

Analysing Urban Dynamics in Historic Settlements Using a Geo-Spatial Infrastructure. The *Venice's Nissology* project

Ludovica Galeazzo

Introduction: Reframing Venice as an archipelago

Venice's Nissology (VeNiss) is a geo-spatial semantic infrastructure that, as a sort of historical Google maps, enables a journey through time and space to discover and visualise the layered histories of the over sixty islands of varying size that form the Venetian lagoon. It tells a story of half a millennium, starting from the sixteenth century, the very moment in which the city began consciously to structure its lagoon territory. Allowing users to move across the decades and the different corners of this unique – now dilapidated – environment, the digital platform brings the once densely-populated settlements to life in their physical appearance as well as in their social arrangement. Through digital 2D and 3D reconstructions, interwoven with pertinent archival and iconographic sources, actors, and events, the web application infrastructure helps uncover the significance of Venice's archipelago and retrieve its history as a physical site but, above all, as an integrated system of calculated politic, socio-economic, and cultural interactions.

The project VeNiss has been awarded an ERC Starting Grant from the European Research Council for the next five years (2023–27) and is based at the University of Padua, in the Department of Cultural Heritage, in partnership with I Tatti, The Harvard University Center for Italian Renaissance Studies.¹ Thanks to the generous ERC support, a sizable interdisciplinary team of art and architectural historians, socio-economic and literary scholars, as well as experts on 3D modelling and semantic web is working to develop a pioneering methodology for grasping the urban dynamics of Venice's cluster of islands, one of the most enduring and contradictory of human-made settlements.

Archipelagos are, generally speaking, fairly peculiar and intriguing sites that lend themselves to opposing binary categorisations: isolated but connected, self-sufficient but dependent, bounded but porous, resistant to innovation but prone to cultural change.² The past few decades have registered an exponential rise in what are normally called 'island studies', which have subverted tropes commonly associated with these settlements such as those of isolation, dependency, and

¹ The project *Venice's Nissology. Reframing the Lagoon City as an Archipelago: A Model for Spatial and Temporal Urban Analysis (16th-21st centuries)* has been funded with a five-year grant by the European Research Council (ERC-2021-StG, n. 101040474).

² Godfrey Baldacchino, 'Islands, Island Studies, Island Studies Journal', *Island Studies Journal*, 1:1, 2006, 3-18.

backwardness.³ However, VeNiss intends to deepen and expand this understanding by framing Venice's domestic archipelago first and foremost as a complex set of human, material, spatial, and physical relationships. By looking at the branched lagoon city and the constant interlinking exchange with its *aquascape*, the project allows for a radical revision of the Venetian fringes as integral contributors to the history of the ancient metropolis. This approach also undermines the supposed contrast too often posited between vitality and stagnation inherent in the opposition of centres and margins. By displaying the driving and supporting functions of the lagoon islands, the platform aims to testify to the cardinal role of the archipelago in the overall processes of Venice-making, while demonstrating that the city would not have reached its economic, social, and cultural prosperity without its aquatic periphery.

The fragmentation of a composite environment



Figure 1 Islands of the lagoon of Venice then and now.

Over the centuries, the long-standing prosperity of the capital has induced a Venice-centric vision that, while determining its historiographical fortune, cast a pall over the dispersed water territory and its crucial function in moulding the city and its society. Exposing this 'grey area' hitherto neglected requires a shift in perspective from the idea of Venice as the monolithic capital that dominated the Mediterranean

³ For a brief overview, see Godfrey Baldacchino, *The Routledge International Handbook of Island Studies: A World of Islands*, Milton: Routledge, 2018 and Michelle Stephens and Yolanda Martínez-San Miguel, *Contemporary Archipelagic Thinking: Towards New Comparative Methodologies and Disciplinary Formations*, London: Rowman & Littlefield Publishers, 2020.

Sea to the polycentric settlement built on, and continually nourished by, a chain of interdependent lagoon islands.

This is a condition that is no longer visibly extant today, because most of these islets lie abandoned and entirely detached from the city centre (fig. 1). The origins of the gradual dissolution of the bond between Venice and its liquid margins lie in the aftermath of the fall of the Republic in 1797. This event had profound consequences not only for the islands' geography – as many sites were razed to the ground or remodelled – but also for the perception of the articulated network of relationships that sustained the lagoon's life.⁴ The suppression of ecclesiastical orders by Napoleon and the islands' conversion to accommodate warehouses, military hospitals and barracks led to radical change. Places that, in spite of their peripheral position, had nevertheless remained open to cultural relations suddenly became inaccessible spaces and the tight relationship of the city to its fringes was abruptly interrupted.

In contrast to today, this 'thinking within the archipelago' was very well understood in the early modern period. For Venetians of that time, the urban centre, its surrounding small territories, and the brackish waters were actually a robust and organic space that resisted the limiting notion of a stark assemblage of interconnected islands. The lagoon represented the environment where the mingling of human action and natural ecosystem was enduring and profound. Occupying a hybrid position between Venice and the mainland, the islands have always been strongly connected to the urban fabric, even following the Republic's territorial and maritime expansion. More than an ornamental frame, these spaces functioned as capillary structures for the political, socio-economic, and cultural interests of the city (fig. 2).



Figure 2 Huegues de Comminelles, *Venetia* from Claudius Ptolomaeus, *Cosmographia*, Florence, 1470 (Paris, Bibliothèque nationale de France, ms. Latino 4802, fol. 132).

⁴ See the edited volume: Giovanni Caniato, Eugenio Turri, and Michele Zanetti, eds, *La laguna di Venezia*, Verona: Cierre 1995.

From the eleventh century, the archipelago hosted ecclesiastical communities of an impressive array of different orders, affording scholars a unique kaleidoscope of religious cultures and practices: the Benedictine, Franciscan, Dominican, Carthusian, Augustinian orders, to name but a few.⁵ While being forerunners in early landfilling operations, these congregations also played major roles as active patrons of pioneering works of art and architecture which, through their agency, travelled far outside the lagoon's contours.⁶ Free from the stricter constraints of the city centre, the islands turned out to be fertile ground for experimenting with new designs. These spiritual places also played an active role as connective nodes in a synergistic network called upon to sustain the social and economic life of Venice's urban framework. First of all, they helped maintain its food supply. In a city deprived of agricultural territory, the lagoon monasteries and convents fulfilled Venice's imperative need for food by producing, processing, and providing foodstuffs for their religious houses and the city.⁷ In addition, they functioned as centres for housing infrastructures that served the daily needs of the larger Venetian community, such as public shelters for boats, customs houses, gunpowder magazines, as well as accommodation for travellers. The distribution of these communal places created a strong social network within the lagoon, in which religious complexes, even those under strict *clausura*, were regularly called upon to open their spaces to passengers in transit across the lagoon. Public guest houses and inns erected by Venetian authorities gave refuge to sailors, fishermen, and merchants during storms and were administered by the monastic communities themselves.⁸

If the allegedly 'impregnable' water walls of the lagoon offered a natural protection against aggressors, over the centuries human hands systematically added

⁵ A few contributions on medieval female and Benedictine monasticism in the lagoon have widened the investigation of the water-bound religious communities. See: Maurizia Vecchi, *Chiese e monasteri medioevali scomparsi della laguna superiore di Venezia. Ricerche storico-archeologiche*, Roma: L'Erma di Bretschneider, 1983; Gabriele Mazzucco, ed., *Monasteri benedettini nella laguna veneziana*, exhibition catalogue (Venice, Biblioteca Nazionale Marciana), Venezia: Arsenale 1983 and the more recent Cecilia Moine, *Chiostrì tra le acque. I monasteri femminili della Laguna nord di Venezia nel Basso Medioevo*, Borgo S. Lorenzo: All'insegna del Giglio, 2013 and Silvia Carraro, *La laguna delle donne: il monachesimo femminile a Venezia tra IX e XIV secolo*, Pisa: University Press, 2015. Nonetheless, these publications offer only a partial view of the area's profound social, political, and economic significance.

⁶ Cfr. Élisabeth Crouzet-Pavan, "Sopra le acque salse". *Espaces, pouvoir et société à Venise à la fin du Moyen Âge*, Roma: Istituto storico italiano per il Medio Evo, 1992.

⁷ On food and water supply in Venice see Donatella Calabi and Ludovica Galeazzo, eds, *Acqua e cibo a Venezia. Storie della laguna e della città*, Venezia: Marsilio, 2015.

⁸ See Ludovica Galeazzo, 'Autorità ecclesiastica e civile nell'iconografia dell'arcipelago veneziano tra XVI e XVII secolo' *In_Bo, Dominio del Sacro. Immagine, cartografia, conoscenza della città dopo il Concilio di Trento*, 12: 16, 2021, 186-97 and Ludovica Galeazzo, 'The Venetian Archipelago: Society, Everyday Life, and Cultural Exchange in the Early Modern Lagoon' in Elena Svalduz, ed., *Market Spaces, Production Sites, and Sound Landscape of European Cities: From History to Regeneration*, Padova: Padova University Press 2022, 69-78.

fortified outposts to reinforce the lagoon's defensive belt. A series of military structures – forts, garrisons, and watchtowers – were located close by strategic sites, in particular along the historical five inlets.⁹ Likewise, lagoon settlements proved to be crucial for the public health apparatus of the city. From the beginning of the fifteenth century, two monastic islands – the Lazzaretto Vecchio and Nuovo – were transformed into permanent citadels of healthcare for fighting pestilences.¹⁰ However, the pioneering Venetian healthcare program was certainly more far-reaching. Like contemporary emergency plans, the whole archipelago was repeatedly deployed as an overflow site in times of crisis, and a selection of additional islands were converted to function as supplementary shelters.¹¹

The aqueous environment was also the stage set on which the Republic promoted the glory and power of the State through ostentatious ceremonies and events contested on water. Official welcomes and pageantry were integral to Venice's calculated statecraft, which heavily relied on the lagoon.¹² Ingeniously staged parades, marine fêtes, competitive regattas, and musical dinners on the water offered extravagant pleasures to patricians, citizens and spectators alike. Chronicles, travellers' memoirs, and prints vividly record the pageantry laid out for popes, emperors, kings, cardinals, and ambassadors visiting the city. Islands were pressed into service as intermediate stately reception areas and became the frontline contact zones of European exchanges. Each guest's solemn entry was personally tailored. Based on their nationality, foreign guests were brought to specific islands for the official accreditation before leaving for their allotted residence in the city centre.¹³

All these actions disclose the considerable dynamism and flexibility of the lagoon settlements that, like pieces on a skilled player's chessboard, at various moments addressed the different needs of the city and contributed to its processes of development.

Visualising the role of Venice's archipelago across space and time

The integration of the diverse islands into a single archipelagic network was the result of a lengthy and complex socio-political as well as conceptual construction process developed by the Republic over the centuries, encapsulating the city's rising

⁹ Mauro Marzo, 'A Theme, a Place: Defense of the Lagoon' in Mauro Marzo, *Fortified Places in the Venetian Lagoon*, Parma: Festival architettura 2012, 31-75.

¹⁰ See *Venezia e la peste: 1348-1797*, Venezia: Marsilio, 1979 and Jane L. Stevens Crawshaw, *Plague Hospitals. Public Health for the City in Early Modern Venice*, Farnham: Ashgate, 2012.

¹¹ Ludovica Galeazzo, 'Oltre i Lazzaretti: le isole minori della laguna veneziana come cordone sanitario d'emergenza in età moderna' in Marco Morandotti and Massimiliano Savorra, eds, *La città e la cura. Spazi, istituzioni, strategie, memoria / The City and Healthcare. Spaces, Institutions, Strategies, Memory*, Torino: Aisu International 2021, 47-60.

¹² Cfr. Patricia Fortini Brown, 'Measured Friendship, Calculated Pomp: The Ceremonial Welcomes of the Venetian Republic' in Barbara Wisch and Susan Scott Munshower, eds, "*All the World's a Stage ...*". *Art and Pageantry in the Renaissance and Baroque*, Part I, *Triumphal Celebrations and the Rituals of Statecraft*, University Park (PA): The Pennsylvania State University 1990, 136-86.

¹³ Stefanie Cossalter, 'Dai porti alle isole. Cerimoniali di accoglienza nella Serenissima' in Sabine Meine, ed., *Spazi veneziani. Topografie culturali di una città*, Roma: Viella, 2014 125-48.

consciousness of its geographically and functionally granular identity. VeNiss aims to reconstruct this broader socio and geographical inclusiveness of the Venetian lagoon by mapping, quantifying, and visualising the islands' supporting functions in an interactive 3D map of the archipelago accessible to both scholars and the general public through a web application.

Within this platform, the long-term relationships between the city and its margins are investigated through four scales of analysis. The first relates to the lagoon's morphology over time as the infrastructure allows for the digital reconstruction of the ancient urban and architectural appearance of the archipelago and its transformation over the past five centuries. On a second level, VeNiss investigates the islands' role in the governance of the capital by mapping the functional use of the lagoon spaces, the regulation of private and public areas, and the allocation of state infrastructure within the peripheral settlements in a long-term perspective. In addition, from a historical point of view, the project reframes the islands as mediators in major Venetian and European events. By exploiting the capacities of computational tools it re-evaluates Venice's principal socio-economic events, political actions, and exchanges through the lens of the archipelago to demonstrate how the lagoon shared or mitigated the impact of religious turmoil, health emergencies, and international crises that permeated the history of Venice. Finally, the infrastructure retrieves islands also as places for innovative forms of art and architecture by comparing, through 2D and 3D models, monastic buildings of different orders and exploring their agency in the circulation of architectural and artistic solutions between the aquatic centres, the city, and the Italian Peninsula. This comparative dimension, supported by computational analyses, helps determine to what extent architectural solutions hinged on religious orders' decisions or, on the contrary, on the peculiar nature of the lagoon site.

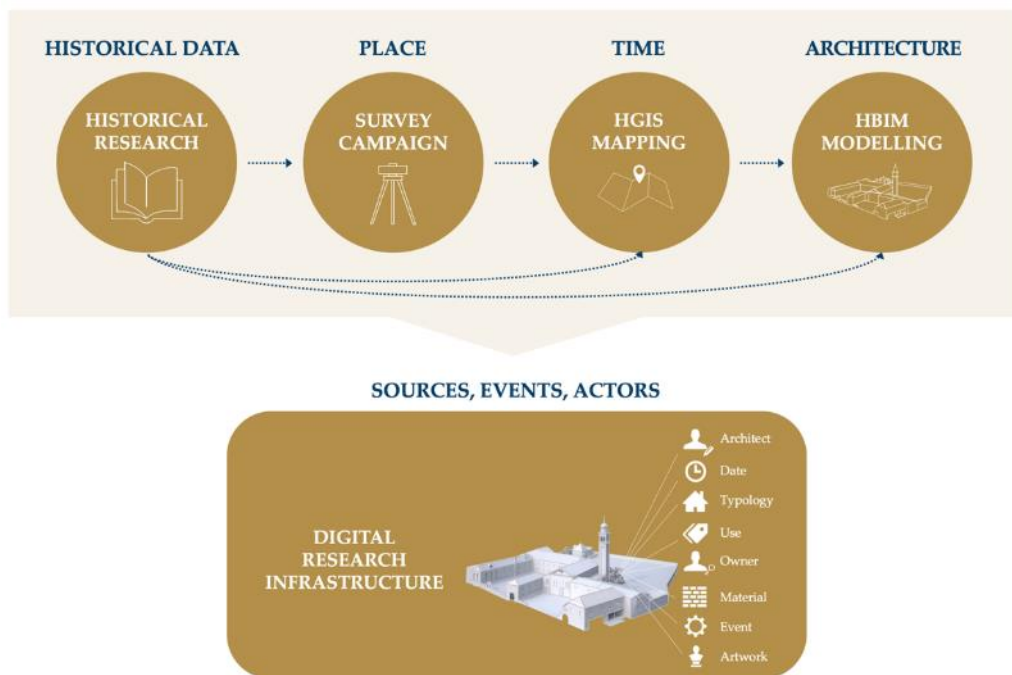


Figure 3 VeNiss analytical and operational methodology.

The development of the project requires different method-oriented steps, which reflect both the twofold nature of this research – historical and digital – and the variegated composition of its inquiries (fig. 3). In the first place, the operational approach includes the collection of the historical data – bibliographic, iconographic, and archival sources – that provide information about the lagoon settlements and their related events and actors. These are disseminated across a profuse number of heterogeneous primary and secondary sources that deal with entirely different aspects of urban life, ranging from urban descriptions, reports, rental contracts, and notarial deeds to maps and drawings, paintings and, for more recent times, accurate surveys, aerial photographs, and orthophotos.¹⁴ The cross-referencing of these protean documents is the key component in establishing a powerful dataset for reconstructing digitally – with the assistance of mapping and computational tools – 2D and 3D models reproducing the physical configuration of settlements and architecture that have been entirely altered or are no longer in place. This extensive documentation of sources, in myriad formats, offers scholars a wide series of historical data that essentially can be classified into four main categories or *entities* that are collected and displayed in the research infrastructure as Linked Open Data: the primary and secondary sources themselves, the events occurred, the actors involved in these sequences of actions, and finally the places that are referenced in these documents.

As regards ‘places’, in many cases the islands’ shapes have been so altered over the centuries that it is difficult to identify any points of reference that can be associated with historical cartographic sources. Therefore, to acquire the present-day geographical dataset of the lagoon, researchers require a topographic and laser scanner survey to investigate ancient remains and semi-submerged ruins. Wall fragments, substructure, and foundations of ancient buildings represent the physical pieces of evidence and the project’s starting point, the first *tesserae* of a mosaic that inevitably requires a series of elaborations, first and foremost detailed measurements. Tracing and surveying still-extant architectural structures is the indispensable basis for creating reference points through which to georeference ancient maps and bring historical material to life.

In order to digitally reconstruct the islands’ former configuration as well as their urban transformation over time, the project employs a historical geographic information system (HGIS)¹⁵ as this tool is capable of integrating and displaying spatial information derived from cartography and combining it with quantitative and qualitative data.¹⁶ Among the many cartographic and iconographical sources

¹⁴ On the historical sources for reconstructing the history of the Venetian lagoon see Ludovica Galeazzo, ‘Venice, the Lagoon, and Digital Cultural Heritage: Mapping the Islands in the Early Modern Period’ in Marco Pretelli, Rosa Tamborrino and Ines Tolic, *The Global City. The urban condition as a pervasive phenomenon*, Torino: Aisu International 2020, 371-81.

¹⁵ The team employs the open-source software QGIS as it has native support for geospatial databases using PostgreSQL through the PostGIS extensions that allow for direct geospatial manipulation and queries within the database itself.

¹⁶ A still valuable overview of HGIS systems is Anne K. Knowles and Amy Hillier, eds, *Placing History: How Maps, Spatial Data and GIS are Changing Historical Scholarship*, Redlands:

amassed, only maps and drawings that can be georeferenced are selected, re-ordered chronologically, georeferenced, and digitised working backwards in time – from present-day cartography to sixteenth-century drawings – with the aims of tracing each building's change (fig. 4).

Building on these bi-dimensional reconstructions, and thanks to extensive extant historical documentation, the project produces the elevations of selected islands comprising their transformations over time. The technique of Building Information Modelling for historical representation (HBIM) is deployed, because this is a system that allows the construction of interoperable and semantically enriched 3D models.¹⁷ These outcomes not only visualise the buildings' geometry in

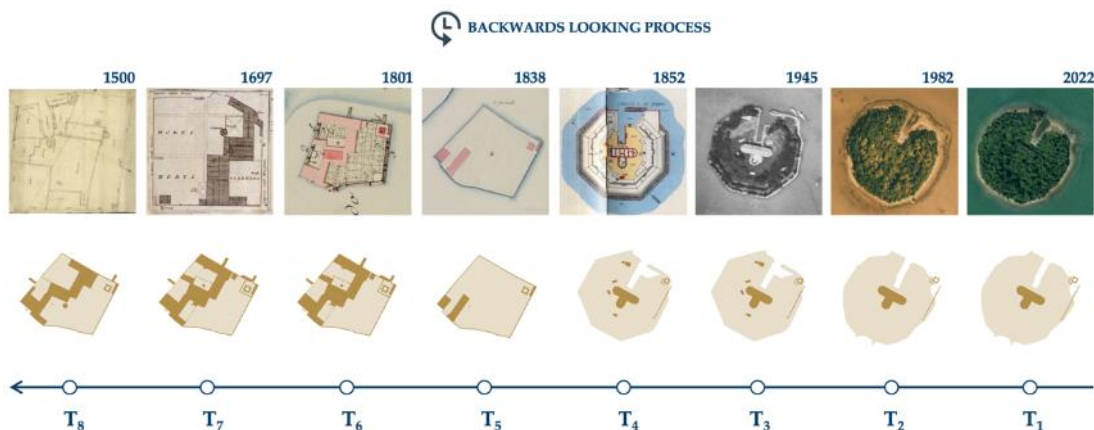


Figure 4 The HGIS methodological approach.

three dimensions, but they also embed metadata that encompass all possible information on the islands' buildings. Representing real places, three-dimensional models cannot just be empty vessels – whatever their level of detail and realism – and they need to reproduce urban space as a social artefact of people's activities played out in specific geographical and temporal circumstances. For this reason, by exploiting the capacities of HBIMs, the project implements virtual reconstructions with time-based data interpretable by a computer. These 3D interoperable models investigate each building's function, typology, material, architect, owner, spatial relationships, and dating parameters as well as information on works of art, objects, patrons, artists, and audience. In doing so, they convey the history of the edifices' construction and transformation, their function and use over time, and their relationships with a given context. The integrated digital reconstructions provide information for critical analyses of artistic solutions and architectural typologies as

ESRI Press 2008. In addition see Ian N. Gregory and Alistair Geddes, eds, *Toward Spatial Humanities: Historical GIS and Spatial History. The Spatial Humanities*, Bloomington: Indiana University Press, 2014.

¹⁷ See Xiucheng Yang, Mathieu Koehl, Pierre Grussenmeyer, and H el ene Macher, 'Complementarity of Historic Building Information Modelling and Geographic Information Systems', *ISPRS – International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, XLI: B5, 2016, 437-43.

well as change in jurisdictions and spatial activities, and the interaction between different actors broadly involved in the place-making practices.

All historical sources, architectural evidence, research findings, georeferenced maps, and digital bi- or two-dimensional models are finally integrated and rendered navigable as open datasets in a robust and flexible platform, a sort of 'flexible canvas' that allows for their seamless interconnection while preserving their contextual meaning in time and space. This appears as an online, geospatial and time-based research infrastructure that enables the intersection of all historical entities to express the urban processes that shaped the city. These are displayed as either textual metadata or geospatial features (spatial descriptions of built structures) on a time-based map interface in the form of Linked Open Data (LOD), thus enabling their free access and linking to external vocabularies.¹⁸ Intended for researchers and the wider public alike, the web application brings together previously fragmented research and helps discover the constellation of actors, events, ideas, and practices of the historic lagoon's urban landscape.

Navigating the lagoon through a map and historical features



Figure 5 VeNiss main page with the map and navigator.

¹⁸ On semantic web technologies see Aba-Sah Dadzie and Matthew Rowe, 'Approaches to Visualising Linked Data: A Survey', *Semantic Web*, 2: 2, 2011, 89-124 and Weiming Huang and Lars Harrie, 'Towards Knowledge-Based Geovisualisation Using Semantic Web Technologies: A Knowledge Representation', *International Journal of Digital Earth* 13: 9, 2020, 976-97.

The digital infrastructure comes as a sort of invitation to join a virtual 'stroll' through place and time. It was resolved to adopt a quite intuitive user interface, which appears to non-technical users as being similar to common web mapping services (fig. 5). The core of the platform is centred around a single map with which the user can interact to visualise places that have widely changed or no longer exist. The page displays a current base map with, in red, overlaid historical features – namely, the shapes describing the former islands or buildings – that represent the ancient landscapes. These digital reconstructions are superimposed on the base map and constrained by both a timeline at the bottom of the page and the bounding box, namely the zoom level. A time slider allows users to select a specific point in time, which then displays the historical features that have a timespan that traverses this year thus bringing the ancient islands to life in their former physical configuration.

In addition, the infrastructure allows users to navigate between the various sources that served as the foundation of the research. Most of the time these data end up just being buried in footnotes, in this case, all entities related to features displayed on the map at a given time are listed on this sidebar, the navigator. These include archival and iconographic sources, bibliographic items, but also actors, events, and places that, at any time, can be filtered by type thus allowing users to consult only documents of interest for their specific investigation. Users can navigate freely within the map and zoom to any site or building. Hovering over a specific feature, this becomes highlighted on the map and entry-level information is displayed. Users can also go in depth by accessing directly the original sources and its associated metadata (fig. 6).

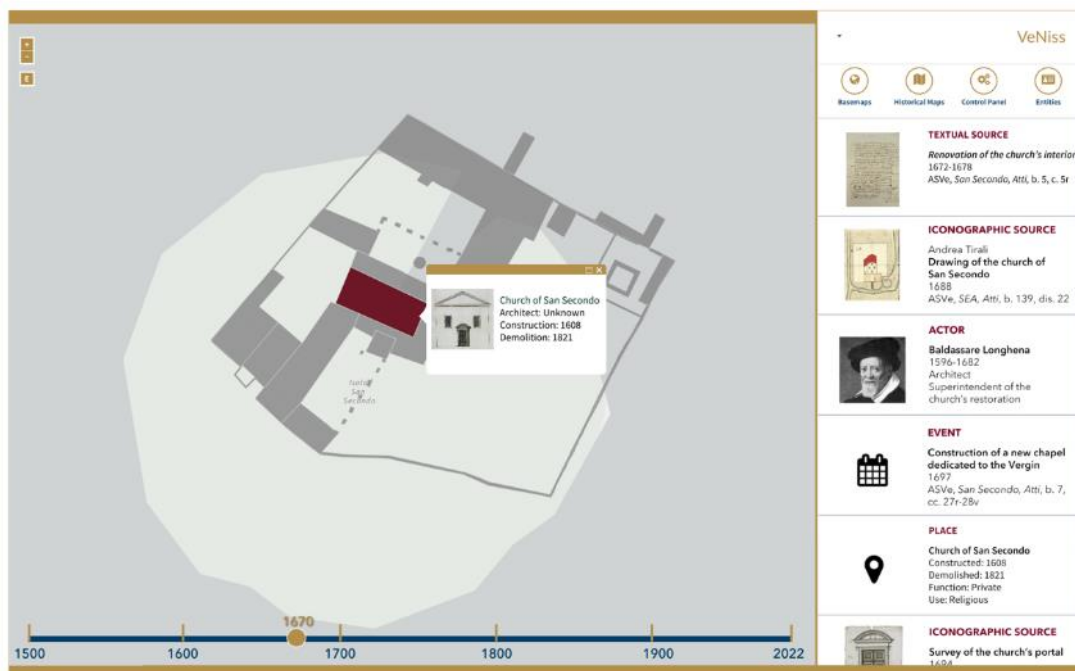


Figure 6 Navigator overlay with specific information of the selected entity.

Alternatively, a set of *narratives* allows the investigation of peculiar aspects of the lagoon such as the city's food supply, public health care, religious communities or events organised on the islands. These are research stories that have a predefined set of queries: selecting a narrative, users are taken to a map that has an article and they can navigate through the text highlighted features, and their related sources on the right used to augment the narrative (fig. 7).

With the aim of making the process of digital reconstruction visible to the public – and therefore open to discussion – as well as to contextualise historical documents, the infrastructure also enables the overlay of georeferenced images on the base map, which served as the basis for drawing the geospatial features. It also allows users to interact with the map by fine-tuning visualisations themselves to create views that answer their own research questions. By applying a series of queries and manipulating features' colours and labels, scholars can effectively visualise links and relationships between places, events, and actors (fig. 8).

Finally, the infrastructure gives the possibility to navigate through 3D virtual models, moving across time. These models are implemented with metadata in the HBIM environment. Imbued with historical meanings, they convey the history of the buildings' construction and transformation, as well as their features, uses, functions, typologies and the constellation of actors, events, ideas, and practices related to a given context (fig. 9).

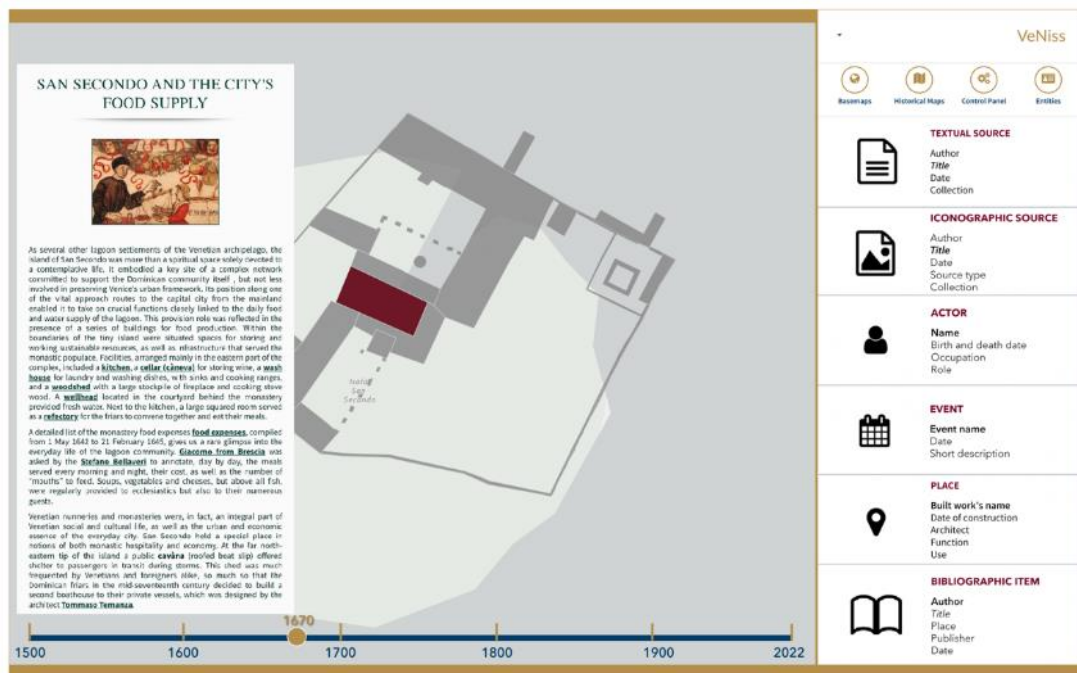


Figure 7 Example of an interactive narrative.

Ludovica Galeazzo Analysing urban dynamics in historic settlements using a geo-spatial infrastructure. The *Venice's Nissology* project



Figure 8 Georeference maps and dynamic feature styling and labelling.

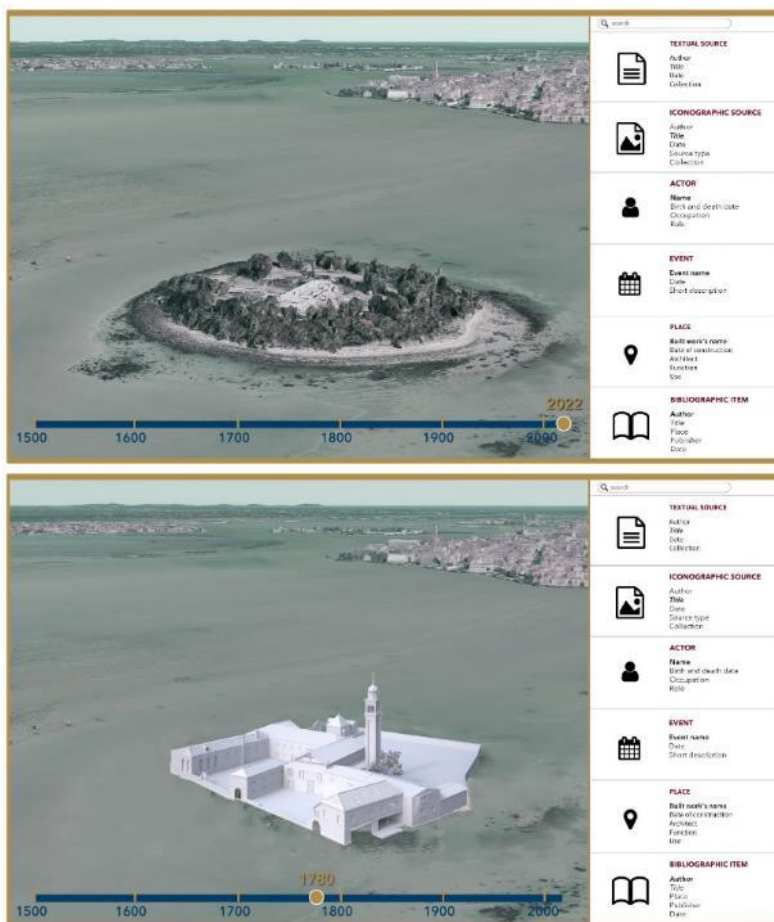


Figure 9 The infrastructure 3D component.

A multi-scale interpretation of urban margins in historic cities

Addressing the tangible and non-tangible elements that compose the lagoon space and its societal structures within a long-term perspective and in relation to the urban fabric, the platform VeNiss aims to reconstruct the far-reaching historical patterns of a deeply singular aquatic landscape. However, this web infrastructure lends itself to be applied globally, either to cities built on a chain of islands or to sprawled urban settlements, thus providing a wide-ranging instrument for any scholar seeking to reconstruct places geospatially throughout time. As the most enduring and remarkable human-made artefacts, cities are the locus of continuous cultural and social processes, the material points of encounter of historical, economic, social, architectural, and artistic practices. Interweaving these dynamics visually within a single and interactive framework, the project reveals the urban space in both its physical and functional dimensions.

This methodology, applied to the specific but rather complex case of the Venetian archipelago, demonstrates how integrated geospatial research can subvert the troublesome tropes traditionally associated with urban margins. While the philological reconstruction of the history of the lagoon islands leads to a radical revision of the function of these aquatic fringes in Venice's framework, this approach more broadly entails a re-evaluation of city's borderlines as sites of incessant synergistic cultural, social, and economic dynamics, thus helping to move the discourse away from the typical schema of 'centre-to-periphery.' In doing so, VeNiss aims to grasp the hidden structure of water urban patterns, bringing to life buried histories of the various pieces shaping the great chessboard that was the Venetian archipelago.

Ludovica Galeazzo is an Associate Professor of architectural history at the Università degli Studi di Padova and the PI of the ERC project *Venice's Nissology* (2023-27). She was a Research Fellow at the Iuav University, a Postdoctoral Associate at Duke University, and a Research Associate at I Tatti (Harvard University). She is a member of the international project *Visualizing Cities* and author of several publications on the relationship between Venetian architecture and digital humanities, including her book *Venezia e i margini urbani. L'insula dei Gesuiti in età moderna*.

ludovica.galeazzo@unipd.it



This work is licensed under a [Creative Commons Attribution-NonCommercial 4.0 International License](https://creativecommons.org/licenses/by-nc/4.0/)