (i.e., national strategies for counterterrorism prevention) [55].

### *1.2. Aim of This Study*

According to the described framework featured by specific gaps in the literature and the relevance of the matter for European cities, this paper aims to present a fast formulation to support the risk assessment of historic urban outdoor areas (uOAs), such as squares, exposed to terrorist events, mainly applied to places located within historic centers of cities. This is a common thread and a progression activity related to previous studies by the authors on observing, analyzing, and assessing terrorist events in common public open spaces [18]. This is the result of recent events in Europe that have involved pubs, museums, theatres, as well as promenades and squares, affecting the security of citizens. As the phenomenological study by the authors has already highlighted [18], such public outdoor places, also combined with the inner uses of public, cultural, and strategic buildings, have a critical level of inherent hazardousness, determined by the higher frequency of events in Europe. Moreover, these scientific endeavors are related to the national project BE $S^2$ECURe—(make) Built Environment Safer in Slow and Emergency Conditions through behavioral assessed/designed Resilient solutions. This project aims to evaluate multi-risk conditions for uOAs during common activities, addressing both sudden and slow onset disasters to human behaviors.

Specifically for the paper contents, this work is structured into the five following sections:

- Method applied to determine the risk assessment formulation (Section 2).
- Characterization of parameters affecting terrorism risk assessment, derived both from previous works and the scientific literature (Section 3), and algorithm setup (Section 4).
- Calibration and test of the formulation in a set of real Italian case studies (Section 5), characterized by cultural/historical relevance.
- Discussion of results related to matrices of terrorism risk for uOAs as both hard and soft targets (Section 6).

## 2. Materials and Methods

As mentioned in the previous section, this work's aim is to set up a rapid formulation for the qualification of risk assessment in uOAs intended as soft targets within the overall urban extension. The conceptual basis of the goal relates to the necessity of discussing the uOAs as systems of buildings, infrastructures, unbuilt areas, and people, focusing on material and immaterial properties and qualities. In that sense, human behavior is ignored due to the dynamic relations among people; however, the possible interferences between physical elements of the uOAs and users are discussed, starting from the existing regulations on mitigative strategies. All the international regulations and guidelines are referenced in Section 3. However, the focus of the formulation setup is on European uOAs. For them, previous phenomenological analysis [18] is pursued, starting from the recorded violent events in Europe within the Global Terrorism Database [56], which became the

basis of the frequentist details within the formulation. Finally, it is useful to remark that the formulation is centered on the built environment in an as-built approach.

The methodological process is structured into two functional phases (Figure 1) for the purpose of formulating the setup:

- The parametrization process and formulation hypothesis where factors to be considered in the terrorism risk assessment for uOAs, and their qualification in terms of association with the risk determinant (Hazard, Vulnerability, Exposure) is identified. That is, it starts from the first results discussed in [12,18] for specific boundary conditions of the matter (attack types and the relevance of building and place usage) (Section 3).
- The collaborative validation of factors and formulations is identified in the previous phase by means of the Delphi technique, while the relationships among them are quantified using the Analytic Hierarchy Process (AHP) (Section 4).

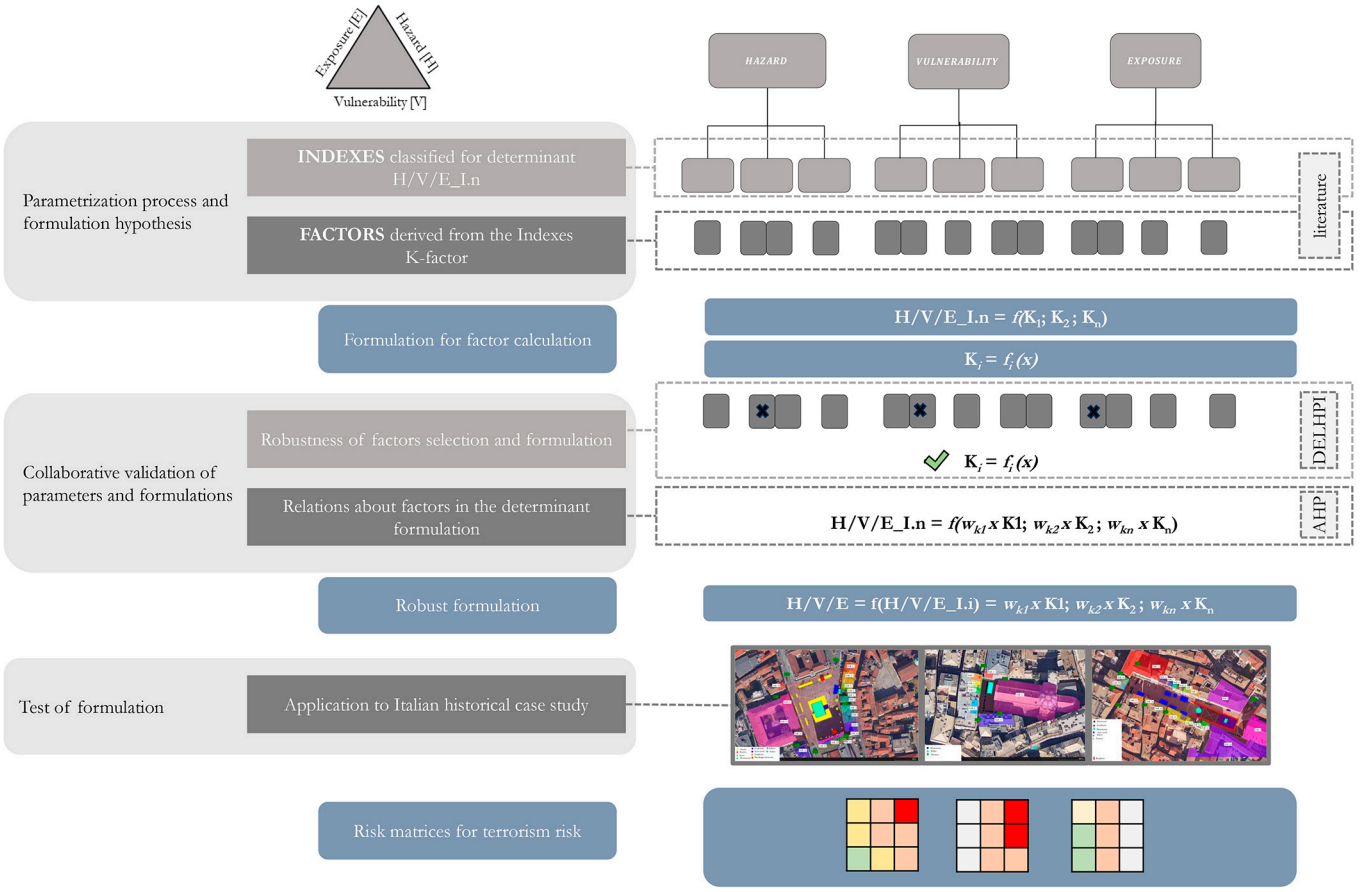


**Figure 1.** Steps and details of the method applied for the test formulation.

Specifically for the structured methods, the Delphi technique allows us to analyze and describe a phenomenon or a problem that is still not fully supported by argumentation, as well as where experts' judgment is required. The proposed technique is based on delivering anonymous questionnaires through controlled feedback to a specific group of experts [57,58]. Specific notes regarding the experts and their numbers are offered in the literature. The survey may involve from 10 to more than 1000 people who have relevant knowledge and experience related to urban risk. As far as the application of the Delphi technique to this work's goals is concerned, the Delphi questionnaire is structured into three main round surveys, mainly applied for the following:

- Validating and implementing the recognized factors (previous operative phase) in the first round of the survey, including association with risk determinants (Hazard, Vulnerability, Exposure).
- Validating the dependencies of elements and properties in the formulation during the second survey round.
- Finally, the validation of influencing factors.

Particularly for the second and third rounds, all the answers can be validated considering the Lawshe Content Validity Ratio (CVR) [59], as usually noted in Delphi applications [60–62]. Clearly, the involved experts were informed about boundary conditions and previous results [12,18] of this study, ensuring a well-thought analysis.

In addition to validating the concerns regarding the influence factors, the AHP was applied. Specifically, similar to the Delphi method, the AHP method is based on the multicriteria theory formulated by Saaty [63], aiming at defining priority scales among a set of elements according to individual judgment. AHP is also based on questionnaires centered on the pairwise comparison among the involved elements, administered to a set of experts. Therefore, as in the Delphi method, all the results are analyzed in terms of consistency ratio (CR): a CR equal to 0% reflects a fully consistent element, while a CR > 10% corresponds to the superior limit of acceptability of consistency. The AHP process for the presented study is applied to the class of elements derived from the third survey round of the Delphi method, deriving their specific weight in the formulation [63]. It is worth noting that both Delphi and AHP are participatory methods and they constitute valid systems in supporting and considering expert judgment in risk identification, assessment, and management [36–38].

At the end of its setup, the formulation is tested on a real sample of squares (Figure 1) in order to validate it and, if required, calibrate it. In addition, its testing allows to determine the reduced risk matrices to describe the uOAs. Here, the testing phase takes advantage of real case studies as part of historic squares in Italy that have already been considered for the same project BE $S^2$ECURe.

## 3. Setting up the Formulation for the Terrorist Risk Assessment for uOAs

### *3.1. The Translation of uOA as a System of Open Space and Uses of Buildings*

As described in the introduction, the main goal of the intended rapid formulation is to support the risk assessment of real uOAs exposed to terrorism events. However, as previously demonstrated in [18], a close relationship exists between open spaces and functions or uses of buildings facing the uOAs in the selection of places by perpetrators. A recent study about the issue [64] has introduced the Space of Relevance (SoR) as the interface of the internal function of buildings and external public uses of uOAs. It is borrowed from the Space of Interferences introduced by Li Piani [65] who has already introduced the concept of interferences among buildings and spaces during violent acts. Each SoR can be delimited on the floor as the external area of the building facing open places, located along the facades with access; the SoR extension is calculated [64] in the following Equation (1):

$$A_{SoR}\ [m^2] = A_{CommBuild}\ [m^2] \times C_B\ [pp/m^2]/C_{OUT}\ [pp/m^2] \quad (1)$$

where

- $A_{CommBuild}$ is the commercial extension of the building.
- $C_B$ is the maximum density capacity of people in the buildings [pp/m2].
- $C_{OUT}$ the maximum density of people when public activities are conducted outside, as considered for public buildings.

$C_B$ and $C_{OUT}$ follow the Italian regulations (D.M. 03/08/2015 and National Ministerial Decree 19/8/1996) but can be extended for other cases in European countries, using the local values.

SoRs identification and qualification, as for position and extension, became functional in assessing real uOAs as complex open and public spaces where their uses and distribution of people may change during the day.

### *3.2. Selection and Determination of Factors Influencing the Terrorist Threat in uOAs*

As described in the previous sections, the terrorist threat is a controversial issue. Due to the project goals, the related risk assessment has to determine a simple formulation based on the risk triangle that is useful in describing the terrorism risk of urban Open Areas (uOAs) in European countries. Previous studies by the authors have defined two main elements to delineate the complex theme. Specifically, in Cantatore et al. [18] the phenomenological analysis of the European threat in the last 20 years has highlighted that the most dangerous and frequent events in uOAs are prevalently featured by the following:

- Attacks in squares and streets (identified as Environmental class "F") where public activities are present (pubs, museums) (Environmental class "B") or representative and/or strategic buildings (Environmental class "D").
- Type of attacks (T) to maximize the relevance of the damages referring to the armed assault (identified as T2) and car-bombing (T3).

Moreover, starting from the same literature framework, the same work [18] has already discussed the set of indexes (properly codified) that describe the determinant macro-properties (see Table 1). Their factorization is discussed in the following sections.

**Table 1.** Summary of indexes related to Hazard, Vulnerability, and Exposure determinants, as in [18].

| Determinant | Code | Index | Description of Index |
|---|---|---|---|
| Hazard | H_I.1 | Target | Inherent and environmental relevance of uOAs to be attacked |
| | H_I.2 | Uses | Typologies of uses influence the choice of a perpetrator aiming at maximizing the effect of the violent act |
| | H_I.3 | Prevention | Qualification of uOAs and their components regarding the presence of countermeasures or mitigative solutions |
| Vulnerability | V_I.1 | Shape of BE | The shape of open spaces influences the attack-type effects |
| | V_I.2 | Accessibility | Geometric dimension of uOAs and their components and permeability to perpetrators and their weapons |
| | V_I.3 | Obstacles | Presence and level of social "attractive" urban furniture in the uOAs and their components |
| Exposure | E_I.1 | Attack type | Effect of violent event related to the weapon type |
| | E_I.2 | Crowd level | Character that reflects the potential numerousness of involved people |
| | E_I.3 | Attack reaction | Potential level of users' protection or obstruction within the uOA and its components thanks to the presence of protective or blocking elements |

Starting from such classification, all the indexes have been matched again with regulations and scientific literature in order to determine their relations with specific descriptors (K-types). For each K-descriptor, a formulation of calculation or assessment is introduced to be shared and validated with the panel of experts for the Delphi and AHP methods. Moreover, the formulation aims to simplify the matter, identifying specific features that are useful for translating indexing into quantitative characteristics. Descriptors and association with indexes are schematized in Figure 2, while a summary of their formulation is provided in Table 2. A detailed description of descriptors and indexes follows in subsequent sections.

**Table 2.** System of K-descriptors and details for their calculation and value ranges.

| Index Name | K Type | Ref. for Values | Normative | General Classif. | Equation | Details of Classification | Value | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Hazard** | | | | | | | | | | | |
| **Target index** | $K_{ENV}$ | [18] | | | $K_{ENV} = [1, \ldots 5]$ | Likelihood levels | Remote | Unlikely | Possible | Likely | Very Likely |
| | | | | | | | 1 | 2 | 3 | 4 | 5 |
| | $K_{SYMB}$ | | | x | $K_{SYMB} = [1, \ldots 5]$ | Symbolicity classes | negligible | low | medium | high | Very high |
| | | | | | | | 1 | 2 | 3 | 4 | 5 |
| **Index of use** | $K_{TUR}$ | | | x | $K_{TUR}$ = Tour.Int = (n.arrivals)/(n.inhab) | Classes of intensity | very low | low | medium | high | Very high |
| | | | | | | | 1 | 2 | 3 | 4 | 5 |
| | $K_{USE}$ | | | x | $K_{USE} = [1, \ldots 5]$ | Classes of use | rarely | low | normal | high | Very high |
| | | | | | | | 1 | 2 | 3 | 4 | 5 |
| **Prevention index** | $K_{CON}$ | [12] | x | | $K_{CON} = \frac{\sum_{i=1}^{n}(Zi/Zeff)}{N.ACCESS}$ | Eff (T2) | Remote control | Direct/local control | Video Surveillance | Innovative systems | |
| | | | | | | Eff (T3) | Innovative systems | Reinforced urban furniture | Barriers | Bollards | |
| **Vulnerability** | | | | | | | | | | | |
| **Shape index** | $K_{SHP}$ | [35] | | x | $K_{SHP} = f_{EXT} \times f_{SHP}$<br>$f_{EXT} = [1, 5]$, $f_{SHP} = f(2P/A)$<br>$f_{SHP} = [1, 1.5]$<br>$f_{SHP} = f(w/l)$ | Classes of $f_{EXT}$ | $0 < 2P/A < 0.02$ | $0.02 \leq 2P/A < 0.03$ | $0.03 \leq 2P/A < 0.06$ | $0.06 \leq 2P/A < 0.03$ | $2P/A \geq 0.09$ |
| | | | | | | | 1 | 2 | 3 | 4 | 5 |
| | | | | | | Classes of $f_{SHP}$ | Compact $w/l \geq 0.7$ | | 1.5 (T2) | 1.0 (T3) | |
| | | | | | | | elongated or very elongated $f_{SHP} < 0.7$ | | 1.0 (T2) | 1.5 (T3) | |

**Table 2.** *Cont.*

| Index Name | K Type | Ref. for Values | Normative | General Classif. | Equation | Details of Classification | Value | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Accessibility index** | $K_{PER}$ | [35] | | x | $K_{PER} = [1,5]$ $\frac{\sum_{i=1}^{n}(A_{vi})}{2P}$ | Classes for r | 0 < r < 0.05 | 0.05 < r < 0.1 | 0.1 < r < 0.2 | 0.2 < r < 0.3 | r > 0.3 |
| | | | | | | | 1 | 2 | 3 | 4 | 5 |
| | $K_{ACC}$ | | x | x | $K_{ACC} = \frac{\sum_{i=1}^{n}(Avi * facc\ i)}{\sum_{i=1}^{n} Avi}$ | $f_{ACC}$ = [1, . . ., 5] | Not accessible | Limitedly | Moderately | Alternatively | Accessible |
| | | | | | | | 1 | 2 | 3 | 4 | 5 |
| **Obstacle index** | $K_{OBST(V)}$ | | | x | $K_{OBST} = \sum_{i=1}^{n} d\ i * finf\ i$ $d_i$ =Ai/Avi | $f_{INF}$ = [1, 1.25, 1.5] | No influence | average increase | increasing | | |
| | | | | | | | 1 | 1.25 | 1.5 | | |
| **Exposure** | | | | | | | | | | | |
| **Index of attack type** | $K_{ATT}$ | [18] | | | $K_{ATT}$ = [4,5] | Consequence levels for Katt | Minor | moderate | Medium | Major | Extreme |
| | | | | | | | 1 | 2 | 3 | 4 | 5 |
| **Crowding index** | $K_{CRW}$ | | | x | $K_{CRW}$ = [1, . . .5] | Occupancy classes for $K_{CRW}$ | negligible | low | medium | high | Very high |
| | | | | | | | 1 | 2 | 3 | 4 | 5 |
| **Index of Reaction** | $K_{OBST(E)}$ | | | x | $K_{OBST(E)} = \sum_{i=1}^{n} d\ i * finfi * fshpob\ i$ | $f_{INF}$ | Decreasing | average decreasing | not influential | average incremental | incremental |
| | | | | | | | 0.5 | 0.75 | 1 | 1.25 | 1.5 |
| | | | | | | $f_{SHPob}$ | negligible | low | medium | high | Very high |
| | | | | | | | 1 | 2 | 3 | 4 | 5 |
| | $K_{CM}$ | [12] | | x | $K_{CM} = W_{EFF}/W_i$ | $W_{EFF}$ = 3 | Alarm countermeasures | Evacuation countermeasures | Systems of physical interventions | | |

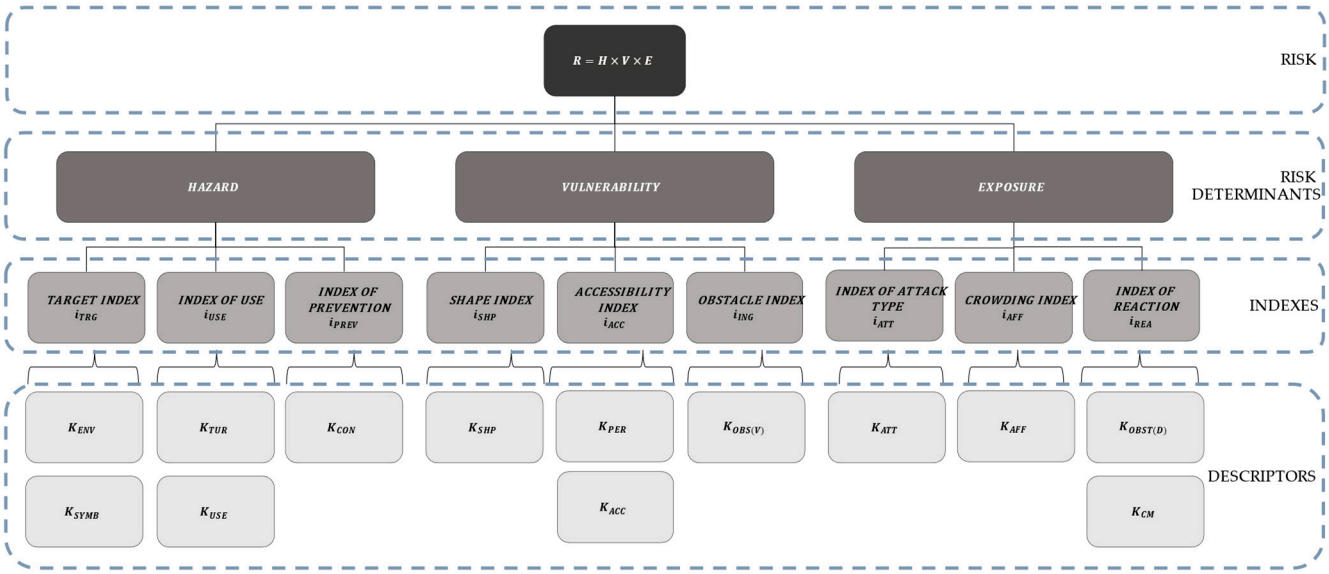


**Figure 2.** Diagram of the system of indexes and K-descriptors organized around single risk determinants.

#### 3.2.1. Descriptors Affecting the Hazard Indexes

Previous studies on European terrorism events have underlined the main relevance of ideology based on the phenomenon. The concept of "target" includes the necessity for perpetrators to understand the attack objective to guarantee the goals and the significance of the attack. These results allow us to understand which elements or features may affect perpetrators in choosing a uOA or a specific component. As the main findings from the literature on the topic, the elements affecting choice are related to (i) the political, religious, and/or cultural symbolism of the place or its components in order to maximize media impact, also considering the resonance of the target type (target index); (ii) the possibility to maximize the effect in terms of the number of potential people involved as an indirect consequence of the uOA uses (use index); and (iii) the level of protection within or along the frontier of the area to attack (protection index) [18].

Target Index [H_I.1]

Considering the target index [H_I.1], the phenomenological analysis in the European continent has highlighted that an inherent level of proneness exists for each class of uses of urban spaces and buildings, particularly concerning the weapon type. In Cantatore et al. [18], the frequency of events for classes of uses and attack types was standardized focusing on "Environmental uses" classes to which a specific level of likelihood is associated. Thus, the following points are important to consider:

- **$K_{ENV}$** is introduced as a descriptor of the statistical relevance of attacks for each environmental class combined with the attack in equivalent levels of likelihood, as already qualified in Cantatore et al. [18], with the following five levels: remote, unlikely, possible, likely and very likely classes. On the other hand, for similar classes of uses, the target choice can be associated with different levels of significance of places due to the political, social, cultural, and/or religious relevance [66,67].
- **$K_{SYMB}$**, as a descriptor of such features, may describe the variation in symbolic relevance of spaces; in fact, if some uOAs have a permanent (as inherent) symbolic significance for the institution and population, for others, the symbolic significance may be considered contingent on the presence of specific events [68]. For the description of this characteristic, five main classes can be introduced, ranging from negligible to very high symbolism classes.

Index of Uses [H_I.2]

As far as the Index of Uses [H_I.2] is concerned, the required descriptors for the "Hazard" have to discuss the attractiveness of the places, leaving the feature independent of the number of people involved. In fact, if the number of people affects the dimension of "Exposure" in risk assessment, the attractiveness of the real place influences the choice of place by perpetrators for soft or hard targets (Gordon Woo defines [4] it as "Interdependence and replacement of targets"). Specifically, the following points are important to consider:

- The $\mathbf{K_{TUR}}$ may be discussed for risk evaluation, as a descriptor of the inherent and potential reflection of representativeness of the place and the city. The touristic inflow usually correlates inhabitants to arrivals, and it may be considered at the city scale for annual, seasonal, or daily references, according to the primary nature of tourism. This is due to previous scientific outcomes in studying the interrelation between the touristic inflow and violent acts, even if their discussion has economic and political reflections [69–71].
- $\mathbf{K_{USE}}$ describes the standard use of the uOA and a single SoR. In fact, alongside the external level of attractiveness of places, the inherent vulnerability of uOAs and their sub-parts (SoRs) to attacks by perpetrators should also consider their use by inhabitants. Some daily conditions of use derived by the nature of the place (e.g., rendezvous points for people) and the use of buildings that border the uOA may also alter the potential level of assault, considering the daily variation (nocturnal, diurnal, evening).

For both descriptors, any normative requirements and ranges exist at the European scale; thus, a system of classes is considered, describing qualitatively the touristic intensity and use of places (Table 2).

Prevention Index [H_I.3]

Finally, focusing on the prevention index [H_I.3], the main significance is related to the presence of prevention strategies or solutions. As it is fully argued in the literature about the theme, the choice of place also depends on the fulfillment capability, according to the meaning and differences between hard and soft targets. In addition, as Quagliarini et al. [12] recently summarized, such solutions must be related to the attack type to consider their efficaciousness. In fact, as their main results, the review of major guidelines in documenting the compatibility and efficacy of preventive solutions, such as remote control, direct/local control, video surveillance, and innovative systems (i.e., face-detecting videos [72]) are recognized as efficient control along the boundaries of uOAs for the T2 attack type; on the other hand, innovative systems, reinforced urban furniture, barriers and bollards for the T3 attack type (see Table 2) [73]. Thus, a quantitative descriptor of the prevention index, such as $\mathbf{K_{CON}}$, should be introduced to describe the presence and the number of protective systems for each possible access point. This involves comparing Zi, the number of effective protective systems, to the maximum number of systems (Zeff = 4) for each access of uOAs and each attack type analyzed in the present study (T2 and T3) (Table 2).

3.2.2. Descriptors Affecting the Vulnerability Indexes

Three major indexes are identified for Vulnerability (Table 1). When the analysis is focused on this determinant, the discussion relates to the main elements or features, which are independent of the perpetrator's will; however, these elements describe the inherent propensity of exposed uOAs to suffer adverse effects when impacted by hazardous events. In detail, the analysis of the Vulnerability aspects of uOAs highlights three main features: (i) the geometric shape of spaces that may affect the potential of the arms (index of shape), (ii) the inherent capacity of places to be accessed by perpetrators (accessibility index), and (iii) the presence of sub-areas or places that can locally increase the crowd levels independently from the main use of places and buildings along the borders (obstacle index).

Index of Shape [V_I.1]

Specifically regarding the shape of BE [V_I.1], the main correlation to the literature is related to the dimension of places and the means of the attack, requiring two factors to assess $K_{SHP}$.

- The first factor qualifies the extension of the uOA ($f_{EXT}$) coherently with the ratio between its perimeter (2P) and area (A) extension, which usually describes the similarity between polygons. As in the other previous cases, five ranges of values are introduced, following the results of [35] (see Table 2).
- Discussing the relationship between the shape of uOA and T2 and T3 attack types, prevalent differences are recognized in the weapon classes: centralized or in movement [74]. All the weapons in T2 (armed assault) can be categorized as "centralized" arms, where the capacity for an attack is related to the maximum achievable distance of cold steel or firearms, including gunshots/ thrown weapons within a 360° range. While considering T3, the focus is on the vehicle that moves into the uOA excluding the possible range of associated arms (e.g., for car bombing). In this case, the ability to achieve and sustain high speeds during motion is a key feature of significance for vehicles [73,75]. Due to that, the index of shape describes the geometric employing the shape factor ($\mathbf{f_{SHP}}$) that relates the width and the length of the places according to the following ratio:

$$f_{SHP} = f(w/l) \quad (2)$$

However, three classes of geometric shapes can be determined in qualitative ranges, as properly described for open areas in Rosso et al. [35], where $f_{SHP} < 0.7$ describes elongated or very elongated shapes, while $f_{SHP} > 0.7$ I is used for compact ones.

The relationship between the value of the shape factor and the associated index is influenced by their interactions with the weapon types. Specifically, for centralized attacks, elongated and very elongated spaces reflect high levels of Vulnerability when exposed to attacks involving moving vehicles [73], while the effect is the opposite when the weapon is centralized. In that sense, for both morphology classes, $K_{SHP}$ is considered either non-influential or influential in terms of Vulnerability, assuming specific coefficients (see Table 2).

Accessibility Index [V_I.2]

Following the assessment of uOA Vulnerability, the second geometric feature is place accessibility [V_I.2]. In this case, the focus is centered on the possibility of the perpetrator accessing the places, thus the index may describe the intrinsic capacity of accesses to facilitate entrance. In this case, two main factors are found to describe the property:

- The physical and geometric accessibility of the perimeter of BE as inherent features for continuous or discontinuous fronts, called $\mathbf{K_{PER}}$ (perimeter factor). It correlates specific values to the ratio (r) between the sum of the width of entrances ($A_{vi}$) and the total perimeter (2P) of squares. Specifically, r values may vary within the limits of 0 (enclosed places) and 1 (open places), even though no major classifications are found in the literature for European uOAs.
- The accessibility to uOAs considers the width of entrances, the urban mobility features, and the presence of physical elements along the entrances, described as $\mathbf{K_{ACC}}$. In detail, it should consider the width ($A_{vi}$) and the accessibility level ($f_{ACC}$) of the i-entrance, properly assessed according to the attack types. Specifically, for T2 attack types, all the entrances can be considered always accessible due to the inherent significance of the entrance, while for T3 attacks, where perpetrators move in vehicles, ease of access is related to the possible levels of car accessibility, defined by urban regulation (e.g., traffic-restricted zone, hourly accessibility, . . .) or geometric restrictions.

Obstacle Index [V_I.2]

Finally, the third element assessed for the Vulnerability of uOAs is described by obstacles [V_I.3]. In detail, the attention is on the physical objects of uOAs that may influence meeting and temporal attractiveness in specific sub-areas. Sights, urban furniture, bar-covered terraces, geomorphological or physical discontinuities (i.e., stairs), and gardens may be considered. Their relevance is not related to the protection level but to the generated attractiveness, which may locally alter the general conditions of risk. For these purposes, all elements are assessed in terms of the number of obstacles, their extension, and the factor of influence as meeting points [75]. Specifically, the obstacle factor is determined considering the ratio between the extension of the i-th type of obstacle and the total surface area of obstacles in the uOA ($d_i$). This ratio is then multiplied by the associated relevance of each obstacle in terms of attractiveness influence ($f_{INF}$), which is described as an increasing factor, an average increasing factor, or not influential (Table 2).

3.2.3. Descriptors Affecting the Exposure Indexes

Considering the discussion of the last risk determinant, the Exposure to terrorism threat in this study is centered on victims, excluding building damages, in line with the data available from events recorded in the GTD database [56]. The qualification of elements that affect exposure in the risk assessment is carried out focusing on the properties that may affect the events before and during the event, overlooking the behavioral response of the people involved and the emergency phase (post-traumatic event). According to the summary in Table 1 and in line with the results discussed in previous studies [12,18], the number of people involved (including victims and the injured) may be considered as a consequence of (i) the attack type as the phenomenology has underlined, (ii) the number of bystanders in the place, and (iii) the presence of protective elements. Besides these elements, three descriptors have been identified and quantified, translating the reference indexes in Table 1.

Attack Index [E_I.1]

When the discussion is centered on the attack type [E_I.1], the focus is on the potential level of people in relation to recurrent boundary conditions. As it is usually reflected by risk management, Exposure includes the level of damage resulting from the phenomenological analysis of previous events. For this study, the relevance of attack typologies in the determinant is related to the phenomenological analyses conducted by the authors. Specifically, in line with the descriptor of the environmental factor, the $\mathbf{K_{ATT}}$ (attack factor) is introduced to describe the effect of the weapon type. Specifically, for each attack type, $K_{ATT}$ relates the statistical relevance of the impact for each combination of environmental classes (square F, SoR of bar or special buildings $F_B$ and $F_D$ respectively) and attack types, with the specific details on those discussed (T2 and T3). The quantification assigns a score (4 or 5) based on the consequence levels for the selected combination in [18].

Crowd Index [E_I.2]

As far as the possible effects are concerned (E_I.2), the Exposure class is also determined by the potential number of people that could be involved in the attack. The crowding index $\mathbf{K_{CRW}}$ describes the possible impact related to the density of people in the open area or outside the public activities facing the open area, and it is properly assessed according to the technicians' experience, in line with the qualitative ranges (see Table 2).

Index of the Attack Reaction [E_I.3]

Finally, "hide" and "run" represent two of the most recommended actions, consistent with several guidelines and norms regarding preventive actions at the national level [13,75]. The detail is on the effect of "obstacles" or "objects" that can participate in violent actions generating protective areas (positive effect) [76] or obstructing the possible evacuation (negative effect) [77]. In the first case, as reported in major national experiences, the

physical object with high resistance and mass can be considered a "protective zone" for both T2 and T3 attacks. On the other hand, it was demonstrated that a system of urban furniture or objects can alter the flux, generating real obstacles during evacuation. It includes elements such as poles with chains, railings, benches, and planters, which are predominantly characterized by horizontal development. Single elements, such as trees, monuments, and bollards, may alter the flux [78]. Thus, the attack reaction [E_I.3] is focused on the potential impact on users' reaction of the physical elements included in the uOAs from a static point of view. Instead, the impact of violent acts should consider the presence of countermeasures specifically fitted for the attack types in terms of users' involvement, according to the results presented by Quagliarini et al. [12]. Here, the presence of coordination and evacuation plans, alarm systems, and suitable physical elements in supporting evacuation (evacuation paths that are narrow, with lighting to ensure a secure emergency exit) influence the emergency phase, limiting the final number of people involved. Thus, two main descriptors are introduced for the assessment of the related index ($i_{REA}$):

- **$K_{OBST(E)}$**, which describes the influence of «obstacles» and «objects» on the identified aims. Specifically, $K_{OBST(E)}$ has to consider their total extent in relation to that of the uOA (d), their shape or the final shape resulting from the replicability of individual elements in the spaces (vertical, horizontal, compact development) ($f_{SHPob}$) and, finally, their influence on protection or evacuation ($f_{inf}$). Thus, $K_{OST(E)}$ should consider all the obstacles in the uOAs and determine a mean value for all the observed objects. Specifically, Table 3 shows the selected influence of obstacles' shape in the process, consistent with the state of the art [12].
- **$K_{CM}$** describes the positive effect on the number of people involved due to the presence of countermeasures. In this case, the factor considers strategies that may influence the preparedness for emergency activities in terms of alarms and evacuation countermeasures (both for T2 and T3). Due to that, $K_{CM}$ has to consider the number of classes of countermeasures in the emergency phase present in the uOA (Wi) and the effective ones discussed in Quagliarini et al. ($W_{EFF}$).

**Table 3.** Summary of the influence determined by obstacle typology on classes of shape and prevalent development.

| Icon | Examples of Shape and Prevalent Development of Obstacles | Influence of Obstacle's Shape |
|---|---|---|
|  | Poles and trees—vertical development | Negligible |
|  | Monuments—vertical development | Low |
|  | Bar covered terraces—Compact development | Average |
|  | Benches, planters, new jersey—horizontal development | High |
|  | Railings, steps—horizontal development | Very high |

#### 3.2.4. Final Remark for Assessing K-Factors and Indexes

Due to the complexity of qualifying all the elements, properties, and characteristics of places, some specifications were required, and they are discussed below.

The formulations concern both uOA and SoR for all the public and symbolic or strategic buildings facing the actual open areas. However, some K-factors require to be linked to one of them in accordance with some main principles:

- Due to the inherent concept assumed in the study of uOA as a system of buildings, infrastructures, and open areas, $K_{TUR,}$ $K_{CON}$, $K_{SHP,}$ $K_{PER,}$ $K_{ACC,}$ $K_{CM}$ are calculated considering the overall uOA, even when describing a SoR. This is due to the overlapping classes of qualities described by the K-factors, which are usually pre-determined by the historical evolution (e.g., the morphology of the city and district) or external strengths (e.g., tourism, local norms).
- The assessment of the SoR explicates its physical qualities when the K-factors describe properties related to their use or function ($K_{env}$, $K_{symb}$, $K_{USE}$, $K_{ATT}$, $K_{CRW}$) or link properties and qualities to their position within the overall uOA. This is the case of obstacles that are discussed in terms of efficacy, shape, or influence when they are included in the perimeter of the SoR. Thus, all the SoR graphical details, starting from their perimeter, are necessary to support the formulation.

### *3.3. The Mathematical Structure of the Risk Determinants*

After selecting and identifying factors that influence terrorist threats in uOAs, the nature of the indexes and descriptors varies in terms of the qualitative and quantitative discussions due to the complexity of the matter. However, some common points can be recognized in order to solve the qualitative–quantitative assessment. In detail, the following points should be considered:

- Considering the relevance of the matter, some parameters cannot be related to specific ranges of values ($K_{SHP}$, $K_{PER}$). Others are related to classes of features that qualitatively describe their relevance (e.g., low, high) ($K_{ENV}$, $K_{SYM}$ $K_{TUR}$, $K_{USE}$, $K_{ACC}$, $K_{ATT}$, $K_{CRW}$, $K_{OBST(E)}$). Due to that, all the descriptors are categorized into five classes of possible quantitative values, considering a range between 1 and 5, each associated with five possible qualitative classes.
- When the descriptors are related to factors that constitute corrective properties, ranges of factors are introduced in three classes in order to address the absence of influential and non-influential factors, as well as the influence of corrective factors ($K_{SHP}$, $K_{OBST(E)}$).
- All the descriptors related to the same index are considered independent and are combined for the index calculation as a product.
- Due to the large variability of the results (in terms of maximum and minimum values), all the indexes are normalized in five ranges, considering the associated final values in terms of class, from 1 to 5. This structure supports the limitation of results and their control in the overall process.
- All the values are conceived in order to exclude the zero value. This is fundamental to solving the undetermined ratios and excluding the zero value for the final risk triad (the minimum value of risk is 1).

As far as the final formulation is concerned, and consistent with the general rules, the terrorist risk for uOAs is structured as the product of three determinants. Each is calculated as the sum of all the indexes properly weighted (w), and it is evaluated for each attack type (T2 and T3), following Equation (3) and the detailed equations (Equations (4)–(6)).

$$R_{(T\text{-}type(F.Fb,Fd))} = H_{(T\text{-}type(F.Fb,Fd))} \times V_{(T\text{-}type(F.Fb,Fd))} \times E_{(T\text{-}type(F.Fb,Fd))} \quad (3)$$

$$H_{T\text{-}type(F.Fb,Fd)} = ((i_{TRG} \times w_{TRG}) + (i_{Use} \times w_{Use}) + (i_{PREV} \times w_{PREV}))/w_{Tot} \quad (4)$$

$$V_{T\text{-}type(F.Fb,Fd)} = ((i_{SHP} \times w_{SHP}) + (i_{ACC} \times w_{ACC}) + (i_{OBST} \times w_{OBST}))/w_{Tot} \quad (5)$$

$$E_{T\text{-}type(F.Fb,Fd)} = ((i_{ATT} \times w_{ATT}) + (i_{CRW} \times w_{CRW}) + (i_{REA} \times w_{REA}))/w_{Tot} \quad (6)$$

Moreover, all of them are calculated for actual open areas (square or street F) and each SoR (public or special buildings, $F_b$ and $F_d$, respectively). This is due to the conceptualization of uOAs as a system of buildings, infrastructures, and unbuilt areas, where the interactions among the building/infrastructure uses and the uses of squares/streets are part of the SoRs (see Section 3.1) within the same uOAs distribution. In that sense, the conceptual extension of uOAs ($A_{tot}$) has to consider the extent of all the SoRs, as well as that of the square/street (Equation (8)). Thus, the values of the determinants are calculated for both the square and each SoR ($R_F = H_F \times V_F \times E_F$; $R_{Fdi} = H_{Fdi} \times V_{Fdi} \times E_{Fdi}$; $R_{Fbi} = H_{Fbi} \times V_{Fbi} \times E_{Fbi}$), considering the ratio between single SoRs and $A_{tot}$. Moreover, for each attack type, a final triplet and risk value ($R_{uOAT\text{-}type}$) are introduced as the values of three determinants that need to be appropriately weighted to the area extension of F, $SoR_{FB}$, and $SoR_{FD}$. More specifically,

$$R_{uOA(\frac{T2}{T3})} = H_{uOA} \times V_{uOA} \times E_{uOA} = \left[\left(\frac{H_F}{A_F/A_{tot}}\right) + \sum_{i=1}^{n} \frac{H_{Fbi}}{A_{Fbi}/A_{tot}} + \sum_{i=1}^{m} \frac{H_{Fbi}}{A_{Fbi}/A_{tot}}\right] \times \left[\left(\frac{V_F}{A_F/A_{tot}}\right) + \sum_{i=1}^{n} \frac{V_{Fbi}}{A_{Fbi}/A_{tot}} + \sum_{i=1}^{m} \frac{V_{Fbi}}{A_{Fbi}/A_{tot}}\right] \times \left[\left(\frac{E_F}{A_F/A_{tot}}\right) + \sum_{i=1}^{n} \frac{E_{Fbi}}{A_{Fbi}/A_{tot}} + \sum_{i=1}^{m} \frac{E_{Fbi}}{A_{Fbi}/A_{tot}}\right] \quad (7)$$

$$\text{where } A_{tot} = A_F + \sum_{i=1}^{n} A_{Fbi} + \sum_{i=1}^{m} A_{Fdi} \quad (8)$$

Table 2 summarizes the K-parameters, formulations, and details used for setting up the formulation, applicable to the AHP and Delhi participatory methods. Specifically, detailed references to the literature and normative are reported when the classes or values are already present; in all the other cases, the formulations are derived; in this latest case, they are reorganized for work purposes, reporting them in the participatory validation process (Section 4).

## 4. Influence Factors and Weighting with Participatory Methods

The indexes and descriptors are submitted to a pool of participants which includes the following:

- Eight master's degree students involved in studying the terroristic phenomenon in Europe.
- Seven European academics with experience in resilient and secure cities.
- Two experts in participatory methods applied to architectural built environment issues (static failure, preventive maintenance).
- Four public policymakers involved in the management of security for big events.

The participants were engaged online to explain the main goal of the questionnaire. However, they were equipped with a set of general information related to the goal of setting up the algorithm before answering the questionnaire.

### *4.1. Validation of Influencing Factors and Formulation*

In accordance with the described method, three levels of detail are required to the participants (Table 4).

- The first and second levels ensure that the indexes and K-types comply with the selected risk determinant and the associated index, respectively. In these phases, the Delphi method follows the "Consensus" goal.
- The third level aims at the acceptability of formulation and ranges for each K-type. Acceptability is measured by "Yes" or "Not" answers, and a field for comments is included.

**Table 4.** Results of the Delphi method (✓ yes, x not).

| | First Round | | First Round | First Round CRV | | Second Round CRV |
|---|---|---|---|---|---|---|
| | **Consensus: the Index is Compliant with the Risk Determinant** | **K-Type** | **Consensus: the Index is Compliant with the Associated Index** | **Formulation and Ranges Are Acceptable?** | **NOTE** | **Formulation and Ranges Are Acceptable** |
| Target index | ✓ | $K_{ENV}$ | ✓ | 0.7143 | | |
| | | $K_{SYMB}$ | ✓ | 1.0000 | | |
| Index of use | ✓ | $K_{TUR}$ | ✓ | 0.5714 | | |
| | | $K_{USE}$ | ✓ | 0.8571 | | |
| Prev. index | ✓ | $K_{CON}$ | ✓ | 1.0000 | | |
| Shape index | ✓ | $K_{SHP}$ | ✓ | 0.8571 | ✓ | 0.8571 |
| Accessibility index | ✓ | $K_{PER}$ | ✓ | 1.0000 | | |
| | | $K_{ACC}$ | ✓ | 0.7143 | | |
| Obstacle index | ✓ | $K_{OBST(V)}$ | ✓ | 0.7143 | | |
| Index of attack type | ✓ | $K_{ATT}$ | ✓ | 1.0000 | | |
| Crowding index | ✓ | $K_{CRD}$ | ✓ | 1.0000 | ✓ | 1.0000 |
| Index of reaction | ✓ | $K_{OBST(E)}$ | ✓ | 0.7143 | | |
| | | $K_{CM}$ | ✓ | 1.0000 | | |

The results of the first and second rounds of consensus met a higher level of acceptability in the first round of the Delphi surveys, both in assigning indexes to the risk determinants and in the association of K-descriptors to indexes.

The third level was addressed in two rounds due to recurrent notes about the ranges. Specifically, $K_{CRD}$, despite reaching an acceptability rate in the round (CRV > 0.5), saw more than half of the participants propose the use and association of standard ranges of values with the qualitative classification, highlighting the opportunity to resolve the issue using normative details. A new classification was determined for the selected K-type, including the opportunity to use national ranges to manage crowding events for $K_{CRD}$.

### *4.2. Quantification of Factor Relations in the Determinant Calculation*

In accordance with the AHP procedures, the participants were invited to determine the final weight of indexes. The choice of the weight of indexes instead of K-parameters results from the necessity to provide an easier way to solve the algorithm and, above all, to understand the major results of the participatory approach. Moreover, in accordance with Equations (2)–(4), the weights are assessed considering single determinants, thus comparing three indexes for time. This is due to the necessity to consider independent Hazard, Vulnerability, and Exposure determinants in alignment with the goals of the work. The final weights for each index and the associated CR values are summarized in Table 5.

**Table 5.** Results of the AHP method applied to the K-descriptors.

| Index Name | Weight | CR (%) |
|---|---|---|
| | Hazard | |
| Target index | 0.6 | 0.6% |
| Index of use | 0.09 | |
| Prev. index | 0.31 | |
| | Vulnerability | |
| Shape index | 0.24 | 6.9% |
| Accessibility index | 0.65 | |
| Obstacle index | 0.12 | |
| | Exposure | |
| Index of attack type | 0.2 | 3.2% |
| Crowding index | 0.65 | |
| Index of reaction | 0.17 | |

Regarding the comparison of participatory methods, consistent opinions can be highlighted at the end of the procedure, supporting the coherence and the structure of the applied method:

- The concurrence between the higher values of CRV parameters for K-types and the weight of the associated index. This is the case of the target and accessibility indexes, where both the CRV values associated with K-parameters showed higher values.
- The relevance of major details about the crowding index in determining the most coherent formulation and the associated final weight of the index.

In both cases, the participants demonstrated a clear and coherent perception of key elements and features to be considered. Similarly, a good alignment with the review research conducted as the foundation of the work can be highlighted.

## 5. Numerical and Theoretical Test and Validation of the Algorithm

The last phase of the work involves algorithm testing to validate the participatory results and the suitability of the elements parametrized, thus testing them.

In order to exploit the calculation tool in accordance with national details, the algorithm was processed for 22 Italian cases, providing different levels of peculiarities, both in symbolicity and time of use. Table 6 summarizes the case studies in accordance with the main conditions and the elements for discussion. More details about $F_B$ and $F_D$ and SoRs extensions are detailed in Appendix A.

**Table 6.** Major details about tested case studies in Italy.

| Italian Case | Touristic Relevance | Symbolicity | Presence of Strategic Buildings | Principal Symbolic Buildings | Presence of Mitigative Strategy |
|---|---|---|---|---|---|
| Milano—Piazza Duomo | High, independent of season and time of day | High—Political and economic | | Duomo, Galleria | yes |
| Napoli—Piazza del Plebiscito | High, independent of season and time of day | High—Cultural | | Basilica Pontificia, Palazzo Reale | yes |
| Roma—Piazza San Pietro | High, independent of season and time of day | High—Religious and political | | Basilica di San Pietro | yes |

**Table 6.** *Cont.*

| Italian Case | Touristic Relevance | Symbolicity | Presence of Strategic Buildings | Principal Symbolic Buildings | Presence of Mitigative Strategy |
|---|---|---|---|---|---|
| Venezia—Piazza San Marco | High, independent of season and time of day | High—Cultural and economic | | Basilica di San Marco, Palazzo Ducale | yes |
| Corato (BA)—Piazza Sedile | Low, citizen uses | Low | | minor churches | no |
| Matera—Piazza Vittorio Veneto | High, "Matera Capitale della Cultura" and "Sassi" UNESCO Site | Medium—touristic | | Balcony on the "Sassi" | no |
| Ostuni (BR)—Piazza della Libertà | Seasonal and mainly nocturnal | Medium—touristic | | | no |
| Trani (BAT)—Piazza Duomo, Piazza Re Manfredi | Medium, presence of cultural attraction | High—Touristic and strategic | Courthouse of the province | Castello Svevo, Representative church of the Romanic style | yes |
| Narni (TR)—Piazza dei Priori | Medium high, independent of season | Medium—cultural | City hall | Palace "dei Priori" | no |
| Caldarola (MC)—Piazza Vittorio Emanuele II | Very low usage by citizens | Low | City hall | Two churches | no |
| Catania—Piazza Università | Medium, presence of cultural attraction and university attractiveness | Medium—touristic | University of Catania | "Machiavelli" Theatre | no |
| Genova—Piazza delle Vigne | Medium, presence of cultural attraction and university attractiveness | Medium—touristic | | Basilica di Santa Maria delle Vigne | no |
| Parma—Piazza del Duomo | Medium, presence of cultural attractions | Medium—touristic | | Basilica Cathedral, Baptistery, Bishop's palace | no |
| Monza—Piazza Trento e Trieste | Medium, business activities | High—political and economic | | | no |
| Perugia—Piazza IV Novembre | Medium, presence of cultural attractions | Medium—touristic | Curia of Bishop | | no |
| Pavia—Piazza del Duomo | Medium, presence of cultural and university attractiveness | Medium—touristic | | Palazzo Vescovile; Cattedrale di Santo Stefano | no |
| Padova—Piazza delle Erbe | Medium, presence of cultural attractions | Medium—touristic | | Palazzo della Ragione | no |
| Reggio Calabria—Piazza Duomo | Medium, presence of cultural attractions | Medium—touristic | | Duomo | no |
| Cagliari—Piazza Palazzo | Medium, presence of cultural attractions | Medium—touristic and strategic | Prefettura; Ecclesiastic Courthouse | Palazzo Regio, Cathedral, Ancient City Hall | yes, but related to strategic buildings |
| L'Aquila—Piazza Duomo | Medium low | Medium—touristic | | Palazzo Poste e Telegrafi, Duomo | no |
| Ancona—Piazza del Plebiscito | Medium, presence of cultural attractions | Medium—touristic and strategic | Prefecture; Headquarter regional Finance police | San Domenico Church | yes, and related to strategic buildings |
| San Gemini (TR)—Piazza San Francesco | Very low, usage by citizens | Low | | San Francesco Church | no |

Data gathering involved using Google Maps details (through Google Earth Pro v.7.3.6.9796 using images ©2023Google, Airbus Maxer Technologies) in order to provide

compatible and homogeneous data. Daily uses and opening times were also gathered using Google Maps details. The use of these details helps in overcoming the regional variability of the data available in vectorial maps (such as GIS data), which may determine local variability when considering the physical objects in the case studies. Finally, due to the variety of physical elements within the analyzed OAs, two main conditions were considered for the algorithm testing: with (S) and without mitigative (NS) strategies. The higher political and religious relevance of some case studies (Milano, Roma, Venezia) has already moved policymakers to introduce physical solutions aiming at increasing the local security of the places. As part of this study, the algorithm was also tested for the assessment of strategies by means of the global risk calculation, in accordance with Equation (7).

Table 7 summarizes the results of all the cases, highlighting the distribution of risk determinants for the environmental classes involved (F, Fb, and Fd), in accordance with their extensions, for both attack types (T2—armed assault, T3—car bombing attack). The mathematical application across several case studies has not established limitations, it solves all the queries, and shows the expected results for most representative and symbolic Italian case studies. This is due to the relevance of both Hazard and Exposure in relation to the places, resulting from the weighted average of SoRs and square extensions. However, additional observations can be noted:

- Considering the variation in risk values for the S and NS cases, the algorithm provided sufficient variations for assessing the presence of physical mitigative or protective strategies. However, in compliance with the gathered data, all the elements aim to reduce the Vulnerability of a place to external attacks (car bombing in movement). In that sense, the reduction affects the Vulnerability values (see the case of Milano and Roma) as a consequence of the physical reduction in the accessibility of openings.
- When provincial case studies are assessed (Trani, Ostuni, Narni), the algorithm returns medium values for the actual state of the places. This is due to the inherent critical features (morphology, accessibility, lower level of protection) rather than the symbology or attractiveness of the places.
- Minor case studies, such as Corato, San Gemini, and Caldarola, reflect minor risk values, as a consequence of the combination of lower levels of attractiveness and symbology of places, combined with variable values of Vulnerability and Exposure.

**Table 7.** Summary of results of applying the algorithm in all the analyzed Italian case studies, expressed in triads of values (H, V, E) for each environmental class (F, Fb, Fd).

| City | | Environ. Class | | T2 | | | | T3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Type | %Area | H | V | E | R | H | V | E | R |
| Milano | NoStr. | F | 71% | 3.55 | 2.84 | 3.55 | | 3.55 | 2.84 | 3.55 | |
| | | Fb | 13% | 0.52 | 0.53 | 0.52 | | 0.52 | 0.53 | 0.52 | |
| | | Fd | 16% | 0.78 | 0.63 | 0.70 | | 0.78 | 0.63 | 0.70 | |
| | | mean | | 5 | 4 | 5 | 100 | 5 | 4 | 5 | 100 |
| | WithStr. | F | 71% | 3.55 | 2.84 | 3.55 | | 3.55 | 1.42 | 3.55 | |
| | | Fb | 13% | 0.40 | 0.53 | 0.52 | | 0.38 | 0.27 | 0.52 | |
| | | Fd | 16% | 0.66 | 0.63 | 0.70 | | 0.70 | 0.31 | 0.70 | |
| | | mean | | 5 | 4 | 5 | 100 | 5 | 2 | 5 | 50 |
| Roma | NoStr. | F | 71% | 3.55 | 2.84 | 3.55 | | 3.55 | 2.84 | 3.55 | |
| | | Fb | 1% | 0.03 | 0.05 | 0.06 | | 0.03 | 0.04 | 0.06 | |
| | | Fd | 28% | 1.39 | 1.11 | 1.39 | | 1.39 | 0.84 | 1.39 | |
| | | mean | | 5 | 4 | 5 | 100 | 5 | 4 | 5 | 100 |
| | WithStr. | F | 71% | 2.84 | 2.13 | 3.55 | | 3.55 | 1.42 | 3.55 | |
| | | Fb | 1% | 0.03 | 0.02 | 0.05 | | 0.03 | 0.01 | 0.05 | |
| | | Fd | 28% | 1.11 | 0.84 | 1.39 | | 1.39 | 0.56 | 1.39 | |
| | | mean | | 4 | 3 | 5 | 60 | 5 | 2 | 5 | 50 |
| | Napoli | F | 65% | 2.58 | 1.94 | 3.23 | | 2.58 | 1.94 | 3.23 | |
| | | Fb | 4% | 0.10 | 0.14 | 0.16 | | 0.11 | 0.09 | 0.15 | |
| | | Fd | 31% | 1.28 | 0.94 | 1.19 | | 1.32 | 0.94 | 1.19 | |
| | | mean | | 4 | 3 | 5 | 60 | 4 | 3 | 5 | 60 |

**Table 7.** *Cont.*

| City | | Environ. Class | | T2 | | | | T3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Type | %Area | H | V | E | R | H | V | E | R |
| Venezia | NoStr. | F | 71% | 3.54 | 2.83 | 3.54 | | - | - | - | - |
| | | Fb | 17% | 0.49 | 0.44 | 0.46 | | - | - | - | - |
| | | Fd | 12% | 0.78 | 0.57 | 0.74 | | - | - | - | - |
| | | mean | | 5 | 4 | 5 | 100 | - | - | - | - |
| | WithStr. | F | 71% | 3.54 | 2.83 | 3.54 | | - | - | - | - |
| | | Fb | 17% | 0.37 | 0.44 | 0.46 | | - | - | - | - |
| | | Fd | 12% | 0.61 | 0.57 | 0.74 | | - | - | - | - |
| | | mean | | 5 | 4 | 5 | 100 | - | - | - | - |
| | Matera | F | 70% | 2.78 | 2.78 | 3.48 | | 2.78 | 2.78 | 2.78 | |
| | | Fb | 27% | 0.75 | 0.93 | 0.85 | | 0.78 | 0.85 | 0.85 | |
| | | Fd | 4% | 0.11 | 0.15 | 0.08 | | 0.11 | 0.11 | 0.08 | |
| | | total | | 4 | 4 | 4 | 64 | 4 | 4 | 4 | 64 |
| Ostuni (BR) | Summer | F | 77% | 2.31 | 3.08 | 3.85 | | 2.31 | 3.08 | 3.85 | |
| | | Fb | 23% | 0.69 | 0.91 | 0.86 | | 0.69 | 0.87 | 0.86 | |
| | | Fd | 0% | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0.00 | |
| | | mean | | 3 | 4 | 5 | 60 | 3 | 4 | 5 | 60 |
| | Winter | F | 77% | 2.31 | 2.31 | 3.08 | | 2.31 | 2.31 | 3.08 | |
| | | Fb | 23% | 0.69 | 0.73 | 0.73 | | 0.69 | 0.69 | 0.73 | |
| | | Fd | 0% | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0.00 | |
| | | mean | | 3 | 3 | 4 | 36 | 3 | 3 | 4 | 36 |
| | Trani | F | 73% | 2.19 | 2.19 | 2.92 | | 2.19 | 2.19 | 2.92 | |
| | | Fb | 7% | 0.22 | 0.21 | 0.23 | | 0.22 | 0.22 | 0.23 | |
| | | Fd | 20% | 0.70 | 0.51 | 0.59 | | 0.70 | 0.59 | 0.59 | |
| | | mean | | 3 | 3 | 4 | 36 | 3 | 3 | 4 | 36 |
| | Corato (BA) | F | 85% | 1.70 | 3.40 | 1.70 | | 1.70 | 2.55 | 1.70 | |
| | | Fb | 14% | 0.28 | 0.58 | 0.28 | | 0.28 | 0.42 | 0.48 | |
| | | Fd | 1% | 0.02 | 0.04 | 0.02 | | 0.02 | 0.03 | 0.02 | |
| | | mean | | 2.00 | 4.00 | 2.00 | 16 | 2.00 | 3.00 | 2.00 | 12 |
| | Narni (TR) | F | 67% | 2.69 | 2.69 | 2.69 | | 2.69 | 2.69 | 2.69 | |
| | | Fb | 33% | 1.23 | 1.23 | 1.23 | | 1.23 | 1.23 | 1.23 | |
| | | Fd | 0% | - | - | - | | - | - | - | |
| | | mean | | 4.00 | 4.00 | 3.00 | 48 | 4.00 | 3.00 | 3.00 | 36 |
| | Caldarola (MC) | F | 76% | 1.52 | 2.28 | 1.52 | | 1.52 | 3.04 | 1.52 | |
| | | Fb | 5% | 0.15 | 0.20 | 0.10 | | 0.15 | 0.21 | 0.10 | |
| | | Fd | 19% | 0.37 | 0.67 | 0.37 | | 0.37 | 0.67 | 0.37 | |
| | | mean | | 2.00 | 3.00 | 2.00 | 12 | 2.00 | 4.00 | 2.00 | 16 |
| | Catania | F | 59% | 1.77 | 2.37 | 2.37 | | 1.77 | 1.77 | 2.37 | |
| | | Fb | 41% | 1.20 | 1.24 | 1.53 | | 1.20 | 1.22 | 1.53 | |
| | | Fd | 0% | - | - | - | | - | - | - | |
| | | mean | | 3.00 | 4.00 | 4.00 | 48 | 3.00 | 3.00 | 4.00 | 36 |
| | Genova | F | 36% | 1.08 | 1.08 | 1.08 | | 0.72 | 0.72 | 1.08 | |
| | | Fb | 61% | 1.69 | 1.82 | 1.70 | | 1.21 | 1.21 | 1.70 | |
| | | Fd | 3% | 0.07 | 0.10 | 0.07 | | 0.07 | 0.07 | 0.07 | |
| | | mean | | 3.00 | 3.00 | 3.00 | 27 | 2.00 | 2.00 | 3.00 | 12 |
| | Parma | F | 59% | 1.78 | 2.96 | 1.78 | | 1.78 | 1.18 | 1.78 | |
| | | Fb | 4% | 0.12 | 0.17 | 0.09 | | 0.09 | 0.09 | 0.09 | |
| | | Fd | 36% | 1.09 | 1.79 | 1.01 | | 1.09 | 1.06 | 1.01 | |
| | | mean | | 3.00 | 5.00 | 3.00 | 45 | 3.00 | 2.00 | 3.00 | 18 |
| | Monza | F | 64% | 1.93 | 2.58 | 1.93 | | 1.93 | 2.58 | 1.93 | |
| | | Fb | 34% | 1.05 | 1.40 | 1.02 | | 1.05 | 1.40 | 1.02 | |
| | | Fd | 2% | 0.01 | 0.02 | 0.01 | | 0.01 | 0.02 | 0.01 | |
| | | mean | | 3.00 | 4.00 | 3.00 | 36 | 3.00 | 4.00 | 3.00 | 36 |
| | Perugia | F | 68% | 2.71 | 2.71 | 2.04 | | 2.71 | 2.04 | 2.04 | |
| | | Fb | 13% | 0.46 | 0.46 | 0.29 | | 0.46 | 0.39 | 0.29 | |
| | | Fd | 19% | 0.76 | 0.76 | 0.57 | | 0.76 | 0.57 | 0.57 | |
| | | mean | | 4.00 | 4.00 | 3.00 | 48 | 4.00 | 3.00 | 3.00 | 36 |

**Table 7.** *Cont.*

| City | Environ. Class Type | %Area | T2 H | T2 V | T2 E | T2 R | T3 H | T3 V | T3 E | T3 R |
|---|---|---|---|---|---|---|---|---|---|---|
| Pavia | F | 42% | 1.67 | 1.67 | 1.25 | | 1.67 | 1.25 | 1.25 | |
| | Fb | 7% | 0.24 | 0.26 | 0.18 | | 0.24 | 0.21 | 0.18 | |
| | Fd | 51% | 2.06 | 2.06 | 1.54 | | 2.06 | 1.54 | 1.54 | |
| | mean | | 4.00 | 4.00 | 3.00 | 48 | 4.00 | 3.00 | 3.00 | 36 |
| Padova | F | 66% | 2.64 | 1.98 | 1.98 | | 1.98 | 1.98 | 1.98 | |
| | Fb | 34% | 1.12 | 1.02 | 1.00 | | 0.90 | 1.02 | 1.00 | |
| | Fd | 0% | - | - | - | | - | - | - | |
| | mean | | 4.00 | 3.00 | 3.00 | 36 | 3.00 | 3.00 | 3.00 | 27 |
| Reggio Calabria | F | 75% | 2.25 | 2.25 | 2.25 | | 2.25 | 2.25 | 2.25 | |
| | Fb | 13% | 0.39 | 0.36 | 0.36 | | 0.39 | 0.32 | 0.39 | |
| | Fd | 12% | 0.36 | 0.48 | 0.36 | | 0.36 | 0.48 | 0.48 | |
| | mean | | 3.00 | 3.00 | 3.00 | 27 | 3.00 | 3.00 | 3.00 | 27 |
| Cagliari | F | 79% | 2.37 | 2.37 | 2.37 | | 1.58 | 1.58 | 2.37 | |
| | Fb | 17% | 0.51 | 0.47 | 0.47 | | 0.37 | 0.34 | 0.47 | |
| | Fd | 4% | 0.12 | 0.12 | 0.08 | | 0.10 | 0.08 | 0.08 | |
| | mean | | 3.00 | 3.00 | 3.00 | 27 | 2.00 | 2.00 | 3.00 | 12 |
| L'Aquila | F | 87% | 2.62 | 2.62 | 2.62 | | 2.62 | 2.62 | 2.62 | |
| | Fb | 5% | 0.16 | 0.11 | 0.16 | | 0.16 | 0.15 | 0.13 | |
| | Fd | 7% | 0.22 | 0.29 | 0.22 | | 0.22 | 0.29 | 0.22 | |
| | mean | | 3.00 | 3.00 | 3.00 | 27 | 3.00 | 3.00 | 3.00 | 27 |
| Ancona | F | 66% | 2.63 | 1.97 | 2.63 | | 1.97 | 1.97 | 2.63 | |
| | Fb | 9% | 0.21 | 0.28 | 0.28 | | 0.85 | 0.61 | 0.78 | |
| | Fd | 25% | 0.85 | 0.75 | 0.72 | | 0.75 | 0.50 | 0.60 | |
| | mean | | 4.00 | 3.00 | 4.00 | 48 | 3.00 | 3.00 | 3.00 | 27 |
| San Gemini (TR) | F | 50% | 1.00 | 1.50 | 1.00 | | 1.00 | 2.00 | 1.00 | |
| | Fb | 17% | 0.36 | 0.54 | 0.34 | | 0.36 | 0.69 | 0.34 | |
| | Fd | 33% | 0.65 | 1.25 | 0.65 | | 0.65 | 1.25 | 0.65 | |
| | mean | | 2.00 | 3.00 | 2.00 | 12 | 2.00 | 4.00 | 2.00 | 16 |

In addition to the mathematical significance reached, these results also align with the main principle of the terrorism phenomenon in classifying hard and soft targets, as introduced by Gordon Woo [4]:

- Protective strategies are independent of the Hazard of places when describing hard targets. Considering the most relevant case studies (Milano, Roma, Napoli, Venezia), the algorithm describes them as hard targets where the violent acts require operative resourcefulness both in planning and executing; in fact, despite the higher symbolicity of places and the high level of protection achieved in the squares, Hazard still maintains superior values, in the range [4 or 5]. This is in accordance with the weights assigned to the target and the protection indexes (0.60 and 0.31, respectively) in the Hazard assessment. On the other hand, the strategies reflect positive effects on reducing the overall risk values, having effects on Vulnerability as the main descriptor of the inherent physical criticalities of places.
- Protective strategies affect the Hazard value of places when the soft targets are assessed. Consistent with the definition of "soft target", the occurrence of events may increase due to the lower level of protection of places, allowing for their replicability. In that sense, the weights assigned to the target and protection indexes are well calibrated, particularly in describing soft targets. This allows for the description of the strategies' effect on reducing both the Hazard and inherent Vulnerability of places.

## 6. Discussion of Results from the Risk Assessment to Its Control and Management

In accordance with the results discussed in the previous section, the 5-point scales of the Hazard, Vulnerability, and Exposure determinants are translated into qualitative

meaning in order to support coherent and intelligible discussions of numerical results. Table 8 summarizes the classes and the qualitative meaning assigned.

**Table 8.** Qualitative description of Hazard, Vulnerability, and Exposure determinants.

| Hazard | Vulnerability | Exposure |
|---|---|---|
| 1–2 unlikely | 1–2 low | 1–2 minor |
| 3 probably | 3 medium | 3 moderate |
| 4–5 likely | 4–5 high | 4–5 critical |

These classes of significance are thus merged with previous results in reading soft and hard targets, as well as with the terroristic principles in terms of result maximization, and three main recurrences can be enunciated:

- Hard targets belong to the higher class of Hazard (likely), exploiting the higher value of damage (E critical).
- Soft targets fit within all the other classes of Hazard (unlikely and probably), varying for all the other determinant classes.
- Due to the lower significance of places (H unlikely) and the lower potential effects (E minor), soft targets do not require any specific measures regarding terroristic attack risks. They are assumed to be negligible due to the lower attractiveness and efficacy of violent events, assuming that Vulnerability is an independent factor.

Due to these results, the risk management of the terrorist phenomenon can be solved by introducing and discussing three classes of risk typologies of real places as the combination of Hazard and Exposure. Moreover, considering Hazard as the determinant to describe a place's proneness to violent acts, Vulnerability and Exposure are discussed in terms of the degree of danger, combining the potency of damage and the intrinsic vulnerabilities of places. These are thus combined to determine equivalent classes of actions to support risk reduction in real places. Table 9 sums up the results in degrees of danger and classes of risk, combining the typologies of soft/hard targets. Figure 3 shows the expanded matrices for four combinations of the same classes of targets.

**Table 9.** Classes of risk associated with specific combinations of H and level of danger, discussed for hard and soft targets, associating red, orange, green, and grey colors to represent high, medium, low, and negligible classes of risk.

| H Values | Degree of Danger | Class of Risk |
|---|---|---|
| | Soft target | |
| H [1, 2] ∧ E [1, 2] | all the combinations | Negligible |
| V [1, 5] | | |
| H [4, 5] | VxE = [1, 9] | Medium |
| V [1, 5]; E [1, 3] | VxE = [9, 15] | High |
| H [1, 2] V [1, 5]; E [3, 5] | VxE = [3, 6] | Low |
| | VxE = [6, 15] | Medium |
| | VxE = [15, 25] | High |
| H [3] V [1, 5]; E [1, 5] | VxE = [1, 4] | Low |
| | VxE = [4, 12] | Medium |
| | VxE = [12, 25] | High |
| | Hard target | |
| H [4, 5] ∧ E [4, 5] | VxE = [4, 10] | Medium |
| V [1, 5] | VxE = [10, 25] | High |

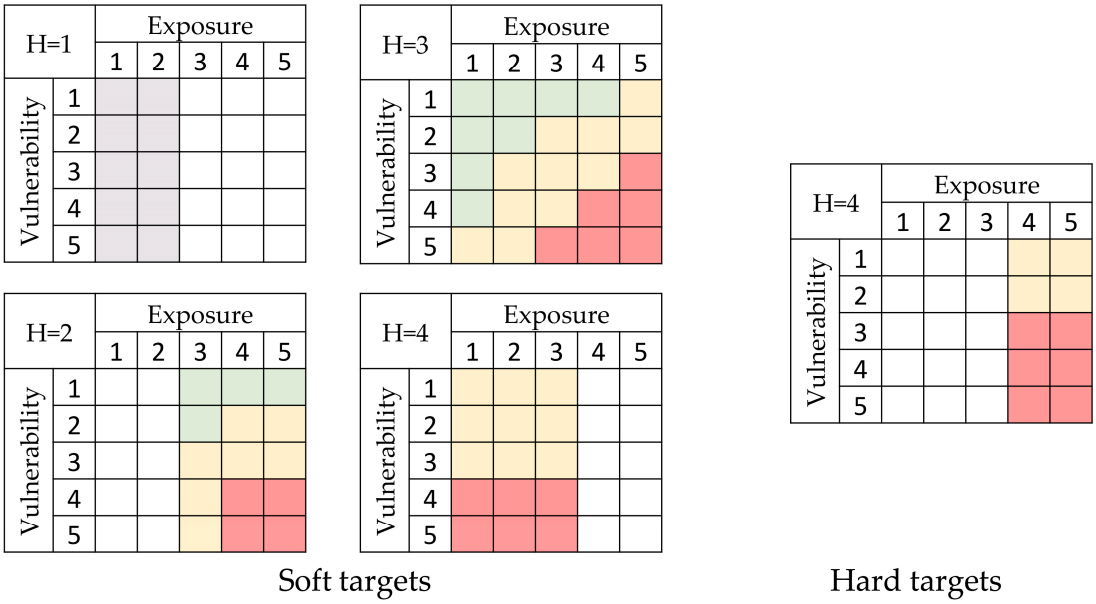


**Figure 3.** Expanded two-dimensional matrices of terrorism risk uOAs for soft (**left**) and hard (**right**) targets, coherently with the classes of risks in Table 9 (red, orange, green, and grey colors represent high, medium, low, and negligible classes of risk).

In more detail, besides the operative benefit of understanding the proneness to a single risk of uOAs, some possible goals can be reached:

- The comprehension of the possible critical points of the place can support the analysis of behavior during the emergency, matching the geometric and physical properties of the place to the users' movements, while also assessing mitigative strategies introduced for the reduction of pre-emergency phase, toward a more comprehensive behavioral–physical-based approach for emergencies [79,80].
- Considering an asynchronous multi-risk perspective, recognizing critical points vulnerable to harm in uOAs, and designing and assessing physical transformations of the place to reduce susceptibility to terrorism offer the opportunity to evaluate the resilience of such strategies in other risk occurrences. The inherent double relationship between the protective and obstructing features of the physical objects in the area may affect emergency conditions for other sudden threats (e.g., earthquakes). In that sense, the design of mitigative and protective solutions may consider all the possible hazards in uOAs, taking advantage of behavior analysis for emergency planning [64,81].
- Considering a synchronous multi-risk perspective, the identification of critical points vulnerable to harm can be correlated with the local distribution of people when external pressures occur, such as heatwaves. Here, the slow nature of natural events may affect the local re-distribution of users within the uOAs, altering the local crowd density and shifting potential point of attacks, as well as affecting user behavior [82].

All these advantages are strictly related to the qualitative approach at the basis of the formulation, which became fundamental in describing a human-based phenomenon. At the same time, some limitations can be expressed.

First of all, it is necessary to test the results related to previous events in order to calibrate the quality of the data. This includes discussing the effects of an event before and after the application of mitigative strategies. However, this can be achieved by including a more comprehensive structure of results that includes the users' movements. On the other hand, this requires that the location has experienced the same type of attack in the same place, which constitutes a significant limitation.

Another limitation of the analysis is related to the independence of the human dimension of the perpetrators. The proposed analysis is centered on the built environment

aligning with the aim of the work and addressing the perpetrator's actions during a violent act may change the final riskiness of the place.

The setup of the discussed algorithm for squares concerns a specific matter, compared to the general phenomenon. This is in line with most of the previous studies found in the literature that tried to solve specific problems in cities exposed to these violent acts. In accordance with European regulations [36–38], all these fields of application require direction toward a common method to first measure the risk and then assess the overall resilience level of cities. The application of a standardized method to assess terrorist risk and the use of a set of parameters to describe and evaluate elements in the scenarios may allow for the complexity of resolving the overall general threat, combining new parameters and re-weighting them within a broader collaborative effort.

## 7. Conclusions

In this work, European theories on the terrorism phenomenon, normative experiences, and phenomenological results about violent acts in urban open and public places (uOAs) are combined to determine a simplified risk matrix for qualifying this urban built environment prone to terrorism. The matrix of risk, properly defined to describe uAOs as either soft or hard targets, resulted from the assessment of the elements (objects and obstacles, buildings, accesses) and properties (functions, geometry, symbolism) that usually feature the real urban built environment, in accordance with city development and urban relevance (political, religious, ...). Such properties, qualities, and deficiencies, both quantitative and qualitative, are translated into descriptors (K-descriptors) by merging scientific and normative experiences to provide a limited number of factors for the study of the real uOAs. The nine K-descriptors, properly identified in formulation and meaning, were discussed for compliance with the three determinants of risk (Hazard, Vulnerability, and Exposure) and shared with the external judges through a participatory method. All the experts involved in the AHP process were coached in the thematic study, presenting previous findings, i.e., the relevance of uOA within the European phenomenon, and the classes of mitigative and preventive strategies. Specifically, the coherence with the determinants and formulations is first assessed using the Delphi method. Then, the K-determinants were evaluated using an AHP process to determine the main relevant ones. The main result of the participatory process is the higher relevance of three main properties: the symbolism of place and its level of protection (target index), which affect the Hazard dimension of the risk, the level of accessibility (accessibility index) for the Vulnerability of the place, and the crowding level for the standard use of the space for the Exposure dimension (crowding index).

The testing phase of the mathematical algorithm on a wider set of case studies in Italy supported the validation of the tool, as well as its potentialities, both in testing possible mitigation strategies and in classifying real case studies as soft and hard targets. In fact, the determination of a formulation as a triad of determinant values allows us to control their variation as single factors and thus to understand the possible effectiveness of space transformation in terms of reduction in inherent vulnerabilities, increasing protection to reduce the likelihood of events, or increasing the users' protection when exposed to the threat.

Finally, the use of SoRs to translate the interferences and inter-relationships between square/street—as physical open areas—and the function of buildings facing these open and public places offer the opportunity to study the actual urban open area as a system of infrastructures, buildings, and uses. This is compliant with the recent studies on the phenomenon in Europe, where the proneness of public places and public buildings to violent actions influences perpetrator choice. In that sense, the physical delimitation of SoR/s within the uOA and their qualification in terms of risk can support the identification of major critical parts of uOAs where violent actions can be perpetrated. This provides the setup for coherent and efficient evacuation plans, going beyond the assessment of the pre-emergency phase toward the resolution of the emergency one, in accordance with the BE $S^2$ECURe project of which this study is part.

**Author Contributions:** Conceptualization, F.F. and E.C.; methodology, F.F. and E.C.; validation, E.Q. and F.F.; investigation, E.C.; resources, E.C.; data curation, E.C.; writing—original draft preparation, E.C.; writing—review and editing, F.F. and E.Q.; visualization, E.C.; supervision, E.Q. and F.F.; project administration, E.Q.; funding acquisition, E.Q. and F.F. All authors have read and agreed to the published version of the manuscript.

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**Data Availability Statement:** Data are contained within the article.

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**Conflicts of Interest:** The authors declare no conflicts of interest.

## Appendix A

**Table A1.** Details of the analyzed squares, considering the position and extension of the SoRs for Fb, Fd, and all physical elements within the place.

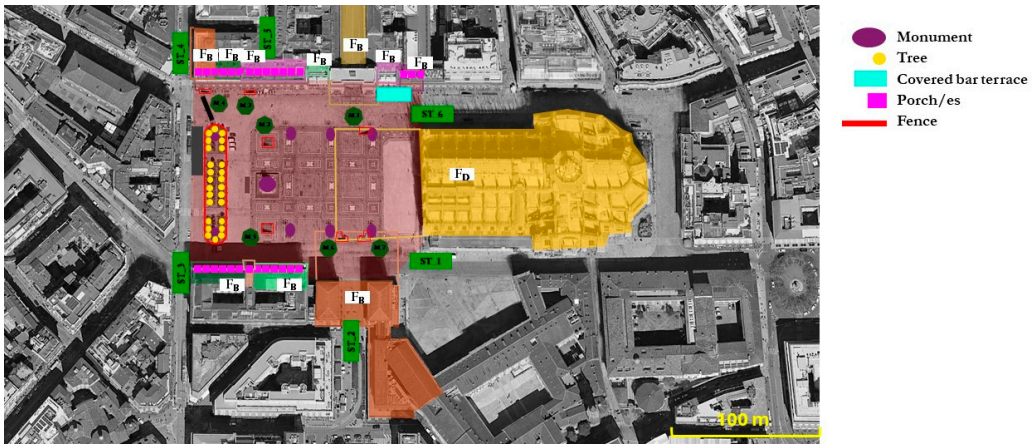
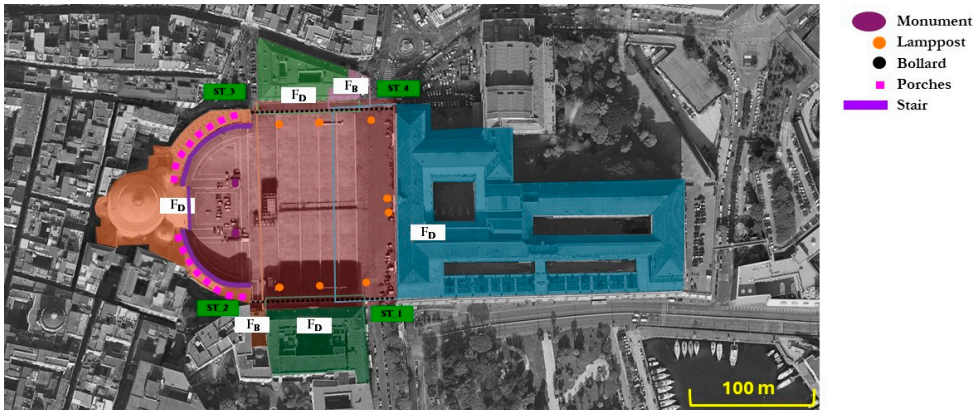
| Case Study | Coordinates |
|---|---|
| Milano—Piazza del Duomo | 45°27′51.34″ N, 9°11′22.41″ E |
|   | |
| Napoli—Piazza del Plebiscito | 40°50′8.97″ N, 14°14′54.90″ E |
|   | |

**Table A1.** *Cont.*

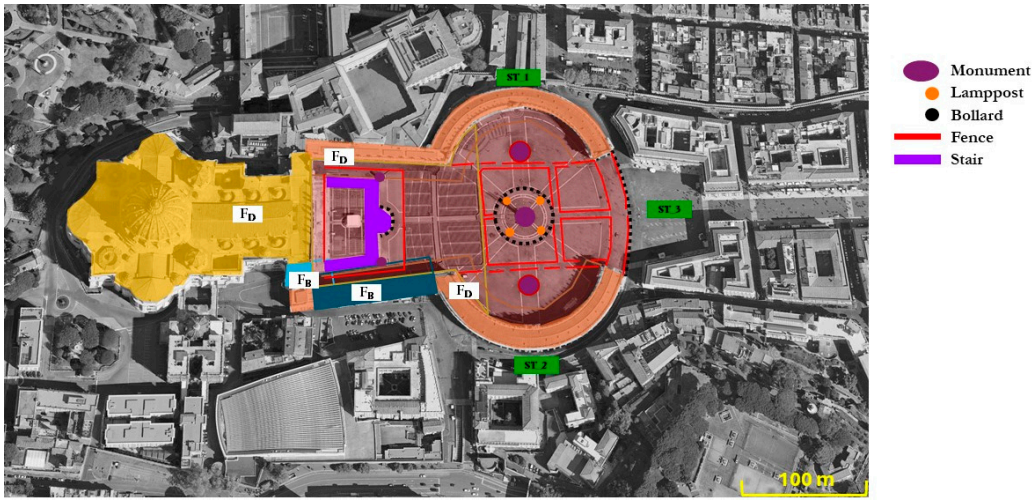
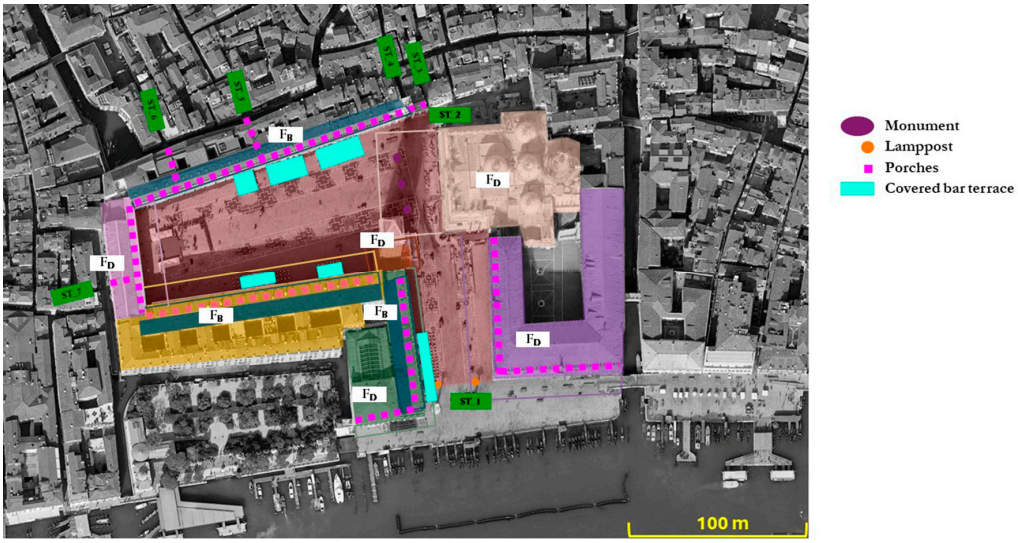
| Case Study | Coordinates |
|---|---|
| Roma—Piazza San Pietro | 41°54′8.01″ N, 12°27′25.78″ E |
|  | |
| Venezia—Piazza San Marco | 45°26′2.59″ N, 12°20′17.88″ E |
|  | |
| Corato (BA)—Piazza Sedile | 41° 9′7.94″ N, 16°24′44.00″ E |
|  | |

**Table A1.** *Cont.*

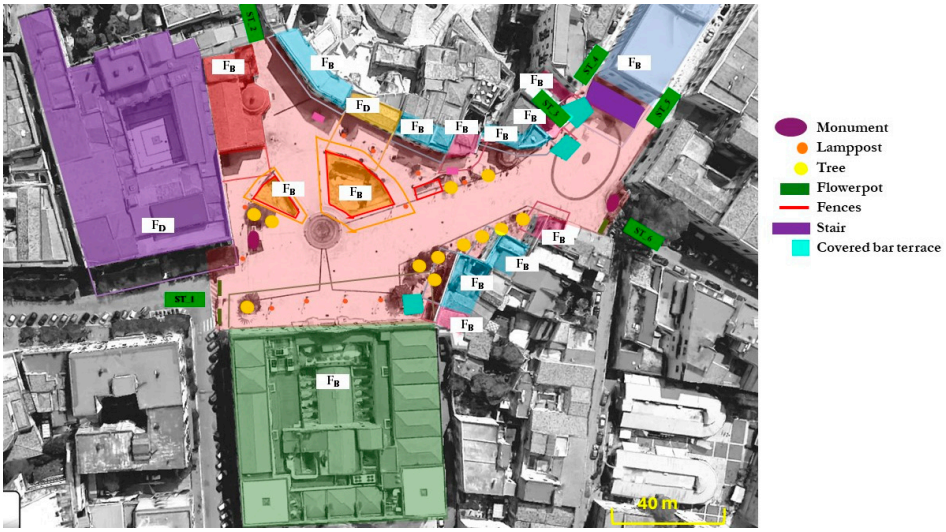
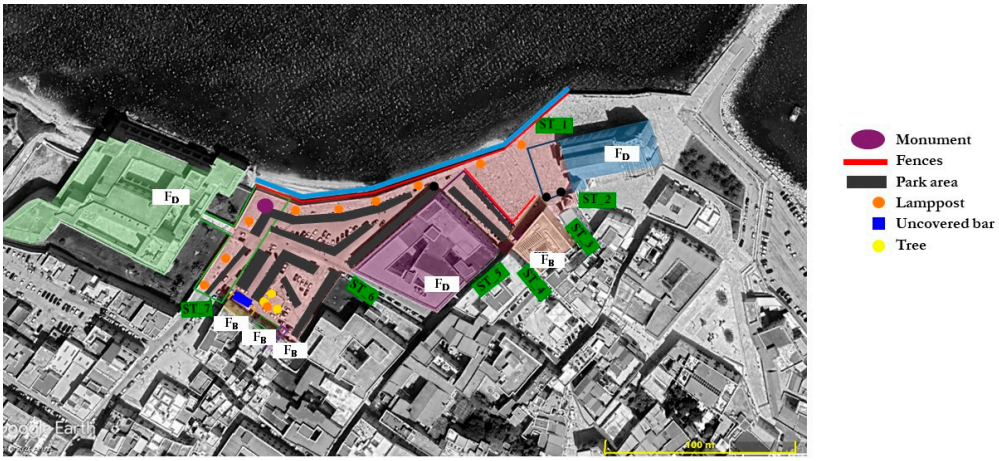
| Case Study | Coordinates |
|---|---|
| Matera—Piazza Vittorio Veneto | 40°40′1.19″ N, 16°36′22.86″ E |
|  | |
| Ostuni (BR)—Piazza della Libertà | 40°43′55.55″ N,17°34′41.72″ E |
|  | |
| Trani (BAT)—Piazza Duomo, Piazza Re Manfredi | 41°16′55.31″ N, 16°25′2.67″ E |
|  | |

**Table A1.** *Cont.*

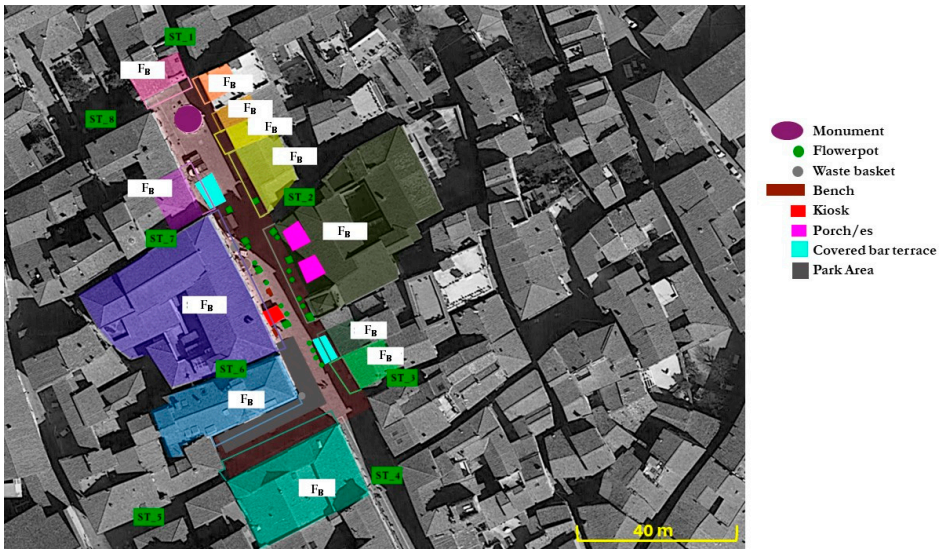
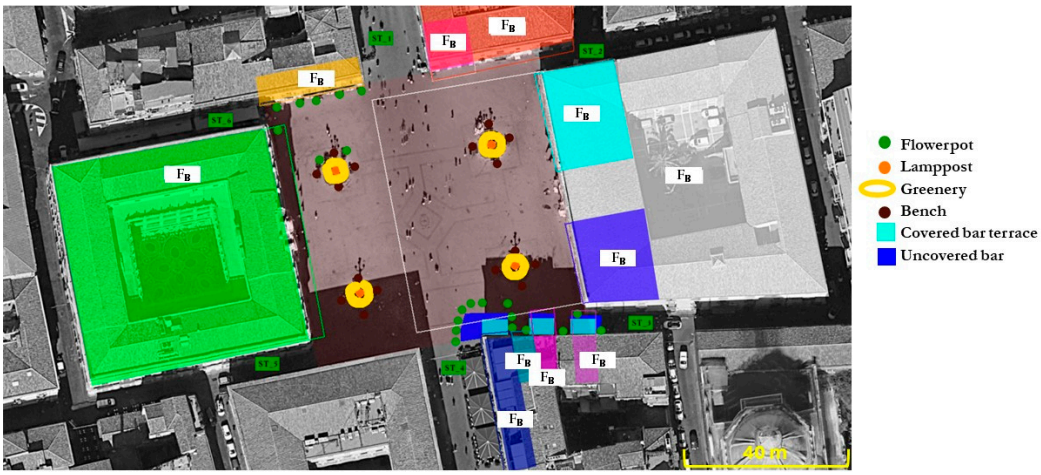
| Case Study | Coordinates |
|---|---|
| Narni (TR)—Piazza dei Priori | 42°31′10.31″ N, 12°30′55.51″ E |
|   | |
| Caldarola (MC)—Piazza Vittorio Emanuele II | 43° 8′17.22″ N, 13°13′34.04″ E |
|   | |
| Catania—Piazza Università | 37°30′13.08″ N, 15° 5′13.74″ E |
|   | |

**Table A1.** *Cont.*

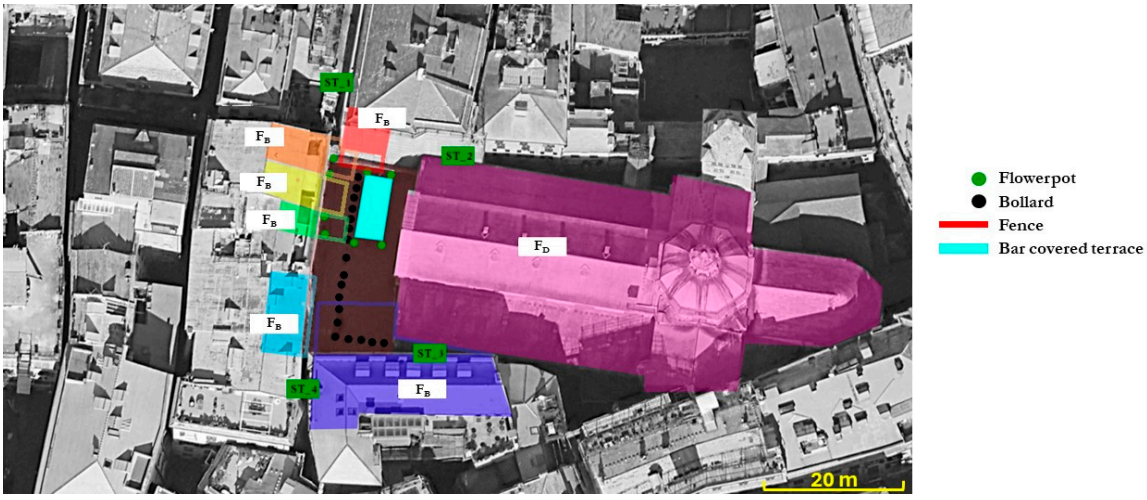
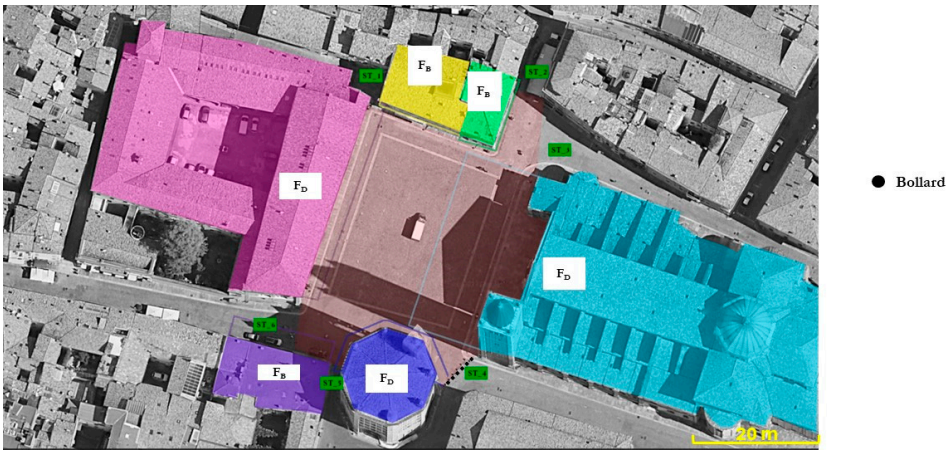
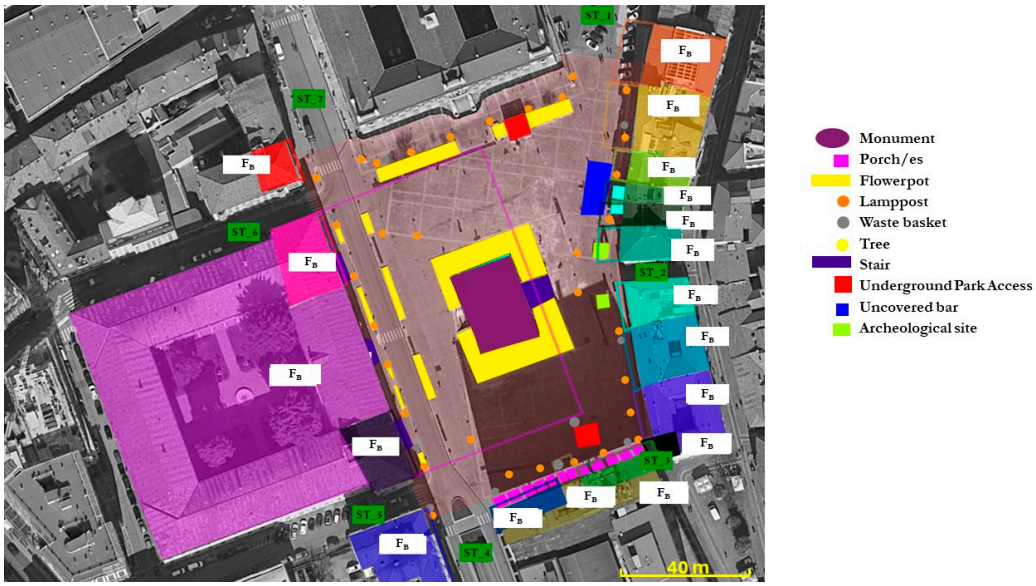
| Case Study | Coordinates |
| --- | --- |
| Genova—Piazza delle Vigne | 44°24′34.46″ N, 8°55′52.36″ E |
|  | |
| Parma—Piazza del Duomo | 44°48′12.69″ N, 10°19′49.65″ E |
|  | |
| Monza—Piazza Trento e Trieste | 45°35′1.32″ N, 9°16′24.57″ E |
|  | |

**Table A1.** *Cont.*

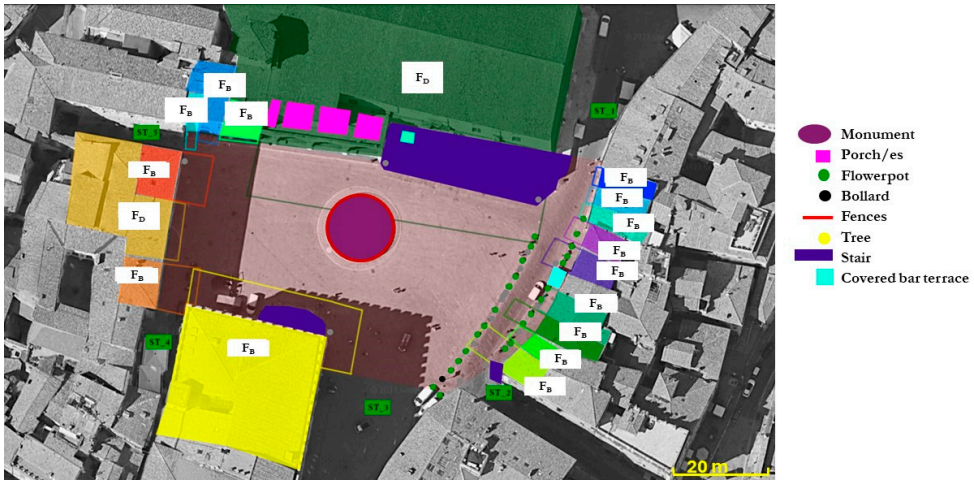
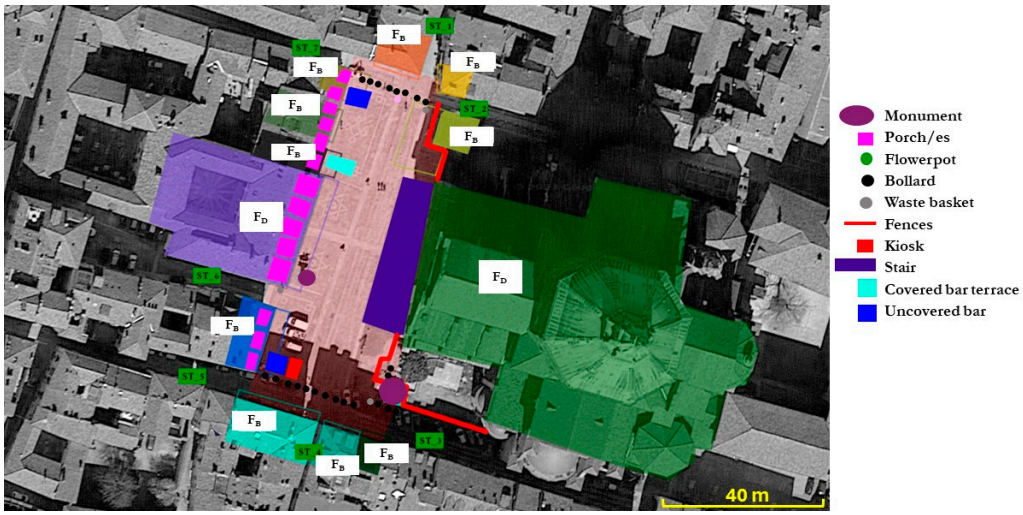
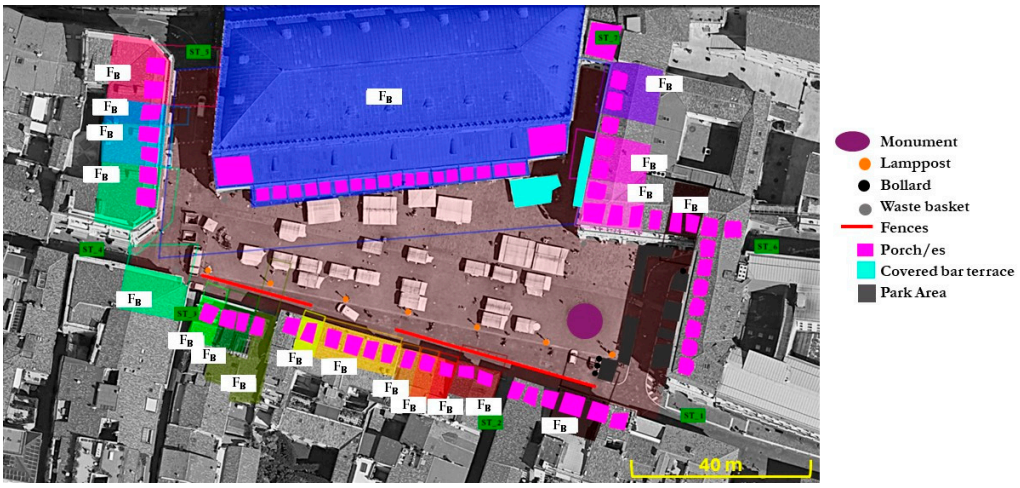
| Case Study | Coordinates |
| --- | --- |
| Perugia—Piazza IV Novembre | 43° 6′43.88″ N, 12°23′20.17″ E |
|  | |
| Pavia—Piazza del Duomo | 45°11′5.57″ N, 9°9′10.10″ E |
|  | |
| Padova—Piazza delle Erbe | 45°24′24.99″ N, 11°52′30.73″ E |
|  | |

**Table A1.** *Cont.*

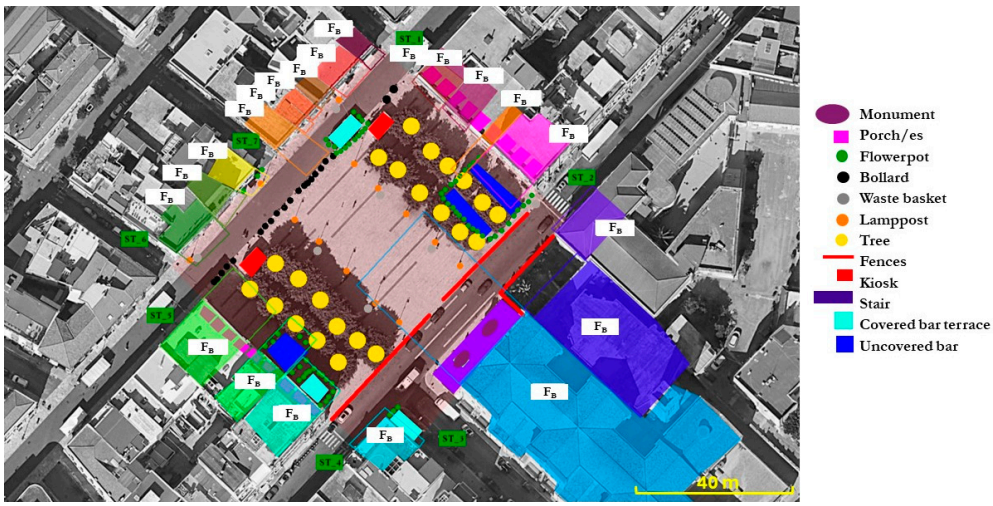
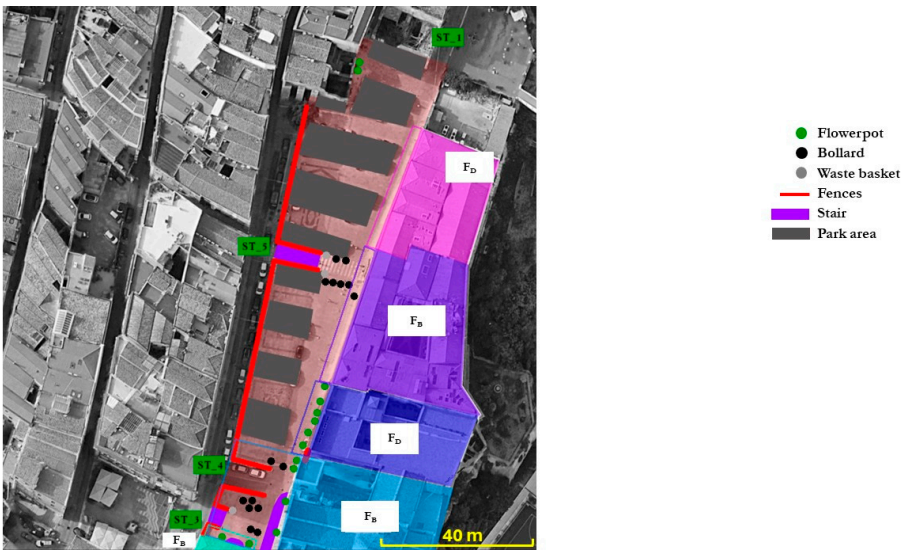
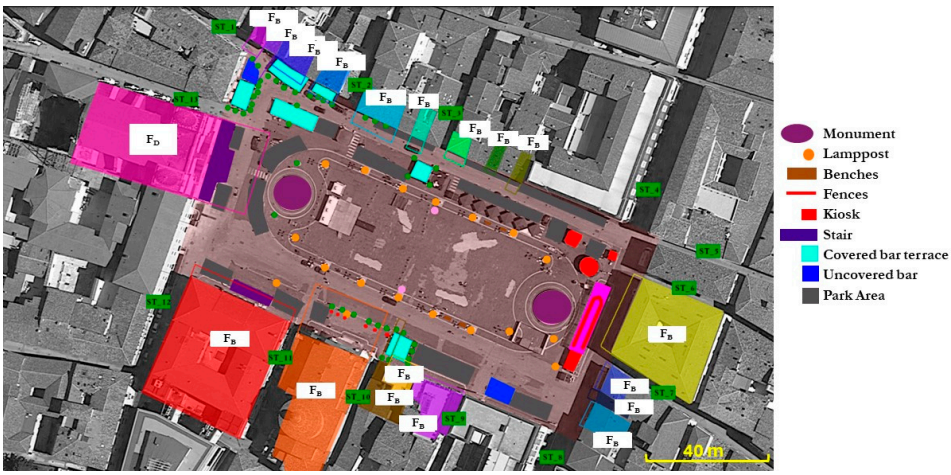
| Case Study | Coordinates |
|---|---|
| Reggio Calabria—Piazza Duomo | 38° 6′21.10″ N, 15°38′29.40″ E |
|  | |
| Cagliari—Piazza Palazzo | 39°13′9.91″ N, 9° 6′59.87″ E |
|  | |
| L′Aquila—Piazza Duomo | 42°20′56.38″ N, 13°23′53.27″ E |
|  | |

**Table A1.** *Cont.*

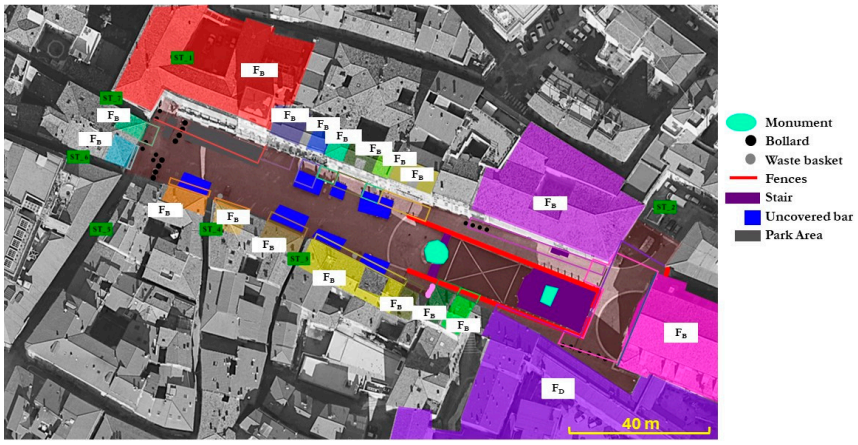
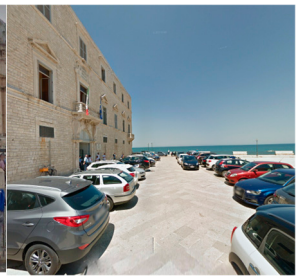
| Case Study | Coordinates |
|---|---|
| Ancona—Piazza del Plebiscito | 43°37′10.62″ N, 13°30′41.70″ E |
|   | |
| San Gemini (TR)—Piazza San Francesco | 42°36′47.88″ N, 12°32′46.47″ E |
|   | |

**Table A2.** Examples of obstacles in case studies classified according to classes introduced in Table 2. All images are extracted from Google maps spherical images.

| Icon | Examples and Locations | | |
|---|---|---|---|
| |  |  |  |
| | Lampposts, trees, and bollards in Piazza Duomo—Reggio Calabria | Lampposts in Piazza Duomo—L'Aquila | Lampposts in Piazza Trento e Trieste—Monza |

**Table A2.** *Cont.*

| Icon | Examples and Locations | | |
|---|---|---|---|
| |  |  |  |
| | Loggia in Piazza del Duomo—Pavia | Flowerpots in Piazza Sedile—Corato (BA) | Loggia around Piazza San Marco—Venezia |
| |  |  |  |
| | Equestrian Statue of Vittorio Emanuele II in Piazza Duomo-Milano | Covered bar terrace in Piazza dei Priori—Narni (TR) | Fountain in the center of Piazza IV Novembre—Perugia |
| |  |  |  |
| | Perimetral bollards in Piazza San Pietro—Roma | Park Areas in Piazza Duomo, Piazza Re Manfredi—Trani (BAT) | Dense bollards line in Piazza delle Vigne—Genova |
| |  |  |  |
| | Stairs within Piazza della Libertà—Ostuni (BR) | Stairs in front of the cathedral in Piazza del Plebiscito—Ancona | Stairs in front of Prefettura in Piazza Palazzo—Cagliari |

## References


1. Bonti, A.; Lijtenstein, C. Reflections on the destruction of memory. Operations towards the recovery of the voluntarily destroyed architecture between the XX and XXI centuries. *An. Investig. En Arquit.* **2020**, *10*, 95–117. [CrossRef]
2. Al-Azm, A. The Threat to Cultural Heritage in Times of Conflict and Its Dynamic Relationship with Gulf Society. In *Social Change in the Gulf Region: Multidisciplinary Perspectives*; Gulf Studies; Springer: Singapore, 2023; Volume 8, pp. 271–286. [CrossRef]
3. Nanninga, P. "Cleansing the Earth of the Stench of Shirk": The Islamic State's Violence as Acts of Purification. *J. Relig. Violence* **2019**, *7*, 128–157. [CrossRef]
4. Woo, G. Understanding the Principles of Terrorism Risk Modeling from Charlie Hebdo Attack in Paris. *Def. Against Terror. Rev.* **2015**, *7*, 33–46.
5. von Schorlemer, S. Fighting Terrorist Attacks against World Heritage–An Integrated Approach. In *50 Years World Heritage Convention: Shared Responsibility–Conflict & Reconciliation*; Springer International Publishing: Cham, Switzerland, 2022; pp. 201–213. [CrossRef]
6. Green Martínez, S. UNESCO Declaration Concerning the Intentional Destruction of Cultural Heritage (2003). In *Encyclopedia of Global Archaeology*; Springer International Publishing: Cham, Switzerland, 2018; pp. 1–6. [CrossRef]
7. UNESCO Declaration Concerning the Intentional Destruction of Cultural Heritage (Doc. 32 C/Res. 33). 2003. Available online: https://unesdoc.unesco.org/ark:/48223/pf0000133874#:~:text=For%20the%20purposes%20of%20this,humanity%20and%20dictates%20of%20public (accessed on 1 July 2024).
8. Council of Europe. *Council of Europe Convention on the Prevention of Terrorism*; Council of Europe Pub.: Strasbourg, France, 2005; ISBN 9287157626.
9. Kedziorek, A.; Jakubowski, A. The Role of the European Union in Combatting the Illicit Trafficking of Cultural Objects-Towards a New Action Plan. *Santander Art Cult. Law Rev.* **2021**, *7*, 13–20. [CrossRef]
10. Rosén, F. The Dark Side of Cultural Heritage Protection. *Int. J. Cult. Prop.* **2020**, *27*, 495–510. [CrossRef]
11. European Commission. *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Action Plan to Support the Protection of Public Spaces*; European Commission: Brussels, Belgium, 2017.
12. Quagliarini, E.; Fatiguso, F.; Lucesoli, M.; Bernardini, G.; Cantatore, E. Risk Reduction Strategies against Terrorist Acts in Urban Built Environments: Towards Sustainable and Human-Centred Challenges. *Sustainability* **2021**, *13*, 901. [CrossRef]
13. Ministère de l'Intérieur, Ministère de la Culture et de la Communication; Secrétariat Général de la Défense et de la Sécurité Nationale. *Gérer La Sureté et La Sécurité Des Événements et Sites Culturels*; 2017. Available online: https://www.culture.gouv.fr/Media/Actualites/Autres-dossiers/Plan-vigipirate/Gerer-la-surete-et-la-securite-des-evenements-et-sites-culturels (accessed on 1 July 2024).
14. Counter Terrorim Policing (UK) Action Counter Terrorism (ACT). Available online: https://act.campaign.gov.uk/ (accessed on 18 April 2020).
15. Coaffee, J.; O'Hare, P.; Hawkesworth, M. The Visibility of (in) Security: The Aesthetics of Planning Urban Defences against Terrorism. *Secur. Dialogue* **2009**, *40*, 489–511. [CrossRef]
16. Coaffee, J. *Beyond Concrete Barriers Innovation in Urban Furniture and Security in Public Space*; GCDN Commissioned Research, Ed.; Global Cultural Districts Network: London, UK, 2018.
17. Coaffee, J.; Bosher, L. Integrating Counter-Terrorist Resilience into Sustainability. *Proc. Inst. Civ. Eng. Des. Plan.* **2008**, *161*, 75–83. [CrossRef]
18. Cantatore, E.; Quagliarini, E.; Fatiguso, F. European Cities Prone to Terrorist Threats: Phenomenological Analysis of Historical Events towards Risk Matrices and an Early Parameterization of Urban Built Environment Outdoor Areas. *Sustainability* **2022**, *14*, 12301. [CrossRef]
19. Hunt, K.; Agarwal, P.; Zhuang, J. On the Adoption of New Technology to Enhance Counterterrorism Measures: An Attacker–Defender Game with Risk Preferences. *Reliab. Eng. Syst. Saf.* **2022**, *218*, 108151. [CrossRef]
20. Pressman, D.E.; Davis, N. Violent Extremism Risk Assessment and Screening Analysis: Applicability, Challenges, and New Developments. *J. Polic. Intell. Count. Terror.* **2022**, *17*, 301–313. [CrossRef]
21. Bridgelall, R. Using Artificial Intelligence to Derive a Public Transit Risk Index. *J. Public Transp.* **2022**, *24*, 100009. [CrossRef]
22. Hussin, S.; Alkaff, S.H.B.O. The Los Angeles Model in Deradicalisation. In *Terrorist Deradicalisation in Global Contexts: Success, Failure and Continuity*; Routledge: Abingdon, UK, 2019; pp. 197–208.
23. Höffler, K.; Meyer, M.; Möller, V. Risk Assessment—The Key to More Security? Factors, Tools, and Practices in Dealing with Extremist Individuals. *Eur. J. Crim. Policy Res.* **2022**, *28*, 269–295. [CrossRef]
24. Huang, J.; Zhang, X. Risk Assessment of Regional Violent Terrorist Attacks in Southern Xinjiang. *China Saf. Sci. J.* **2022**, *32*, 192–199.
25. Zhu, R.; Hu, X.; Li, X.; Ye, H. A Personalized and Practical Method for Analyzing the Risk of Chemical Terrorist Attacks. *IEEE Access* **2020**, *8*, 81711–81723. [CrossRef]
26. Mullerova, J.; Nemec, V. Risk Analysis of Chemical Hazard Affecting the Air Quality in Pezinok District. In Proceedings of the International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM, Albena, Bulgaria, 28 June–7 July 2019; Volume 19, pp. 273–278.

27. Liu, J.; Piegorsch, W.W.; Grant Schissler, A.; Cutter, S.L. Autologistic Models for Benchmark Risk or Vulnerability Assessment of Urban Terrorism Outcomes. *J. R. Stat. Soc. Ser. A Stat. Soc.* **2018**, *181*, 803–823. [CrossRef] [PubMed]
28. Fischer, K.; Hiermaier, S.; Riedel, W.; Häring, I. Morphology Dependent Assessment of Resilience for Urban Areas. *Sustainability* **2018**, *10*, 1800. [CrossRef]
29. Sitnikova, O.; Melnyk, A. Development of the Algorithm to Assess Vulnerability of Radiation Sources. *Nucl. Radiat. Saf.* **2022**, *1*, 71–76. [CrossRef]
30. Westbrook, T.; Schive, T. Urban Security and Counterterrorism: An Approach to Proportionality. *J. Strateg. Secur.* **2021**, *14*, 70–85. [CrossRef]
31. Moghaddam, A.; Afsharnia, M.; Peirovi Minaee, R. Preparing the Optimal Emergency Response Protocols by MOPSO for a Real-World Water Distribution Network. *Environ. Sci. Pollut. Res.* **2020**, *27*, 30625–30637. [CrossRef]
32. Garzia, F. New Security Risk Assessment and Genetic Algorithms Based Methods to Optimize Risk Reduction Countermeasures for Cultural Heritage Sites. *Int. J. Comput. Methods Exp. Meas.* **2023**, *11*, 45–54. [CrossRef]
33. Garzia, F. Novel risk assessment methodology for cultural heritage sites. In *Proceedings of the WIT Transactions on the Built Environment*; Hernández, S., Marseglia, G., Eds.; WIT Press: Southampton, UK, 2021; Volume 203, pp. PI149–PI160.
34. D'Amico, A.; Russo, M.; Bernabei, L.; Angelosanti, M.; Cantatore, E.; Bernardini, G.; Fatiguso, F.; Salvalai, G.; Mochi, G.; Quagliarini, E.; et al. A Survey Form for the Characterization of the Historical Built Environment Prone to Multi-Risks. *Riv. TEMA* **2022**, *8*, 77–88. [CrossRef]
35. Rosso, F.; Bernabei, L.; Bernardini, G.; Russo, M.; Angelosanti, M.; Currà, E.; Quagliarini, E.; Mochi, G. Urban Morphology Parameters towards Multi-Risk Scenarios for Squares in the Historical Centers: Analyses and Definition of Square Typologies and Application to the Italian Context. *J. Cult. Herit.* **2022**, *56*, 167–182. [CrossRef]
36. Poljanšek, K.; Casajus Valles, A.; Marin Ferrer, M.; De Jager, A.; Dottori, F.; Galbusera, L.; Garcia Puerta, B.; Giannopoulos, G.; Girgin, S.; Hernandez Ceballos, M. *Recommendations for National Risk Assessment for Disaster Risk Management in EU*; Publications Office of the European Union: Luxembourg, 2019.
37. The United Nations Office for Disaster Risk Reduction (UNISDR). *National Disaster Risk Assessment*; UNDRR: Geneva, Switzerland, 2017.
38. European Commission. *Risk Assessment and Mapping Guidelines for Disaster Management*; European Commission: Brussels, Belgium, 2010.
39. Monahan, J. The Individual Risk Assessment of Terrorism. *Psychol. Public Policy Law* **2012**, *18*, 167–205. [CrossRef]
40. Ruiz Estrada, M.A.; Koutronas, E. Terrorist Attack Assessment: Paris November 2015 and Brussels March 2016. *J. Policy Model.* **2016**, *38*, 553–571. [CrossRef]
41. Paton, D.; Violanti, J.M. Terrorism Stress Risk Assessment and Management. In *Psychology of Terrorism*; Bongar, B., Brown, L.M., Beutler, L.E., Breckenridge, J.N., Zimbardo, P.G., Eds.; Oxford University Press: New York, NY, USA, 2007; pp. 225–246.
42. Stewart, M.G. Terrorism Risks and Economic Assessment of Infrastructure Protection against Progressive Collapse. *J. Struct. Eng.* **2021**, *147*, 4021165. [CrossRef]
43. Crichton, D. The Risk Triangle. *Nat. Disaster Manag.* **1999**, *102*, 102–103.
44. Hagenlocher, M.; Thieken, A.; Schneiderbauer, S.; Ayerbe, I.A.; Dobes, P.; Donovan, A.; Morsut, C.; Paris, N.; Pedoth, L.; Tonmoy, F. Risk Assessment. In *Science for Disaster Risk Management 2020: Acting Today, Protecting Tomorrow*; Publications Office of the European Union: Luxembourg, 2020; pp. 54–65.
45. Saulnier, D.; Dixit, A.; Nunes, A.; Murray, V. Disaster Risk Factors–Hazards, Exposure and Vulnerability. In *WHO Guidance on Research Methods for Health Emergency and Disaster Risk Management*; World Health Organization: Geneva, Switzerland, 2021; pp. 151–163.
46. Arrighi, C.; Tanganelli, M.; Cristofaro, M.T.; Cardinali, V.; Marra, A.; Castelli, F.; De Stefano, M. Multi-Risk Assessment in a Historical City. *Nat. Hazards* **2023**, *119*, 1041–1072. [CrossRef]
47. Xofi, M.; Domingues, J.C.; Santos, P.P.; Pereira, S.; Oliveira, S.C.; Reis, E.; Zêzere, J.L.; Garcia, R.A.C.; Lourenço, P.B.; Ferreira, T.M. Exposure and Physical Vulnerability Indicators to Assess Seismic Risk in Urban Areas: A Step towards a Multi-Hazard Risk Analysis. *Geomat. Nat. Hazards Risk* **2022**, *13*, 1154–1177. [CrossRef]
48. Yang, Z.; Zhao, T.; Tian, Y.; Zhang, Y.; Chen, X. An Integrated Assessment of Tropical Cyclone Risks in Mainland China by Considering Hazard, Exposure, Vulnerability and Mitigation. *Hydrol. Res.* **2022**, *53*, 1090–1106. [CrossRef]
49. Yaofang, Z.; Jian, C.; Zhixuan, Q. Nonlinear Impact Analysis of Built Environment on Urban Road Traffic Safety Risk. *Syst. Sci. Control Eng.* **2023**, *11*, 2268121. [CrossRef]
50. Sakti, A.D.; Anggraini, T.S.; Ihsan, K.T.N.; Misra, P.; Trang, N.T.Q.; Pradhan, B.; Wenten, I.G.; Hadi, P.O.; Wikantika, K. Multi-Air Pollution Risk Assessment in Southeast Asia Region Using Integrated Remote Sensing and Socio-Economic Data Products. *Sci. Total Environ.* **2023**, *854*, 158825. [CrossRef] [PubMed]
51. Bernardini, G.; Quagliarini, E. Terrorist Acts and Pedestrians' Behaviours: First Insights on European Contexts for Evacuation Modelling. *Saf. Sci.* **2021**, *143*, 105405. [CrossRef]
52. Urlainis, A.; Ornai, D.; Levy, R.; Vilnay, O.; Shohet, I.M. Loss and Damage Assessment in Critical Infrastructures Due to Extreme Events. *Saf. Sci.* **2022**, *147*, 105587. [CrossRef]

53. Ornai, D.; Elkabets, S.M.; Kivity, Y.; Ben-Dor, G.; Chadad, L.; Gal, E.; Tavron, B.; Gilad, E.; Levy, R.; Shohet, I.M. A Methodology of Risk Assessment, Management, and Coping Actions for Nuclear Power Plant (NPP) Hit by High-Explosive Warheads. *Adv. Eng. Inform.* **2020**, *46*, 101192. [CrossRef]
54. Yao, X.; Wei, H.-H.; Shohet, I.M.; Skibniewski, M.J. Assessment of Terrorism Risk to Critical Infrastructures: The Case of a Power-Supply Substation. *Appl. Sci.* **2020**, *10*, 7162. [CrossRef]
55. Wulf, W.A.; Haimes, Y.Y.; Longstaff, T.A. Strategic Alternative Responses to Risks of Terrorism. *Risk Anal.* **2003**, *23*, 429–444. [CrossRef]
56. National Consortium for the Study of Terrorism and Responses to Terrorism (START) Global Terrorism Database (GTD). Available online: https://start.umd.edu/gtd/ (accessed on 1 July 2024).
57. Gordon, T.J. The Delphi Method. *Futur. Res. Methodol.* **1994**, *2*, 1–30.
58. Linstone, H.A.; Turoff, M. *The Delphi Method*; Addison-Wesley: Reading, MA, USA, 1975; ISBN 0201042940.
59. Lawshe, C.H. A Quantitative Approach to Content Validity. *Pers. Psychol.* **1975**, *28*, 563–575. [CrossRef]
60. Sadi, S.; Gholami, J.; Fereydooni, M.; Moshari, S. Development of Water Conservation Indicators for Office Buildings Using Delphi Method. *Jordan J. Mech. Ind. Eng.* **2022**, *16*, 247–259.
61. Kang-Hyun, P.; Dae-Sung, H.; PARK, H.A.E.Y.; Sung-Min, H.; Park, J.-H. Pilot Research for Development of Multi-Faceted Lifestyle Profile Components Affecting Health and Quality of Life: Delphi Survey. *Korean J. Occup. Ther.* **2019**, *27*, 105–120. [CrossRef]
62. Almathami, H.K.Y.; Win, K.T.; Vlahu-Gjorgievska, E. Development and Validation of a New Tool to Identify Factors That Influence Users' Motivation toward the Use of Teleconsultation Systems: A Modified Delphi Study. *Int. J. Med. Inform.* **2022**, *157*, 104618. [CrossRef] [PubMed]
63. Saaty, T.L. The Analytic Hierarchy Process: A New Approach to Deal with Fuzziness in Architecture. *Archit. Sci. Rev.* **1982**, *25*, 64–69. [CrossRef]
64. Cantatore, E.; Esposito, D.; Sonnessa, A. Mapping the Multi-Vulnerabilities of Outdoor Places to Enhance the Resilience of Historic Urban Districts: The Case of the Apulian Region Exposed to Slow and Rapid-Onset Disasters. *Sustainability* **2023**, *15*, 14248. [CrossRef]
65. li Piani, T. Progettazione Strutturale e Funzione Sociale Dello Spazio (Quale) Vulnerabilita e Soluzione Al Terrorismo Urbano. *Secur. Terror. Soc. (Sicurezza Terror. Soc.)* **2018**, *8*, 7–15.
66. Crenshaw, M. *Terrorism in Context*; Penn State Press: University Park, PA, USA, 2010; ISBN 027104442X.
67. Piazza, J.A. Rooted in Poverty?: Terrorism, Poor Economic Development, and Social Cleavages. *Terror. Polit. Violence* **2006**, *18*, 159–177. [CrossRef]
68. Crenshaw, M.; Pimlott, J. *Encyclopedia of World Terrorism*; Routledge: Abingdon, UK, 2019; ISBN 1315480352.
69. Albu, C.E. Tourism and Terrorism: A Worldwide Perspective. *CES Work. Pap.* **2016**, *8*, 1.
70. Drakos, K.; Kutan, A.M. Regional Effects of Terrorism on Tourism in Three Mediterranean Countries. *J. Confl. Resolut.* **2003**, *47*, 621–641. [CrossRef]
71. Enders, W.; Sandler, T. Causality between Transnational Terrorism and Tourism: The Case of Spain. *Stud. Confl. Terror.* **1991**, *14*, 49–58. [CrossRef]
72. Divizinyuk, M.; Kasatkina, N.; Melnyk, B. The Use of Electrical Monitoring and Surveillance Systems to Prevent Emergencies of a Terrorist Nature (on the Example of Motor Vehicles). In Proceedings of the 2019 IEEE 20th International Conference on Computational Problems of Electrical Engineering (CPEE), Lviv-Slavske, Ukraine, 15–18 September 2019; IEEE: Piscataway, NJ, USA, 2019; pp. 1–4.
73. Federal Emergency Management Agency. *FEMA 430: Site and Urban Design for Security: Guidance Against Potential Terrorist Attacks*; FEMA: Washington, DC, USA, 2007. Available online: https://www.fema.gov/sites/default/files/2020-08/fema430.pdf (accessed on 1 July 2024).
74. Federal Emergency Management Agency. *Reference Manual to Mitigate Potential Terrorist Attacks against Buildings (FEMA-426/BIPS-06)*, 2nd ed.; Buildings and Infrastructure Protection Series; FEMA: Washington, DC, USA, 2011.
75. National Countr Terrorism Security Office (NaCTSO); United Kingdom Home Office; Centre for the Protection of National Infrastructure. *Protecting Crowded Places: Design and Technical Issues*; Great Britain Home Office: London, UK, 2012. Available online: https://assets.publishing.service.gov.uk/media/5a78c6a740f0b62b22cbcb49/design-tech-issues.pdf (accessed on 1 July 2024).
76. Garcia, M.L. *Design and Evaluation of Physical Protection Systems*; Elsevier: Amsterdam, The Netherlands, 2007; ISBN 0080554288.
77. Álvarez, G.; Quiroz, M.; León, J.; Cienfuegos, R. Identification and Classification of Urban Micro-Vulnerabilities in Tsunami Evacuation Routes for the City of Iquique, Chile. *Nat. Hazards Earth Syst. Sci.* **2018**, *18*, 2027–2039. [CrossRef]
78. Federal Emergency Management Agency. *Evacuee Support Planning Guide*; FEMA P-760; FEMA: Washington, DC, USA, 2009.
79. Keykhaei, M.; Samany, N.N.; Jelokhani-Niaraki, M.; Zlatanova, S. A Situation-Aware Emergency Evacuation (SAEE) Model Using Multi-Agent-Based Simulation for Crisis Management after Earthquake Warning. *Geo-Spat. Inf. Sci.* **2023**, 1–24. [CrossRef]
80. Yang, Y.; Yin, J.; Wang, D.; Liu, Y.; Lu, Y.; Zhang, W.; Xu, S. ABM-Based Emergency Evacuation Modelling during Urban Pluvial Floods: A "7.20" Pluvial Flood Event Study in Zhengzhou, Henan Province. *Sci. China Earth Sci.* **2023**, *66*, 282–291. [CrossRef]

81. Cavalieri, F.; Franchin, P.; Giovinazzi, S. Multi-Hazard Assessment of Increased Flooding Hazard Due to Earthquake-Induced Damage to the Natural Drainage System. *Reliab. Eng. Syst. Saf.* **2023**, *237*, 109348. [CrossRef]
82. Quagliarini, E.; Bernardini, G.; D'Orazio, M. How Could Increasing Temperature Scenarios Alter the Risk of Terrorist Acts in Different Historical Squares? A Simulation-Based Approach in Typological Italian Squares. *Heritage* **2023**, *6*, 5151–5186. [CrossRef]