International Journal of Heritage Studies

ISSN: 1352-7258 (Print) 1470-3610 (Online) Journal homepage: www.tandfonline.com/journals/rjhs20

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To cite this article: Jesse Rafeiro & Ana Tomé (28 Aug 2026): Virtual reconstruction beyond the past: heritage future-making at the Capuchos convent in Alferrara, Portugal, International Journal of Heritage Studies, DOI: 10.1080/13527258.2026.2723873

To link to this article: https://doi.org/10.1080/13527258.2026.2723873

Published online: 28 Aug 2026.

INTERNATIONAL JOURNAL OF HERITAGE STUDIES
https://doi.org/10.1080/13527258.2026.2723873

Virtual reconstruction beyond the past: heritage future-making at the Capuchos convent in Alferrara, Portugal

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ABSTRACT

While virtual reconstruction commonly aims to visualise the past, this article argues that its knowledge production can also contribute to heritage future-making. We explore this in the ruins of the Capuchos Convent in Alferrara, Portugal, a largely forgotten site founded by Franciscan friars in the sixteenth century. After nearly two centuries of abandonment, and midway through a 25-year recovery plan, the site's identity is being reconsidered through new trajectories and heritage programmes that echo past uses while responding to increasing drought and water scarcity in southern Portugal. These include selective recovery, curated decay, and agricultural learning rather than total restoration. Key to this is the convent's sophisticated gravity-fed hydraulic system. Currently inactive, its network of mines, channels, conduits, and storage tanks allowed the former community to inhabit and cultivate the landscape across centuries. Combining non-invasive digital surveying with comparative analysis and local testimony, we clarify the remaining fragments of this system while showing how this knowledge identifies pathways for further interpretation and reactivation. The research contributes to underdeveloped discussions on virtual reconstruction as heritage practice by showing how knowledge generated from derelict and forgotten sites can inform future-oriented decisions about interpretation, selective intervention, and possible reuse in the Anthropocene.

ARTICLE HISTORY
Received 2 August 2026
Accepted 20 August 2026

KEYWORDS
Virtual reconstruction; heritage future; water heritage; convent architecture; Anthropocene

1. Introduction

Over the last two decades, virtual reconstruction has become an established method in archaeology and architectural history. The Seville Principles, an international set of guidelines for computer-based visualisation in the field of heritage, define it as the use of a virtual model to visually represent a built artefact or structure at a specific moment in the past, based on surviving physical evidence, documentary sources, and comparative inference (ICOMOS 2017). Among existing scholarship, researchers have tended to focus attention on questions of

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historic authenticity, the methodological and technical challenges involved in depicting the past and aspects of public engagement (Demetrescu and Ferdani 2021; Petrelli 2019). While virtual reconstruction research has undoubtedly generated insights into the realities of the past, it has generally offered limited reflection on how the methods and outcomes of its knowledge production participate in the field of heritage and still less on how they might shape heritage futures.

Adopting Lowenthal's (1998) distinction between history as critical inquiry into the past and heritage as the selective use and transmission of the past in the present, we argue that most virtual reconstruction research has been concerned with history rather than heritage. This is not to suggest that virtual reconstruction cannot transmit new values and approaches to living memory through a better understanding of the past. For instance, some projects imply future-orientation by making marginalised histories visible in ways that are politically and socially consequential, rather than merely illustrative (Amakawa and Westin 2018; González-Tennant 2013). Yet most virtual reconstruction projects are conducted within designated heritage contexts like museums, archaeological sites and protected historic buildings, where such projects are dictated by strong preservationist agendas and authorised discourses that often constrain historical narratives. This article instead questions what happens when we use virtual reconstruction at sites where these conditions do not apply, and where heritage identity remains open and unsettled.

We will attempt to answer this through the context of the forgotten ruins of the Capuchos Convent in Alferrara, Portugal. After nearly two centuries of abandonment and midway through a deliberately delayed 25-year recovery plan, the convent is beginning to define itself according to new trajectories shaped by aspects of curated decay, selective reuse, and a stronger role within the pedagogical farm located on its property. Central to these current imaginaries is the site's gravity-fed hydraulic system composed of a dispersed network of springs, conduits, channels, storage tanks, and outflow routes that supplied water for human occupation and agriculture for centuries. In a region increasingly marked by episodes of drought, these resources may support not only new programming but also future climate adaptation. Within these conditions, the goal of the present research is to use virtual reconstruction not only to understand the past operation of the hydraulic system but to speculate how it might become relevant again in consideration of contemporary needs. Although the system is inoperative today, water continues to move through some fragments, springs and talwegs, suggesting that some of its functions may be partially recoverable.

Rather than using the space of this article to rehearse the technical operations of virtual reconstruction in detail or to explain the degrees of certainty and hierarchies of evidence, we focus instead on producing a narrative account of what was discovered, with whom, and how the knowledge produced reveals new insights. We focus on understanding a largely forgotten form of communal life as well as how this knowledge impacts the interpretive, programmatic, and infrastructural options for a heritage site redefining itself. Here, the product of virtual reconstruction is not the primary outcome. Instead, we see it as part of an organic and discursive heritage practice (Aiello, Rafeiro, and Tomé 2026; Jeffrey et al. 2020), whose value lies in reflection, collaboration, and decision-making possibilities.

2. Heritage as future-making

Since the nineteenth century, especially as formulated by Western ideals, heritage practices have been primarily organised around the material preservation of selected physical relics inherited from the past. This preservationist impulse was tied to modern anxieties about the perceived loss of tradition, through which institutions, legislation, and civic initiatives came to define heritage as something to be protected and then transmitted to future generations (Lowenthal 1998). Yet this emphasis also marginalised more fluid forms of transmission including ritual, language, memory and myth which are paradoxically more likely to bridge continuities between past and future. Critical heritage studies have been key in challenging this status quo. They have contested the idea that heritage is intrinsic to objects, arguing instead that heritage is a social process through which cultural and social values are produced (L. Smith 2006). From this perspective, the survival of physical objects is not the only, or even the most effective form of continuity between the past and future. In some cases, as some have argued, selective disappearance may even increase the memory-making impact and social value of sites where significant historical events took place (Holtorf 2006, 2015). Likewise, the slow processes of ruination and decay may generate new forms of societal relevance by opening unforeseen channels of heritage-making beyond the fossilisation of the past (DeSilvey 2017; DeSilvey and Harrison 2020; Lambrechts et al. 2025).

In response to the Anthropocene's overlapping ecological and moral dilemmas, heritage is today increasingly confronted with questions about its role in shaping our common future. This marks a further shift from understanding heritage primarily as the safeguarding of material things to understanding it as a diverse set of practices of care that bring people, materials, environments, species, institutions, and values into relation. In this sense, heritage operates as a form of active futurology (Harrison 2015). Such a shift does not purely abandon preservation, but it does challenge the assumption that this is heritage's primary task. One way to conceptualise this is to ask how heritage can move from a damage mitigation paradigm towards an adaptive paradigm that taps into traditional knowledge systems as resources for the future (Boccardi 2015, 95):

> In the face of what is possibly the greatest challenge that human civilization has ever faced, how can cultures, which developed over millennia of adaptation and interaction with the environment, come to our help? Could our historic cities and cultural landscapes, managed according to traditional knowledge, hold useful lessons that we can draw upon, in combination with modern science and technological innovations, to plan for the environment as a whole and finally change what appears to be a completely unsustainable pattern of production and consumption? From this perspective, what should we keep and repair and what should we let go?

As the Anthropocene forces us to acknowledge, human culture is impossible to untangle from the more-than-human world. Therefore, it is only logical that our modes of coping with an unstable climate should take influence from practices in the past – even if they are adapted to entirely new circumstances. Such processes of change are at the heart of how heritage is made in the first place (Holtorf 2015). These future-oriented perspectives force us to ask more pragmatically how different forms of heritage values, practices and materials might be cared for and transformed in relation to the challenges that future generations will inhabit – even if this future is unknown to us (Harrison et al. 2020).

In architectural heritage, responses to the Anthropocene tend to follow the familiar rubrics of material conservation and risk mitigation. In the context of climate disaster and war, for instance, the normative response is to mitigate damage from the dangers of unforeseen future events, rather than investigate the ways in which traditional forms-of-life supported by these structures can stimulate new modes of adaptation. By prioritising built knowledge over intangible knowledge systems, these approaches may even eradicate the helpful ecological lessons and memory traditions of sites by introducing programmatic retrofits without clear programmatic continuities. Yet, the core values of heritage increasingly reside in the meanings and values humans invest in heritage objects, not in their physical substance alone (Araoz 2011). Thus, when considering the rapid social and ecological changes of the present, heritage management is increasingly challenged to move from management of protection towards management of change, in which value may be sustained through *adaptation to* change more than *mitigation of* it.

Digital tools can become important for heritage sites as a means of instigating new forms of social change by bringing forward narratives traditionally overlooked or concealed by official or expert narratives (Amakawa and Westin 2018; González-Tennant 2013). Yet, most of the digital heritage scholarship involved in practices of virtual reconstruction, building management, and physical conservation has not engaged with such critical practices, often framing their contributions around demonstrations of technological ingenuity (Huggett 2015; Stobiecka 2020). As such, digital tools may produce visually compelling and information-rich models of heritage sites and objects while offering little reflection on how those models generate heritage value and without considering the post-production value of their efforts into the future (Larsen 2018). Digital practices would benefit from a future-oriented shift since although replicas of the past will not help future generations in the Anthropocene, the changed behaviours and management practices induced by digital forms of mediation might.

Thus, the virtual reconstruction of the Capuchos Convent was not only approached through data acquisition and analysis, but also through instances of collaborative knowledge production and sharing. The non-invasive digital surveying and modelling methods were complemented by visits to other convent sites and exchanges with their management teams. A heritage event and an exhibition were also held to present preliminary findings, including a live demonstration of the ground-penetrating radar methods and a guided visit through the ruins. During these activities, participants were invited to discuss and question the researcher's interpretations as well as to suggest solutions to some of the unresolved questions of the reconstruction. In one instance, this led to situated knowledge of the past to be drawn out from a local resident. These knowledge sharing encounters also permitted greater transparency about the processes involved in virtual reconstruction research, helping to break the barriers often created between technical experts and publics. Frequent discussions with the Capuchos Convent's management also provided insight into how the findings might contribute to visitors' experience of the site and what implications the reconstruction hypotheses could have for future rehabilitation and heritage programmes. This active dialogue was also central to steering future research directions.

3. Conventual heritage in an era of environmental consciousness

Studies of monasteries and convents have often been framed by scholarly and professional concerns with religious history, monumental architecture, and art-historical value, frequently in ways that support heritage designation, museumification, or physical conservation. Countless case studies across different regions, historical periods, and architectural styles have been explored within this rubric while the ecological sophistication of these sites, including their resource management and landscape practices, has received less attention – despite that they approximate practices we might retrospectively call 'sustainable' today (Mallarach, Corcó, and Papayannis 2014).

In recent years, largely in response to growing ecological concerns, new approaches have begun to shift attention away from monasteries and convents as self-contained monuments and towards the natural environments, material conditions, and landscape practices that made these forms of life possible. These studies have shown how monasteries transformed landscapes by establishing dependent settlements, developing roads, creating social networks and managing natural resources (Röckelein 2020). As such, they have also shown the necessity of being cautious of our retrospective view of such landscape practices as 'sustainable', since they could also participate in harmful forms of religious, economic, and social control over surrounding communities (Arnold 2007; J. L. Smith 2019).

Within Portugal, researchers across the last two decades have also broadened our understanding of hydraulic systems across the nation's diverse hydrogeological landscapes and encouraged greater appreciation of the architectonic sophistication of these traditional water management practices. These have primarily examined selected case studies through non-invasive analogue survey techniques, including photography, planimetric drawings, and written observation of surviving fragments to speculate on how these systems once functioned (de Mascarenhas et al. 2010; de Mascarenhas, Abecasis, and Jorge 1996; Jorge 2020; Maduro, de Mascarenhas, and Jorge 2017). Interdisciplinary research between historians and hydrologists has since extended this work by studying the efficiency of gravity-fed hydraulic systems on which conventual and monastic communities relied, demonstrating that such systems may compare favourably with, or even outperform contemporary 'smart' technologies (Cristina et al. 2021; Rodrigues and Monteiro 2023).

This existing research is crucial to pointing out the relevance of such systems in the present but has so far had limited influence beyond academia and has provided little insight into how historic hydraulic knowledge might be operationalised within the field of heritage. Most studies have focused on sites whose heritage trajectories are already relatively established, whether through formal conservation, heritage designation or institutional constraints. In these examples, analogue documentation involving photography, measured drawing, and written observation has been essential for identifying surviving features, but provides limited clarity about the many hidden connections and subsurface routes common to such systems. These observations indicate the potential of virtual reconstruction methods to support an alternative mode of analysis that asks how historic hydraulic knowledge might acquire renewed relevance within heritage-making practices.

4. The Capuchos Convent

The Capuchos Convent, formally known as Nossa Senhora da Conceição de Alferrara, was founded in 1578 on the southern slope of the Serra dos Gaiteiros, between Palmela and Setúbal. It belonged to the Franciscan Strict Observance (*Estreitíssima Observância*), a reformed branch that pursued a rigorous return to Franciscan poverty and contemplative withdrawal. In terms of balancing needs for isolation with community support, the convent's setting was ideal. Proximity to the town of Setúbal meant ties to surrounding communities could be maintained through mendicant hospitality and preaching while in the mountains, the friars could retreat in isolation.

The site's limestone and dolomite geology also contributed to maintaining a solitary lifestyle. Marked by faults and exposed areas of rock, reliable spring water could be tapped into throughout the year. Over several centuries of habitation, the convent captured and channelled water through a gravity-fed hydraulic network comprised of dispersed structures that provided water for drinking, washing, and likely sustaining vegetable and medicinal gardens in their vicinity. The name of the territory Alferrara likely reflects this abundance of water. It is believed to derive from the colloquial Arabic *al-kharrarat*, meaning 'waterfall', (Machado 1958, 194) suggesting that the site's relationship to water was likely recognised during the Islamic occupation of Iberia.

The final chapter of the convent's religious life concluded around 1834 following the dissolution of Portugal's religious houses. This contributed to a prolonged period of abandonment in which the convent's hydraulic system gradually ceased to function owing to a combination of vegetal overgrowth, soil erosion, and material decay. Although the lands were placed at public auction and acquired by the O'Neill family in 1837, the Capuchos Convent appears to have remained almost entirely abandoned (Pina 1996). The only transformation at this time seems to have been in relation to water, which was redirected from the conventual systems towards irrigated agricultural production, particularly the family's orange cultivation in the lower cultivated areas. This industrial agricultural phase also proved temporary. After the 1969 earthquake, the property was increasingly abandoned and was eventually sold in the 1970s to a real-estate group that intended to subdivide and resell it. Public opposition prevented the sale which led to its eventual acquisition by the Associação de Municípios da Região de Setúbal (AMRS) – an intermunicipal association comprising nine municipalities – in 1983. After this, the 46-hectare plot was redeveloped into a pedagogical farm in 2011.

Since then, the property has been rebranded as the Quinta de São Paulo where it continues to offer an educational programme for schoolchildren from across the Setúbal region. Groups of approximately 20–30 students are brought to the farm daily to gain direct contact with farm animals, plants, and agricultural practices, as well as informal learning about the histories of local flora and fauna. Given the self-sustaining character of life in the convents in prior centuries, the AMRS suggests that these activities could be extended into interpretive work around the convents, allowing heritage practice to be connected to ecological learning.

Beyond its function as a pedagogical farm, the site has come increasingly to support a range of activities over the past two decades, including guided heritage and geological visits, interpretation initiatives with academic partners, municipal meetings, artistic events, and performances. These activities were made possible by campaigns carried

out between 2011 and 2017, which focused on the rehabilitation of the São Paulo Convent and the temporary stabilisation of the Capuchos Convent ruins as part of a 25-year recovery plan aimed at aligning the farm's cultural mission with a careful long-term strategy (Aleixo and Mestre 2020). Around the midpoint of this recovery period, the long-term future of the Capuchos Convent remains open, in part owing to its informal heritage status. Although publicly owned, it does not possess a conventional heritage status. Its significance is instead actively produced through the ongoing activities held there and, in some cases, through the memories of locals who have accessed it in less permitted ways.

The ruin has been central to this living memory, as the site has been abandoned for roughly the past two centuries (Figure 1).

At present, therefore, the two main future management trajectories being considered take this condition into account. One possibility is a strategy of curated decay, in which slow material degradation is accepted and allowed to progress alongside more informal, outdoor-focused heritage activities. This approach would be conducive to more informal uses and open to more-than-human inhabitation of the ruin, perhaps with a programme of integrated rewilding (Vázquez 2026). Another possibility involves more permanent stabilisation and adaptive reuse. This approach would still aim to keep the ruin largely exposed as it is, rather than follow a typical 'return to the past' scenario. This would imply a more refined structural stabilisation system that could make the interior spaces more

Figure 1. Convent of the Capuchos at S. Paulo, 1930 (reproduction). Photograph by Américo Ribeiro. AR16197. Digital reproduction from the original negative. Américo Ribeiro collection, Américo Ribeiro photographic archive, DIMUP | DECDSJ |Setúbal city council.

habitable and better suited to modern requirements for sustained occupation and expanded cultural programming.

Crucial to both possibilities, recent research has identified the site's water heritage as a central element of its future identity and as a possible basis for aligning ecological learning, adaptive reuse, and the wider cultural mission of the farm. Various adaptive reuse scenarios combining water with different cultural programmes and degrees of ruination have been recently explored (Reina Ortiz, Rafeiro, and Tomé 2026).

Another motivation for a water heritage framing within these scenarios is that scientific studies increasingly identify water scarcity, drought, and extreme heat as escalating regional threats. Europe has warmed twice as fast as the global average since the 1980s, making it the fastest-warming continent. Heatwaves are becoming more frequent and severe, while southern Europe is experiencing widespread drought. Global climate change scenario modelling has also placed the Mediterranean among the world's principal hotspots of severe drought-related water scarcity, with impacts expected as early as the 2020s and 2030s, making locally adapted water governance and diversified supply systems increasingly urgent (Ravinandrasana and Franzke 2025, 6). This is particularly significant in Setúbal, where recurrent drought has been recorded since the late 1970s (Silva et al. 2022, 17–18), where water scarcity is now the most acute in mainland Portugal (Agência Portuguesa do Ambiente 2024), and where climate projections indicate intensifying drought and heat through the end of the twenty-first century (Município de Setúbal 2024, 143–148).

Within this context, the convent's hydraulic system can therefore be understood in three related ways: as a recoverable and historically grounded example for small-scale regional water management practices, as a catalyst for new heritage programmes, and as a possible form of emergency support during periods of drought. In the first case, recovering such systems can demonstrate how religious communities made use of groundwater tapped from the particularities of local limestone geology using mines, channels and storage networks fed exclusively by gravity. Comparable convents in other geological and topographical conditions such as Arrábida, Sintra, Varatojo and Mértola show that such systems remain relevant today, since water continues to move through their historic infrastructures. Second, reintroducing water could support the site's future as a pedagogical landscape, linking the memory of Franciscan self-sufficiency to programmes around medicinal gardens, small-scale agriculture, cooling, sustainable water use, and ecological maintenance. Third, as the Setúbal region faces hotter and drier conditions increasingly conducive to forest fires, site management has suggested that the springs could potentially contribute to feeding an emergency freshwater reservoir by readapting existing tanks from the site's industrial orange-farming phase. This would offer an alternative to current firefighting practices that rely on aircraft collecting seawater, whose salt can exacerbate ecological damage over the long term.

At present, these water-related programming directions are difficult to define in precise terms. Virtual reconstruction is therefore being explored to consolidate existing knowledge of how water once moved through the site to further clarify which fragments, routes, and capacities could inform the site's future identity. Future phases of the project will then determine whether the hydraulic system should be exposed, activated, rehabilitated, or retrofitted. Here, virtual reconstruction is being used not only to consolidate

existing knowledge but also actively contribute to the site's future identity and imaginaries.

5. Virtually reconstructing the Capuchos Convent's hydraulic system

Considering these conditions, Historic Building Information Modelling (HBIM) was chosen because of the inherent versatility it affords to future planning in uncertain contexts. The process was conceived as an adaptation of Building Information Modelling (BIM), a tool developed for the design, construction, and management of contemporary structures, to the recording and analysis of historic buildings (Murphy, McGovern, and Pavia 2009). Thus, while BIM was designed as a construction-planning tool to simulate future construction, cost planning, and facilities management in support of buildings throughout their life cycle, HBIM has adapted the program's ontologies to the field of heritage. It has been most frequently used in applied circumstances to facilitate restoration through rigorous documentation and management protocols (Chow et al. 2019; Penjor et al. 2024) though a growing number of cases have repurposed it for virtual reconstruction research, especially as a database to structure speculation around the various heterogeneous data about depictions of the past (Martínez-Carricondo et al. 2020; Rafeiro and Tomé 2023). Across these cases, HBIM combines digital survey data, archival drawings, written descriptions, photographs, and material observations within a metadata structure that allows these sources to be embedded in or associated with model geometry so that future users can distinguish between evidence, speculation, and data source.

For the Capuchos Convent, an absence of any record drawings or written materials explicitly describing the convent or its hydraulic system meant that the virtual reconstruction process relied foremost on collecting various digital surveys about the physical site as it survives (Figure 2). A terrestrial laser scan (TLS) was used to survey the main architectural spaces using a process known as time-of-flight measurement, which works by calculating distances of emitted laser pulses as a dense 3D point cloud composed of hundreds of thousands of measured points. Additionally, an unmanned aerial vehicle (UAV) photogrammetric survey was used to capture terrain data and roof areas that were difficult to access. The process generates complementary point clouds using overlapping photographs of the same subject from different viewpoints that are then aligned automatically by software. A ground-penetrating radar (GPR) survey complemented these surface recording methods by transmitting electromagnetic pulses to see beyond surfaces, useful for finding elements like water conduits buried in the ground without the need for excavation.

The digital datasets were then imported into the HBIM environment and used as references for manually modelling the terrain and architectural elements (Figure 3). Where visible and surveyable, features of the hydraulic system were modelled directly from the point cloud, with their materiality and tectonic logic recorded in the model. In cases where subsurface elements were found in the GPR survey, they were modelled with low fidelity. Where evidence was insufficient from the digital tools, plausible hypotheses were proposed based on architectural intuition combined with comparison to similar convent sites in Portugal.

Figure 2. Digital surveying at the Capuchos Convent. Top left: TLS survey; top right: UAV photogrammetry. Bottom: GPR survey of the cooling house area.

The process also necessitated forms of knowledge that did not originate in the digital survey itself. Local testimony, site-management discussions, weather events, and comparison with other conventual hydraulic systems were other forms of input, even if not translated directly into model geometry. Beyond structuring data, these inputs also play a crucial role in the heritagisation process by shifting attention away from 'scientific' historical accuracy and high-fidelity representation alone, and towards the collaborative production of meaning and trust across different knowledge systems (Galeazzi 2018; Jones et al. 2018; Muñoz Morcillo et al. 2017; Swords et al. 2021). Before the virtual reconstruction process began, several aspects of the hydraulic system remained unclear: how water entered the convent, how the surviving vestiges related to one another in daily use, and how clean water, wastewater, and outflow were organised across the site. The reconstruction clarified these issues by proposing a series of probable hydraulic

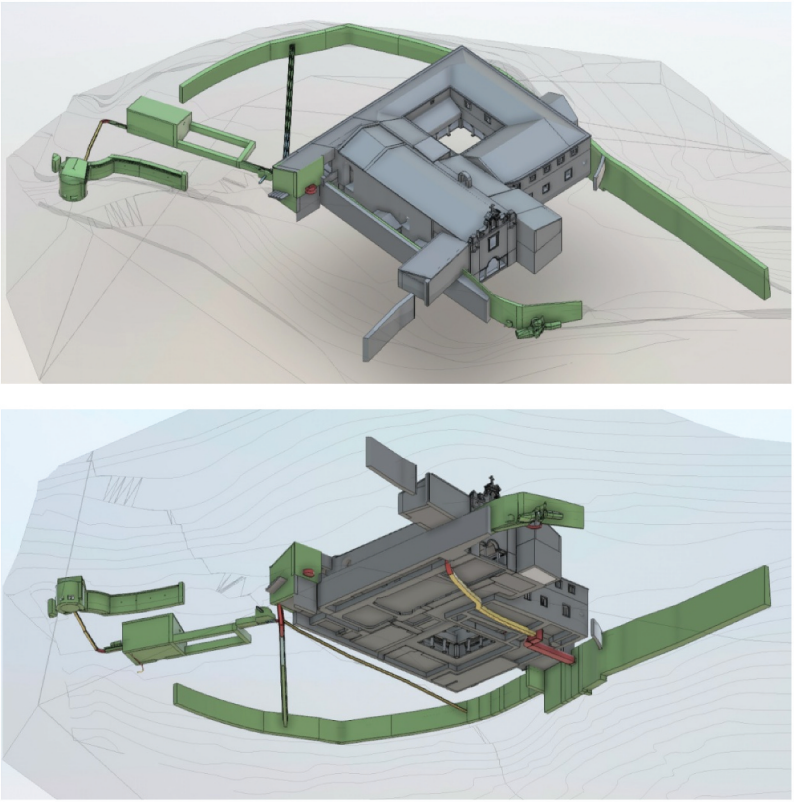

Figure 3. HBIM reconstruction model of the Capuchos Convent and its hydraulic system. Colour coding distinguishes levels of certainty with green indicating observed or high-confidence elements and red marking lower-confidence speculations. Grey is reserved for the convent itself.

sequences and by challenging several previous interpretations of the site. The following section describes how these discoveries emerged and how they begin to inform future trajectories for the site – as either physical restoration campaigns or as seeds for new heritage values, programmes or activities.

6. From virtual reconstruction to heritage futures

The virtual reconstruction led to the identification of three likely water-access points that could have supplied water in the past: a mine in front of the church façade to the west; a fountain on the east side, behind the church; and, towards the northeast, a conduit head known as the cooling house (Figure 4). Of these, at least two seem likely as possible activation points for water in the future. These two structures roughly correspond with existing hydrological surveys of the mountains which depict the course of two springs on either end of the convent.

The mine to the west is the first of these possible activation points. Built at a scale that allowed human access for maintenance, it consisted of a long underground tunnel embedded in the hillside, likely discharging into a small water chamber or collecting

Figure 4. Planimetric view of the terrestrial laser scan (TLS) survey, identifying key locations associated with the convent's hydraulic system and clarifying the water paths. Supply: S1, mine; S2, fountain; S3, cooling house. Uses: U1, kitchen; U2, latrines; U3, washing house. Storage: C1, storage tank. Outflow: O1, kitchen drain; O2, fountain and storage-tank overflow drain; O3, latrine drain.

box. From there, water likely passed through an open channel near the church façade, crossed the church nave, and continued into the interior. The mine is constructed with masonry side walls and a roof formed from two obliquely placed limestone slabs set in an inverted 'V' configuration.

Interpretation of the mine was later informed by conversations arising from a heritage community event hosted at the Capuchos Convent (Figure 5). The event was part of an annual gathering composed primarily of managers of former convents belonging to the Arrábida Province and members of the local community. These annual gatherings

Figure 5. Heritage community event held at the Capuchos Convent with local residents and managers of former convents in the Arrábida Province.

usually centre on presentations by convent managers about their historical and conservation research. Because the gathering was held at the Capuchos Convent, the programme also featured an exhibition of the project's preliminary findings, a live GPR demonstration, and a guided visit through the ruins. The visit allowed participants to question or contest recent findings, as well as to offer suggestions regarding the persisting uncertainties about the hydraulic system. One particularly significant contribution came from a local resident who reported that he had entered the Alferrara mine in the 1990s, during his early adulthood, when it was still accessible. He recalled that it contained a central gallery acting as a fork, from which several passages branched underground in a T-shaped configuration, with the mine beginning near the façade and continuing towards the west.

Such a configuration would not be unusual, as a similar typology is seen at the Arrábida Convent (de Quintela et al. 1996) and at the Franciscan convent in Varatojo, where branching conduits appear to have expanded over time as the community grew or as access to water diminished (de Mascarenhas et al. 2010). Although this testimony did not provide metric information with which to define the mine geometrically in the virtual reconstruction, the knowledge acquired from his situated experience contributed to a central typological interpretation. He also expressed interest in participating in a future live-modelling exercise to allow his recollections to be explored more systematically.

At the time of the survey at the Capuchos Convent, the mine was heavily obstructed by soil erosion and impossible to access. However, an unusual storm event in February 2026, during a month classified as the wettest February in mainland Portugal in 47 years (IPMA 2026), cleared a significant portion of the mine from its accumulated soil, raising the possibility that water could once again flow through parts of the system. Although running water needs to be confirmed deep within the mine, reactivation here could be

possible by either clearing and stabilising the existing mine or extending it through further excavation in emulation of the historic technique itself.

The results also clarified the possible daily relationship of this mine to water inside the convent. Subsurface anomalies identified by GPR on the ground floor suggest the presence of a channel running from the church façade through the refectory, likely supplying water to the kitchen before continuing towards a gutter visible in the retaining wall on a similar alignment. This route would be consistent with the need to move water through the convent while also directing outflow. This also clarified the *de profundis*, a ritual space where the religious community paused to cleanse before mealtime. The remains of a small basin built into the wall, with an exit hole, suggest that water could be refilled and channelled out for this practice. A GPR anomaly extending in the direction of the refectory suggests that this basin may have been connected to the same underground channel identified there. Given the small scale of the convent and the lack of evidence for a cistern within any of the interior spaces or cloisters, it is also possible that water for the washbasins was supplied manually rather than through a permanent hydraulic connection, as other researchers have suggested in similar cases (Jorge 2018, 46). These findings suggest that access to water within the convent was limited and likely depended, at least in part, on manual labour to transport it from the exterior.

The cooling house offers a second possible point of reactivation. It is one of the most significant surviving fragments of the Capuchos Convent's hydraulic landscape, likely built in the seventeenth century and later restored during a 2016 campaign of physical repairs. It is a rare and unusually refined element within the ruins on the site. Its largely regular geometry is interrupted only by localised areas of exposed masonry on the façade. This preserves its association with the European grotto tradition and the Franciscan ideal of cave retreat. This contrasts with its finely frescoed interior, comprising yellow and ochre vegetal motifs of acanthus, flowers, and fruit. Yet, a discovery of a likely connection between it and the washing house approximately ten metres to its south suggests that this structure was not only a space of silent retreat and cooling, but also part of a pragmatic water-supply sequence. This link is an underground conduit found in the GPR survey – likely comparable in typology to one found in the Convent of Vilar de Frades in Braga, where a preserved sixteenth century builder's contract describes a comparable conduit typology (Pereira and Ribeiro 2022, 77).

Once this speculative element was positioned in the model, the relationship between the source in the cooling house and the remains of a faucet inlet in the washing house became clearer, suggesting a credible gravity-fed route between them. The configuration follows a similar typology at the nearby Arrábida Convent where water enters the washing house through a vertical channel, where it could be collected in large, glazed earthenware basins likely used for the friars' ablutions or for kneading bread (de Quintela et al. 1996, 356). At Arrábida, overflow from the washing house passed through the wall into a large exterior tank before continuing through a long floor channel towards another tank in the main vegetable garden. Following this logic, the adjacent tank at Capuchos Convent may also be understood as a comparable storage tank for collecting surplus water and reusing it for irrigation.

A post-survey discussion with the Capuchos Convent's management further reinforced the likelihood that the cooling house structure will be central to the project's decision-making framework in the near future (Figure 6). Water is still visible directly

Figure 6. Cooling house interior, left, and adjacent nineteenth century well, right, with running water visible.

beside it in a nineteenth century well introduced by the O'Neill family to divert the water supply towards the industrial orange farm below the hill. The reactivation of the water source here could potentially lead to two outcomes: first, it could be redirected along the same route used during the O'Neill agricultural phase to feed the masonry storage tanks originally used for orange grove irrigation. From this point, the water could support agricultural activities at the pedagogical farm and provide an emergency resource during periods of regional drought or forest fire. In this case, the continuities between the site's monastic and industrial heritage would work in synergy to expose the centrality of water use in both periods, without prioritising either legacy in a purist way. A second possibility would be to close off the well and instead redirect water back through the cooling house towards the convent where it could again feed the washing house and fish tank. In this way, it would function in a manner comparable to the Arrábida Convent, where similar hydraulic features are not only accessible to visitors but remain actively used to irrigate vegetation of the terraces and citrus tree garden. In this context, several educational possibilities have already been proposed, including medicinal gardens that would allow schoolchildren and adult visitors alike to learn about the region's ongoing ethnobotanical practices (Novais et al. 2004). This selection approach would offer an alternative to conventional heritage preservation tactics that are dependent on the preservation of the entire architectural ruin, instead allowing selected practices and infrastructures to be reactivated in ways that bridge the past under contemporary climate pressures.

7. Conclusion

Virtual reconstruction has most often been used to give visual form to historical research and to structure the data that contribute to 'objective' visions of the past, understood as the reassembly of geometries in their former place and grandeur. In the Capuchos

Convent case study, virtual reconstruction has helped clarify a minor history involving a group of friars' former living relationship to the landscape but has also actively contributed to reshaping the site's heritage identity and trajectories into the future. Rather than impose a single preservation outcome or assume that each relic found must be preserved or restored, new knowledge about the past contributes to decisions about which elements should remain visible, which might be reburied or removed, and which may be allowed to disappear and be laid to rest within the digital record itself.

The reconstruction gave greater clarity to the site's past water sources and daily practices. Resident testimony proved especially important for reinterpreting a mine that had long been obstructed by eroded soil. Even if the mine's restoration is not ultimately pursued, the reconstruction of the water path into the interior of the convent suggests important knowledge about centuries of historic rural life in the region. The convent's former friars likely had a more limited, labour-intensive, and seasonal relationship with water than present-day assumptions might suggest. Such observations are important for future value-shaping discussions because they can help cultivate an appreciation of local water not as an abstract or endlessly expendable resource, but as a finite, unstable, and socially embedded element of the landscape, rather than as a resource extractable from its local, social, cultural, and ecological contexts (Linton 2014).

The reconstruction also clarified potential zones for recuperation, while giving new significance to the cooling house, once thought to be solely a place of retreat. Its connection to the terrain, springs, and surviving hydraulic fragments became clearer through the combination of digital surveying results and comparison with another typologically similar convent. As a result, this area is likely to become a major nexus for future investigation and possibly a key site of renovation. Water currently collected there by circumstance could be more intentionally redirected either towards new activities at the pedagogical farm below or back into the convent through its original pathway, supporting new agricultural programming that echoes practices of the past. In this sense, the project uses reconstruction not to fix a single historical image of the convent, but to open a field of informed possibilities that activate new ways of understanding its living landscape.

In the short term, virtual reconstruction will continue to serve as a foundation for further study. Since the interpretations remain provisional, future work should include hydrological testing and targeted archaeological inspection pits in collaboration with the AMRS' archaeological division. These interventions would allow the most consequential hypotheses generated by the reconstruction to be tested without extensive excavation across the site. The virtual reconstruction has already helped map these points of interest and will, in turn, assist in recording and interpreting the next set of discoveries. As the main sources, channels, storage points, and discharge routes become better understood, the reconstruction may also support future water-flow simulation to test whether parts of the historic system could be reactivated under present conditions.

More broadly, the Capuchos Convent case suggests that virtual reconstruction can produce insight at sites where heritage significance does not fall within the usual designation frameworks. Places such as this, which may appear marginal or lacking in conventional historical significance, can still operate as reservoirs of ecological knowledge when studied as part of a living landscape. In Portugal there are hundreds of small-scale rural convent sites, many of which lie in precarious states across the country's

diverse landscapes. Our approach has shown that the decision to revive such sites should therefore not only be undertaken when they can be restored as architectural relics. Reconstructing their historic water management practices could tap into forgotten modes of dwelling made possible by local hydrogeological conditions that are increasingly relevant under present conditions of drought.

Building on the growing network created through the annual Arrábida Province gatherings, future work could extend virtual reconstruction methods across other convent houses to support their public education missions, conduct comparative typological analysis and even selective reactivation or adaptation. Beyond convents, opportunities also exist at the urban scale, where historic water-management infrastructures such as aqueducts, qanats, weirs, and cisterns are increasingly being revived across Europe, South America, the Middle East, and Asia to offset climate pressures on contemporary systems. Virtual reconstruction could contribute to the identification, interpretation, and evaluation of more such sites while providing a documentary basis for extended hydrological analysis. Such cases would inevitably involve communities of different sizes, varied forms of governance, heritage organisations, and collaborative approaches tailored to local contexts. They may also require different combinations of technologies, including larger scale forms of territorial analysis made possible with tools like GIS. We suggest the importance of these typically overlooked and forgotten sites may instead lie in the new purposes they might hold within the Anthropocene. In this sense, virtual reconstruction can help turn ruins into resources for ecological imagination in consideration of the challenges that future generations may face.

Acknowledgements

We thank Fábio Vicente (AMRS) for his unwavering support throughout this research, including facilitating site access, sharing his expertise, and devoting considerable effort effort organizing the public event and exhibition. We also thank Andreia Sousa, Jones Catarino, and António Santos of Global Geosystems for conducting the ground-penetrating radar survey and guiding us through the data and its interpretation. We are further grateful to Inês Almeida, Francisca Andrade, Rita Ruivaco, Sofia Pereira and Patrícia Linhol for contributing to our understanding of the Capuchos Convent.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was funded by the European Union's Horizon Europe research and innovation programme under the Marie Skłodowska-Curie grant agreement No. [101207766]. Initial funding for this work came from [JSPS KAKENHI] grant number [25K17761] carried out at Tokyo College, The University of Tokyo. This research was also funded in part by the Fundação para a Ciência e a Tecnologia, I.P. (FCT, [UID/6438/2025] https://ror.org/00snfqn58) under Grant [UID/6438/2025] (https://doi.org/10.54499/UID/06438/2025) of the research unit CERIS. For the purpose of Open Access, the author has applied a CC-BY public copyright license to any Author's Accepted Manuscript (AAM) version arising from this submission.

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