Technological Innovation and Multidisciplinary Approaches in Venetian Archaeology

Lily Selthofner, 2023

The rising tides of Venice's acqua alta represent more than just flooding – they reveal the constant dialogue between the city's past and present, between preservation and transformation. As a choreographer and anthropologist, I explored these themes in my multimedia performance "Acqua Alta," investigating how water shapes not only Venice's archaeological and artistic heritage but also its living cultural identity through movement, opera, narrative, and multimedia architectural adaptation.

This paper analyzes three archaeological studies that demonstrate different approaches to understanding Venice's complex built heritage. The articles examine remote sensing techniques for uncovering lost lagoon settlements, forensic investigation of burial practices, and innovative methods for preserving historic buildings against climate change effects. Together, they reveal how interdisciplinary approaches are essential for both understanding Venice's past and protecting its future.

Article 1: How to Find Lost Lagoon Settlements

Remote sensing applications and archaeological research in the Northern Lagoon of Venice: the case of the lost settlement of Constanciacus, is an article that explicates the process of using remote sensing to "…shed new light on early patterns of occupation in the Northern Venetian Lagoon; to explore the communication network between the mainland and the sea; and to examine the evolution of settlements along the commercial routes of the Lagoon through time" (2040). The article more specifically delves into the various remote sensing (RS) methods, including aerial photographs, High Resolution (HR) satellite images, and subsequent data enhancement and processing techniques used to "emphasize the presence of anomalies of the terrain and vegetation that can be related to archaeological structures," specifically in emphasizing features relevant to the archaeological past of the islands (2040, 2045).

Thus, the article's main focus is to explain which RS methods are used, focusing on HR satellite images from Ikonos and Quickbird satellites. To enhance the available RS data, different techniques (with various success rates and further applications) were used and explained, including methods such as pan-sharpening, data fusion, Vegetation Indices (VIs), and Principal Component Analysis (PCA) (2046-2048). Then, the article discusses how the remote sensing data was processed and evaluated alongside GIS (geographic information systems) and archival documents, towards the project's goal of uncovering the archaeological past of the islands.
The project explores *Constanciacus,* a small group of islands in the Northern Venetian lagoons, where presently only two emerged strips remain, the abandoned islands of Sant'Ariano and La Cura. The area has an ancient history spanning the medieval period, towards an eventual

abandonment of the site due to fluctuating water levels creating erosion and gradual sinking (2042). Further, the RS data reveals remnants from an unpublished, unsystematic excavation done in the 1970s (2043). Since then, the site has been completely abandoned (2042). The article also discusses an excavation of the monastery of Sant'Ariano in 2009 – which was discovered via a field-walking survey, and in archival documents is said to have been built around 1160, and abandoned in the 16th century due to rising water levels (2044). Within the site, there are three main environmental contexts, which necessitate different processes to enhance RS data for effective analysis, including "… (i) the areas that are currently emerged in a stable way (which constitute the largest part of the case study islands); (ii) the areas that are temporarily emerged and that are subjected to flooding dependent on the state of the tide or the seasonal changes; and (iii) the shallow lagoon areas surrounding the islands." (2045).
The primary data discussed in this article includes a wide variety of enhancement and processing techniques that emphasize archaeological features in RS data from HR satellite imagery. The satellites Ikonos and Quickbird provide both panchromatic and multispectral images (panchromatic images have a higher spatial resolution and lower spectral resolution, whereas multispectral images have higher spectral resolution and lower spatial resolution). This data is first processed with a wide variety of procedures, including pan-sharpening, data fusion, vegetation indices, and Principal Component Analysis (PCA), to make underground or underwater features more distinguishable (2046-2048). Then, the data is analyzed through photo-interpretation in context with GIS and archival documents.

When it comes to interpreting the collected data, the article emphasizes the necessity to be cautious when using photo-interpretation techniques in a lagoon environment, because environmental factors like salinity, tidewater transgression, and humidity in the soil can create patterns of varied vegetation growth that resemble those sometimes created by underground archaeological features (2045). So, while the potential benefits of using RS are that the islands are abandoned and have almost no elevated structures, photo-interpreters must be familiar with how the environment may influence data outcomes, and the processing methods used to circumvent these issues, to make the most educated analysis of the data (2045).
Contemporary archaeological researchers are likely the audience of this article, who may glean helpful information they can apply to their own projects. This project is relevant to present-day archaeological innovations because *Project Constanciacus* aims to create an archaeological and natural protected area in collaboration with local and regional institutions that will be open to the public (2042). Thus, it is especially important to glean helpful information from RS methods because they are non-invasive, which will not harm the protected flora and fauna. This article provides an example of a contemporary approach to an archaeological project that aims to be minimally invasive – setting an example of how new tools such as RS and GIS methods can make archaeological projects have more ethical impacts and outcomes.

This article may be particularly helpful to archaeologists and interdisciplinary scientists who work with RS in unique environments since the main focus of the article is to discuss how various processing methods have been more or less effective when applied to RS data. The diverse macro environments of the site each present unique challenges to accurately analyzing RS data – meaning that the data processing techniques discussed here could be a helpful tool for other archaeologists faced with sites with similar environmental contexts Further, the article discusses the preliminary benefits, challenges, and analysis results of using GIS methods and RS data to contextualize data from other sources, "…including literature datasets, archive data and historical cartography" (2048). As both RS and GIS methods are interdisciplinary archaeological approaches, innovating constantly to improve analysis potential, this article can help guide other excavations since it provides a thorough preliminary sampling of the various effectiveness of these methods in different contexts.

The scope of this article in discussing RS processing methods is largely based on the caveats, uncertainties, and limitations faced by using RS methods in specific environments. Each processing method also has limitations that render it beneficial only in certain instances. In general, pan-sharpening (most successfully using the

Gram-Schmidt method) is demonstrated (both by the text and visuals in the article) to improve the visibility of underground features. Ikonos multispectral bands used to assess overall vegetation quality and change were enhanced using various Vegetation Indices (VIs) depending on the vegetation coverage type and density. Principal Component Analysis (PCA) is also explained and employed to supplement available information regarding surface distinctions.

As for the future of *Project Constanciacus,* the article states that the current RS data is still being evaluated, and more RS data is being acquired – meaning the data and evaluations offered in the conclusion section are still preliminary (2046, 2049). Once the collection and assessment are complete, "…it will be possible to compare the trace visibility as detected through single original data, and visibility after processing, to be able to evaluate techniques and data types useful in this particular environment." However, at this point in the research process, only individual estimates of the effectiveness of various data collection and processing techniques are offered (2049). Primarily, this article serves as an early report of which RS methods have been most helpful in diverse environmental contexts. More widely, the article shows the potential of remote sensing and interpretation methods, including using GIS methods to co-contextualize RS data with other available data, towards painting a picture of the archaeological past – primarily large features – in a site with varied environmental contexts and an ancient history (2049, 2048).

Article 2: Forensic Science, Ancient Disease, and Folklore

Forensic Approach to an Archaeological Casework of "Vampire" Skeletal Remains in Venice: Odontological and Anthropological Prospectus is part of a research project on mass graves located on Nuovo Lazzaretto in Venice, which was home to plague cemeteries, where the bodies of plague victims (believed to be victims of pestilence, or particularly fatal diseases, often referring to the bubonic plague) were buried, during the 16th and 17th centuries (1634). This article dives into the details of one specific corpse, known as ID 6, who was found with a brick in her oral cavity. The research question at hand hopes to use the examination of these skeletal remains to shed light on reasons for a vampire folk belief, and how such a belief may impact burial rites. The content of the article addresses how an interdisciplinary approach to interpreting her remains can offer a more holistic analysis.

More specifically, the site of this burial was found to have two macro-stratigraphic units, one containing "…mixed disjointed skeletal remains with ancient postmortem fragmentation and sharp/blunt breaks; the other unit contained human remains of primary deposition, generally showing no post-burial disturbance." The intact bodies are dated to the 17th-century plague by devotional medals coined on the 1600 Jubilee found within the layer. It is supposed that these corpses were buried by digging into the previous graves (of presently disjointed skeletal remains), perhaps dating back to the previous Venetian plague in 1576 (1635). Within these two stratigraphic units, the body which this article goes into detail about is speculated to be initially laid to rest in the earlier of the two burial periods. The skeleton is "…preserved from half the chest to the skull because it was cut at the humeral diaphysis when later graves were dug (1635).

While traditional archaeological theory was used to analyze the gravesite, anthropological (study of humans) as well as odontological (dentistry) theories and techniques were used, in an interdisciplinary approach, in this documentation and analysis. In all, this article stands as a testament to the wealth of information that can be gleaned using multiple different applied disciplines, particularly disciplines that can be found within the forensic sciences in this case. The archaeological theory used throughout this article begins primarily with taphonomy (the study of how organisms decay) and thanatology (the interdisciplinary, scientific study of death and the losses it brings about, on biological, psychological, and social levels) used at the site of excavation. Through these approaches, researchers deduced that the bones could not have been transferred postmortem (after death) and that the brick was highly unlikely to have collapsed into her oral cavity. Thus, the subsequent question becomes why this brick was intentionally placed, especially considering the danger of infection the sextons faced in handling a plague-stricken corpse (1635).

Furthermore, taphonomy and folkloric studies are used in tandem to discuss potentials as to why her corpse may have been considered vampiric: the shrinking of the skin upon death creates the illusion of growing hair and fingernails. Further archaeological evidence, such as the positioning of her shroud, supports the narrative that the gravediggers placed the brick into her mouth

postmortem. Folkloric studies also rule out the potential that the brick was placed into her mouth at the time of primary deposition since there is no reference for such a rite in this historical and cultural context (1637).

Other theories that provide the bulk of evidence used to support analysis include odontology, which reveals that the age of the corpse is around 61, plus or minus five years. Odontology also reveals that the individuals in the grave didn't suffer from sustained malnutrition or disease in childhood. These demographic factors are used alongside archaeological interpretation to explore the cultural and place-based context of the evidence, and the implications of such burial rites being performed specifically in Venice, to plague corpses.

The research explained in this article relates to contemporary archaeology in a few primary ways. Firstly, the article uses images to contextualize the information discussed in the text portions. Many of these images use standard archaeology techniques, such as offering top view and lateral views of the skull with the brick repositioned in the oral cavity. The brick is also depicted in a standalone image next to a ruler for scale – which is especially important in this case as the asymmetrical nature of the brick cannot be seen in the other two images. These same principles are used in the odontology section of the article, with a supplemental image showing how the X-ray image of the teeth was taken for age estimation, as well as the X-ray image itself.

The depiction of the X-ray method reveals that while this article focuses a lot on odontology, the anticipated audience of this article may be more familiar with the archaeological or anthropological methods discussed than the odontological. The interdisciplinary approach used to interpret the corpse is itself a prevalent contemporary archaeological concept. The specific paradigm of interdisciplinary approaches allows the remains to be understood from different angles, with different ways of knowing adding pieces to the larger picture, allowing for a more holistic interpretation. The specific blend of disciplines used to understand these unique skeletal remains sets an example of how to glean various types of information from a site, and how all of this information can add up in analysis.

The article also engages in contemporary archaeological practice by articulating the discussion of gender in archaeology, particularly in speculating the gender of skeletal remains. In the abstract, the article explains that "Both the skull morphology and the dimensions of the caput omeris suggest the body was a woman." Later in the article, a bit more detail is provided as to the stage of analysis, stating "The individual… currently still under analysis, is at the moment identified as an adult woman by the general skull morphology and caput humeris size" (1635). This article does a good job of conforming to contemporary standard practice of being speculative instead of assumptive, as archaeological techniques for gendering skeletons are limited in scope. Further, the article announces that the individual is still under analysis, so these results are subject to change.

There are uncertainties discussed in the article. The gender of the skeleton, the age of the skeleton upon death, and the reasons for such a unique burial, are all articulated to be speculative assumptions. The article also states that further analysis is still being conducted (1635). The conclusion offers an analysis that, while assumptive, links the story back to the pieces of evidence accumulated that support each aspect of the story (including the timeline of when gravediggers would have inserted the brick into her mouth in relation to the time of her death) (1637). In all, this article offers an understanding of how interdisciplinary forensic science approaches can help us understand vampiric folk beliefs and surrounding rituals, as evidenced by the human remains found at this site.

Article 3: Climate Change Effects Assessment Innovations

A Multidisciplinary Approach for the Vulnerability Assessment of a Venetian Historic Palace: High Water Phenomena and Climate Change Effects, is an article that illustrates the different methodologies implemented to improve the interpretative process of vulnerability assessment, of historic Venetian buildings that are susceptible to damage from climate change. Improved vulnerability assessments open the opportunity for possible restoration interventions. The system of methodologies outlined in this article, and the case study illustrate how all of these methods come together to form a comprehensive picture of building vulnerability, as the effects of climate change continue to progress and evolve (1). Thus, the research question at play is within the scope of how new policies surrounding the restoration and transformation of Venice can be more effectively enacted using the interdisciplinary approach the article discusses in detail (4).

The region being discussed is Venice, with data spanning as far back as the mid-1800s being discussed in the article, as well as future predictions based on these longstanding data sets. The temporal focus remains on how present-day conservationists can use the outlined methods to assess the susceptibility of historic buildings to damage from climate change, towards the end of both restoration and transformation (4). The specific case study that the article uses as an example of how these methodologies interplay is the Palazzo Malipiero, a large building in Campo San Samuele in the *sestiere* of San Marco, facing the Grand Canal (9).

The caveats and uncertainties are plenty when it comes to climate change-related research, as future predictions are never certain, and severe weather events could drastically impact current conservation efforts at any moment. Further, the issue of climate change is incredibly complex, particularly in a place with an intimate relationship to water, high amounts of tourism, and a plethora of historic buildings, as in the case of Venice (2).

The work discussed in this article is highly relevant to both present-day archaeology, and to public welfare more generally – as the effects of climate change continue to become more severe

throughout the world. Efforts to combat climate change in Venice have particularly direct impacts on the quality of life of citizens, as *aqua alta* (high tides) becomes an increasingly frequent occurrence that destroys buildings, and makes daily living/transportation difficult. Alongside these seasonal issues, climate change also increases extreme weather effects, which can unexpectedly cause heavy damage to historic sites. The Venetian economy is reliant on tourism, while overpopulation can devastate the city at the same time, creating a unique paradox that triangulates the effects of climate change. Due to the unique climate-change-related issues Venice faces, some interdisciplinary archaeological techniques discussed in this article are more relevant to Venice specifically, while others (including the more broad policies enacted in Italy, which these methods help fulfill) subsequently set a great example for other areas to address the climate-induced material damage. For example, building preservation faces unique issues of combatting wet-dry cycles and rapid salt crystallization due to evaporation, which is unique to the lagoon system of Venice (3). However, innovative and efficient approaches to building vulnerability assessment, using local customs, materials, knowledge, and history, alongside quantitative assessment, set a great example for how other communities with historic buildings may craft their uniquely helpful multi-disciplinary approaches to conservation.

This article brings a particular focus to archaeological theory. In particular, Venice calls for a unique approach to conservation that has resulted in new policies based on "…heritage resilience combining preservation with transformation" (4). The research in this article is in line with policies within *Piano Nazionale di adattamento ai Cambiamenti Climatici* (National Plan of Adaptation to Climate Change), which contend with ideas of "safe conservation" with both natural disasters (which can cause sudden and severe building destruction), and climate change, and call for a unique assessment of vulnerability (4). Two main concerns are storms and tides. Recently, low-intensity rainfall has been decreasing while intense storm events have been increasing, and high tide frequency has been increasing as well (5).

To combat these specific climate effects, the multi-disciplinary approach specifically cultivated for addressing Venetian climate change focuses on a close examination of ground-floor building conditions concerning their elevation above mean sea level, also considering historical transformations (7). Historical Analysis (HA) references historical data to plan artifact surveys, which take into consideration prior amendments to buildings (for example, *cadenas,* or tightly lined brick underneath buildings up until the mean sea level at the time of construction, are often exceeded, and thus buildings have been adjusted to accommodate higher daily tide levels) (7). HA also considers data already collected on how specific materials used in historic buildings are impacted by the specific climate and weather conditions of Venice, as a coastal place.

Another methodology used in this article is the Geometrical Survey (GS), which helps track the spatial layout of Venice concerning tidal destruction. Stratigraphic analysis (SA) applies the principles of stratigraphy to buildings as a survey technique using the Masonry Technique Form

– which is a visual investigation of the mechanical characteristics of building material (8). Material-Constructive Survey (MCS) is used to identify materials used at the time of construction and how they transform throughout time. Lastly, Crack Pattern and Degradation Analysis (CPDA) follows building degradation (8). In conversation with one another, these tools can help highlight inefficient construction or human intervention, towards overall vulnerability assessments. These methods include both qualitative and quantitative measurements, that help create a wider standard for conservation procedures in Venice specifically (8).

This article references outside research on Venice and climate change quite frequently, as well as data on climate change more generally (using data from the IPCC, for example). This is helpful both to contextualize the theory and methods offered within the article and to paint a broader picture of the current discourse and action. More specifically, this article often uses data documenting weather and climate patterns, which span far back into Venice's history, to offer predictions for future climate change effects (5).

The article also dives into a specific case study to portray the effectiveness and procedures of the interdisciplinary approaches outlined in the procedure for Venetian building conservation. The data that was collected through the various methods of conservation analysis are thoroughly explicated, using visuals both of the case study itself and of infographics that can be applied (both indirectly and by literally overlapping photographs) to other historic Venetian buildings (16, 17). Other data sets are available to contextualize the analysis of the data collected on Palazzo Malipiero, the case study building, such as architectural elements mapping, and figures that detail future predictions (13, 21).

The scope of the article offers fewer interpretations of the data at hand and focuses instead on how these specific methods can be used in replicable ways. The discussions and conclusions section of the article emphasizes that all of these methods effectively improve the interpretative model towards a more uniform mode of vulnerability assessment (22).

In all, this article offers methods that are discussed in a way that is meant to be helpful for future researchers and conservationists, as well as present ones. It is expected that these methods both operate as a new standard and have room to innovate, as the scope of multi-disciplinary approaches often offers. The policies and methods are also specifically in conversation with MOSE – the in-ocean collapsible dam system which creates a barrier protecting Venice when tides reach high enough levels. This project was only recently enacted in 2020, even though it was proposed in 1987 and has been in progress since 2003 (3). Thus, the methods offered are especially effective in setting a precedent on how to measure any potential improvements, or minimizations of climate change-related building destruction, resulting from MOSE. Simultaneously, the multidisciplinary approach offered engages with the documented and

structural history of Venice and contends with its future, creating one piece of a comprehensive plan to protect this UNESCO World Heritage site, located in a coastal area (2).

Conclusion:

The three studies demonstrate how Venice's unique environmental challenges require innovative archaeological approaches. Remote sensing technology, forensic analysis, and architectural preservation techniques each offer distinct yet complementary methods for understanding the city's heritage. As climate change threatens Venice's historic sites, these interdisciplinary approaches provide crucial tools for both documenting the past and protecting it, setting a model for heritage preservation in vulnerable coastal sites worldwide.

Works Discussed: Citation

Berto, L.; Talledo, D.A.; Bruschi, G.; Zamboni, I.; Lazzarini, E.; Zofrea, C.; Faccio, P.; Saetta, A. A Multidisciplinary Approach for the Vulnerability Assessment of a Venetian Historic Palace: High Water Phenomena and Climate Change Effects. Buildings 2022, 12, 431. https://doi.org/10.3390/ buildings12040431

Nuzzolese, Emilio, and Matteo Borrini. "Forensic Approach to an Archaeological Casework of "Vampire" Skeletal Remains in Venice: Odontological and Anthropological Prospectus*." *Journal of Forensic Sciences*, vol. 55, no. 6, 12 Aug. 2010, pp. 1634–1637, https://doi.org/10.1111/j.1556-4029.2010.01525.x. Accessed 12 Nov. 2019.

Traviglia, A., and D. Cottica. "Remote Sensing Applications and Archaeological Research in the Northern Lagoon of Venice: The Case of the Lost Settlement of Constanciacus." *Journal of Archaeological Science*, vol. 38, no. 9, Sept. 2011, pp. 2040–2050, https://doi.org/10.1016/j.jas.2010.10.024. Accessed 9 May 2023.