sustainability

MDPI

Article

Principles and Sustainable Perspectives in the Preservation of Earthen Architecture from the Past Societies of the Iberian Peninsula

Sergio Manzano-Fernández, Fernando Vegas López-Manzanares *, Camilla Mileto and Valentina Cristini

Centro de Investigación en Arquitectura, Patrimonio y Gestión para el Desarrollo Sostenible (PEGASO), Universitat Politècnica de València, 46022 Valencia, Spain; sermanfe@upv.es (S.M.-F.); cami2@cpa.upv.es (C.M.); vacri@cpa.upv.es (V.C.)

* Correspondence: fvegas@cpa.upv.es

Abstract: In recent years, special attention has been paid to the lessons in sustainability offered by traditional and vernacular architecture, especially with regards to the promotion of both material and technical production in earthen construction. However, these systems were already widely found in past societies, whose legacy in terms of construction is presented through the complex cultural framework of archaeological sites, which require highly variable work that lacks professional consensus, usually transcending the adaptive and sustainable nature originally observed. This dual nature aids the social operation of these scenarios and can prematurely hinder earthen construction's life cycle and didactic quality, cementing its status as a necessary reflection for the identification and prevention of future problems. In terms of sustainability, the aim of this study is to analyze the spectrum of architectural interventions used for the preservation of earthen structures in archaeological sites in the Iberian Peninsula, in natural, social, and economic terms, while examining their capacity to adapt in the face of adverse phenomena. For this reason, following bibliographical review and fieldwork collection, a database was established combining a series of architectural characteristics and a history of interventions in 85 selected archaeological sites conserved in situ. Following reflection on these sites, maps were drawn up to show the geographical scope of these principles and offer a general overview of perspectives, highlighting the aspects deserving of varying levels of attention, as well as proposing strategies for sustainable preservation which will allow its transmission over time for the scientific and cultural enjoyment of coming generations.

Keywords: sustainability; traditional construction; archaeological sites; conservation; intervention; environment; culture; local materials; earthen construction; management

Citation: Manzano-Fernández, S.; Vegas López-Manzanares, F.; Mileto, C.; Cristini, V. Principles and Sustainable Perspectives in the Preservation of Earthen Architecture from the Past Societies of the Iberian Peninsula. *Sustainability* **2024**, *16*, 5172. https://doi.org/10.3390/su16125172

Academic Editor: Young-joo Ahn

Received: 21 May 2024
Revised: 13 June 2024
Accepted: 16 June 2024
Published: 18 June 2024

1. Introduction

In recent years, much thought has been given to the sustainable framework of architecture and heritage, prompted by different threats at both European and global levels. From the first increased efforts for safeguarding as established in objective 11.4 of the 2030 Agenda [1], to the clear desire for increased energy savings and reduced CO_2 emissions in response to climate change, a wide range of fields is affected. The search for climate neutrality is clearly set out in the strategic priorities of the European Union [2], with the energy cost of construction accounting for 40% of the approximate total generated in the EU and the waste from construction, especially extraction and transformation processes, accounting for 25% to 30% [3–6]. Against this backdrop, some of the current efforts to shed light on the search for solutions in architectural heritage in order to extract positive contributions include [7]: the use of comparative cycles considering the full life cycle [8] of traditional and modern execution [9] and the return to the use of local materials, such as earth, for construction and introducing these strategies into contemporary society.

However, the wide range of case studies in the field of heritage results in a series of special conditions linked to sustainability that are not always in line with saving energy, as their functionality is dependent on cultural or exhibition use (as seen in examples of isolated defensive architectures or archaeological remains). This awards equal importance to the life cycle and footprint of the modern material interventions carried out within them [10], as well as on the perspectives highlighting the cultural, economic and environmental contributions of their constructive characteristics [11]. This importance has been reflected in Europe-wide promotional events such as the European Heritage Day in 2022 and 2023 [12,13], which promoted local values and identities.

Although these concerns were not studied in past societies, thanks to archaeological sites, constructive methodologies reveal principles which are very much in keeping with the new holistic model of cities dependent on their surroundings and the exchange of energy [14], as seen until the time of preindustrial communities [15]. Among these, it is worth noting earthen architecture, with earth being one of the materials most widely used throughout the world despite the challenges of conservation which arise once original protections are lost, based on the execution process and characteristics. The ease of sourcing and transforming the material attracted growing international interest [16], including plans drawn up by organizations such as UNESCO [17] and ICOMOS-ISCEAH for dissemination and protection. Increased efforts were also made in the detailed characterization of its major traditional families—mixed techniques, cob, adobe, and rammed earth [18]—their multiple subvariants [19,20] and their possible conservation [21,22].

Perspectives linked to this type of structure include a respect for nature (given its complete lack of pollution; limited transformation; transfer; high availability; use of soil; bioclimatic factors; and geographical morphology) [23], as well as the reuse of foundations or lower levels for the architectural executions from later occupation [24]. There is also a cultural richness to the techniques used, such as constructive legacies perfected over time and in local spaces that blend into the surroundings, and resolves different needs with the ability to unite communities and create specific idiosyncrasies and characteristic identities. Thus, this study can provide valuable information on the mitigations of climate change, as well as understanding the dynamics of the collapse and the recovery of societies and ecosystems in the past after experiencing their different contextual crises [25]. These and other principles have been compiled and organized as lessons on vernacular heritage in the field of environmental, sociocultural, and socioeconomic sustainability through projects such as VerSus: Lessons from Vernacular Heritage in Sustainable Architecture [26,27], which was recently cofunded by the European Union between 2012 and 2014, with a total of 15 parameters for the analysis of different case studies and the proposal of guidelines for their optimization. The solid results of this project guaranteed its prolongation between 2019 and 2023 in the form of VerSus+: Heritage for People [28,29], applying similar methodologies to create tools for the cultural transmission of values inherent to vernacular architecture, where the specific case of archaeology is less explored.

Although these remains are not frequently seen as a source of inspiration for the architecture of the future, reflecting on the conserved panorama of this type of heritage leads to two-fold conclusions: the study of indicators for case studies and the degree of compliance with sustainability in its current state of transformation, examining the completed actions and their engagement with the environment, culture, and economy. Due to the specificities of use, these modern social challenges make no reference to characteristic aspects of heritage intended for habitation, such as energy efficiency and optimization, but to the carbon footprint of its life cycle, conservation work and enhancement.

Within the Iberian Peninsula, very small-scale examinations are currently being carried out on this, usually linked to the sustainability principles of conservation charters, including minimal intervention and material authenticity, as well as local participation in excavation and conservation work, the use of adjoining material [30], the cultural transmission of characteristics [31], and the tourist approach to its use [32], without specifically addressing earthen architecture and focusing instead on specific case studies.

However, as these constructive techniques have mostly been defended for their value within the field of archaeology in the Iberian Peninsula [33,34], their study focuses mostly on the characterization [35,36], excavation, scope, and cultural position within the different societies [37], as well as on the search for guidelines for conservation [38]. Broadly speaking, this heritage has barely been documented and valorized, especially in the case of more fragile typologies such as domestic, productive, and funerary archaeological heritage compared to monumental and defensive heritage. Thus, severely compromising analysis on a territorial scale given the lower number of case studies.

This study aims to address this scope, as part of a research endeavor dedicated to globally analyzing the natural [39], social and anthropic risks [40] associated with this type of architecture and context within the Iberian Peninsula (Figure 1), using basic documentation resulting from bibliographical review and in situ data collection. Statistical management from the sustainable viewpoint of its characteristics for intervention, constructive systems, and integration into natural surroundings, as well as the cultural promotion of the urban context, reflects a series of independent considerations which highlight whether or not new perspectives are needed when addressing and overcoming this type of challenge.

Figure 1. Partially collapsed rammed earth walls under contemporary protective cover at the archaeological site of Medina Siyasa (Cieza, Murcia).

2. Materials and Methods

The aim of this study is to show the level of adaptation to the contemporary criteria of sustainability of the earthen archaeological heritage conserved in situ in the Iberian Peninsula, thanks to the cross-referencing of data using tools for the sustainable analysis of heritage developed in the last few years, and combined with a database featuring the case studies identified in the Peninsula through bibliographical review and documented through fieldwork completed in 2022 and 2023 [39]. This process is expected to include reflection on whether all the qualitative arguments are applicable to the archaeological case studies, as well as providing an examination of the difficulty of incorporating different theories, concepts, and data on environmental and social change as mentioned earlier [41].

2.1. Tools for the Assessment and Analysis of Sustainable Principles and Perspectives in Archaeological Heritage

Qualitative and quantitative approaches in the sustainable analysis of heritage have been explored in recent years, particularly in terms of the environment and climate change based on the definitions of vulnerability and adaptive capacity [42–44], although the social and economic aspects are mostly addressed through qualitative analysis [24,45–47]. In this context, one of the methodological tools which best sums up the environmental, sociocultural and socioeconomic dimension of architectural heritage is the 15-indicator wheel created during the VerSus project [26], which is used as a starting point for this research (Figure 2). This diagram lists 5 sustainable principles for each dimension, including respect for nature; suitable location; reduction of pollution and waste materials; contribution to health; reduction of natural hazard effects; protection of cultural landscape; transfer of constructive cultures; enhancement of creativity; recognition of intangible values; promotion of social cohesion; support for autonomy; promotion of local activities; optimization of construction efforts; extension of the building's life; and saving resources. These qualitative criteria are supported quantitatively in aspects such as the carbon footprint of their life cycle [9].

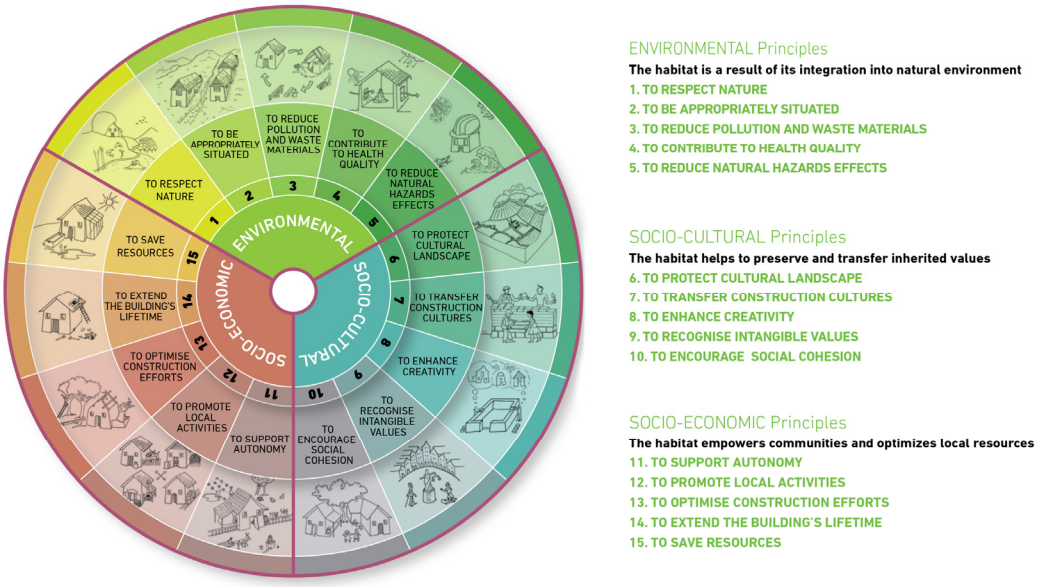


Figure 2. Sustainable principles identified in the VerSus project for vernacular heritage, addressing the environmental, sociocultural, and socioeconomic dimensions. Source: https://esg.pt/versus/pdf/versus_booklet.pdf (accessed on 26 April 2024).

However, several indicators are not applicable to earthen archaeological case studies and can be reoriented or ruled out depending on their usefulness in the analysis. Thus, there are two major characteristics which invalidate them: on the one hand, the lack of residential function, preventing an examination of the use of the bioclimate, as well as of the quality of life or reduction of natural threats; and on the other, the impossibility of self-management, which cannot be applied to self-sufficiency of the community or the promotion of autonomy, as detailed projects and plans with extreme sensitivity to the conservation are required.

Factors which could be conceptually adapted are the favoring of creativity, which is the intervention criterion for the maintenance of traditional construction, although limited flexibility means that this factor is relegated to decisions on interventions, particularly with regards to shelter; and social cohesion, as its contribution to facilitating coexistence between neighbors is limited to the monumental and cultural recognition of the remains or the dynamization of the municipality through valorization.

2.2. Description of Case Studies

The database was established following the selection of case studies from archaeological sites featuring earthen structures conserved in situ in the Iberian Peninsula (Figure 3). This selection was based on the exhaustive use of bibliographical national indirect sources: the Archive of the Spanish Cultural Heritage Institute (IPCE), Excavaciones Arqueológicas de España (EAE), and Noticiario Arqueológico Hispánico (NAH); as well as regional collections: the Museo de Prehistoria de Valencia (MUPREVA), Anuario Arqueológico de Andalucía (AAA); repositories: the Calaix (GENCAT) and Museo Arqueológico de Alicante (MARQ); and other publications and reports from archaeological excavations.

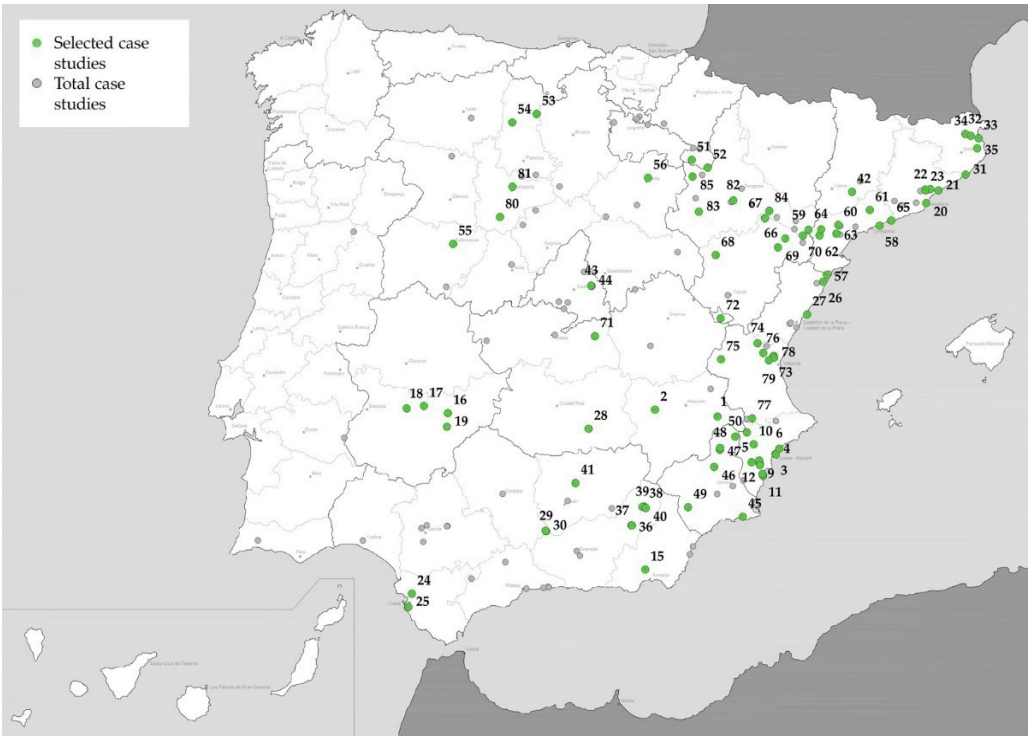


Figure 3. Distribution of total and selected case studies for the sustainability analysis in the Iberian Peninsula, characterized by the presence of earthen architectural structures.

The characteristics of these cases correspond to the most fragile typologies which are those least valued by society, that is, domestic, productive, and funerary, while excluding defensive and monumental typologies which tend to enjoy better intervention and valorization conditions. Equally, these structures mostly date from protohistory and the Roman era, with some incorporations from prehistory and the Middle Ages, which expand the spectrum of earthen constructive solutions and guarantee the representation of the four major families currently identified.

Based on these criteria, an initial preselection of 170 case studies was made, finally choosing 85 archaeological sites considered to be of greater interest. The absence of case studies with these characteristics conserved in situ in Portugal, although studied recently with growing interest [48], has led to a definitive sample being established for the Spanish territory.

Data were collected on all these case studies, considering the current characteristics of conservation, intervention and musealization, as well as strategies to mitigate natural effects and human threats which could speed up their disappearance. These factors mainly include different conservation strategies (Table 1), the material and transformation processes involved, as well as valorization efforts and, occasionally, the urban situation.

Table 1. Selected case studies and interventions on earthen structures.

Archaeological Site	Non-Intervention	Backfilling	Maintenance/ Drainage	Capping	Encapsulation (Compatible)	Encapsulation (Incompatible)	Consolidation (Compatible)	Consolidation (Incompatible)	Chemical Treatment	Restoration	In Situ Reconstruction (Compatible)	In Situ Reconstruction (Incompatible)	Ex Situ Reconstruction (Compatible)	Ex Situ Reconstruction (Incompatible)	Sheltering (Temp., Perm., Partial, Total)	Container Building	Relocation
1. El Amarejo												✓					
2. Libisosa		✓	✓				✓								✓	✓	
3. Tossa de les Basses	✓																
4. Tossal de Manises			✓			✓						✓					
5. Peña Negra												✓					
6. Illeta dels Banyets			✓			✓						✓					
7. El Arsenal		✓															
8. Caramoro I		✓															
9. La Alcudia		✓				✓						✓	✓		✓		
10. El Monastil			✓				✓					✓			✓		
11. La Fonteta		✓	✓			✓						✓					
12. Rábita Califal			✓												✓		
13. El Oral		✓													✓		
14. Cabezo redondo						✓									✓		
15. Los Millares													✓				
16. La Mata		✓	✓							✓	✓				✓		
17. Casas del Turuñuelo							✓								✓		
18. Casa del Mitreo															✓✓		
19. Cancho Roano			✓				✓				✓				✓		
20. Domus Avinyó			✓				✓		✓							✓	
21. Ca L'Arnau y Can Rodón															✓		
22. Turó d'en Roïna/Can Taco			✓												✓✓		
23. Horno Camp d'en Ventura de l'Oller																✓	
24. Doña Blanca			✓												✓		
25. Horno de la Torrealta y Camposoto			✓													✓	
26. Puig de la Nau											✓						
27. Orpesa la Vella		✓															
28. Cerro de las cabezas			✓		✓		✓			✓	✓		✓				
29. Cerro de la Cruz		✓	✓				✓						✓		✓		
30. Horno El Ruedo			✓												✓		✓
31. Turó Rodó											✓						
32. Mas Castellar	✓	✓					✓										
33. Ampurias			✓							✓					✓		
34. Horno Clos Miquel			✓													✓	
35. Illa d'en Reixac															✓		
36. Cerro Santuario/Basti		✓															
37. Cerro Cepero/Basti		✓													✓		
38. Necrópolis de Túrugi					✓					✓					✓		
39. Castellón Alto			✓						✓			✓					
40. Cerro de la Virgen															✓		
41. Cástulo										✓					✓		
42. Vilars d'Arbeca					✓							✓					
43. Casa de los grifos			✓							✓						✓	
44. Casa de Hippolytus			✓						✓							✓	
45. El Molinete			✓			✓			✓						✓		
46. Medina Siyasa												✓			✓		
47. Coimbra del barranco ancho		✓										✓					
48. Villa de Los Cipreses	✓																
49. Cortijo del centeno			✓								✓				✓		
50. Villa de Los Torrejones															✓		
51. Villa Romana Piecordero I						✓									✓		
52. Alto de la Cruz		✓															
53. Horno La Jericó																✓	
54. Villa romana La Olmeda			✓				✓									✓	
55. Cerro de San Vicente																✓	

Table 1. *Cont.*

Archaeological Site	Non-Intervention	Backfilling	Maintenance/ Drainage	Capping	Encapsulation (Compatible)	Encapsulation (Incompatible)	Consolidation (Compatible)	Consolidation (Incompatible)	Chemical Treatment	Restoration	In Situ Reconstruction (Compatible)	In Situ Reconstruction (Incompatible)	Ex Situ Reconstruction (Compatible)	Ex Situ Reconstruction (Incompatible)	Sheltering (Temp., Perm., Partial, Total)	Container Building	Relocation
56. Numancia											✓						
57. Moleta del Remei													✓				
58. Villa romana Els Munts			✓				✓								✓		
59. Tossal del Moro	✓																
60. Calvari el Molar						✓											
61. Horno de Fontscaldes										✓						✓	
62. Coll del Moro		✓		✓		✓	✓										✓
63. Castellet de Banyoles	✓																
64. Turó del Calvari			✓	✓					✓								
65. Ciutat Ibèrica de Calafell											✓				✓		
66. El Palao		✓										✓					
67. Cabezo de Alcalá		✓															
68. La Caridad					✓						✓				✓✓		
69. Hornos Mas de Moreno															✓		
70. San Cristóbal	✓	✓															
71. Plaza de los moros						✓				✓	✓		✓		✓		
72. La Celadilla			✓												✓		
73. Alquería de Bofilla												✓					
74. Castellet de Bernabé	✓										✓						
75. Los Villares/Kelin												✓					
76. Tossal de Sant Miquel									✓								
77. Bastida de les Alcusses													✓				
78. Tos Pelat	✓					✓											
79. Lloma de Betxí			✓												✓		
80. Cerro de La Mota			✓													✓	
81. Soto de Medinilla		✓															
82. Contrebia Belaisca			✓								✓				✓		
83. Bílbilis				✓											✓✓		
84. Lépida Celsa						✓	✓								✓✓✓		
85. La Oruña															✓		
Total (n)	8	19	29	3	4	12	12	0	6	8	12	14	7	0	43	12	2
Total (%)	9%	22%	34%	4%	5%	14%	14%	0%	7%	9%	14%	16%	8%	0%	51%	14%	2%

Cases may present more than one strategy, and more than one shelter system (temporary low or medium impact, permanent-partial, permanent-total), each of them being represented by an ✓.

The usual intervention strategies for earthen archaeology [21,39,49] include a deliberate decision against taking action on remains found, recognized as non-intervention; the replacement of earth removed for excavation and returned to the ground, as re-burial; actions intended to prolong the life cycle of elements preventively, as maintenance and preventive conservation; the protection of upper sections with protection shelters, which are usually more resistant, as sheltering; the execution of sacrificial layers across the entire exposed area using compatible or incompatible materials, as encapsulation; the actions which aim to resolve existing functional or slight structural damage with compatible or incompatible materials, as consolidation; material reinforcement through the application of different organic, inorganic, or organic siliceous compounds, as chemical treatment; the repairs and compatible reintegrations of the volumetry, as restoration; the partial or total execution of structures, with or without compatible materials, directly on the remains (in situ) or in immediate or remote surroundings (ex situ), as reconstruction; the execution of temporary or permanent protection structures with no direct connection to the remains, as sheltering; the construction of complete protections, such as a newly constructed building which confines them, resulting in container buildings; and the physical move of remains to settings offering greater control or protection, as relocation. When different systems from

the same strategy have been observed within the same archaeological enclave, the most unfavorable may be considered for analysis purposes.

In addition, the material is considered as compatible with the original when employing analogous materials or, failing this, materials which have shown compatible rigidity, breathability and behavior, such as earth and lime [20]; as different from the original when incorporating techniques executed using external materials or introducing contemporary forms of protection; and as incompatible with the original when using materials that have been shown to alter the original systems due to undesired waterproofing and rigidity (as is the case of Portland cement) or excessive loads (such as concrete) [20]. These situations can occur independently or in combination.

Finally, the circumstances surrounding valorization have been collected based on accessibility and adaptation to the development of visits following carefully considered and defined routes, both for pedestrians and traffic, as well as on the quality of dissemination in the field of earthen architecture through different tools [40] implemented for signage and dissemination.

Eventually, the urban situation can be relied upon to complement certain principles as it records the characteristics of the context where the structures are found, distinguishing between those with a clearly defined isolation from the population structure: those usually found in natural settings; those found in non-built urban settings; and those in built-up areas.

This information is managed in GIS for statistical examination and the discrimination of themed blocks of interest analytically and visually showing the recurrence of different case studies through heatmaps. Thus, the heatmaps for adaptation to the different dimensions of sustainability show the geographical scope of cases using QGIS 3.10 software in a 70 km radius.

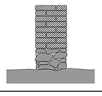
2.3. Cross-Referencing of Information, Decisions and Criteria

After defining the sustainable principles and determining factors obtained from the bibliography reviews and data collection, it is necessary to discuss and establish the criteria governing whether adaptation to indicators is required after cross-referencing both aspects. This calls for careful consideration of these characteristics, establishing the basis for arguments which can define the significance of this earthen heritage. In this regard, certain strategies related to the contribution of material should be observed independently based on their compatibility or lack thereof with preexistence, in the same way that the wide spectrum of possible protections and coverings can yield highly variable impact results in the context, both in terms of material or magnitude issues and habitat modification.

2.3.1. Material Aspect

The material aspect is an indispensable factor for contributing to the reduction of the carbon footprint resulting from extraction and transformation for the purposes of conservation and protection [9]. This criterion has thus been considered applicable to nature and the reduction of pollution in the environmental setting, with the lack of cost in obtaining, transforming and moving earth-based materials being seen as a positive unlike industrial ones such as cement or concrete [8,50,51]; in the transmission of constructive techniques and intangible values in the social aspect, given their representation in the communal architectural legacy which identifies the territory; and in the saving of resources in the field of economy, as these earthen contributions are usually the result of small interventions while modern ones are associated with large and medium-sized sheltering. Equally, reconstruction tasks may or may not be seen as positive if local materials are used. This does not apply to ex situ work carried out independently from the remains. In general, their impact will be positive in promoting the municipality and adding dynamism to local activity, but will be damaging in cases of incompatibility, for almost all the principles relating to the three dimensions of sustainability (Table 2).

Table 2. Compliance (✓), non-compliance (×), or not applicable (-) criteria with environmental, sociocultural, and socioeconomic sustainability factors for the different intervention strategies.

Intervention		Environmental					Socio-Cultural						Socio-Economic			
Identification	**Visual Identification**	**To Respect Nature**	**To Be Appropriately Situated**	**To Reduce Pollution**	**To Contribute to Health Quality**	**To Reduce Natural Hazard Effects**	**To Protect Cultural Landscape**	**To Transfer Construction Cultures**	**To Enhance Creativity**	**To Recognize Intangible Values**	**To Encourage Social Cohesion**	**To Support Autonomy**	**To Promote Local Activities**	**To Optimize Construction Efforts**	**To Extend Building's Lifetime**	**To Save Resources**
Non-intervention		✓	-	✓	-	-	✓	✓	×	✓	-	-	×	-	×	✓
Backfilling		✓	-	✓	-	-	×	×	×	×	-	-	×	-	✓	✓
Maintenance/Drainage		✓	-	✓	-	-	✓	✓	×	✓	-	-	✓	-	✓	✓
Capping		✓	-	×	-	-	✓	✓	✓	✓	-	-	✓	-	✓	✓
Encapsulation (compatible)		✓	-	✓	-	-	✓	✓	×	×	-	-	✓	-	✓	✓
Encapsulation (incompatible)		×	-	×	-	-	✓	×	×	×	-	-	✓	-	×	×
Consolidation (compatible)		✓	-	✓	-	-	✓	✓	×	✓	-	-	✓	-	✓	✓
Consolidation (incompatible)		×	-	×	-	-	✓	×	×	×	-	-	✓	-	×	×
Chemical treatment		×	-	×	-	-	✓	✓	×	✓	-	-	✓	-	✓	×
Restoration		✓	-	✓	-	-	✓	✓	×	✓	-	-	✓	-	✓	✓
In situ reconstruction (compatible)		✓	-	✓	-	-	✓	✓	×	✓	-	-	✓	-	✓	✓
In situ reconstruction (incompatible)		×	-	×	-	-	×	×	×	×	-	-	✓	-	×	×
Ex situ reconstruction (compatible)		✓	-	✓	-	-	✓	✓	×	✓	-	-	✓	-	×	✓
Ex situ reconstruction (incompatible)		×	-	×	-	-	×	×	×	×	-	-	✓	-	×	×
Sheltering		×	-	×	-	-	×	✓	✓	✓	-	-	✓	-	✓	×
Container building		×	-	×	-	-	×	✓	×	✓	-	-	✓	-	✓	×
Relocation		✓	-	✓	-	-	×	✓	×	✓	-	-	✓	-	×	✓

In sociocultural terms, the transmission of techniques occurs in very different ways in terms of hardness, rigidity or durability, ranging from proper interpretation derived from integral consolidation of the original remains (Figure 4a); homogenization by applying sacrificial coatings (Figure 4b); to increased hardness, either by unintentional exposure to fire events of the original earthen vestiges (Figure 4c), or through in situ reconstruction using contemporary materials for imitation purposes (Figure 4d).

(**a**) (**b**) (**c**) (**d**)

Figure 4. Sociocultural transmission of traditional constructive information: (**a**) original preservation display in Bílbilis (Calatayud, Zaragoza); (**b**) technique homogenization by applying sacrificial layers in Coll del Moro (Gandesa, Tarragona); (**c**) hardened display after unintentional exposure to fire events in Tossal del Moro (Pinyeres, Tarragona); (**d**) hardened display using contemporary material reconstructions in El Amarejo (Bonete, Albacete).

It is worth noting situations where this criterion cannot be applied across the board, as is the case of earth encapsulation in relation to the transmission of constructive cultures. In this situation, a systematic application of sacrifice layers, even when using traditional material, contributes to the invisibilization of systems such as adobe, which can be easily confused with rammed earth or cob under a uniform continuous rendering. This gives rise to a visual homogenisation of all the systems for the interpretation and transmission of cultures to the wider public. However, as the traditional technique considers the execution of earthen renderings to protect the structural sections from decay, it is considered positive in this case by considering encapsulation as a coating extended to horizontal surfaces.

2.3.2. Protection Structures

Furthermore, protection structures are an indispensable conditioning factor for respecting nature, conservation of the cultural landscape, creativity and the extension of useful life (Figure 5a,b). In this regard, sheltering with contemporary materials does not blend in in terms of tradition and environment, but alters the overall harmony, ultimately bringing about the decontextualization of the elements in their habitat, transformed at this point into museum pieces (Figure 5c). In terms of protection of the cultural landscape shaped over the centuries, this is also an issue at the social level, leading to considerable modification due to the introduction of powerful new focal points (Figure 5d). This has also been considered the only characteristic that can encourage creativity, given that a priori, the objective of archaeological valorization of the remains must be accurate when addressing any elements with scientific evidence, adhering to these, and discriminating or transmitting with full transparency any additions supported merely by hypotheses [52]. However, these protections could allow the intangible value of its original condition to be conserved, despite the alteration to the habitat transforming this into a more nebulous criterion for a positive rating.

(**a**) (**b**) (**c**) (**d**)

Figure 5. Sheltering impacts according to the different typologies: (**a**) textile sheltering in Turó d'en Roïna/Can Taco (Montornès del Vallès, Barcelona); (**b**) temporary partial sheltering until its promotional enhancement in Cerro de la Virgen (Orce, Granada); (**c**) permanent partial sheltering with contemporary materials in Rábita Califal (Guardamar del Segura, Alicante); (**d**) permanent total sheltering in Contrebia Belaisca (Botorrita, Zaragoza).

Finally, it is also a vital characteristic for prolonging useful life, along with re-burial and encapsulation, as these interventions greatly guarantee resistance to the passing of time and long-term use. Meanwhile, savings in local resources are more variable as these can be understood as positive when protections ensure maintenance and consolidations are kept to a minimum, but actions mostly show less compliance when the transformations and materials required involve a high level of manipulation and external movement.

Eventually, the environmental principle of reduction of the impact of natural threats may be studied in terms of the response to violent events and the creation of secure surroundings during the visit where this is reinforced with maintenance and preventive conservation work. However, the absence of a residential function and the high dependency on intrinsic factors in the response to vulnerability and risks to this type of heritage [39], together with any dimensional or constructive characteristics which may have been conserved, limit the applicability of this principle in heritage.

3. Results

The cross-referencing of data relating to the surroundings, executed interventions and principles of sustainability from environmental, sociocultural and socioeconomic perspectives provide results which can be studied individually, based on the different factors recognized for each standpoint. Thus, a general geographical panorama can be outlined for this specific heritage, identifying its main shortcomings in terms of future increased attention and the development of customized strategies which require a higher level of compliance.

3.1. The Environmental Perspective

The breadth of the terminology used in the environmental sustainability of architecture makes it impossible, when speaking of earthen archaeology case studies with no residential function, to reflect on aspects relating to health and comfort. However, it allows a more in-depth analysis of areas such as energy. The excavation of these structures integrates these constructions into the heritage circuit of the region, calling for actions promoting the intrinsic values which they house and, when possible, applying these directly in new tasks for prevention and protection.

In this respect, the case studies are seen to be highly variable, involving extractions, manufacturing, maintenance and recycling of materials with a limited footprint based on

traditional techniques [53] (Figure 6a); as well as protections and structures characterized by their industrial production, and requiring a high level of energy in the process (Figure 6b). At an intermediate level, globalization and the loss of constructive technical legacy have brought about the development of an industry capable of premanufacturing traditional materials such as adobe, with a lower cost of production but a greater carbon footprint due to the transport of pieces.

(**a**) (**b**)

Figure 6. Intervention strategies and their carbon footprint: (**a**) volumetric reintegration of walls using adobe and nearby obtained materials in Cerro de la Cruz (Almedinilla, Córdoba); (**b**) reconstructions of elevations using colored concrete instead of earthen walls in Medina Siyasa (Cieza, Murcia).

Harmonious Integration into Nature and Reduction of Pollution

Earthen archaeology, stripped of its original protections in relation to the environmental context, requires an intervention which can guarantee the maximum possible physical conservation of remains over time with minimal contributions from materials which are out of keeping, incompatible, or which have been extensively transformed (Figure 7). These principles cannot always be met, and it becomes necessary to sacrifice one or several of these in order to consider other social and anthropic factors, resulting in a wide range of interventions [54].

(**a**) (**b**) (**c**) (**d**)

Figure 7. Intervention strategies with varying degrees of harmony and integration: (**a**) nearby and compatible material consolidation in Coll del Moro (Gandesa, Tarragona); (**b**) pavement re-burying in El Oral (San Fulgencio, Alicante); (**c**) piece by piece relocation of a Roman kiln in El Ruedo (Almedinilla, Córdoba); (**d**) capping using a top row of collapsed and unintentionally fired adobes and chemical treatment in Turó del Calvari (Villalba de los Arcos, Tarragona).

Thus, in the sample selected, the intervention strategies used in 56% of cases are systems based on the use of local materials, such as earth and lime, to create new pieces

or surfaces more or less intrusive for consolidating existing structures, like Cancho Roano (Zalamea de la Serena, Badajoz); replacing lost render, eventually spreading to horizontal surfaces, thus encapsulating the remains, such as Calvari del Molar (El Molar, Tarragona); structural reintegration, including Cerro de la Cruz (Almedinilla, Córdoba); and compatible reconstruction on larger or smaller scales, either in situ, like Numancia (Garray, Soria) or ex situ, as Bastida de les Alcusses (Moixent, Valencia). As with the pre-existing elements, these additions could eventually be removed to return to the natural setting with no foreign materials introduced or be reused with new resources, except in cases where the lime percentage limits the fertility of the earth.

In addition, the lack of interventions as for the earthen bench in Mas Castellar (Pontós, Gerona) [55]; the compatible consolidations for the benches in Coll del Moro (Gandesa, Tarragona) (Figure 7a) [56]; the re-burials of remains, either temporarily or definitively, as in the adobe pavements of El Oral (San Fulgencio) (Figure 7b) [57] or the outer wall in La Fonteta (Guardamar del Segura, Alicante) [58]; or relocation to surroundings with controlled degradation, as in the kiln of El Ruedo (Almedinilla, Córdoba) (Figure 7c) [59], result in a neutral natural landscape, similar in appearance to that prior to excavation, except for the carbon footprint necessary for its occasional transport. Of all the cases observed, movement is just a few meters, preventing its destruction by executing an adjoining pathway for motorized transport as in the kiln of El Ruedo; or is one which relates to small pieces, as in Coll del Moro. The only case requiring transfer on a larger scale is that of the kiln of Arroyo Villalta (Bobadilla, Málaga) transported from its original location to the Museum of Antequera [60].

In some cases, the discovery of fully conserved pieces which had survived collapse has enabled these to be recycled and used for protection. This is the case for the Turó del Calvari (Villalba de los Arcos, Tarragona), where the unintentional firing of the adobe had conserved it, taking advantage of its greater hardness to replace the upper coping of the wall and using it for capping (Figure 7d) [61]; or in Coll del Moro, where the simple stones lending support to the elements prevent load contributions from new materials and minimize the impact of agents such as rainfall. This strategy could be applicable to both dimensions of impact as it has often been observed through the superimposition of harder contemporary elements, such as the ceramic roof tiles in the Roman domus in Bílbilis (Calatayud, Zaragoza).

In keeping with this scenario, 44% of cases include some type of intervention executed with contemporary and industrial materials (Table 3). This is the case of protections with render, which use a high percentage of colored hydraulic lime and cement for the dosage, as in Illeta de Banyets (El Campello, Alicante) [62]; consolidations using cement mortar, as in the Roman kiln of Ventura de l'Oller (St. Perpètua de Moguda, Barcelona); treatments with chemical products such as ethyl silicate in enclaves such as Rábita Califal (Guardamar del Segura, Alicante) [57]; monolithic reconstructions such as Medina Siyasa (Cieza, Murcia), or brickworks, such as La Fonteta (Guardamar del Segura, Alicante) and Coimbra del Barranco Ancho (Jumilla, Murcia), which use hollow ceramic bricks with a colored cement render [57]; or finally, the construction of protective structures using metal materials of different sizes and longevity as in Lépida Celsa (Velilla de Ebro, Zaragoza), the necropolis of Túgi (Galera, Granada) and Casa del Mitreo (Mérida, Badajoz), forming a sort of container building as it spreads across all elevations as seen in Cerro de la Mota (Medina de Campo, Valladolid) and Casa de los Grifos (Alcalá de Henares, Madrid). These last examples, in addition to generating emissions due to the transformations required during execution, have a notable impact on the surroundings, jeopardizing the visual harmony of the habitat with invasive structures which are the result of prioritizing the physical conservation of remains over surroundings (Figure 8). This percentage is slightly increased to 46% in accordance with the principle of pollution reduction.

Table 3. Counting of positive and negative contributions from the environmental perspective in selected case studies.

Environmental Perspective	High Contribution		Low Contribution	
	n *	%	n *	%
To respect nature	105	56%	83	44%
To reduce pollution	102	54%	86	46%

* Each case study may provide more than one structure.

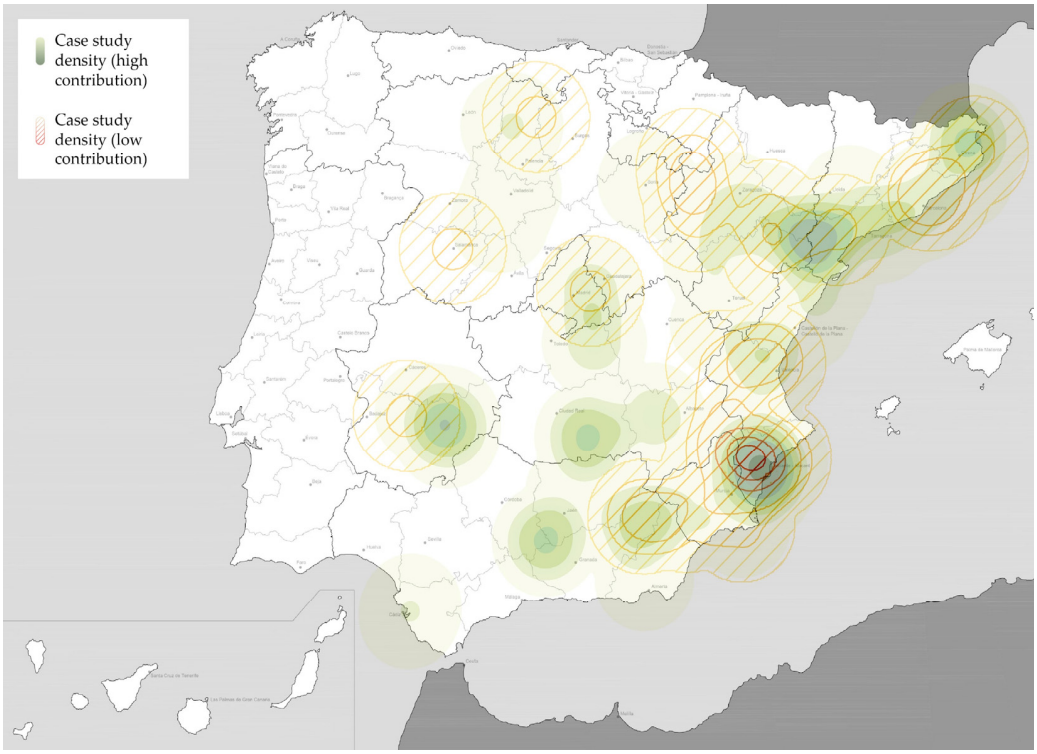


Figure 8. Heat map of the density of case studies with contributions aligned or not aligned with environmental principles, within a radius of 70 km.

3.2. Sociocultural Perspective

The cultural aspect of earthen architecture has recently been defended from the perspective of sustainability and has been repeatedly praised for its values and contributions on an intangible level [63], as well as for the contributions which can still be made to future societies [41,64].

In the case of archaeology, these values become highly important in the cultural field, as the use of earthen architecture in past societies in the Iberian Peninsula has been very much underrepresented, despite its confirmed widespread use in domestic, productive and funerary construction. This clearly strengthens the tangible and intangible local values defining its identity, which had been shunned in favor of functionalism [65]. It also provides a wide range of opportunities, such as the added value provided by these enclaves thanks to the conservation of these structures, which are few and far between, non-renewable, and of which very few results have been conserved.

The ability to provide foundations for social and cultural cohesion in order to reflect diversity, represented in the constructive legacy and the links to geographical space, allows its promotion mirroring the local history of humanity and territorial demands [64]. Issues such as maintenance of the cultural landscape and constructive techniques, along with sustainable tourist operations, can be positive contributions for reinforcing these aspects, both now and in the future.

3.2.1. Cultural Landscape

The landscape study of archaeological enclaves, analyzed as a separate discipline from the second half of the 20th century [66], allows human interactions to be understood from scales far greater than individual ones, and can offer an example of architectural integration for the future. Therefore, conserving this landscape enables transformations and adaptation through mediums resulting from this relationship, becoming an indicator for cultural sustainability. Thus, from an optimal perspective, earthen archaeology must be understood within and as a part of its context and linked to concepts such as authenticity [67], which can be altered by the insertion of large structures introducing substantial modifications, foreign materials and the transfer of elements for the purposes of study or conservation.

In this respect, 46% of the interventions carried out on this heritage, according to the sample, can be seen to prevent the introduction of these modifications as the original physical document is protected by measures with localized impact (Table 4), including preventive conservation, as in Rábita Califal (Guardamar del Segura, Alicante); restoration, as in Cerro de las Cabezas (Valdepeñas, Ciudad Real) [68]; chemical treatments, as in the domus Avinyó (Barcelona); respectful restorations, as in Cástulo (Linares, Jaén); or compatible in situ and ex situ reconstructions, as in Calafell (Altafulla, Tarragona). In contrast, up to 54% of case studies feature solutions which lead to the short-term invisibilization of the original landscape due to the re-burial of structures, as in Soto de Medinilla (Valladolid); or in the long term due to their inevitable destruction, as in the case of the structures adjoining the wall of Tos Pelat (Moncada, Valencia), with the exception of cases where the exposure to high temperatures has fired pieces such as adobe, offering far greater durability. Nor is this indicator linked to reconstructions which are materially or technically incompatible in situ, such as Coimbra del Barranco Ancho (Jumilla, Murcia), or altered by different types of shelter, including notable examples such as the urban insertion of the kilns of Torrealta and Camposoto (San Fernando, Cádiz); or the execution of large urban container constructions such as casa Hippolytus (Alcalá de Henares, Madrid).

Table 4. Counting of positive and negative contributions from the sociocultural perspective in selected case studies.

Sociocultural Perspective	High Contribution		Low Contribution	
	n *	%	n *	%
To protect cultural landscape	103	54%	88	46%
To transfer const. cultures	149	77%	49	23%
To enhance creativity	60	31%	134	69%
To recognize intangible values	145	75%	49	25%

* Each case study may provide more than one structure.

Furthermore, the strategic selection of locations to control the territory, proximity to river courses or internal and external hierarchies of the habitats can be compromised by actions transferring them for their protection. As the sample shows 2% of case studies affected by these strategies, this situation is not frequently observed in Spain. However, in some contexts where location is relevant, such as outside necropolises structures, they can be specifically identified in ex situ recreations, as in El Castillo (Castejón, Navarra).

3.2.2. Constructive Culture and Territorial Identity

The conservation of local constructive materials and techniques, developed from prehistory to preindustrial society, shows the wealth of options and solutions resulting from the ability to develop the best possible living conditions [64], validated as a sustainable system from which lessons can be extracted for architecture in the future. Their physical dissemination to the wider public allows the expression of this diversity and the creation of identity-based links with the past that are representative of the inhabited place.

Unlike postindustrial architecture, where the geographical scope of societies is better defined, in the field of archaeology it becomes more complicated to define which techniques belong to different societies, as well as their cultural exchange and interaction when attempting to ascertain local idiosyncrasies. At present, different efforts are being undertaken by the professional community in associating these techniques to define the scope of societies, albeit with no conclusive results, but the resulting spontaneity in construction brought about by mere problem-solving should not be neglected. In any case, preserving this heterogeneity for future study is valued as a major indicator of sociocultural sustainability.

The sample shows a variable percentage of conservation in material and technical terms. The first, due to its greater demands in terms of maintenance, was only applied in 45% of case studies with strategies and finishes that were fairly similar to the original ones, as in Casas del Turuñuelo (Guareña, Badajoz) and Coll del Moro (Gandesa, Tarragona). In contrast, up to 54 different structures, accounting for 49% of the total, include different materials, from ceramic hollow brick to protections of different types including protective sheets or structures. In 7 of these case studies, 6% of the total, an incompatibility is identified which results in new damage to the remains, including salts from limited breathability in saline atmospheres, as in La Fonteta (Guardamar del Segura, Alicante) or excessive loads, as in the colored concrete of Medina Siyasa (Cieza, Murcia).

In terms of constructive techniques, imitations of these are documented in a large number of case studies with imitations using contemporary materials, especially in cases associated with adobe constructions. In this regard, up to 67 structures have been documented with a high degree of rigging similarity, corresponding to 65% of the sample (Table 5), compared to 34% as different and 1% as incompatible.

Table 5. Similar, different and incompatible cases from the material and technique perspectives.

Sociocultural Perspective	Similar		Different		Incompatible	
	n *	%	n *	%	n *	%
Material	49	45%	54	49%	7	6%
Constructive technique	67	65%	35	34%	1	1%

* Each case study may provide more than one structure.

3.2.3. Social Cohesion

One of the least evident aspects when analyzing whether earthen archaeology adhered to sociocultural sustainable principles is social cohesion, as the nature of the local community makes it impossible for these spaces, such as laundries and fountains, to be used for collective gathering and wellbeing. However, their excavation is considered a municipal milestone that is made all the more meaningful by the limited number of case studies conserved. These can generate spaces for different generations to gather and for developing participative and communal activities where inhabitants can group together to uncover their history. In this respect, one of the variables making this possible is the musealization of spaces, understood as a set of processes guaranteeing the visit and dissemination of structures found to the general public. Ease of access, which would also consider parameters such as urban location, could also be considered as a factor favoring these principles.

Based on the sample analyzed, 75% of case studies feature musealization tasks, as seen in Peña Negra (Crevillente, Alicante); while 82% are accessible by motorized transport, which is not the case in valorized paths such as El Oral (San Fulgencio, Alicante). However, only 48% show a selection of earthen architecture with varying degrees of precision in signage and autonomous visits, as in Los Villares (Caudete de las Fuentes, Valencia); while 42% has a stable service of guided visits, as in Medina Siyasa (Cieza, Murcia). Discrimination according to these factors shows that only 28% of cases positively combine all these features, as is the Cerro de la Mota (Medina del Campo, Valladolid).

In this regard, the potential sustainable impact in the social field derived from tourist satisfaction should not be forgotten [69], which besides the obvious physical contribution can be strengthened with digital support that is capable of improving these experiences [70]. Although this is present in different sites, such as at La Olmeda (Pedrosa de la Vega) through 3D recreations. Usually a historical approach is chosen, ignoring earthen construction, compromising the contribution in this field (Table 6) (Figure 9).

Table 6. Musealization contributions from the sociocultural perspective.

Sociocultural Perspective	High Contribution		Low Contribution	
	n	%	n	%
Musealization	64	75%	21	25%
Motorized access	70	82%	15	18%
Earthen structures signage	41	48%	44	52%
Musealization + motorized access + earthen struct. signage	25	28%	60	72%

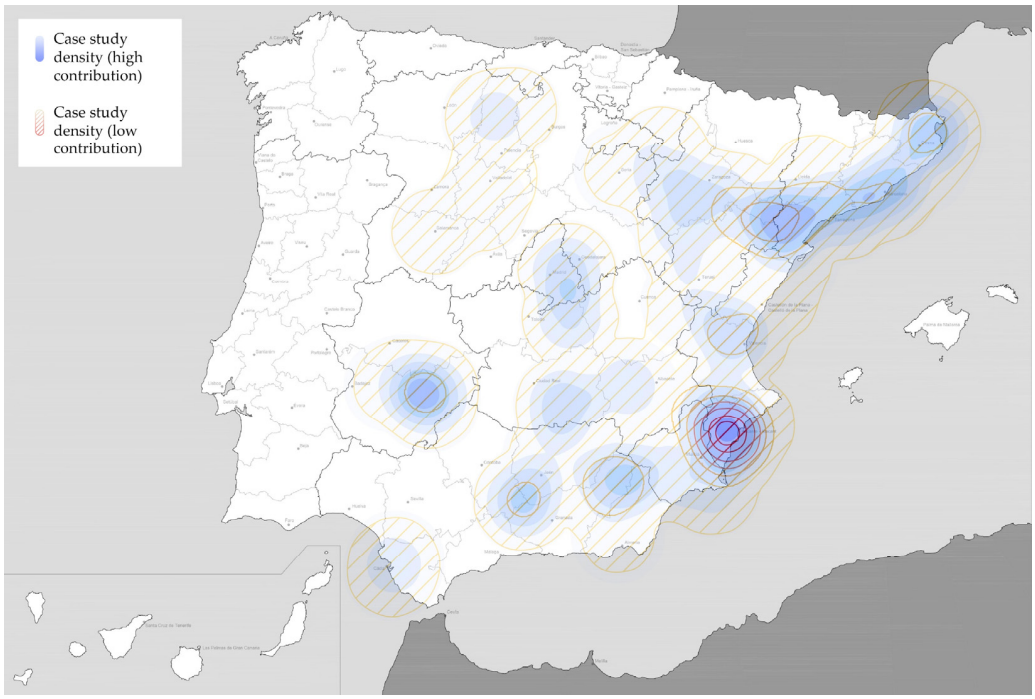


Figure 9. Heat map of the density of case studies with contributions aligned or not aligned with the sociocultural principles, within a radius of 70 km.

3.3. Socioeconomic Perspective

In keeping with the rich cultural value detailed from earthen architecture that is being increasingly recognized [64], these assets can be exploited through the aforementioned interventions for valorization and musealization, aiding the development of tourism to increase local economic activity by attracting new visitors. This dynamic model for archaeological management, in communication with the wider public and relevant to political decision-making, was first applied in the 1970s and 80s in the United States and Europe, respectively [71], for the purposes of urban regeneration, although the European Cultural Convention of 1954 had already highlighted the importance of preserving common European cultural heritage.

In the Iberian Peninsula, as the regulations evolved, they were more geared to values such as authenticity, as seen in the Archaeological Excavations Act (1911); as well as recognition of historical–artistic value (1915); social belonging (1926); the inclusion of criteria influenced by the Athens Charter (1933); new uses (1955); use of traditional techniques (1971); and some final innovations (1985), which were not always incorporated [72]. Despite these protection regulations and taking into account that this territory includes areas with a particular association to tourism, the current existence of severe demographic issues such as the depopulation of numerous interior areas [73,74] requires solutions guaranteeing sustainable development over time in order to benefit from circumstances such as the heritage on offer.

However, tourism and local activity are not the only challenges faced by these heritage complexes at an economic level. The intervention tasks, decisive in determining their useful life span and the sustainable use of resources, can provide a context aligned in varying degrees with the principles of socioeconomic sustainability.

3.3.1. Sustainable Tourism and Promotion of Local Activity

The desire to provide accessibility to heritage [75] strengthened for its public and collective ownership [76], as well as offering a new social adaptation to remains, now obsolete and no longer serving their original function, leads to the existence of study functions linked to tourist promotion and the exploitation of enclaves. In its finest way, this takes place during all the stages of its lifespan [77], from the exposition of the different excavation seasons and their findings to professionals and the press, as in the case of the Casas del Turuñuelo (Guareña), to its subsequent opening to the public with the widest offer, after a multidisciplinary process of musealization and in a manner guaranteeing the adequate physical preservation of the remains [77]. These were already established in the charters of protection and archaeological management of Lausanne (1990) and Malta (1992) which would eventually contribute to its conservation [78]. Later on, through the ICOMOS Charter for the Interpretation and Presentation of Cultural Heritage Sites (2008), this concern would be explicitly established under the sustainable conscience, as well as new contributions that would highlight the inability of many assets to absorb the visit without compromising economic and social sustainability and continuity [69,79]. Accurate targeting of the market, which could focus on the lack of original earthen architectures preserved in situ and the natural environment to enhance its promotion, would be particularly successful by complementing the structured development of history with a participatory experience ensuring quality and material authenticity [69]. In this process, it must not be forgotten that the necessary infrastructure must be built in a sustainable and asset-sensitive manner [70], as described in the chapter on sociocultural impact, especially when modern social events are to be integrated.

This accessibility and valorization, which are not always optimal [80] due to the characteristics of the elements conserved, constitute tools for the dynamization of municipalities, promoting the attendance of visitors and their occasional local consumption in interrelated sectors, and thus improving residents' life in the field of economic sustainability. Moreover, in cases where excavation tasks and conservation solutions do not involve extensive technologies or require complex transformation processes for their materials, they could boost the hiring of local labor in certain stages of the process.

For the purposes of this study, any intervention which still preserved bare structures is considered a positive addition to this indicator, as 86% of cases in this situation have been set up for tourism use. However, visits cannot usually be carried out until the suitable musealization elements are in place, with defined circulation paths to prevent unwanted treading on earthen structures and information signage. Based on this added factor, the percentage of case studies promoting the dynamization of local activity would fall to 77%, as seen in the case of Turó d'en Roïna/Can Taco (Montmeló/Montornès del Vallès, Barcelona), the Roman villa Els Munts (Altafulla, Tarragona) and the kilns in Doña Blanca (Puerto de Santa María, Cádiz).

Finally, 14% of cases would re-bury the structures, limiting their dissemination, or not intervene, facilitating their eventual destruction from natural and anthropic reasons, and hindering sustainable operation.

3.3.2. Resisting the Passing of Time

Compatible actions for protection, such as confining to the ground or with no physical connection to the remains, work on prolonging the heritage's useful life, adding plant substrates, sacrificial layers, or contemporary elements between them and most of the natural degradation agents. Despite it all, different social and anthropic risk factors can noticeably alter the useful life and must be closely studied and resolved in detail in each of the case studies. In this regard, 78% of the sample has undergone interventions to improve durability, with different degrees of efficiency and intrusion in terms of construction.

In contrast, the absence of interventions or the introduction of incompatible materials jeopardizes the durability of archaeological remains, as introducing new agents into the system can lead to increased damage in the future. Equally, these interpretive reconstructions are neutral strategies in this regard and over time must provide evidence of their own resistance. Of the entire sample, 22% of structures meet this condition, but provide no optimal contribution to the resistance of original remains over time.

Moreover, while transport sacrifices the contextualization of remains, it can also greatly safeguard and extend their lives, particularly in cases not motivated by laboratory study, but from a move from areas that will be used for the execution of civil or urban works, and thus foreseeing their burial or eventual destruction once they have been documented. Conversely, the usual chemical treatments with ethyl silicate or nanosilica sacrifice the original internal structure of these elements in order to increase resistance, a process which is irreversible. These solutions, found in 9% of the sites selected, take on a significant importance in relation to the heterogeneity of the intervention.

3.3.3. Responsible Use of Resources

While the use of local and traditional materials in the repair of earthen structures requires monitoring in order to record degradation, resorting to more frequent maintenance tasks than those provided in large areas, it can result in a saving in resources over more technological solutions [45], which require a higher economic cost in execution and subsequent repair and maintenance. The cyclical attention to and replacement of sacrificial layers allows costs to be controlled more closely, preventing squandering as seen with larger structures which must also be maintained due to erosion for similar or higher costs.

Thus, major interventions such as the installation of complete shelters with large surfaces would not require a measured use of local resources. However, this type of installation could offer future partial returns, given that the mitigation of certain natural effects could lead to a reduction in the level of maintenance and repair required and be limited to effects derived from damp, wind or anthropic factors. This is not the case with the use of contemporary materials such as hydraulic lime or cement in earthen structures as new problems arise due to the anomalous rigidity and breathability, which are highly likely to damage the original remains, and require repair actions on compromised starting points.

Based on the sample, 54% of structures implement strategies with greater savings in resources, while 46% use contemporary solutions (Table 7). Nevertheless, the waning number of professionals working on the execution of traditional earthen constructive techniques and the specific conditions of each municipality require more in-depth studies to accurately identify the economic costs of each intervention.

Table 7. Counting of positive and negative contributions from the socioeconomic perspective in selected case studies.

Socioeconomic Perspective	High Contribution		Low Contribution	
	n *	%	n *	%
To promote local activities	170	86%	27	14%
To extend building's lifetime	156	79%	41	21%
To save resources	107	54%	90	46%

* Each case study may provide more than one structure.

The surfaces obtained from heat mapping studies reflect the geographic scope of these contributions according to their alignment or not with the principles, similar to the environmental and sociocultural ones (Figure 10).

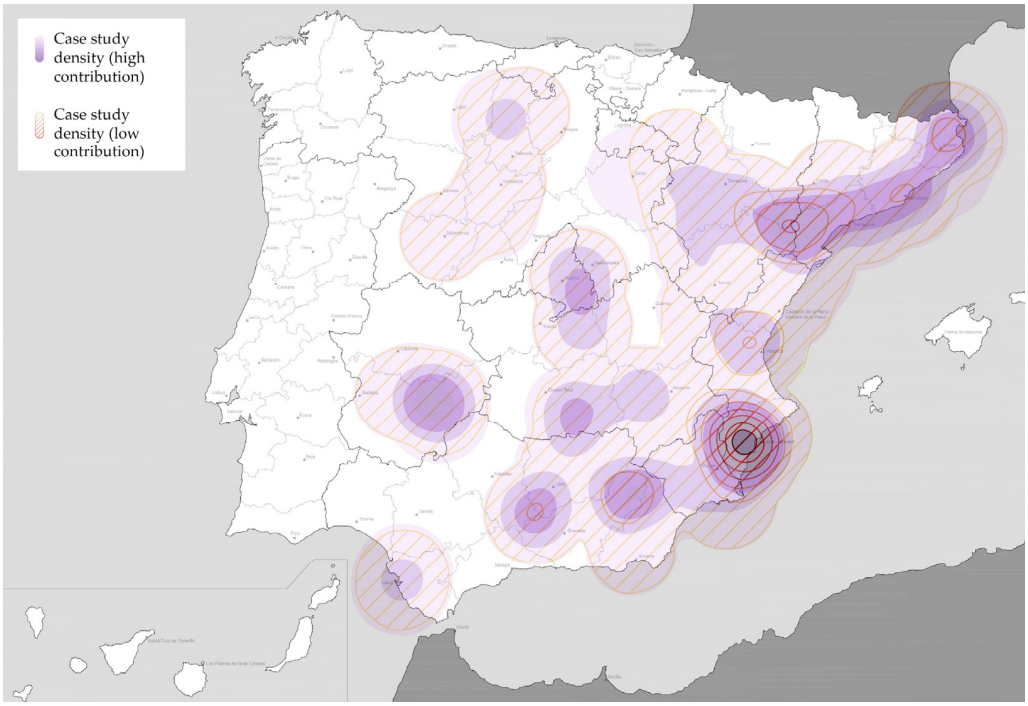


Figure 10. Heat map of the density of case studies with contributions aligned or not aligned with the socioeconomic principles, within a radius of 70 km.

4. Discussion

The data obtained present results showing the general situation of these heritage case studies, although these are subject to conditioning factors and the particularities of different origins, with limitations in terms of information and criteria.

The difficulty of adhering or not to sustainable indicators in terms of material when the earthen construction displays intermediate hardness can lead to confusion in classification. While the addition of local earth to dosages which are predominantly cement or hydraulic lime has been ruled out in most cases, discrimination in absolute terms is complex and could require detailed plans in this respect. Moreover, the issues arising from indecision relating to the project and the lack of universal solutions in the conservation of earthen architecture at archaeological sites are directly carried over to sustainability issues. Obtaining dual or opposing responses to different indicators within single strategies, for example, contrasts with the cultural landscape in the visibilization processes for constructive techniques without adding rendering to show specific constructive features.

Some of the limitations detected for qualitative analysis correspond to a real saving in resources. The decision to comply or not based on the use of local materials may seem

vague in certain case studies, and these would require detailed studies, which include monitoring of economic cost and guaranteeing the execution of traditional techniques with local materials.

In contrast, strategies such as shelters are susceptible to variation and modification of the statistical results of this study, as 50% of these, 27% of the total case studies, are temporary. These scenarios are generally resolved using different types of textile and horizontal protection shelters, mostly appearing spontaneously between excavation campaigns or awaiting the assignment of resources could change greatly based on future valorization projects and selection of the most relevant strategies.

Finally, the uncertainty of whether the widely used irreversible chemical treatments will result in future issues for the conservation and study of this heritage call into question whether their useful lives can be expanded. The current added resistance and its virtues in freezing the condition following excavation, particularly on vertical surfaces, seems to suggest that this could be a positive development.

5. Conclusions

The panorama of earthen architectural heritage in archaeology, seen through the lens of sustainability indicators for heritage, helps determine the current degree of compliance in order to identify any aspects requiring greater attention and the proposal of strategies. Broadly speaking, these are sustainable architectures which have not been intervened in keeping with these precepts in a notable number of case studies from the peninsula.

The environmental perspective is generally applicable to half of the structures observed, mostly due to the widespread use of contemporary shelters and envelopes in their protection processes, as well as dosages with higher hardness in restoration. From this, it can be deduced that compared to the approximately 50% of respectful interventions with a lower demand for resources and pollution, the rest is divided between interventions that prioritize freezing the historic document, isolating it from its reactions to degradation agents, and more intrusive and incompatible interventions.

In sociocultural terms, the results are less satisfactory. While the technique has been reproduced to a large extent in up to two thirds of the sample, in half of the sample it has been executed with different materials. This shows a desire to transmit factors such as bond or appearance, without the sacrifice entailed by the lack of original protections, creating a message that cannot transfer all expressions of local constructive legacies and architectural identities. Conversely, this scenario can lead to confusion in the field of culture, and ultimately to a greater disconnection from it, further compromising the social recognition of these systems which is already on shaky ground in contemporary society.

At a socioeconomic level, the wide benefits reported by conservation and valorization tasks, which in most cases entail a simpler promotion of activities and an extension of useful life, allow compliance in 75–85% of case studies. Thus, a poor response at the level of tourist use is found in a scenario greatly conditioned by extrinsic factors found in the context, such as depopulation, as a large part of the sample shows a satisfactory degree of promotion and resistance. However, this could be a response to the conditioning factor of in situ conservation proposed in this study, as structures which have been destroyed or lost due to degradation effects probably did not have this promotion and assistance following their excavation. There is also another perspective relating to savings in resources, where values refer back to the equal distribution of the sample with adaptation or, lack thereof, the indicators identified.

The search for balanced systems in the conservation of earthen archaeological structures shows that there is clearly room for improvement for Spanish case studies, although it is important to keep in mind its privileged starting point and the rich cultural offering found throughout a large part of the country. Although this study focuses on the general context of the Iberian Peninsula, this is a global issue which is increasingly being recognized by the wider public, bridging the gap with past constructive cultures and expanding the

options for fitting this architecture into contemporary societies with a view to guaranteeing its sustainable enjoyment for future societies.

Author Contributions: Conceptualization, S.M.-F., C.M., F.V.L.-M. and V.C.; methodology, S.M.-F., C.M. and F.V.L.-M.; software, S.M.-F.; validation, S.M.-F.; formal analysis, S.M.-F.; investigation, S.M.-F.; resources, S.M.-F., C.M., F.V.L.-M. and V.C.; data curation, S.M.-F.; writing—original draft preparation, S.M.-F.; writing—review and editing, S.M.-F., C.M., F.V.L.-M. and V.C.; visualization, S.M.-F.; supervision, C.M., F.V.L.-M. and V.C.; project administration, C.M. and F.V.L.-M.; funding acquisition, C.M. and F.V.L.-M. All authors have read and agreed to the published version of the manuscript.

Funding: This work is part of the research project "Risk-Terra: La arquitectura de tierra en la Península Ibérica: Estudio de los riesgos naturales, sociales y antrópicos y estrategias de intervención e incremento de la resiliencia" (Ref. RTI2018-095302-B-I00; main researchers: Camilla Mileto and Fernando Vegas), funded by the Spanish Ministry of Science, Innovation and University. This research has been developed within a doctoral thesis funded by the Spanish Ministry of Science, Innovation and University (Ref. PRE2019-089629).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The original contributions presented in this study are included in the article; further inquiries can be directed to the corresponding author.

Acknowledgments: To the Ministry of Science and Innovation of Spain for funding the research that is part of the present study at the Research Centre for Architecture, Heritage, and Management for Sustainable Development (PEGASO) at the Polytechnic University of Valencia. In addition, to the guides of the different archaeological sites for sharing their experiences and knowledge in the preservation and dissemination of each of them.

Conflicts of Interest: The authors declare no conflicts of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

References

1. Organización de las Naciones Unidas. Agenda 2030 Sobre el Desarrollo Sostenible. Available online: http://www.un.org/sustainabledevelopment/es/ (accessed on 24 April 2024).
2. Von der Leyen, U. My Agenda for Europe. Available online: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024_es#documents (accessed on 26 April 2024).
3. European Commission. *Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions, the European Green Deal, COM (2019), 640 Final*; European Commission: Brussels, Belgium, 2019.
4. European Commission. *Commission Staff Working Document. Sustainable products in a Circular Economy—Towards an EU Product Policy Framework Contributing to the Circular Economy, SWD (2019) 91 Final*; European Commission: Brussels, Belgium, 2019.
5. Steemers, K. Environmental Research in Architecture. *Scroope Camb. Archit. J.* **2011**, *20*, 14–19.
6. Ingersoll, R. The Ecology Question and Architecture. In *The SAGE Handbook of Architectural Theory*; Crysler, G., Cairns, S., Heynen, H., Eds.; SAGE Publications Ltd.: Los Angeles, CA, USA, 2012; pp. 575–591.
7. Torres Zarate, G. Arquitectura Vernácula y Sustentabilidad. *Horizontes Rev. Arquit.* **2011**, *3*, 16–19.
8. Buyle, M.; Braet, J.; Audenaert, A. Life Cycle Assessment in the Construction Industry: A Review. *Int. J. Energy Environ.* **2012**, *6*, 397–405.
9. Mileto, C.; Vegas, F.; Llatas, C.; Soust-Verdaguer, B. A Sustainable Approach for the Refurbishment Process of Vernacular Heritage: The Sesga House Case Study (Valencia, Spain). *Sustainability* **2021**, *13*, 9800. [CrossRef]
10. Rodrigues, V.; Martins, A.A.; Nunes, M.I.; Quintas, A.; Mata, T.M.; Caetano, N.S. LCA of Constructing an Industrial Building: Focus on Embodied Carbon and Energy. *Energy Procedia* **2018**, *153*, 420–425. [CrossRef]
11. Davis, H. Architectural Education and Vernacular Building. In *Vernacular Architecture in the Twenty-First Century: Theory, Education and Practice*; Asquith, L., Vellinga, M., Eds.; Taylor & Francis: New York, NY, USA, 2006; pp. 231–244.
12. Shearer Demir, H. *Understanding Sustainable Heritage*; Sustainable Heritage Brochure: Strasbourg, France, 2022; pp. 8–18.
13. Shearer Demir, H. *Living Heritage Today*; Living Heritage Brochure: Strasbourg, France, 2023; pp. 9–10.
14. Bettini, V.; Cabula, E.; Capra, G.F.; De Riso, S.; Rosnati, C. I Limiti Della Sostenibilità: Indicatori versus Sostenibilità. *Arch. Studi Urbani Reg.* **2003**, *2001*, 1000–1024.

15. Maldonado, L.; Vela-Cossío, F. El Patrimonio Arquitectónico Construido Con Tierra. Las Aportaciones Historiográficas y El Reconocimiento de Sus Valores En El Contexto de La Arquitectura Popular Española. *Inf. La Constr.* **2011**, *63*, 71–80. [CrossRef]
16. Matero, F. *Making Archaeological Sites: Conservation as Interpretation of an Excavated Past (2006)*; Sullivan, S., Mackay, R., Eds.; The Getty Conservation Institute: Los Angeles, CA, USA, 2013.
17. UNESCO World Heritage Centre. *World Heritage Earthen Architecture Programme 2009/2017*; UNESCO World Heritage Centre: Paris, France, 2008.
18. Craterre. La Roue Des Techniques. In *Bâtir en Terre: Du Grain de Sable à l'Architecture.*; Anger, R., Fontaine, L., Doat, P., Houben, H., Van Damme, H., Eds.; Belin, Cité des sciences et de l'industrie: Paris, France, 2009; p. 26.
19. Knoll, F.; Pastor Quiles, M.; De Chazelles, C.-A.; Cooke, L. *On Cob Balls, Adobe, and Daubed Straw Plaits a Glossary on Traditional Earth Building Techniques for Walls in Four Languages*; Landesmuseum für Vorgeschichte: Langenweißbach, Germany, 2019.
20. Mileto, C.; Vegas, F. *Proyecto COREMANS. Criterios de Intervención En La Arquitectura de Tierra*; Ministerio de Educación, Cultura y Deporte: Madrid, Spain, 2017.
21. Cooke, L. *Conservation Approaches to Earthen Architecture in Archaeological Contexts*; British Archaeological Reports: Oxford, UK, 2010.
22. Bendakir, M. *Les Vestiges de Mari: La Préservation d'une Architecture Millénaire*; Editions de La Villette: Paris, France, 2009.
23. Achenza, M.; Giovagnorio, I. Environmental Sustainability in Vernacular Architecture. In *VerSus: Heritage for Tomorrow: Vernacular Knowledge for Sustainable Architecture*; Correia, M., Dipasquale, L., Mecca, S., Eds.; Firenze University Press: Firenze, Italy, 2014; pp. 41–48.
24. Gandreau, D.; Sadozaï, C.; Moriset, S. Earthen Architecture on Archaeological Sites: Sustainability Principles vs Decay Processes. In *Earthen Construction Technology: Proceedings of the XVIII UISPP World Congress*; Daneels, A., Torras Freixa, M., Eds.; Archaeopress: Crowmarsh, UK, 2018; pp. 5–14.
25. Silva, F.; Coward, F.; Davies, K.; Elliott, S.; Jenkins, E.; Newton, A.C.; Riris, P.; Vander Linden, M.; Bates, J.; Cantarello, E.; et al. Developing Transdisciplinary Approaches to Sustainability Challenges: The Need to Model Socio-Environmental Systems in the Longue Durée. *Sustainability* **2022**, *14*, 10234. [CrossRef]
26. Guillaud, H.; Moriset, S.; Sánchez Muñoz, N.; Sevillano Gutiérrez, E. (Eds.) *VerSus: Lessons from Vernacular Heritage to Sustainable Architecture*; Éditions CRAterre: Grenoble, France, 2014.
27. Correia, M.; Dipasquale, L.; Mecca, S. (Eds.) *VerSus Heritage for Tomorrow: Vernacular Knowledge for Sustainable Architecture*; Firenze University Press: Firenze, Italy, 2014.
28. Rakotomamonjy, B.; Moriset, S.; Sánchez Muñoz, N.; Mabille, M.; Carbonelle, A. (Eds.) *VerSus Plus Heritage for People: Educational Tools to Transmit Heritage Values*; Éditions CRAterre: Grenoble, France, 2022.
29. Dipasquale, L.; Mecca, S.; Montoni, L. (Eds.) *Heritage for People: Sharing Vernacular Knowledge to Build the Future*; DIDA Press: Firenze, Italy, 2023.
30. Safont Cruz, E. El Desarrollo Sostenible En La Conservación de Patrimonio Arqueológico: Los Yacimientos de Sant Gregori y Torrucles En Burriana (Castellón). *Rev. PH* **2023**, *110*, 317–319. [CrossRef]
31. Santos Sánchez, K.; Martínez Valle, S.; Carrascosa Moliner, B. Proceso de Puesta En Valor Sostenible En El Yacimiento Arqueológico de La Calerilla de Hortunas, Requena (Valencia). Vinculación, Sensibilización y Transmisión. In *Oleana: Cuadernos de Cultura Comarcal*; Centro de Estudios Requenenses, Ed.; Ayuntamiento de Requena: Requena, Valencia, 2016; Volume 30, pp. 451–468.
32. Moreno Melgarejo, A.; Sariego López, I. Relaciones Entre Turismo y Arqueología: El Turismo Arqueológico, Una Tipología Turística Propia. *PASOS Rev. Tur. Patrim. Cult.* **2017**, *15*, 163–180. [CrossRef]
33. Sánchez García, A. La Técnicas Constructivas Con Tierra En La Arqueología Prerromana Del País Valenciano. *Quad. Prehistòria Arqueol. Castelló* **1999**, *20*, 161–188.
34. Pastor Quiles, M. *La Construcción Con Tierra En Arqueología. Teoría, Método, Técnicas y Aplicación*; Publicaciones de la Universidad de Alicante: Alicante, Spain, 2017.
35. Mateu Sagués, M.; Bergadà, M.M.; Garcia i Rubert, D. Manufacturing Technical Differences Employing Raw Earth at the Protohistoric Site of Sant Jaume (Alcanar, Tarragona, Spain): Construction and Furniture Elements. *Quat. Int.* **2013**, *315*, 76–86. [CrossRef]
36. Cutillas-Victoria, B.; Lorenzon, M.; Yagüe, F.B. Earthen Architecture and Craft Practices of Early Iron Age Ramparts: Geoarchaeological Analysis of Villares de La Encarnación, South-Eastern Iberia. *Open Archaeol.* **2023**, *9*, 20220304. [CrossRef]
37. Belarte Franco, M.C. *L'utilisation de La Brique Crue Dans La Péninsule Ibérique Durant La Protohistoire et La Période Romaine*; de Chazelles, C.-A., Klein, A., Pousthomis, N., Eds.; Editions de l'Espérou: Montpellier, France, 2011.
38. Arjonilla Álvarez, M.; Espinosa Gaitán, J.; García Fernández, F.J.; García de Casasola Gómez, M.; Gómez Villa, J.L.; Jiménez Viera, A.; Vargas Vázquez, S. *Guía de Buenas Prácticas Para La Intervención Arqueológica Sobre Arquitectura En Tierra Cruda*; Consejería de Turismo, C.Y.D.J.D.A., Ed.; Instituto Andaluz del Patrimonio Arquitectónico: Sevilla, Spain, 2024.
39. Manzano-Fernández, S. Arquitectura de Tierra En Yacimientos Arqueológicos de La Península Ibérica: Estudio de Riesgos Naturales, Sociales, Antrópicos y Estrategias de Intervención. Ph.D. Thesis, Universitat Politècnica de València, Valencia, Spain, 2023. Available online: https://riunet.upv.es/handle/10251/197994 (accessed on 6 April 2024).
40. Manzano-Fernández, S.; Mileto, C.; Vegas López-Manzanares, F.; Cristini, V. Conservation and In Situ Enhancement of Earthen Architecture in Archaeological Sites: Social and Anthropic Risks in the Case Studies of the Iberian Peninsula. *Heritage* **2024**, *7*, 2239–2264. [CrossRef]

41. Guillaud, H. Cultural Values of Earthen Architecture for Sustainable Development. In *Vernacular Heritage and Earthen Architecture: Contributions for Sustainable Development*; Correia, M.R., Carlos, G.D., Rocha, S., Eds.; CRC Press: London, UK, 2014; pp. 9–14.
42. Nakhaei Ashtari, M.; Correia, M. Assessment of Vulnerability and Site Adaptive Capacity to the Risk of Climate Change: The Case of Tchogha Zanbil World Heritage Earthen Site in Iran. *J. Cult. Herit. Manag. Sustain. Dev.* **2022**, *12*, 107–125. [CrossRef]
43. Daly, C. A Framework for Assessing the Vulnerability of Archaeological Sites to Climate Change: Theory, Development, and Application. *Conserv. Manag. Archaeol. Sites* **2014**, *16*, 268–282. [CrossRef]
44. García, B.M. Resilient Cultural Heritage for a Future of Climate Change. *J. Int. Aff.* **2020**, *73*, 101–120.
45. Correia, M.; Juvanec, B.; Mileto, C.; Vegas, F.; Gomes, F.; Alcindor, M.; Lima, A. Socio-Economic Sustainability in Vernacular Architecture. In *VerSus: Heritage for Tomorrow: Vernacular Knowledge for Sustainable Architecture*; Correia, M., Dipasquale, L., Mecca, S., Eds.; Firenze University Press: Firenze, Italy, 2014; pp. 56–63.
46. Reeder-Myers, L.A. Cultural Heritage at Risk in the Twenty-First Century: A Vulnerability Assessment of Coastal Archaeological Sites in the United States. *J. Isl. Coast. Archaeol.* **2015**, *10*, 436–445. [CrossRef]
47. Taçon, P.S.C.; Baker, S. New and Emerging Challenges to Heritage and Well-Being: A Critical Review. *Heritage* **2019**, *2*, 1300–1315. [CrossRef]
48. Bruno, P. Arquitecturas de Terra nos Espaços Domésticos Pré-Históricos do Sul de Portugal. Sítios, Estructuras, Tecnologías e Materiais, Universidade de Lisboa. Available online: https://repositorio.ul.pt/handle/10451/3475 (accessed on 14 January 2024).
49. Pedelì, C.; Pulga, S. *Conservation Practices on Archaeological Excavations: Principles and Methods*; Getty Conservation Institute: Los Angeles, CA, USA, 2013.
50. Ventura, A.; Ouellet-Plamondon, C.; Röck, M.; Hecht, T.; Roy, V.; Higuera, P.; Lecompte, T.; Faria, P.; Hamard, E.; Morel, J.-C.; et al. Environmental Potential of Earth-Based Building Materials: Key Facts and Issues from a Life Cycle Assessment Perspective. In *Testing and Characterization of Earth-Based Building Materials and Elements: State-of-the-Art Report of the RILEM TC 274-TCE*; Fabbri, A., Morel, J.C., Aubert, J.E., Bui, Q.-B., Gallipoli, D., Reddy, B.V.V., Eds.; Springer International Publishing: Cham, Switzerland, 2022; pp. 261–296. [CrossRef]
51. Arrigoni, A.; Beckett, C.; Ciancio, D.; Dotelli, G. Life Cycle Analysis of Environmental Impact vs. Durability of Stabilised Rammed Earth. *Constr. Build. Mater.* **2017**, *142*, 128–136. [CrossRef]
52. Jiménez Viera, A. Consideraciones básicas para la caracterización tipológica y constructive de la arquitectura y construcción protohistórica en tierra en el suroeste de la Península Ibérica. In Proceedings of the ARAR Arqueología & Arquitectura. La Arquitectura de Tierra en el Mediterráneo Antiguo: Perspectivas, Estrategias y Metodologías, Guareña, Spain, 21–24 February 2024.
53. Fernandes, J.; Mateus, R.; Bragança, L. Vernacular Heritage and Earthen Architecture. In *Vernacular Heritage and Earthen Architecture: Contributions for Sustainable Development*; Correia, M.R., Carlos, G.D., Rocha, S., Eds.; CRC Press: London, UK, 2014; pp. 623–629.
54. Manzano-Fernández, S.; Mileto, C.; Vegas López-Manzanares, F.; Cristini, V. Degradación e Intervenciones En Construcción Con Tierra de Yacimientos Arqueológicos de España. In Proceedings of the Seminario Iberoamericano de Arquitectura y Construcción con Tierra (21. Memorias), Bogotá/Tibasosa, Colombia, 9–13 November 2023; pp. 301–310.
55. Pons, E.; Asensio, D.; Morer, J.; Jornet, R. Un Edifici Singular Del Segle V AC Trobat Sota La Torre de Defensa de l'oppidum Ibèric (Mas Castellar-Pontós, Alt Empordà). *Ann. l'Institut d'Estudis Empord.* **2016**, *47*, 13–46. [CrossRef]
56. Jornet Niella, R.; Belarte Franco, M.C.; Asensio Vilaró, D.; Morer de Llorens, J.; Sanmartí Grego, J.; Bertral Arias, A. *Memòria de Les Intervencions Arqueològiques Aljaciment Ibèric de Coll Del Moro (Gandesa, Terra Alta). Campanyes 2015, 2016, 2017 i 2018*; Generalitat de Catalunya. Departament de Cultura: Tarragona, Spain, 2018.
57. Abad Casal, L.; Sala Sellés, F. *El Poblado Ibérico de El Oral (San Fulgencio, Alicante)*; Diputación Provincial de Valencia, Servicio de Investigación Prehistórica: Valencia, Spain, 1993.
58. López Mira, J.A.; Simón García, J.L. *La Rábita—La Fonteta: Un Yacimiento Arqueológico Milenario*; Generalitat Valenciana: Alicante, Spain, 2022.
59. Muñiz Jaén, I. Seguimiento Arqueológico En La Villa Romana de 'El Ruedo' (Almedinilla-Córdoba) II. *Anu. Arqueol. Andalucía 1998* **2001**, *3*, 215–223.
60. Ayuntamiento de Antequera. El Horno Romano Hallado en Las Obras del AVE ya Está en el Museo de la Ciudad de Antequera. Available online: https://www.antequera.es/noticias/buscador-de-noticias/El-horno-romano-hallado-en-las-obras-del-AVE-ya-esta-en-el-Museo-de-la-Ciudad-de-Antequera (accessed on 2 May 2024).
61. Bea Castaño, D.; Diloli Fons, J.; Ferré Anguix, R.; Roqué, R.; Sardà Seuma, S.; Vilà Llorach, J. Consolidación y Musealización Del Yacimiento Protohistórico Del Turó Del Calvari de Vilalba Dels Arcs (Terra Alta, Tarragona). In Proceedings of the IV Congreso Internacional Sobre Musealización de Xacementos Arqueolóxicos: Conservación e Presentación de Xacementos Arqueolóxicos no Medio Rural. Impacto Social no Territorio, Santiago de Compostela, Spain, 13–16 November 2006; pp. 163–170.
62. Pérez Jiménez, R. *Restauración Arquitectónica y Conservación En Yacimientos Arqueológicos. FRAC (Fichas de Restauración Arquitectónica y Conservación)*; MARQ Museo Arqueológico Provincial de Alicante: Alicante, Spain, 2008.
63. Lenzerini, F. Intangible Cultural Heritage: The Living Culture of Peoples. *Eur. J. Int. Law* **2011**, *22*, 101–120. [CrossRef]
64. Guillaud, H. Socio-Cultural Sustainability in Vernacular Architecture. In *VerSus: Heritage for Tomorrow: Vernacular Knowledge for Sustainable Architecture*; Firenze University Press: Firenze, Italy, 2014; pp. 48–56.
65. Loubes, J.-P. *Traité d'Architecture Sauvage*; SEXTANT Editions: Paris, France, 2010.

66. Vela Cossío, F.; Salto-Weis Azevedo, I. Understanding Landscape and the Values of Traditional Architecture and Construction. In *Vernacular Heritage and Earthen Architecture: Contributions for Sustainable Development*; Correia, M.R., Carlos, G.D., Rocha, S., Eds.; CRC Press: London, UK, 2014; pp. 435–440.
67. Marino, B.G. The Sense and Boundaries of Authenticity: The Case of Arg-e Bam (Iran). *Loggia Arquit. Restauración* **2020**, *33*, 58. [CrossRef]
68. Picazo Carrión, M.L.; Vélez Rivas, J.; Torres González, T.; Fernández Maroto, D.; Miguel, C.A.; Pérez Avilés, J.J. Algo Más Que Restauración y Consolidación: El 'Cerro de Las Cabezas', Un Ejemplo de Yacimiento Arqueológico Al Alcance de Todos. In *I Congreso Nacional Ciudad Real y su Provincia, Tomo III*; Alía Miranda, F., Anaya Flores, J., Mansilla Plaza, L., Sánchez Lillo, J., Eds.; Instituto de Estudios Manchegos (CSIC): Ciudad Real, Spain, 2015; pp. 451–466.
69. Blasco López, M.F.; Recuero Virto, N.; Aldas Manzano, J.; Garcia-Madariaga, J. Tourism Sustainability in Archaeological Sites. *J. Cult. Herit. Manag. Sustain. Dev.* **2018**, *8*, 276–292. [CrossRef]
70. Gálicz, I.V.; Magda, R.; Dávid, L.D. Archaeological Parks in the Service of Tourism—A Comparative Analysis of Hungarian and Western-European Archaeological Parks. *Sustainability* **2024**, *16*, 3313. [CrossRef]
71. Lazarević, S.; Arbutina, D.; Popović, S.G. The Role of the Archeological Heritage Sites in the Process of Urban Regeneration of UNESCO's Cities—Boka Bay Case Study. *Sustainability* **2022**, *14*, 1566. [CrossRef]
72. García-Soriano, L. La Restauración de La Arquitectura de Tapia de 1980 a La Actualidad a Través de Los Fondos Del Ministerio de Cultura y Del Ministerio de Fomento Del Gobierno de España. Criterios, Técnicas y Resultados, Universitat Politècnica de València, 2015. Available online: https://riunet.upv.es/handle/10251/58607 (accessed on 7 April 2024).
73. Ministerio para la Transición Ecológica y el Reto Demográfico. *Directrices Generales de la Estrategia Nacional Frente al Reto Demográfico*; Ministerio para la Transición Ecológica y el Reto Demográfico: Madrid, Spain, 2023.
74. Zúñiga-Antón, M.; Guillén, J.; Caudevilla, M.; Bentué-Martínez, C.Y. Mapa 174. Zonificación de los Municipios Españoles Sujetos a Desventajas Demográficas Graves y Permanentes. StoryMap. Available online: https://storymaps.arcgis.com/stories/9dd9b6e20cad403c95e87d4cc493c8fb (accessed on 26 January 2024).
75. Juncà Ubierna, J.A.; Amigo Alvaro, R.; Ruiz Díaz, F.J.; García García-Castro, C.; Zarza Alejo, R. *Accesibilidad Universal Al Patrimonio Cultural. Fundamentos, Criterios y Pautas*; Ministerio de Sanidad, Política social e Igualdad: Madrid, Spain, 2011.
76. Conforti, M.E.; Mariano, C.I. Comunicar y Gestionar El Patrimonio Arqueológico. *Arqueología* **2013**, *19*, 347–362.
77. Querol, M.Á.; Martínez Díaz, B. El Patrimonio Arqueológico En La Normativa Internacional. *Complutum* **1996**, *6*, 295–306. Available online: https://revistas.ucm.es/index.php/CMPL/article/view/CMPL9696330295A (accessed on 4 May 2024).
78. Baena Tortosa, E. Approach to the Dissemination of Archaeological Heritage in the Province of Huelva. *J. Tour. Herit. Res.* **2020**, *3*, 15–33.
79. Benur, A.M.; Bramwell, B. Tourism Product Development and Product Diversification in Destinations. *Tour. Manag.* **2015**, *50*, 213–224. [CrossRef]
80. Kavoura, A.; Bitsani, E. Managing the World Heritage Site of the Acropolis, Greece. *Int. J. Cult. Tour. Hosp. Res.* **2013**, *7*, 58–67. [CrossRef]