Raising awareness of the cultural, architectural, and perceptive values of historic gardens and related landscapes: panoramic cones and multi-temporal data

Alberta Cazzani, Carlotta Maria Zerbi, Raffaella Brumana & Anna Lobovikov-Katz

ONLINE FIRST

Springer

Springer

ORIGINAL PAPER

Raising awareness of the cultural, architectural, and perceptive values of historic gardens and related landscapes: panoramic cones and multi-temporal data

Alberta Cazzani[1] · Carlotta Maria Zerbi[1,2] · Raffaella Brumana[3] · Anna Lobovikov-Katz[4]

Abstract
Historic gardens and their related landscapes are often experienced only for their social, aesthetic, and environmental resources, yet their cultural, architectural, and perceptive significance is often ignored. The paper demonstrates how historic and educational values of historic gardens and related landscapes can be revealed by combining historic maps, reading perspective cones, and also applying advanced digital and educational methods and techniques. Historical maps, especially military and cadastral maps, associated with historical iconography, can provide us with a lot of information to study historical gardens and also to define conservation and valorization plans that are related to the history of the site: geomatics tools to georeference and co-relate metric and non-metric historical maps provide growing useful outputs, that can be deployed through the use of Virtual Hubs, boosting the availability of content and the accessibility of open data for policy makers, experts, and non-expert members. Moreover, they can also support heritage education programs providing the opportunity to allow to understand the wealth of sites now simplified, in their system, with different functions and with a transformed context. The study of historic gardens involves the analysis of the landscape in its dynamism and complexity, defines tools that make users more aware of the richness of our heritage.

Keywords Historic gardens · Landscape preservation · Conservation plans · Multi-temporal maps · Virtual hubs · Georeferencing · Panoramic views · Virtual museum · Heritage education

Introduction

Often historic gardens, especially if not particularly famous, today in urban context and public property, are considered for their social and environmental role, but much less for their cultural and landscape values. Even if the historical/cultural value is significant, the users do not always recognize it and are not helped to understand it.

This fact constitutes not only a problem of not knowing and promoting important sites of our heritage but it is also a problem in terms of site maintenance and management. In fact, management often appears more attentive to respond to social needs (playgrounds, toilets, furnishings, sports equipment, parking lots, facilities, etc.) than to preserve and enhance the historical, architectural, and landscape components. Even for the botanical heritage, plant safety is considered more important than the botanical value or the architectural and perceptive role of the plant itself.

Innovative multimodal approaches to the study of historic gardens, including an analysis of the landscape in its dynamism and complexity, could help to define new strategies and

✉ Alberta Cazzani
alberta.cazzani@polimi.it

Carlotta Maria Zerbi
c.zerbi@lunigiana15.it

Raffaella Brumana
raffaella.brumana@polimi.it

Anna Lobovikov-Katz
alobovikovk@gmail.com

1 DASTU, Department of Architecture and Urban Studies, Politecnico di Milano, Piazza Leonardo da Vinci 26, 20133 Milan, Italy

2 Studio Lunigiana15, Viale Lunigiana 15, 20125 Milan, Italy

3 DABC, Department of Architecture, Built Environment and Construction Engineering, Politecnico di Milano, Via Ponzio 31, 20133 Milan, Italy

4 Faculty of Architecture and Town Planning, Technion - Israel Institute of Technology, Technion City, Haifa, Israel

🍀 Springer

tools to improve site maintenance and make users more aware of the richness of our heritage.

The present paper discusses resources and methodologies to favour and implement that process. It first describes the role of historical maps, especially military and cadastral maps, with their plentiful information and complex symbolism in revealing the diachronic evolution of gardens and the surrounding landscape, specially stressing the need for cross-comparison and data integration. Secondly, the paper tackles the use of historical information for the conservation and architectural maintenance of the sites, discussing how historical maps associated with historical iconography can provide fundamental bases to define appropriate conservation, enhancement, and promotion plans for historic gardens. The third chapter of the paper introduces geomatics-based methods and projects able to provide technical solutions implementing such interventions. Finally, the fourth part of the work provides examples of geomatic tools and heritage education programs for historic landscape and garden enhancement, highlighting approaches to rediscover perception as a natural way to understand the true richness of historic sites, now almost concealed to the layman, because of simplifications occurred in their design, changes in their functions, and transformations in their context.

Nineteenth century cartography: uncovering the past to reveal the present of our historic gardens

Historical cartography is a fundamental tool to understand the complexity and richness of our historical landscapes. Past graphic resources, in fact, providing first-hand outlooks over their original times, uncover information partially concealed, often modified, or even erased by the passing years, such as toponyms, physical objects, boundaries, owners, and land use. The analysis of the historical cartography, carried out in conjunction with an in-depth reading of bibliographic resources, with iconographic research, the consultation of archival documents, the study of remote (aerial and satellite) images, and the direct recognition through inspections, surveys, and archaeological or diagnostic investigations can shed light upon the evolution of heritage sites, characterizing their persistence and transformations. This comparative, diachronic, and multidisciplinary interpretation of past and current data is a fundamental part in the preparatory phase that will lead to the drafting of a conservation and enhancement project for a historical asset: be it a specific site, a settlement, or a portion of landscape, that analysis makes it possible to identify its characteristic elements upon which to base new interventions. In the specific case of historic gardens, the analysis of the available maps from different eras is fundamental to highlight the historical significance of the sites and the architectural, sculptural, vegetal, and perceptive elements that are still preserved on site. Those elements need in fact to be safeguarded, their value should be enhanced, and they must be promoted and made known to the wider public that might enjoy the garden today.

Complex information about the constitutive elements of the landscape, which can be retrieved from Lombard historical cartography

For the study of the historical landscape in the Lombard area, we have available some nineteenth century map collections of great importance.

The corpus of military maps prepared by the Italian Military Geographical Institute (IGM) starting from 1872, i.e. after the unification of Italy, responds to the need to have a precise and homogeneous picture of the whole national territory, especially for military purposes. The IGM maps constantly increased information detail at every one of their successive editions: after the first survey carried out in the late 1800s and updated in 1914–1915, a second complete survey followed in the 1930s, which was published in 1936–1937. Further updates were made in the 1950s, 1960s, 1970s, and 1980s. Altogether, read in parallel with other coeval cartography, the IGM maps are a rich and fundamental historical document for studying the evolution of Italian landscape, and Lombardy as one of its parts.

Focusing on the North of Italy, some other collections of maps are available, with varying degrees of detail on the land features, property boundaries, and built structures. In particular, the cartography drawn up for the management of taxation, such as the cadastral maps, are interesting sources of information not only about the physical but also the economic aspects of the land. The Teresian, Napoleonic, Austrian or Lombard-Venetian Cadastres, and the Cadastre of the Kingdom of Italy globally span almost two centuries, between 1722 and the end of the nineteenth century, and describe with varying technical means the main elements of the populated landscape.

Coming to the area all around Milan, another extraordinary document from the past is present and can be analyzed: it is named "*Carta Topografica dei Contorni di Milano riconosciuta sul terreno e in parte rilevata e disegnata nella proporzionale scala di 1 a 25.000 dall'I.R. Primo Ingegnere Geografo Pensionato Giovanni Brenna*" (i.e. topographic map of the Milan surroundings recognized on the ground and partially measured and drawn in the proportional scale of 1:25.000 by the I.R. First Engineer Geographer Pensioner Giovanni Brenna), but is commonly known as "Giovanni Brenna's map" (Viganò 1983; Cazzani 2009; Donati 2012).

Collectively, the synchronic and diachronic study of this material is often sufficient to render a clear picture of the evolution of landscape planning, ordering, and management during the past couple of centuries, and to support an analysis of the perceptual aspects of the territory and gardens, including elements to be remembered, re-told, restored, and revived.

## A perceptive language of maps: signs, symbols, and representation

Each stage in the history of land description is characterized by different rules of expression and changing symbolic representations. As we propose to use maps as historical documents to re-propose a perception of the past condition of the land, we must always remember the origin of cartography, i.e. that it was really created for practical purposes, mostly fiscal and military. Hence, oftentimes we cannot take cartographic documents to be completely objective: they do not reflect reality like mirrors, but rather filter, interpret, and transform it, selecting—sometimes even deforming—the represented contents according to the historical moment, the needs of those who commissioned the map, and the skill of the draftsman (Emanueli 2016).

In this sense, they favour the recapturing of a long-gone perception of the land, but for our modern eye, it may not always be easy and immediate to draw useful information from them. The data they contain should be utilized with care and wisdom. In fact, ancient cartography (especially when depicting large areas) often highlighted only some of the main elements of the territory, selected according to the purpose for which the map was prepared, without always showing precise metric or geometric references, and thus upsetting our mental reconstruction of lost features. Maps produced to illustrate water systems are a good example of this: they tended to focus merely on the characteristics of a specific watercourse and its relationships with the surroundings. Who knows what reflected into those waters? On the other hand, the maps utilized for border enforcement between states or neighbouring valleys surely represented all the most important characteristics of a territory (orography, hydrography, indications on the agricultural landscape such as terraces, fields, and types of crops, presence of woods, villages, main buildings), and they often did so with artistically refined painting-like representations, i.e. in a way we would call today pictorial more than technical. How can we now recover an idea of distances and imagine the true dimensions of those same land elements? We also find maps intended to guide pastoral journeys, that is to say visits carried out for either religious purposes (contact with communities and apostolate) or economic affairs of the clergy (control of ecclesiastical goods, tax collection, etc.). In these maps (Fig. 1, Archiepiscopal Curia of Milan collection, n.d), buildings were often represented in a stylized manner, sketching only some peculiar architectural features useful for their recognition. Depending on the drafter, the general level of precision could be fairly high with much added detail even on the orography and geometry of the territory (to help orientation and evaluation of the distances between the places to visit), or rather poor, with buildings interconnected in a free and often very unrealistic way. How to imagine the views that those people would have enjoyed in their travelling?

With more modern maps, these ineffable effects of subjective representation are reduced, as the role of technology gradually becomes predominant in the purposeful effort to describe territory as a geometrically subdivided and economically organized object of interest. More advanced approaches to land measurement and two-dimensional rendering of the landscape push the drafting of maps toward increased objectivity, while the management of complexity becomes the limit of representation. Having to fit a tremendous number of coexisting items of information through a dimensionally flattened and shrunk medium drove the evolution of new symbols and signs, besides forcing choices in the type of data to be transferred to paper. Coming back to the

Fig. 1 Extract from a map prepared for a pastoral visit of San Carlo Borromeo's to Cesano, circa 1566, drawn with sepia ink on hand paper. Source: Archiepiscopal Curia of Milan Archives
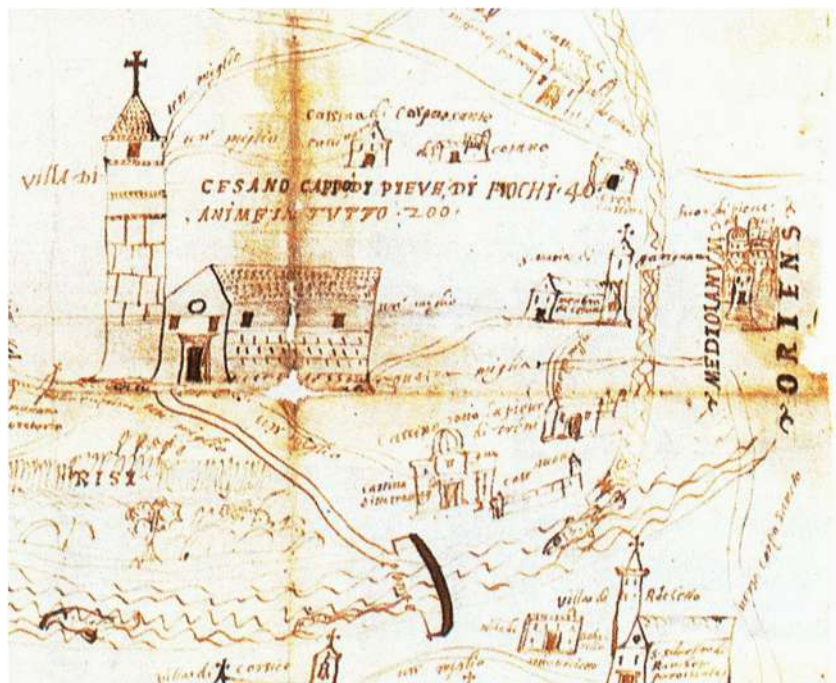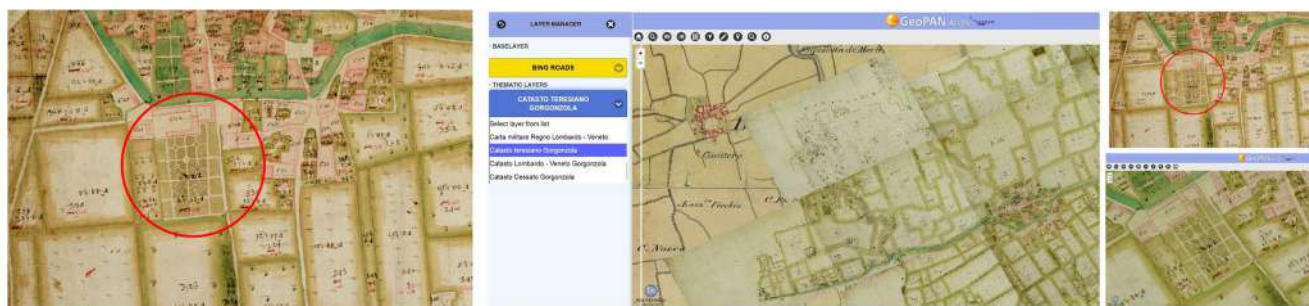
Fig. 2 Extract from the Teresian Cadastre (left), Municipality of Gorgonzola, sheet X, 1721 (source: Milan State Archives), and the GEOPAN APP (centre and right) with the georeferenced layers of the historical cadastres (Courtesy of © POLIMI, dABCLAB - Gicarus). The red circle indicates the area of the current Sola Cabiati Park in Gorgonzola, at the time residence of Duke Gabrio Serbelloni. The map clearly indicates the compositional plan including a large Italian garden with *parterres en broderie*. The site was integrated into the surrounding agricultural landscape, characterized by vegetable gardens (coloured in green) and plots with "*aratorio vitato e moronato*", i.e. arable land with vineyards (represented by a specific sign that symbolizes a pole supporting the vine plant), and numerous mulberry trees (*moroni* in the local dialect—represented with a green dot and often planted in a row along the edges of the various cultivated lots)

description of the Lombard territory, the diverse map collections that we have available convincingly report different aspects of reality by different approaches and symbolic means.

The Teresian Cadastre is generally recognized as a very innovative work, illustrating with particular symbolism the different agricultural crops, also specifically highlighting the gardens (Fig. 2). Started in 1718 at the behest of Emperor Charles VI of Habsburg and carried on by his daughter, the Empress Maria Theresa, it was published between 1722 and 1726 and was partially updated in the 1770s.

As such, it set the scene for the successive cartographic surveys of the 1800s, which however developed with very different characteristics in terms of symbolic representation, i.e. they were graphically simplified, with less detail drawn directly in the map, but richer in toponyms, more abundant, and written out precisely. Among the nineteenth century cadastres of this sort, the Lombard-Venetian Cadastre is particularly interesting for the study of the Lombard landscape and the evolution of its historic gardens. It was drawn up staring from 1853 (after the return of the Austrians to Lombardy) with a geometric-parcellar and non-descriptive approach (Fig. 3). The maps, measured on a scale of 1:2000 for the rural land and 1:1000 for the urban areas, show with great precision the building system, the road, and the irrigation networks, along with many toponymical indications. The territory is divided up into parcels numbered progressively, which refer to the corresponding registers in which are reported—for each parcel number—the owner's name and surname, the cadastral quality and class, the size, and the income. By consulting the registers alongside the map, it is possible to know not only the parcel owners of the time but also the different land uses of the various parts of a complex, adding much to our mental representation of the past reality.

Compared with the coeval cadastral maps, Giovanni Brenna's map is much more precise and detailed in depicting of the landscape, despite being drawn up on a territorial scale. It refers specifically to a broad area surrounding the city of Milan, including the Groane territory, the Lambro Valley, some areas adjacent to the Adda river, and plains south of Milan. For its scale, surveying procedures, abundance and precision of details, and number of toponyms, Brenna's map is comparable with the later cartography drafted by the IGM, and proves to be of even higher quality in terms of drawing refinement and ability to summarize and describe the landscape. In fact, in addition to the orography, the map displays the network of rivers and minor waterways, such as canals and secondary irrigation ditches; the road network and road classification; the settlements (using different symbols for different types of building including religious buildings, and adding the precise denomination of places and major sites of interest); the parks and gardens (with a precise indication of the compositional plan); the agricultural use of the land and the crops (each crop corresponding to a different hatch, specified in the legend); other components of the urban and rural landscape, such as farmhouses, enclosures, and bird snares; and the industrial activities, such as furnaces, spinning mills, and flour mills (Cazzani et al. 2019a). The detail and clarity, with which the compositional elements of the territory are graphically represented, make of this map a precise and very useful reference to the characteristics of the landscape, the relations among its elements, and even the layout of the historical gardens as they were at the time. Examples of Brenna's maps can be found in Fig. 4 and the "The Cusani Traversi Tittoni historical garden in Desio: a critical multi-temporal analysis considering historical maps" section, below.

As for the IGM maps, although the first surveys were made on the model of the Brenna cartography and in the same scale (1: 25000), the level of detail is often lower because of the additional territorial complexity and on the strategic importance of the data to be rendered. Being a survey made for military purposes, some information could be approximate and not exhaustive (e.g. the farmhouse census) and others could have been deliberately omitted or concealed (for example, airports or railway stations were often not explicitly indicated).

Fig. 3 Extract from the Lombard-Venetian Cadastre, Gorgonzola, sheet II, 1855–1857 (source: Milan State Archives). The red circle indicates the area of the current Sola Cabiati Park in Gorgonzola, at the time holiday residence of the Marquis Busca. The map displays the buildings, roads, and waterways, omitting the layout of the gardens and green areas. The garden of the villa is devoid of details, but it is recorded that it was then crossed by a ditch or *roggia*, fed by the nearby Martesana canal (*Naviglio*). From the cadastral records connected to the parcels of this area, it is possible to deduce the overall increase in irrigated land compared with the situation depicted by the eighteenth century cadastre, with a consequent increase in forage production, cattle breeding and, ultimately, dairy production (GEOPAN APP, Courtesy of © POLIMI, dABCLAB - Gicarus)

Signs and symbols used in the IGM maps are explained in a rich legend, accompanied by some written explanations, entitled "*Segni convenzionali e norme sul loro uso*" (i.e. conventional signs and rules on their use, IGM 1950), which shows how the maps are actually much more detailed than they seem at first view, but not so easy to read (Fig. 5).

In addition to the obvious indication of the administrative limits (of state, region, province, municipality), the IGM maps report the description of the orography (glaciers, rocky massifs, spikes, reefs, beddings, dolinas, depressions, basins, landslides, gully, and bad-lands), including contour lines and quantitative measures of heights, as well as low points in lakes and seas, and the description of the hydrography (reporting waterways courses, waterfalls, canals and irrigation ditches, springs, wells, aqueducts, cisterns and drinking troughs, etc.). They also represent features with changing appearance, like variable islands in the rivers, or the normally dry riverbeds that can form streams. They accurately describe the infrastructures system, fundamental elements to be aware of in order to move well around the territory: besides the roads, which are drawn differently according to their type and accessibility (toll

Fig. 4 Extract from Giovanni Brenna's map, Barlassina sheet, 1837. Source: Civica raccolta delle stampe "Achille Bertarelli", Milan. On the right, the city of Cesano Maderno, with the Borromeo Palace and gardens extending eastwards. On the left of the map can be appreciated details of the orography and woodland renderings in the neighbouring territory of Limbiate. The rural areas are filled with plots of cultured land, with clear indications of crops, paths, borders, ditches, and rows of trees

Fig. 5 Extract from the IGM map, 1888, sheet 45. Source: Politecnico di Milano Library. The red circle indicates the area of the current Sola Cabiati Park in Gorgonzola, at the time Villa Sola Cabiati. In the area corresponding to the garden are visible some trees, the neighbouring *roggia* (ditch) and the pond fed by it, which was introduced as part of the English restyling of the previous Italian layout. The site is still closely connected to the surrounding agricultural landscape, with arable land, rows of trees and crossed by several irrigation ditches.

road, vehicle accessible, cart or mule tracks, easy and difficult paths, sheep tracks, etc.), they indicate railways with different symbols for different technological implementations (with one or two railroad tracks, electric or steam traction, narrow gauge, under construction or abandoned, etc.) and the presence of stations, over and underpass, toll booths, level crossings, etc. The natural and artificial elements of the landscape that characterize the territory along the roadways such as rows of trees, farming or wood boundaries, divisions (walls, fences, nets and barbed wire, hedges) and also junctions, crossings, passages, tunnels, and bridges are all clearly drawn with many specific symbols, as well as buildings and monuments of all sorts (houses, farmhouses and cabins, towers and bell towers; "*opifici*" that means productive buildings like mills, sawmills, paper mills, hammers, kilns, lime kilns, foundries; thermoelectric and hydroelectric power plants, canopies and barracks; churches, parishes, chapels and oratories, aedicules and Madonna statues, cemeteries, isolated crosses, monuments, and commemorative stones; fortifications and ramparts, cableways, funiculars, and chair lifts; airports and seaplane bases radiotelegraph stations; mines, oil wells, caves and caverns, lighthouses), each of which deserves an individual symbolic representation. The IGM maps also include toponyms and indicate precisely the use of the land describing the features of natural (marsh, peat bogs, plains and hills reclaimed lands, seashores, dunes, etc.) and agricultural landscape (paddy fields, saltworks, vineyards, terracings, etc.) and the vegetation. Among the crops, are highlighted tree crops more than herbaceous ones because they are considered long-lasting and more important from a topographical point of view. Irrigation and drainage channels,

walls, and hedges that make up the divisions between plots are indicated, but so as not to suffocate the road and contour line symbols view. The presence of gardens, vegetable gardens, vineyards (even specifying if it is short vine or ground raised, row vines, vines supported by trees), orchards, olive groves, citrus groves, and pastures. Concerning the woods, a particular aspect certainly reported due to its military interest is the coverage, distinguishing between dense and sparse woods (to indicate the obstacle to movement on land) and copse, and then are indicated the main tree species that can be found in woods, tree groups, rows, and in isolated specimens (larch, fir, pine, oak, elm, chestnut, beech, poplar, willow, cypress, sycamore, acacia, juniper, olive tree, citrus, carob and almond, palms, Prickly pears, etc.) (Fig. 6).

From the combined analysis of Lombard-Venetian cadastral, Brenna's, and IGM maps, we have an unusual richness of information about the changes that the Lombard territory underwent. For many areas, especially around Milan, we may be able to reconstruct a real feeling of what the rural plots, the planned landscape, and the historic gardens would have featured. Knowing who owned the land, what that was used for, how much income it produced, how it was laid out, what vegetation was present, and what buildings, what views it had, and how the terrain appeared all around, if it was accessible, and to what extent, if it was under sunny or shady exposure, if it had access to water elements, can really promote more than knowledge but almost a sensorial perception of a historic environment. Reaching this level of awareness depends on the correct interpretation of the different symbols left behind by map drafters in changing jargons though the years.

Fig. 6 Extract from IGM map legends (IGM 1950) showing the rendering of planted areas with details on the symbolic representation of fields, orchards and meadows, gardens, vineyards, olive and citrus groves, pastures, and woodlands, with specific symbols for different tree species
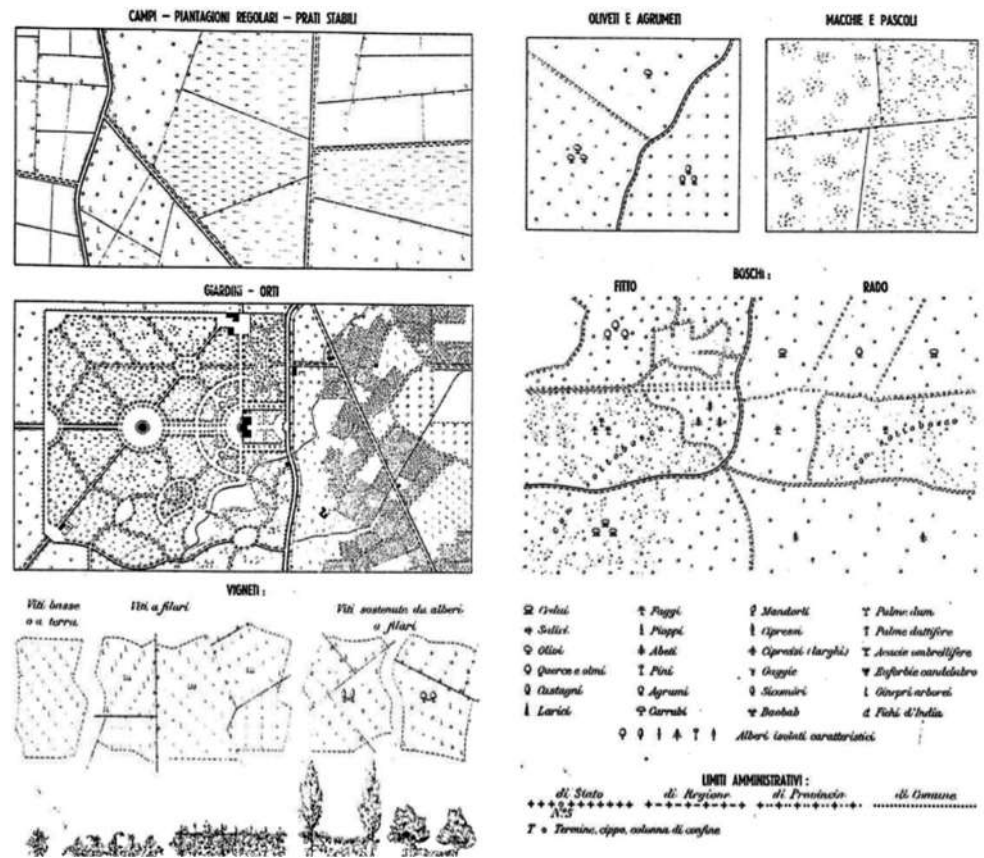
Historical maps: a reference to define conservation and valorization plans for historic gardens

Historic gardens are a polymateric system, designed by man, an architectural composition created mainly using plant material, in order to satisfy aesthetic-decorative purposes, but also productive functions (of fruits, flowers, timber, vegetables, crops). They are therefore a multifunctional as well as polymateric work, which also acquires over time a wealth of meanings that gradually stratify in it: cultural, architectural, botanical, agronomic, aesthetic, social, ecological. A garden also has important relationships with the context and the landscape (agricultural, natural, or urban) that surrounds it: systems of views, visual axes, perspectives, access avenues, fences, are the perceptive components of the site.

The preservation of these meanings is very delicate, both for their complexity and for the precariousness of the materials that make up the garden: living components, in constant evolution, therefore dynamic, subjected to diseases and atmospheric events, strongly dependent on the maintenance, use, and management criteria that have been adopted over time (Boriani and Cazzani 2004; Harney 2014).

It is important to note that, in regard to the historical gardens, starting from the second post-war period, there has been a change in the methods of government and ownership regime that have

frequently caused the loss of the historical, morphological, and material characteristics of a particular heritage. A profound organizational and economic crisis involving many park and garden owners was followed by a massive acquisition campaign by public bodies. The transfer of ownership and the consequent collective use have frequently led to their use as public green areas, without taking into due consideration the historical typological characteristics of these plants. The introduction of elements of furniture or recreation (such as life trails, games for children, flooring in modern materials, benches, lighting systems), the spontaneous opening of new paths due to an ever-increasing influx of visitors, the use of lawn areas as areas for sports activities, and the insertion of service structures (car parks, theaters or outdoor cinemas, toilets, picnic areas, etc.) are just some of the problems that they invested historic parks and gardens following the opening to the public.

For the most important sites, specific studies, plans, and projects have been carried out, while much still remains to be done for the government and management of the numerous smaller sites spread throughout the territory, privately or public owned, not always managed appropriately: underestimated in their architectural and landscape importance, they are often subjected to pressures of use or transformation projects not always congruent with the needs of protection and conservation that they present and, indeed, very often, in serious contradiction with them.

Fig. 7 Villa Tittoni in Desio. Left, view of the perspective axis with the villa on the background (© Roberta Tassi 2017). Right, bird's eye view of the site, photographed from a helicopter (Source: Fototeca ISAL-BAMS Photo Rodella)

It is known that an historic garden is a continuously evolving artefact (especially for the plant components) and at the same time a monumental and cultural asset that must be preserved (Watkins and Wright 2007). In particular, historical gardens currently intended for public use should be considered not only as recreational spaces but also as cultural sites, paying particular attention so that any new functions—as well as related integrated with the contemporary social needs—are compatible with the historical, architectural, and landscape layout. Instead, these sites often suffer from an identity loss problem. Management criteria often treat them to simple public green areas, ignoring their historical and cultural significance. Therefore, considering the complexity of historic gardens and their relationship with the context is fundamental for future conservation and it is the starting point to set management and promotion plans (Cazzani et al. 2019b).

It is therefore very important to spread adequate sensitivity awareness toward the topic, starting with analysis methodologies that help us to understand and spread the cultural, architectural, and perspective values of the sites, also as a social and environmental heritage (Unesco 2011).

Considering what was explained in the "Nineteenth century cartography: uncovering the past to reveal the present of our historic gardens" section, historical maps—of course connected with other historical research—can help us to understand the stratification and changes that happened in the site, to define a conservation and reuse project linked to the past, and to explain the complexity of the historic values—often now hidden—to all the current users (Cazzani et al. 2019a).

The Cusani Traversi Tittoni historical garden in Desio: a critical multi-temporal analysis considering historical maps

We particularly want to illustrate how nineteenth century historic maps helped us to understand the complexity of the landscape and architectural layout of the historic garden of Villa Cusani Traversi

Tittoni (for short, Villa Tittoni) in Desio (Fig. 7), a large municipality North of Milan. The site was built on an area previously occupied by a castle surrounded by green areas intended for hunting, commissioned in 1340 by Barnabò Visconti, Lord of Milan. The complex was transformed, between fifteenth and seventeenth centuries, in a suburban villa with functions of representation and management of the surrounding agricultural properties. The current layout dates back to the second half of the eighteenth century, when Ferdinando Cusani, heir of the family who owned the site since the seventeenth century, entrusted the famous architect Giuseppe Piermarini with the transformation works of the villa, and the renowned gardener Antonio Villoresi with the redesign of the park, extended to around 30 ha around the villa, which becomes one of the first English gardens in northern Italy (Brioschi et al. 2017).

Ercole Silva, in his treatise "*Dell'Arte de' Giardini inglesi*" (i.e. on the art of the english gardens) published in 1801 (Silva 1801), exalts the Villa Tittoni garden as "*…una vaga veduta che è un superbo quadro di paesaggio…*" (i.e. a vague view that is a superb landscape painting) and provides a detailed description, later magnificently illustrated by the engravings by Giuseppe Levati and Gaetano Riboldi included in the second edition of the treatise published in 1813 (Silva 1813).

In the 1840s, the Desio area was one of those surveyed in aforementioned Giovanni Brenna's map (Cazzani et al. 2019a).

In the map extract of Fig. 8, it is clearly legible the presence of the garden adjoining Villa Tittoni (on the map indicated only as "*Villa Traversi*"). The size of the garden appears considerable, if compared with the extension of the Desio urban settlement, with a compact system, connected to an articulated road system, distributed around the main religious building, central element of the urban settlement. The garden was still closely linked to the surrounding agricultural landscape, characterized mainly by vineyards. The "*Roggia Traversi*" (i.e. the Traversi ditch) is also recognizable which, starting from the Seveso river in Lentate,

Fig. 8 Desio plan, extract from Giovanni Brenna's map, Verano sheet, 1837. Source: Civica raccolta delle stampe "Achille Bertarelli", Milan
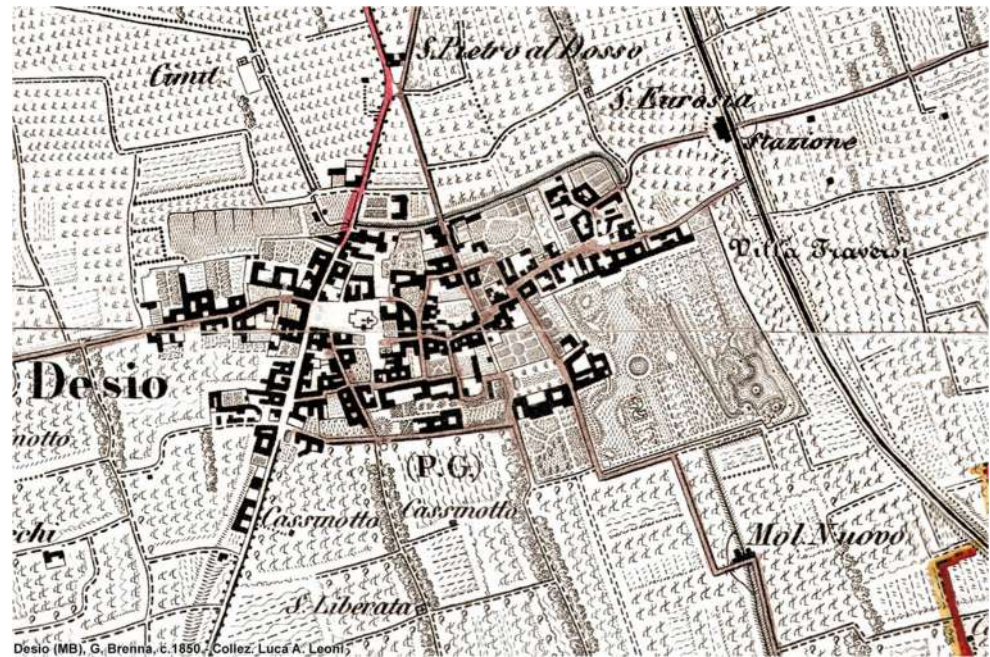
constitutes an important infrastructure project aimed at bringing enough water to the garden.

The complex of Villa Tittoni is so relevant that the Lombard cartographer Brenna also dedicates a 1:3000 scale enlargement to it, in order to document its richness. As illustrated in Fig. 9, the site appeared to have, in addition to the mansion and a neo-Gothic tower (the so-called Traversi Tower, added in 1817 by the architect Pelagio Pelagi), a very articulate landscape composition. In fact, the layout is characterized by a formal part consisting of a long perspective axis, enclosed by woody wings, to which the

Fig. 9 G. Brenna (cartographer), L. Zucoli (engraver), "*Pianta del Parco e giardino Traversi in Desio*" (i.e. plan of the Traversi Park and garden in Desio), engraving on heavy paper, 1838. Source: Civica raccolta delle stampe "Achille Bertarelli", Milan. The map displays a legend that explains the main architectural and plant components present in the garden, identified as (1) *"Palazzo"* (palace), (2) *"Torre e Museo"* (tower and museum), (3) *"Caffè haus"* (coffeehouse), (4) *"Fattoria"* (farmhouse), 5. *"Abitazione del botanico"* (botanist's house), (6)*"Grotta del Tasso"* (badger hut), (7) *"Tempietto d'Imene"* (Hymenaeus small temple), (8) "*Romitaggio*" (hermitage), (9) *"Labirinto"* (labyrinth), (10) *"Grande Serra"* (large greenhouse), (11) *"Serra degli Ananas"* (pineapples greenhouse)
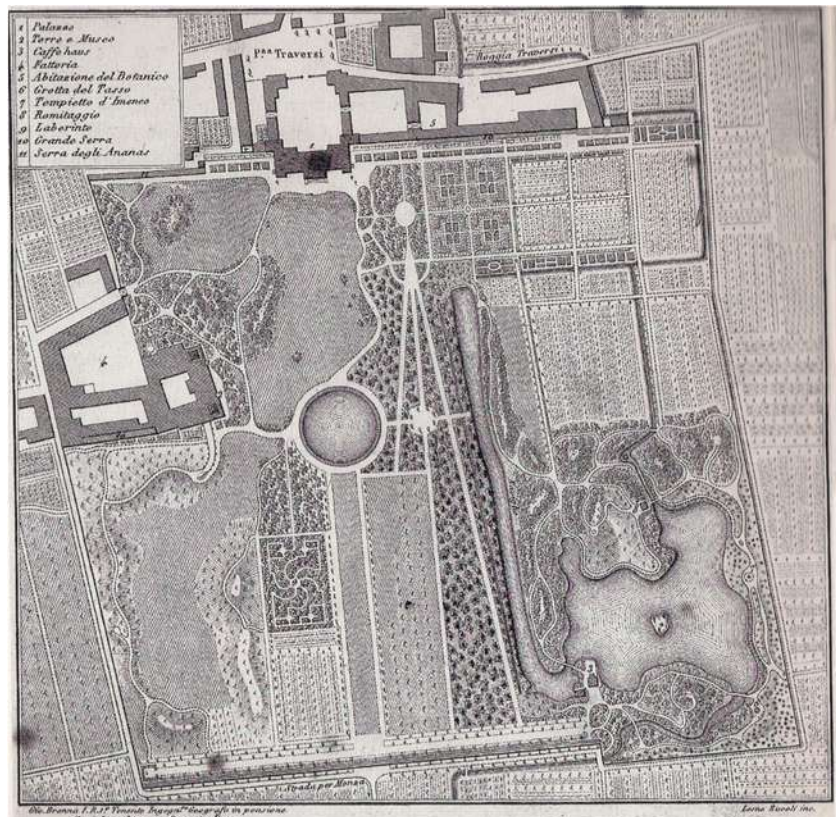
Fig. 10 Detail of the pond area extracted from Brenna's "*Pianta del Parco e giardino Traversi in Desio*" (i.e. plan of the Traversi Park and garden in Desio, left), in which are indicated two visual points described by E. Silva and engraved by G. Levati and G. Riboldi: view 1, "*Veduta del laghetto nella villa Cusani a Desio*" (i.e. view of the pond in Villa Cusani in Desio, centre), and view 2, "*Capanna boscareccia nella suddetta villa*" (i.e. Wooded hut in the aforementioned villa, right) (Silva 1813). Considering the historic map and the coeval views is useful to read the perceptive components of the garden settlement

south elevation of the residence overlooked, geometric flowerbeds and terraced gardens adorned with rare plants and fountains, greenhouses with exotic flowers and fruits, vegetable gardens, and orchards, a trident of paths immersed in a chestnut wood, a circular pool surrounded by horse chestnuts and a hornbeams labyrinth; and by a large part treated in a naturalistic way, with wide meadows, hills, and valleys furrowed by sinuous paths. In addition (Fig. 10), a canal fed a large pond with an island in the centre (inspired by the garden created by the Marquis René-Louis de Jardin in Ermenonville) and on whose banks were the ruins of a castle (later known as *"Romitaggio"*, i.e. hermitage), an Ionic temple with the statue of Hymenaeus supported by eight Ionic columns; the *"Capanna del Tasso"* (i.e. the Badger hut, with thatched roof and walls adorned with four paintings depicting

episodes of the liberated Jerusalem, in honour of the famous Armida garden), a mill and a coffeehouse with a boat dock.

Although the Lombard-Venetian Cadastre map (Fig. 11) does not provide essential information about the garden itself (it just confirms the existence and position of the main waterways, the ditch and the pond), it clarifies that new features were introduced as regards the structure of the villa. In particular, it is noteworthy that the entrance gates, previously facing the main road, are now embellished by an architectural exedra opposite the façade.

The comparative reading of the IGM cartography (Fig. 12) dated 1888 and 1936 and of the Lombardy Region *CTR – Carta Tecnica Regionale* (i.e. Regional Technical Map) dated 1984–90 (Fig. 13) shows the evolution of the Villa Tittoni complex up to modern times. Analyzing the IGM cartography, it

Fig. 11 Extract from the Lombard-Venetian Cadastre, Desio sheet, 1854. Source: Milan State Archives. It is possible to read the complex of Villa Tittoni, the water network and the lake, but the landscape plan is not recognizable in detail (GEOPAN APP, Courtesy of © POLIMI, dABCLAB - Gicarus)
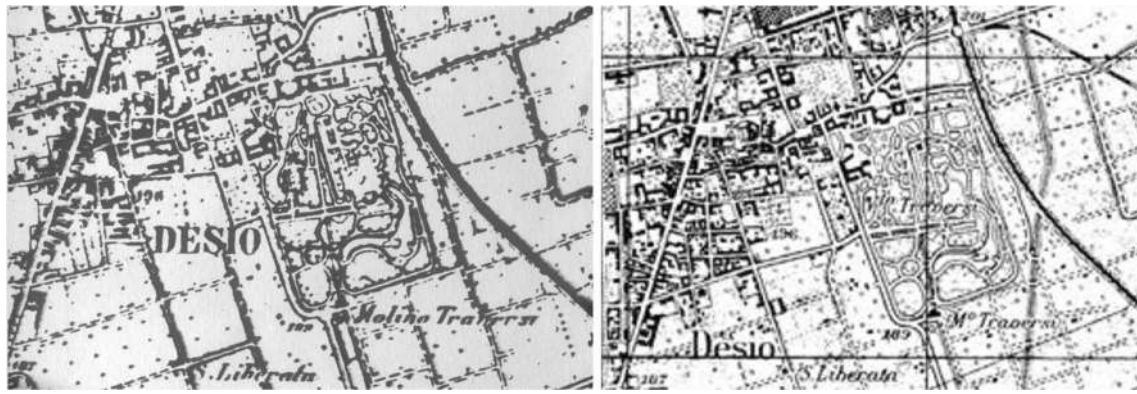
Fig. 12 Desio plan, Villa Tittoni. Extract from IGM map dated 1888 (*left*) and 1936 (*right*)

appears that the urban core of Desio develops gradually North and along the main road. The use as a vineyard of the agricultural landscape disappears and gives way to arable land or lawn, crossed by rows of tree and a dense network of country roads. Looking at 1888 IGM (Fig. 12), it is evident the presence of the railway that laps the garden, whose compositional layout is recognizable with the trident of paths, the pond, and the clearing areas interspersed with wooded areas crossed by winding paths. It is still clearly visible the *Roggia Traversi* (i.e. Traversi ditch), which crossed the garden and fed the *"Molino Traversi/M⁰ Traversi"* (i.e. Traversi mill).

From the second half of the twentieth century, a progressive decline of the complex began, which was gradually reduced in size and complexity. The CTR map (Fig. 13) reports the toponym of "Villa Traversi" (erroneously referred to the neo-Gothic tower instead of the villa) and a very schematic indication of the compositional layout which indicates the presence of wooded areas interspersed with clearings and a complex system of path, and the absence of the artificial pond, which disappeared due to years of neglect and the consequent degradation process starting from the 1940s. The map is very useful for understanding how the Eastern

portion garden was split up, the area once occupied by the pond, which took place both by private individuals, who opened commercial establishments, and by the municipality who built a school. What is not clearly shown is that, to the west, the neo-Gothic tower and a contained portion of the garden connected to it are also alienated as they are purchased by a private individual, who creates a commercial activity and a small museum of mineralogy. But the CTR map is especially useful for reading the outcome of the extensive and consistent urban expansion that has completely changed the relationship between the garden and the context. The agricultural landscape that connected to the garden is completely occupied by intense urbanization, both residential and industrial, and by a road infrastructure increasing. This intense transformation of the landscape surrounding the garden has evidently caused a deep alteration of the visual and perceptive, as well as architectural, characteristics of the site.

Today the complex is owned by the Municipality of Desio, which discontinuously uses the mail villa for representation and cultural/exhibition activities, while the east building is now a popular municipal library and the west wing is partially used as municipal warehouses. Open to the public since 1977, the garden is

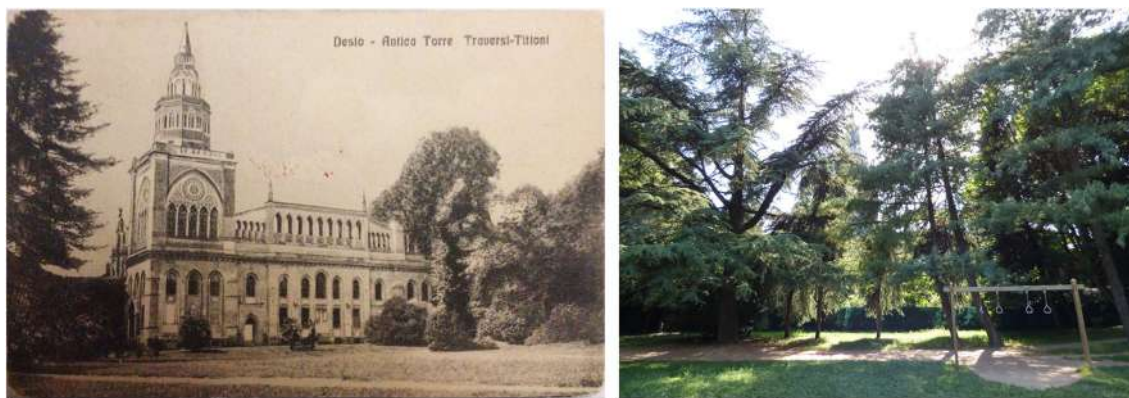**Fig. 13** Desio plan, Villa Tittoni. Extract from Lombardy CTR map dated 1984-90

Fig. 14 Left, old postcard of the neo-gothic Traversi Tower in Villa Tittoni historic garden, Desio. Right, current picture of the same view for comparison (© Carlotta Maria Zerbi 2016)

now a place daily frequented by users interested above all in the recreational and ecological aspects of a large green area of public access, equipped with typically modern furnishings and functions such as a children's playground, a fitness trail, and a dog area, or attracted by the leisure opportunities offered through various events, rather than being aware of the artistic and cultural value of one of the most important historical gardens in the Milan area.

Historical references and critical comparative analysis to define conservation and management plans, including the promotion of users' perceptive experience

The garden of Villa Tittoni—as demonstrated by the historical evolution and critical analysis above—was an extraordinary complex, with wide perspective views, woods, canals and romantic ponds, hills and valleys furrowed by sinuous paths, a labyrinth, geometric flower beds and terraced gardens adorned with rare plants and fountains, greenhouses with exotic flowers and fruits, vegetable gardens and orchards, and even bridges and castles, ruins and sculptures. Today, due to

the splits and transfers of land during the twentieth century, neglect and abandonment, profound changes in the methods of use and use, the simplification of management criteria, and the profound changes in the context, the historical layout of the site—albeit still legible—is degraded and simplified.

Some of its most majestic features are now concealed by vegetation (Fig. 14), have been removed in the course of less than conservative renovations (Fig. 15), or disfigured by intervening modern functions that impinge on adjoining areas (Fig. 16).

It is important to highlight that this garden is among the most important in the Brianza area: among the most illustrious and important Milanese noble families, they owned and transformed it, involving the most famous architects and gardeners of the time, Giuseppe Piermarini, Antonio Villoresi, and Palagio Palagi in particular. Not only did the architectural heritage show a remarkable artistic value but the garden in the nineteenth century was also well known for the botanical collections it possessed.

The precise descriptions reported by Ercole Silva in his well-known treatise on garden art, and the careful planimetric survey drawn up by the famous cartographer Giovanni Brenna, in addition to the numerous iconographic and documentary testimonies,

Fig. 15 Left, Painting by F. e C. Lose depicting the main perspective axis of Villa Tittoni complex in Desio (Bianchi 1828), with the basin designed by architect G. Piermarini in the foreground. Right, current picture of the same view for comparison (© Carlotta Maria Zerbi 2016)
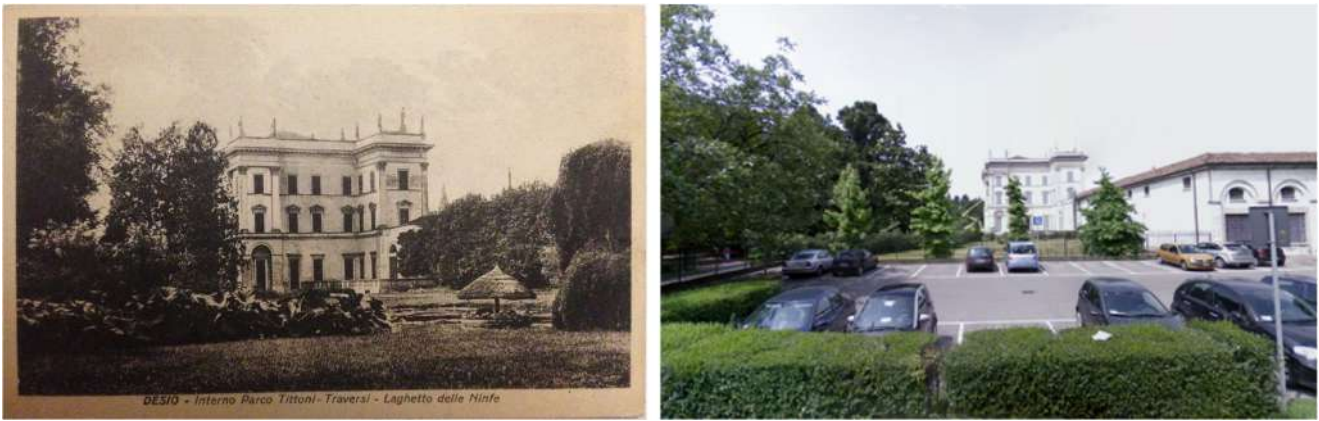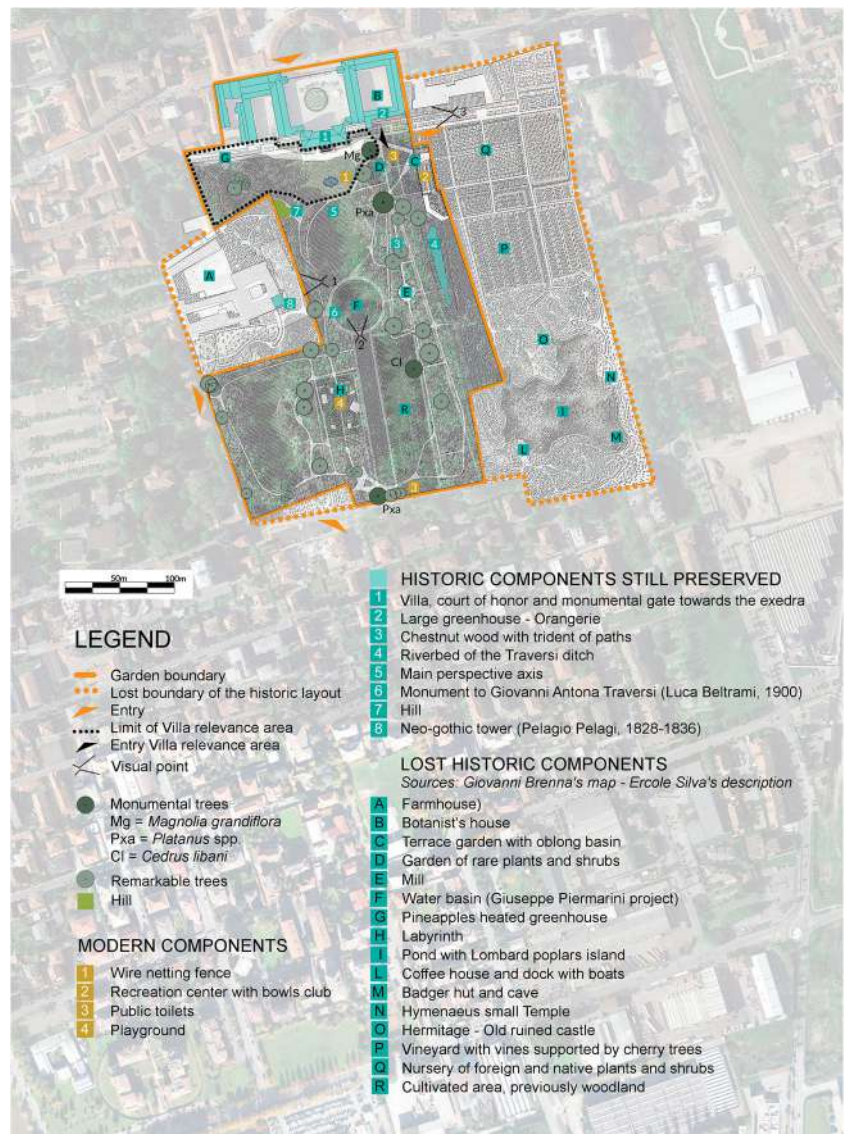
Fig. 16 Left, 1935 postcard of the *"Laghetto delle Ninfe"* (i.e. Nymphs Pond) in Villa Tittoni historic garden in Desio. Right, current picture of the same view for comparison (© Carlotta Maria Zerbi 2016)

Fig. 17 Villa Tittoni historic garden in Desio: analysis of historical elements conserved and lost, and of modern elements introduced in the garden over the past few years

show that the Tittoni garden was considered among the most significant and important of the era, of particular interest for having experimented and created one of the first and most important landscaped gardens in Lombardy.

Although the historical layout is now simplified both in the architectural components and in the furnishings and botanicals due to degradation and transformation phenomena, it is therefore essential to be able to enhance and bring out the identity of this garden from the components still present, defining a program of conservation and enhancement of residual evidence, as well as reuse and landscape redesign to adequately respond to new social and collective functions and to current urban and landscape conditions. Highlighting and promoting the historical-documentary and landscape-botanical value of this garden at a local level is the first fundamental step to be able to elaborate a restoration and reuse project that can tell everyone the history of the site.

The analysis of the historical documents set out above has in fact shown multiple elements and areas that still highlight a significant value are numerous (architectural, landscape, perceptive, botanical): they have the potential to be recovered and enhanced (Fig. 17). Understanding with greatest possible precision and perceptive clarity what appearance the various parts of the garden had and what features they used to give to the general layout of the complex is paramount for establishing a present plan of conservation, management, and re-functionalization.

It is important to plan conservation and promotion interventions, with the aim of highlighting the extraordinary identity—now sometimes blurred and hidden—of this place, making it clear in the eyes of the visitor and therefore respected and appreciated by future users. The management of an extraordinary complex like Villa Tittoni requires informed decisions regarding the conservation and valorization of the main structural and perspective views, the pathways, the statues, and other ornamental and functional furnishings, besides the care of the green components, including the re-introduction of specific plant species and the reinterpretation of original planting schemes and ornamental vegetable features (Fig. 18). In addition, a learned awareness about the evolution/transformation of the site allows the design of possible new conceptual elements able to reveal the past. This approach can create interesting modern layers, well-integrated within the historic settlement to complete the contemporary garden, where reconstructions of long-lost elements are unnatural and counterfeit (Fig. 19).

Historical maps and documents can thus help conceive, implement, and explain preservation projects: the new plants, the reintegration of new production areas, the restoration of waterways or water features, the recovery of the landscape texture will not appear as random ideas of a designer's, but, possibly, a reinterpretation of signs retrieved from the historical cartographic sources.

The final step in a conservation plan is the enhancement of the comprehension and use of the site by the public. Average users have not demonstrated, to date, to be particularly aware of the artistic and cultural value of this important and fragile historic garden. The non-recognition by the community of its extraordinary documentary testimonial value also depends on the choices made in recent years by the municipal administration, which has privileged the role of the garden as a public green space, rather than a historical and architectural asset of high landscape value.

Fig. 18 Enhancement project of the Villa Tittoni playground in Desio. The theme of the labyrinth, once present in the garden, is re-proposed, made by *Ilex crenata* hedges and by a collection of evergreen *Viburnum*. In the loops are placed children playground features of "mineralogical" inspiration to promote the nearby mineral museum, located in the Neo-Gothic Traversi Tower (Courtesy of D. Figliuolo, G. Karsioti, F. Scarnecchia)
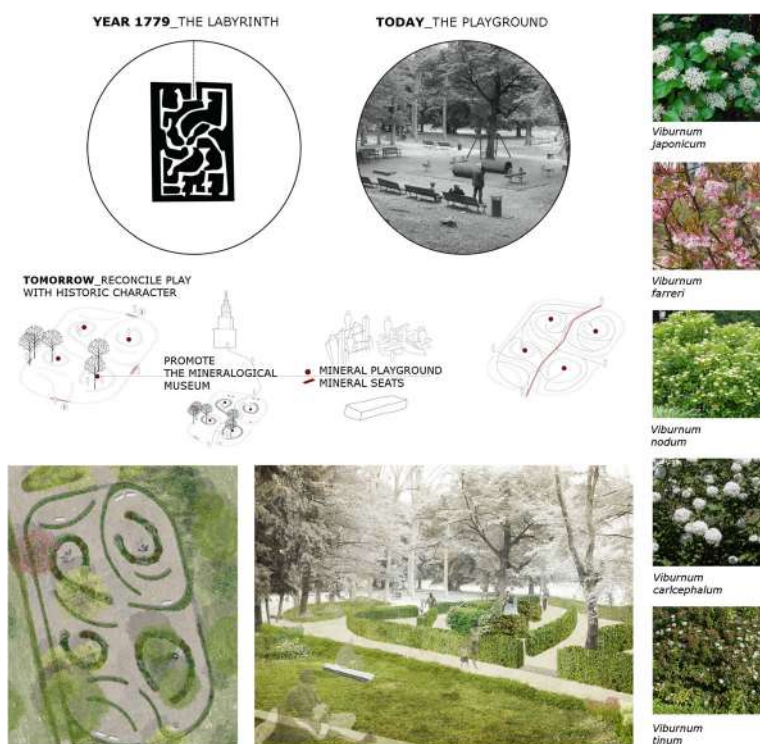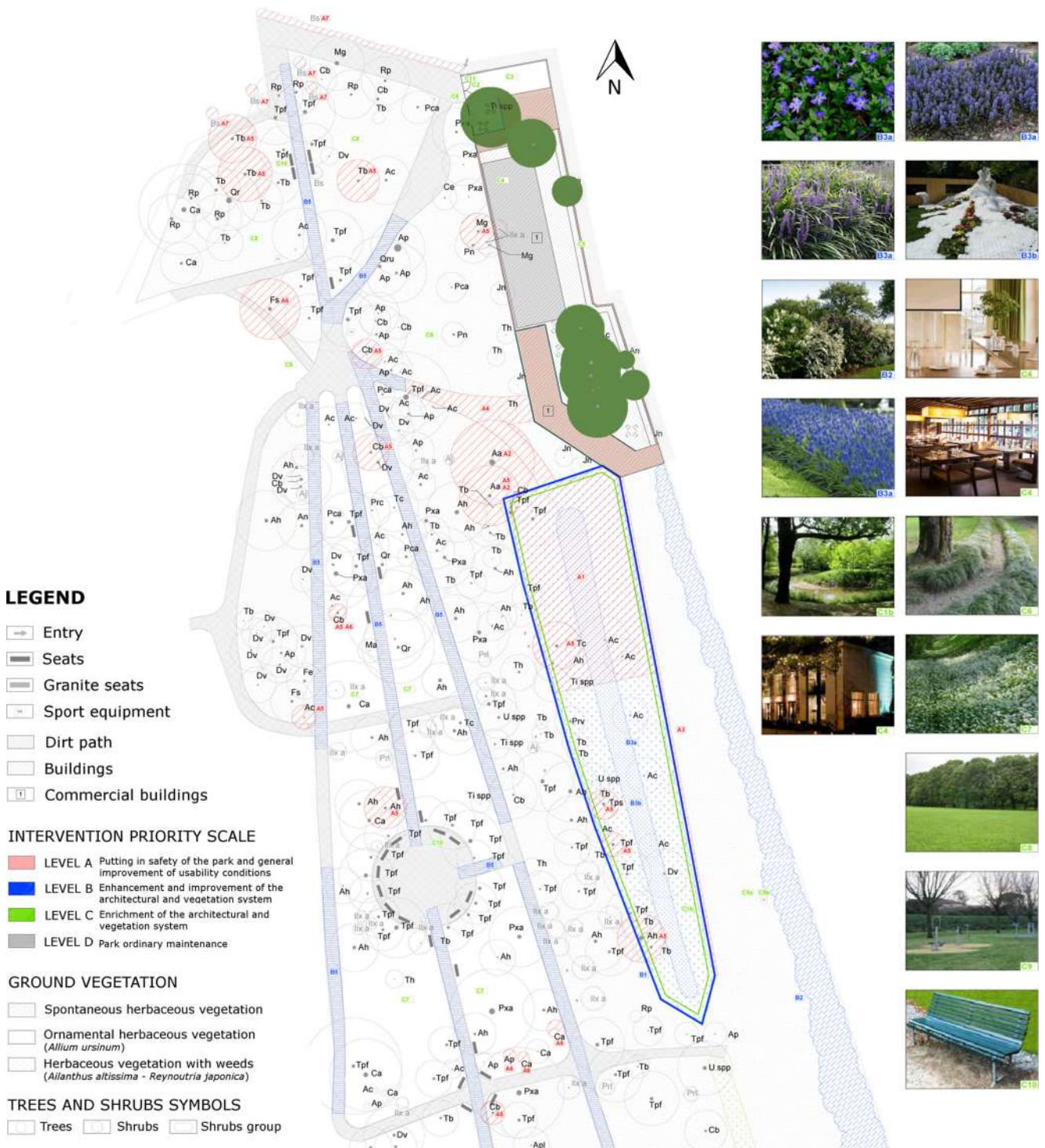
Fig. 19 Redevelopment proposal of the water features in Villa Tittoni complex in Desio. Planting of blue blooms perennial and bulbous plants (as *Muscari armeniacum*) to reveal the canal and the water basin once present in the garden Traversi Tittoni in Desio (Courtesy of M. Brevaglieri, A. Cavalli, L.G. Golzio)

It is therefore important to find new ways and solutions possibly technologically supported by multi-temporal geospatial based applications (see the "4D maps, historical views, and panoramic cones: making historical and other values accessible to large public by means of advanced methodologies and applications" section), and to set heritage education programs (see the "Making historic, artistic, architectural, and landscape values of the gardens understandable to the general public: challenges and solutions" section) to involve the community in the rediscovery process and consequent valorization of the site, making historical

elements now hidden understandable, turning them into an emblem of local history, an element of pride, worthy of being respected and preserved. The goal must be to disseminate and promote the architectural and landscape value of this site, to disclose the significance of the periurban landscape around it, in order to increase a social, cultural, and artistic resource of Milan hinterland.

4D maps, historical views, and panoramic cones: making historical and other values accessible to large public by means of advanced methodologies and applications

The perception of the historical stratified values of the historical gardens and in general built environment landscapes requires a step forward in the effort that can be nowadays offered by the IT and geomatics side in order to boost the comprehension within large public of visitors, digital encounters planning their physical visits, and students.

A systematic habit to use the historical metric maps represents—as seen in the previous paragraph—the first step to read the transformations occurred across the centuries as documented by the historical maps: the availability of WMS (WebMapService), WTMS (WebMapTiledService), and WFS (WebFeature Service) allows to easily publish such map collection progressively digitalized and georeferred, correlating the current state of the art with the past, as well as creating applications to manage services for the users, visitors, and so on (Previtali and Latre 2018).

Such applications let people visitors and students access to such stratified layers with the possibility to identify the stratified signs, the remaining ones: they represent a rigorous support to understand such values as highlighted in the reading of the network made by the natural and artificial water channel in the Park of the Royal Villa in Monza better addressing masterplan and design, and decision-making taking in account and valorizing all the sign of the past (Cazzani et al. 2019a). They need to be systematically adopted to carry on a deeper swot analysis able to include all such values (Brumana et al. 2015), and used in order to better address real estate planning introducing Heritage Urban Landscape as a component of the planning to preserve the complex urban areas as in the case of the Strasbourg border area of the 2 countries France and Germany (Yang et al. 2019).

Contemporary the perception of the historical values of a complex place like the "historical gardens" characterizing most of the villas heritage passes through the integration of wonderful views immortalized by everybody within the selfies, enriching the pure aesthetical recognized value with added knowledge: rising awareness of the historical importance of such views highlighting many aspects of the anthropic intervention on the gardens, like the terraces, art facts, in general all the elements characterizing a voluntary design (including the "English Garden" design that even if is considered natural it is not natural at all! Vice versa it has been characterized by a series of intents and roles and scenic effects).

Traces and signs of an exceptional variety that risk being forgotten and going into oblivion, the "wow" effect and beyond the breathtaking views. The richness of the production of historical views that characterized the "Grand Tour" to Italy in the past centuries and inspired authors and landscape painters from all over Europe represents an invaluable source of details and information that testify traces of the distinctive signs of historic gardens. And therefore, they can be used to enrich awareness of the historical past and its distinctive signs perceived over the centuries. Technologies can help locate views spatially by helping to enhance the perception of the panoramic cones and their safeguard in the masterplans and consequently in the design, avoiding the many interruptions that new buildings have often interrupted. Historical views are in turn a part of that tangible and nontangible cultural heritage and therefore must be protected as the Manu facts and botanic values testified by the remains. Such views are an added value to the bird flight maps with the privileged point of view from top to bottom: they integrate the human sight point of view, sometimes rigorously following the perspective roles, mostly not. But for sure they introduce a further reading component that helps in the direction of rising consciousness by the people in the fruition of all the tangible and intangible values. Multi-spatiality of the same place requires to be correlated within a whole and holistic approach as it is the case of multi-temporal big data coming from Earth Observation for Cultural Heritage, (Agapiou et al. 2015) boosting data access and supporting awareness rising among citizens and operators.

GEOPAN APP-VM: multi-temporal metric maps—Open Data HUB for virtual museum

Recent experiences have been carried out to enhance geographic data fruition by remote web3D access to large public, through application developed to boost the redistribution of geographic open data and tuning them for the specific case of virtual museum (VM) access (Brumana et al. 2018; Caspani et al. 2017). The *Museo del Paesaggio del Lago di Como* (i.e. Landscape Museum of the Como Lake) has been set up in Tremezzo at Villa Mainona within an European Regional Research[1]; it has

---

[1] PORL FESR 2007/2013 (European Funding Research and Development) 'Multimedia system for the presentation and participated recognizing of the environmental values of the landscape of the Lake of Como, Axe 4 – Safeguarding and valorization of natural and cultural heritage, Line 4.1.1.1 Promotion and diffusion of sustainable fruition. Creation and promotion of tourist itineraries for the sustainable use of cultural and environmental resources (*Sistema multimediale per la presentazione e per il riconoscimento partecipato dei valori ambientali del paesaggio lariano*, Asse 4 - Tutela e Valorizzazione del patrimonio naturale e culturale, Line 4.1.1.1 Promozione e diffusione di una fruizione sostenibile. Realizzazione e promozione di itinerari turistici per la fruizione sostenibile delle risorse culturali e ambientali). Province of Como (Scientific Responsible and project coordinator), with the support of Polimi (Prof. S. Della Torre, R. Brumana for the construction of the Tremezzina multimedia museum).

been opened to the public in April 2019, even if limited to temporary visits till to the definitive opening to public. It houses a collection of ancient maps and views of the Lake of Como conceived to be strictly connected to a multimedia system for the presentation of the cultural and environmental heritage of the Como area and in particular of the Tremezzina area: the area attracts toward 200,000 visitors per year in the worldwide famous Villa Carlotta Historical Gardens. The objective of creating a landscape museum is to increase the perception of the landscape values within the visitors. The virtual museum intends to foster the consciousness of the many values with the support of the digitization and information technologies including virtual reality and augmented reality to support better informed on-site visits (Fig. 20).

Within this framework, an application addressed to the virtual museum visit ("GEOPAN APP-VM") has been developed with new communication tools that takes benefit from reuse of open data generated on historical georeferenced maps combined with other cultural digital resources (Brumana and Achille 2007): a geo-temporal customizable interface has been realized to support the museum visit and at the same time the physical visit of the landscape and gardens with the objective to transfer to the visitors (physical and remotely) the landscape values across the centuries with the help of historical maps (Milan State Archives ASMI, Archivio di Stato di Milano, n.d).

The experience of the virtual museum of the Landscape of the Lake of Como demonstrated the importance to gradually introduce such opportunities to improve narrative storytelling empowered by the open-access services developed on the historical maps, and demonstrated the potential in growing awareness rising of the cultural value of historic landscape within large public.

Open Access Atlas geoportals and related services (OGC and Inspire compliant) have been introduced for many years together with the historical map services, allowing a number of analysis of the transformations of the built environment across the centuries in order to support informed sustainable planning (Molnar et al. 2019; Cuca et al. 2011). Virtual Hub brokering and accessing services based on temporal spatial and semantic subsetting have been recently introduced and applied to large dataset as in the case of GEO-Global Earth Observation (Nativi et al. 2013) in order to optimize the access to Open Data set, avoiding time and costs related to the data search. Virtual hubs for facilitating access to open data can support the development of applications based on multi-temporal map data access (Mazzetti et al. 2015); in particular, the application "GeoPanAtl@s APP" (2020b) provided a live access to multi-temporal historical cadastral and topographical maps through an open source geoportal using an European Virtual Hub (Previtali and Latre 2018). It can integrate, access, and visualize geographic data available as Open Data: an advanced brokering system and exploitation of virtual hubs potential that was made possible in the last development within the 3-year project ENERGIC-OD (https://www.energic-od.eu/ 2020h). The GEOPAN APP web-based application has been developed for desktop and mobile, (2020g); it can rely on a double modality of access, via web browser or via Android application, for a flexible use (on site, at home etc.).

An interface has been adapted and developed for the Virtual Museum of the Landscape of Como Lake on the "Tremezzina" area. It has been tested to be tuned in support of geo-based narratives to raise awareness among visitors of an unknown piece of history, as the landscape characterizing the waterfront view together with the hillside area of Tremezzo.

Fig. 20 The Multimedia Virtual Museum of the Landscape of Como Lake (Villa Mainona, Tremezzina, Como) (Courtesy of © POLIMI, dABCLAB - Gicarus)
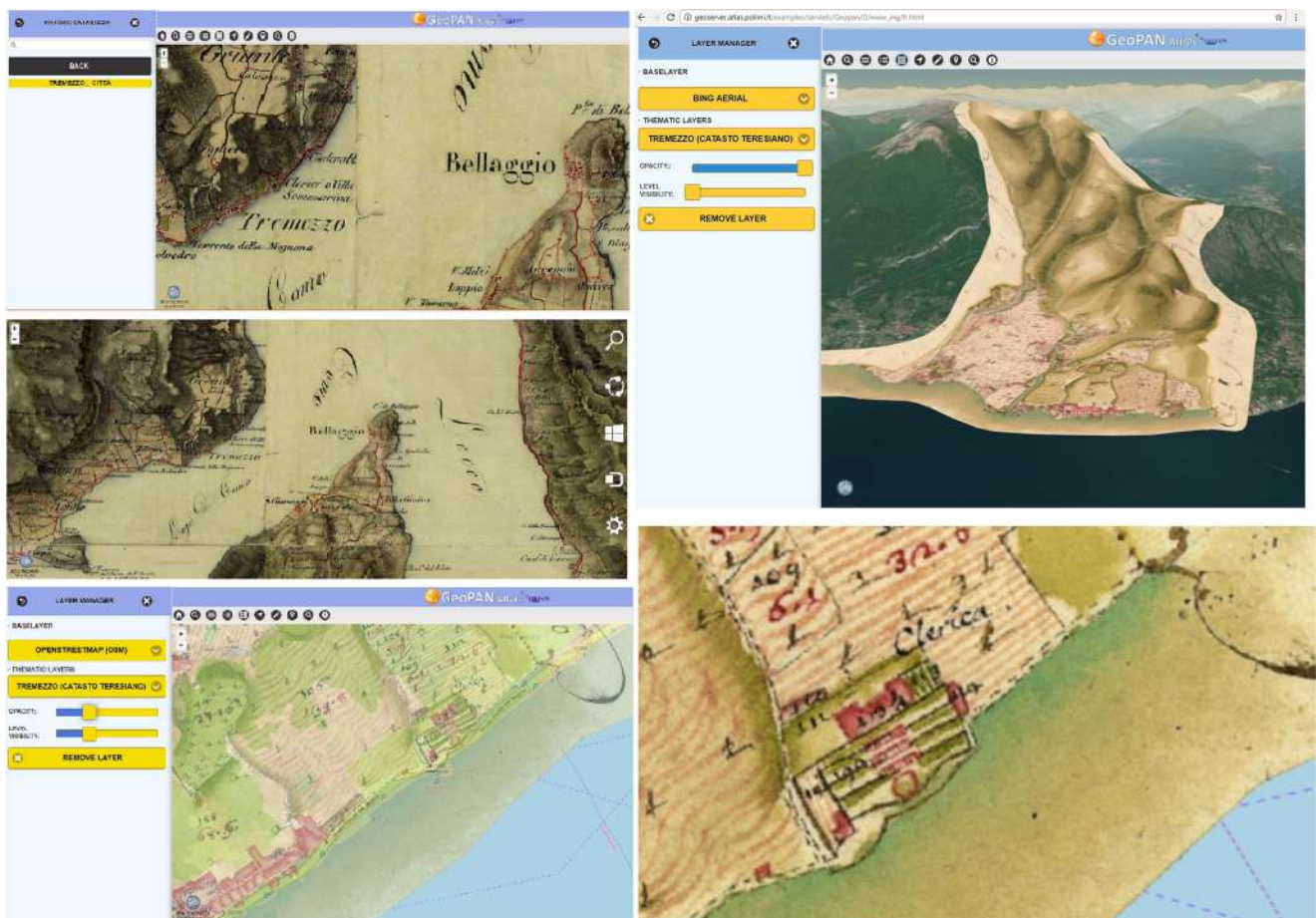
Fig. 21 The GEOPAN APP can be accessed before and after the visit in order to retrieve the cultural stratified information related to the geospatial multi-temporal layers of the historical Cadastres: the Map of the Teresian Cadastre (1723) of Tremezzo with the Gardens of Villa Carlotta and the characteristic terraces (Courtesy of © POLIMI, dABCLAB - Gicarus). Source: Como State Archives

To this aim, the application GEOPAN APP has been updated—using the Virtual Hub brokering and accessing services—with the series of historical cadastral maps series of the Tremezzina area and with the open layers of Como Lake. The historical Cadasters (1723, 1859, 1881) have been digitized and registered on the current map layers applying affine transformation in order to preserve the geometry of the content (Brumana and Achille 2007). The migration of all the data and layers, images, and video from the Google Earth © interface, enriched by explanations and related information, is on course. The possibility to use search functionalities based on semantic word and temporal selections can be used to personalize and develop the different narratives in function of the visiting preferences. The APP relies on an agile architecture with double modality of access, via web browser for desktop devices or via Android application for smartphones and tablets.

It supports multiple thematic modalities of query based on semantic and temporal subsetting; a simultaneous visualization of different superimposed historic maps facilitated by the layers manager implemented that goes beyond Google's approach (layer on-off) helping to recognize permanencies and mutations over time. Furthermore, it offers basic features such as drawing on

the map, take video, geolocation, and path tracking that may encourage active users' involvement and contribution. The GEOPAN APP can be accessed before and after the visit in order to retrieve the cultural stratified information related to the geospatial multi-temporal layers of the historical Cadastres. A number of layers (SHP) extracted from the cadastral series (Como State Archives Collection, n.d) have been integrated in order to let visitors follow the transformations occurred in the past, as the dense path network including the vaulted passages built across the sloped morphological shape of the hillside and lake side, and the famous historical villa gardens like the Gardens of Villa Carlotta Sommaruga (Fig. 21).

The interface allows a personalized visit by the people accessing the multimedia system through the selection of few themes for each storytelling focusing single themes in the museum visits: i.e. the Villas and Palaces with their gardens, the terraces realized across the centuries with dry wall hosting the lemon cultivations and gardens, the history of the merchants across Europe through the "lemon route", coming from Tremezzo getting European cities selling lemons cultivated in the XVII cen. on the Lake of Como, and particularly in Tremezzo, with a great rich market being not yet available

the antibiotics at that time: they exchanged such precious product buying spices arriving from the north harbours (i.e. Rotterdam, Amsterdam), thus growing a dense network of Emporium across European cities (i.e. Lipsia, Berlin, and many others) through the network of relatives, sons, and parents. Getting rich they build precious palaces and villas in Tremezzo still existing (i.e. the Brentano's family palaces, Carli's family villas) and geolocated in the historical and current maps.
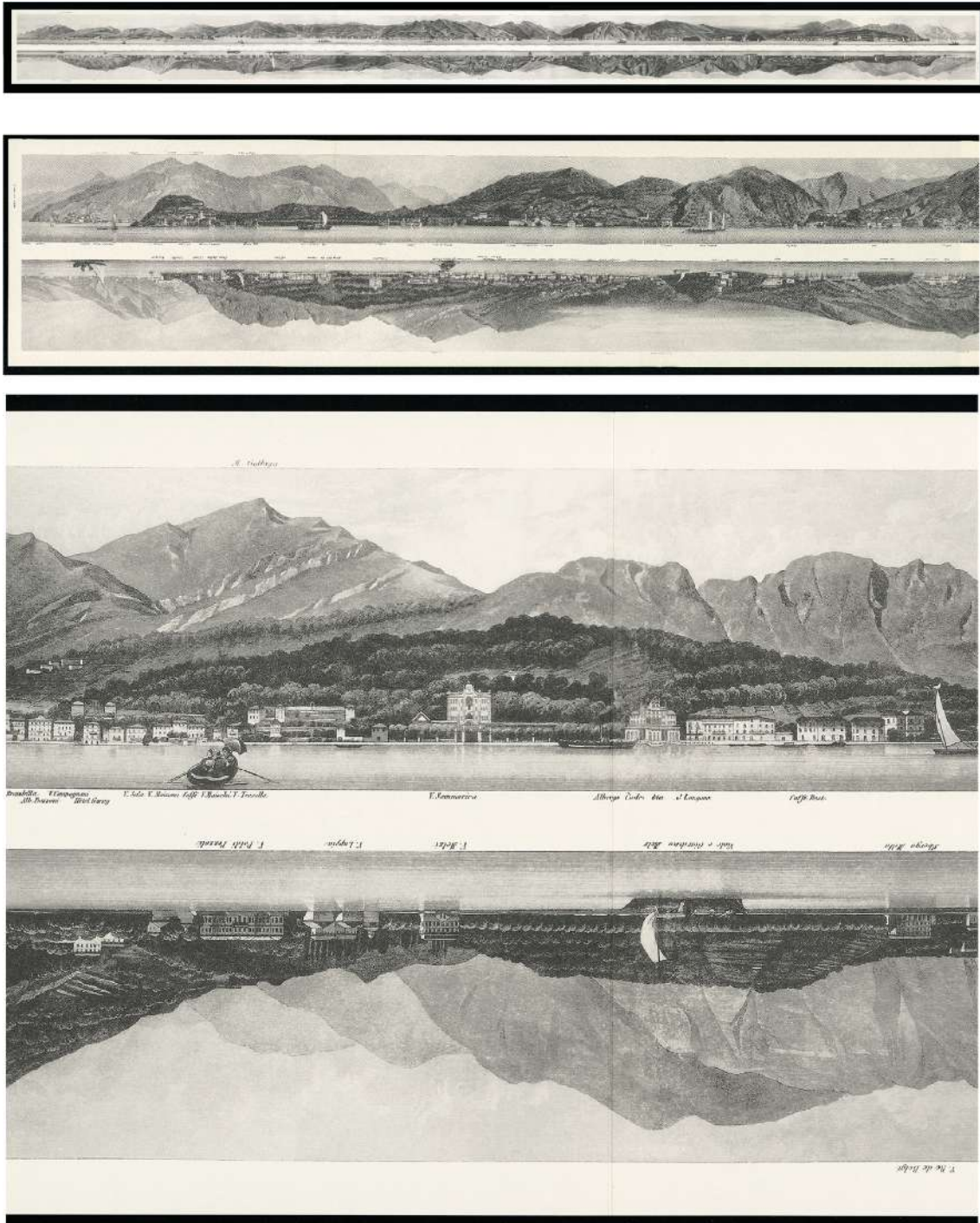

Fig. 22 *"Stampa panoramica da Como a Menaggio e da Bellagio a Como"*, i.e. panoramic print from Como to Menaggio and from Bellagio to Como, by Giuseppe Giudici engraver, edited by Gaetano Brigola, 1863. Top, complete artwork and bottom, a detail. The map has been digitalized for the Multimedia Virtual Museum of the Landscape of Como Lake, and it is accessible by the navigating tool (© POLIMI, dABCLAB - Gicarus)

Historic panoramic water view front map correlation to the current one

The Museum of the Landscape of the Como Lake hosts a precious collection of historical views along the Lake of Como, with the famous historical gardens and panoramic views. The experience of the Virtual Museum of the Landscape of Como Lake highlighted that visitors are attracted to navigating across the centuries using the historical maps related to the current ones. In the same time, the exhibition of the historical views highlighted, beside the amazing impact of the views, that it is difficult for the visitors to relate the views to the tangible position. The possibility to help visitors to retrieve the "original position of the views" could help in the direction to enrich the awareness of the perspectives views in order to protect them as an historical stratified value.

The GEOPAN APP-VM interface intends to contributes to allow the visitor to know the territory of Tremezzina and Lake Como giving progressively access to the richer "multi-institutional" collection of historical panorama views of Como Lake progressively made available on digital format: it has been started to integrate within the multimedia museum some maps of the collection of Landscape Museum and additional resources available in Europeana within a geo-temporal web-based environment, that can be used within the museum, at home, and on site for an extended experience.

To this aim, the precious detailed panoramic map on the Lake of Como ("*Stampa panoramica da Como a Menaggio e da Bellagio a Como*", i.e. Panoramic print from Como to Menaggio and from Bellagio to Como, by Giuseppe Giudici engraver, edited by Gaetano Brigola, 1863) has been digitized with the aim to help the comprehension of the variety of the stratified values lake across the centuries (Fig. 22). The map represents an extraordinary living archive of information: the Historical Villa with the amazing designed gardens with the main artefacts (as the small temples), churches, anthropic traces of the built environment as the terraces used in the past for the lemon cultivations, landscape skylines, just to name few anthropic and natural contents. The richness of content cannot be comprehended just at a glance during a visit to the historic maps' exhibition. It requires a further step.

To this aim, 5 panoramic cones to help the landscape layer perception have been obtained (Barazzetti et al. 2013) taking high-resolution images from the opposite lake side with calibrated head for gnomonic projections and GPS data to geolocate the panoramic water view front cones (Brumana et al. 2015). This allows us to see the waterfront front continuity, enriched with other content (Fig. 23). All the cones have been correlated to the map digitalized and correlated to the panoramic cones thanks to the identification of hot points recognizable among the historical and current panoramic views. Obviously, it is
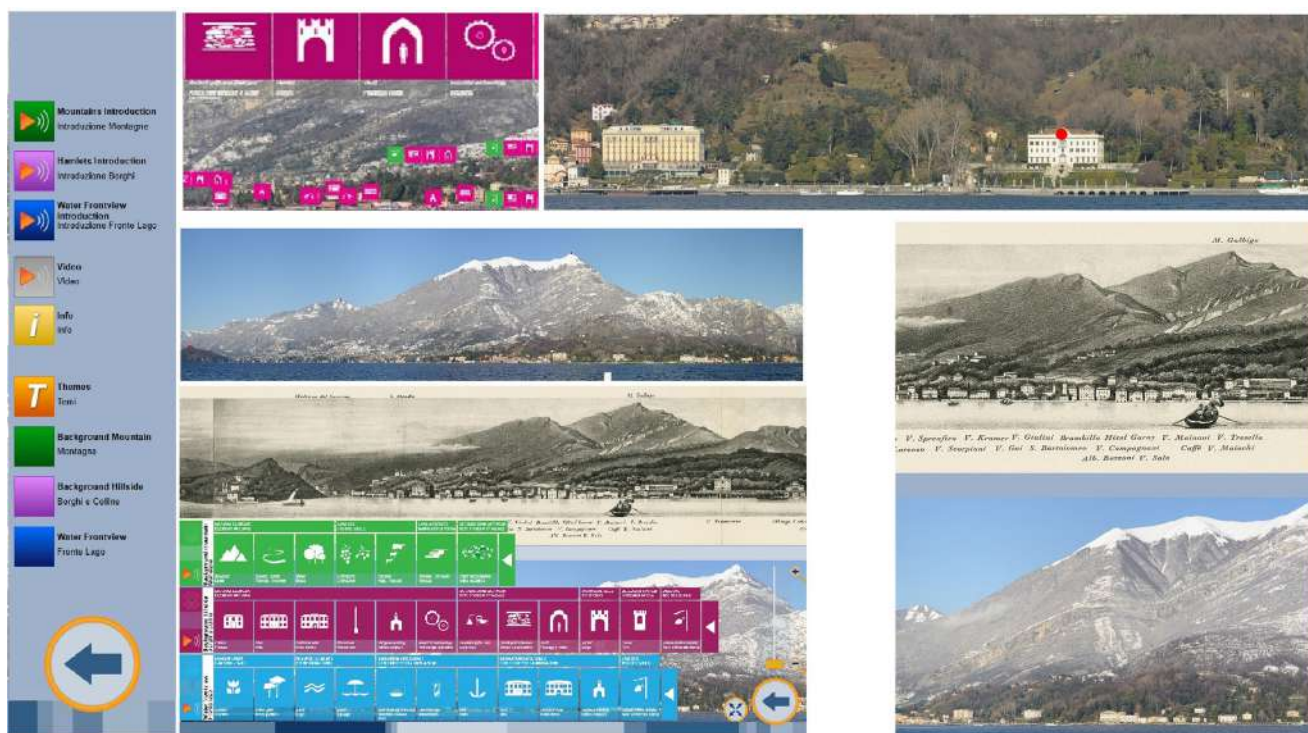

Fig. 23 The touch screen–based interface to access the panoramic maps correlation and the dashboard icons added to guide the visitors across the virtual tour through many themes (i.e. villa and gardens, lemon terraces cultivations, palaces of the lemon merchants, historical paths and vaulted passages) (Multimedia Virtual Museum of the Landscape of Como Lake, Courtesy of © POLIMI, dABCLAB - Gicarus)

not a rigorous metric product due to the fact the historical map has been acquired from different points of view and the single portions are not known and not fully considered pure perspectives. Even if not fully metric to allow the superimposition of different layers, the application of different transformation algorithms allows to create correlation improving the reading of non-metric maps boosting the interpretation across the centuries of the built environment also to non-expert users, as in the case of perspective views or water view front (Balletti and Guerra 2009). Nevertheless, also in this case, the correlation of the 2 maps produced an acceptable result allowing us to recognize the natural and architectural elements contained.

An on-site touch screen–based interface allows visitors to access the virtual museum connected to a projector to help create multimedia access, and the co-relation of the two panoramas today and in the past:

- The historic and current water view fronts are correlated to each other
- The two panoramas slide and zoom in a synchronous way
- A number of themes and subthemes of the territory are displayed (on both panoramas) by means of icons the

visitor can choose the subtheme they want to know more about
- Images, video, and text have been related to the hyper textual canvas in order to enrich the perception of the stratified richness of the built environment of the landscape
- An icon-based checkboard allows users to select the different themes
    –Helping the tourist to correlate the panoramas old and new panoramas (landscape change)
    –Requires medium skills form the user

Toward web-based historic panoramic view related to current views: Open Data Europeana collections

The enhancement of applications as storytelling instruments supported by geospatial data can be further implemented relating and geo-locating other historic panoramic views of Como Lake, coming from the historical waterfront views, and also from available Open Data, as it is the case of Europeana Collection, within a multi-temporal geographic environment.

Fig. 24 The concept framework for a possible reuse of Europeana open data Collection: historical perspective views of the Como Lake (courtesy of Sara Caspani)
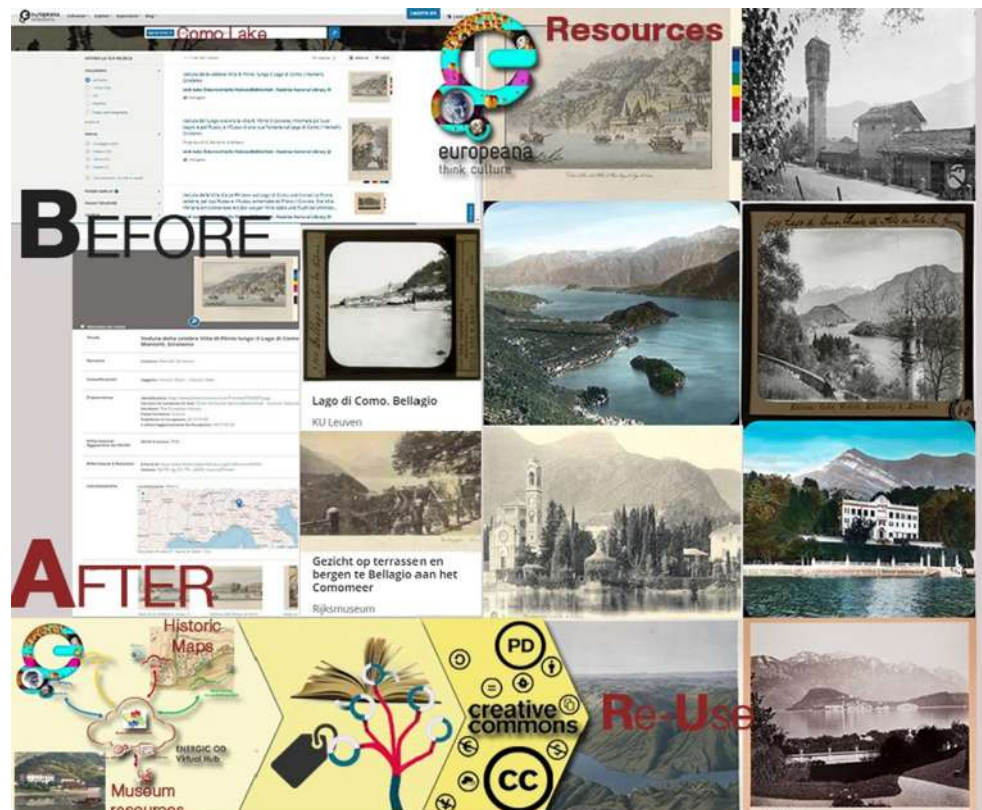
Fig. 25 Historical views of Bellagio. KU Leuven. Glasdia'skunstgeschiedenis. Université de Louvain, tussen 1839 en 1939; Lago di Como. Bellagio (Europeana Collection)

Historical landscapes and gardens have been recognized in the past with their values leaving many fine examples of views: a number of panoramas and perspectives have been realized and acquired by different authors across the centuries as documented by the rich collections hosted by many museums. People visiting the museum find it generally difficult to relate such views to the physical environment and scarcely use them to deeper understand the historic value of the subjects illustrated.

The progressive digitization of such collections makes the single items accessible by places, authors, or dates thanks to semantic search as in the case of the thousands of historical views made accessible by the geoportals (as the Lombardy Region MIBACT Archives, 2020a) or by Europeana (2020c, 2020d, 2020e).

The concept framework for a possible reuse of the Europeana open data Collection within a multi-spatial and multi-temporal dimension is introduced to improve the reading of historical perspective views of the Como Lake. A potential enrichment of the applications to put in place a possible reuse of open cultural data already available in digital the repository such as Europeana (historic panorama of Como Lake, paintings depicting customs and traditions, influential people), comparing the past and currents views could enrich even more informative and communicative dimension of the exhibition of such ancient views (Fig. 24).

The twinned Como Lake sides: the historical views Gardens of Villa Melzi (Bellagio) and the Gardens of Villa Carlotta (Tremezzo)

The following views are just an example of the numerous views acquired from historic perspective cones, made accessible from such collections as in the case of the two sides of Tremezzo and Bellagio facing each other on a unique landscape inspiring thousands of authors' views (Fig. 25).

Their description contains useful details but not one piece of information is derivable about the point of view and the cones (Table 1). The main objective is to implement a friendly and intuitive interface in virtue of continuous involvement of customer and stakeholder. Given that the comprehension of ancient perspective views is often hard for the public, it has been experimented the potential of geo-based redistribution of such views helping people to better correlate them to the current space.

Table 1 A dataset of the Europeana collection: the open data can be related to the Virtual Hub

Glasdia'skunstgeschiedenis. Université de Louvain, tussen 1839 en 1939; FotograafonbekendToegevoegdeinformatieopdia; Huidigelocatie: Italia, Bellagio; EuroPhot. Kunstgeschiedenis. Diverse periodes. Architectuur. StadEuroPhot. Art history. Various periods. Architecture. City; (nl) Lago di Como. Bellagio. Identifier:9988546660101488

http://mint-projects.image.ntua.gr/photography/ProvidedCHO/KU Leuven/9988546660101488

https://www.europeana.eu/portal/record/2024903/photography_ProvidedCHO_KU_Leuven_9988546660101488.htm

KU Leuven. Public Domain Mark - http://creativecommons.org/publicdomain/mark/1.0/

Provider:Photoconsortium, Last Updated In Europeana:2019-10-07)

Dimension: height 258 mm, width 383 mm; Lingua: Olandese; Fiammingo;Data Di Creazione: 1824–1888

Editore:Rijksmuseum; RP-T-1948-519; Paese Fornitore: Netherlands

Identificatore:http://hdl.handle.net/10934/RM0001.COLLECT.26623

Pubblicato In Europeana: 2016-08-16; L'ultimo Aggiornamento Da Europeana: 2018-03-17

Dataset: 90402_M_NL_Rijksmuseum; collectie: tekeningen

The geolocation of the panoramic cones on the historical Military Map within the GEOPAN APP allows us to make evident to the visitors the historical spaces acquired with different details by the different authors (Fig. 26). The positioning of such locations within historical and current maps raises awareness among the visitors of the lake and of the museums on the physical spaces considering their stratified anthropic and natural values. The cone locations stimulate us to visit the places, enriching the consciousness of their historical identity.

Geo-localization plus tracing of optical cones within the geographic space can drive the user to contextualize the panorama with respect to the territory (also a time contextualization thanks to integration of historical maps as navigation base) with the support of an illustrated timeline. Linking historical 2D and 3D information (maps and panoramas) is intended to help users, even non-experts, through the recognition of the ancient optical cones of views registered by the ancient maps and to correlate and appreciate the current ones enriched by stratified values.

The research offered the opportunity to enrich the app with a new feature of images comparison (historic panorama and current views) by correlation of homologous points as obtained in the upper described case. In particular, the twin lake side historical views (historical and current) interface allowed us to highlight the special twins of the historical Gardens of Villa Melzi

(Bellagio) and the Gardens of Villa Carlotta (Tremezzo) on the technical map (Fig. 27). The touch screen interface allows while navigating across the 2 current and panoramic maps to recognize the twin villas, and to add details as the other views coming from other collections as in the case of the Bertarelli Collection and Europeana Collections (2020f) (Fig. 28).

The intention of museum directors is to continue to promote a better comprehension of the exhibition valorizing the ancient maps of the lake landscape with their beautiful views, helping the discovery and recognition of the current correspondent view, developing an ad hoc interface to locate historic "Panoramas in a Geo-context" in order to highlight the "Panorama's changes over Time" and also to valorize the conic views and bird's eye view maps available as open data belonging to Europeana digital dataset, being that the maps exposed in the museum have not been yet digitalized due to the museum opening matters. The result is to provide outreach/dissemination/speaking engagements. Information about innovative way of use and reuse of open data with the purpose of landscape valorization can exploit the network of Europeana Network Association and, possibly, Europeana Space (http://www.europeana-space.eu/). Target: stakeholders, experts, scholars.

In this regard, easy, intuitive, and user-friendly features should be implemented to compare images relating historical and current views, on course of development for the web application in order to manage the different open data sources.

Fig. 26 The twinned sides of the historical panoramic view cones of the two waterview front sides (the Como-Tremezzo side and the Bellagio side): the Gardens of "Villa Sommariva" (Villa Sommaruga Carlotta, Tremezzo) and Villa Melzi (Bellagio) in green (GEOPAN APP, Courtesy of © POLIMI, dABCLAB - Gicarus)
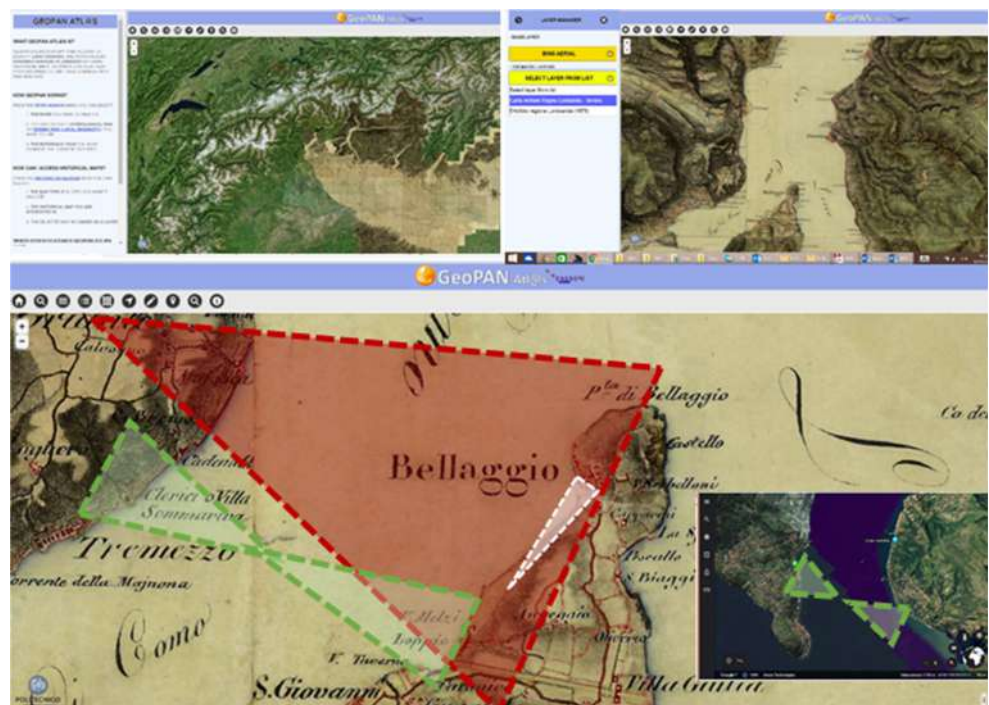
Fig. 27 The twin panoramic historical views of the Villa Melzi Gardens and Villa Sommariva (Villa Carlotta) Gardens. Modified detail of the panoramic print by Giudici-Brigola engraving, 1863 (see Fig. 23) (Courtesy of © POLIMI, dABCLAB - Gicarus)
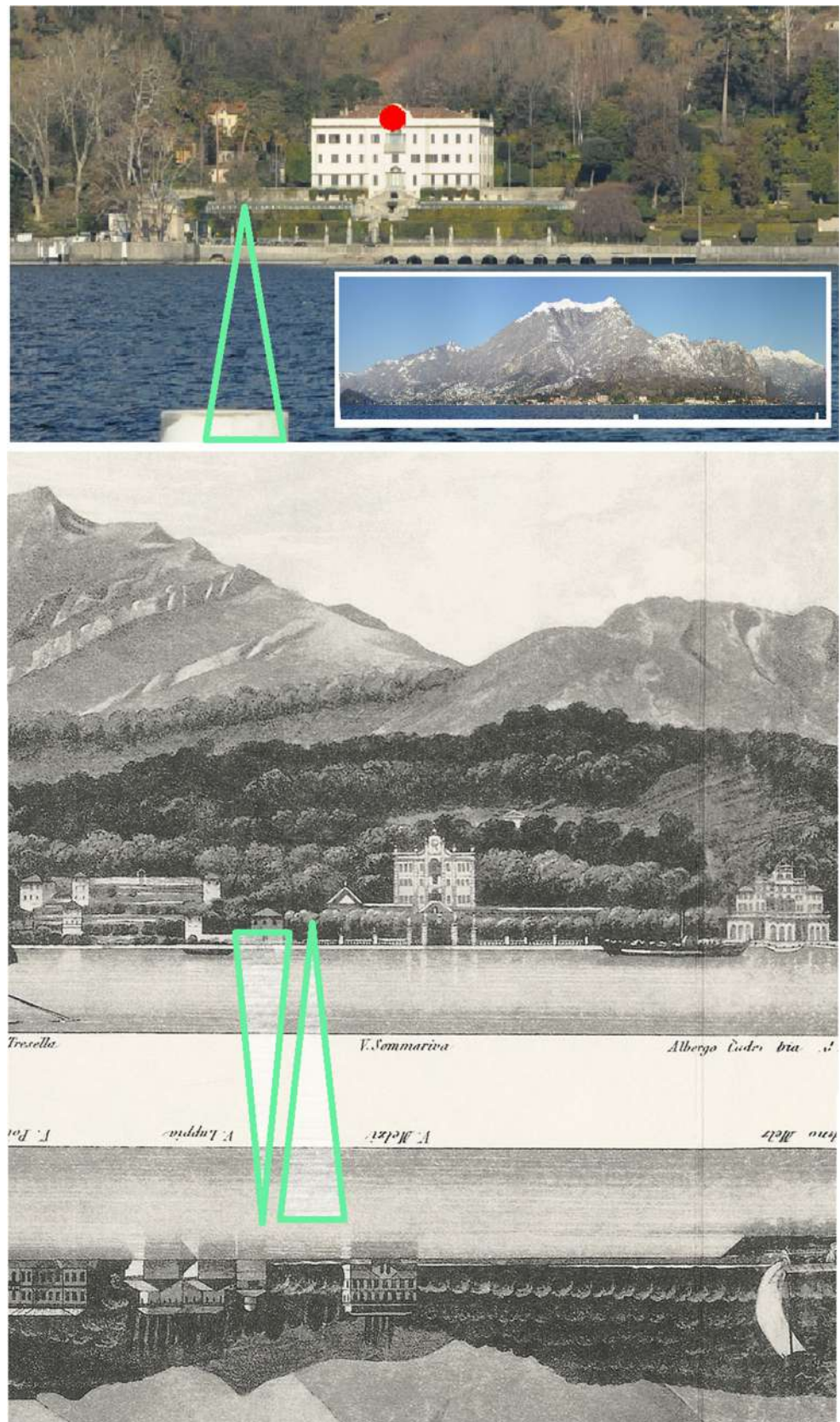
Fig. 28 The twin panoramic views of the Villa Melzi Gardens, Villa Serbelloni and Villa Carlotta Gardens referenced in the multimedia interface. Top: details of the famous terrace privilege view of Villa Melzi toward Bellagio's peninsula: Google Earth © (left), Google picture of the terrace © (centre), and water colour sketch from the terrace of Villa Serbelloni (right, ©Anna Lobovikov-Katz). Centre: Historical view of Villa Melzi and gardens: on the left "Bellagio. Villa Melzi, Campi Filippo; Naymiller Filippo - Stampe e incisioni - Lombardia Beni Culturali Bellagio. Codex, Pavia (IT) - http://www. codexcoop.it; Milano (MI), Civiche Raccolte Grafiche e Fotografiche. Civica raccolta delle stampe "Achille Bertarelli"; on the right, the Panoramic historical view (Brigola, 1863) that has been made navigable in the Multimedia Museum (Courtesy of © POLIMI, dABCLAB - Gicarus). Bottom: "Tremezzo. Villa Carlotta ex Villa Sommariva – Stampe e incisioni – Lombardia Beni Culturali; Codex, Pavia (IT) - http://www.codexcoop.it; Milano (MI), Civiche Raccolte Grafiche e Fotografiche. Civica Raccolta delle Stampe Achille Bertarelli; on the right, the Panoramic historical view (Brigola, 1863)

The "Panoramas in Geo-Context APP" layout proposal (on developing) represents the concept framework for a geo-time space application to valorize landscape knowledge by an innovative access to digital cultural open data and historical perspective view of the Lake of Como and the optic cone of the view referred on the historical maps (Fig. 29). By way of example: available tools such as JuxtaposeJS, imgSlider, Cocoen, Image Comparison Slider have been used to compare the data. This way the experience of the territory in the past will span from the traditional 2D–3D representation to the integration of the ancient perspective views, correlating the 2D–3D metric representation to the non-metric perspectives.

The Geopan APP-VM "Panoramas in Geo.Context" aims:

- To present the app and its functionalities to refer the ancient perspective views on the historical registered 3D

maps, through the optic cone view (with posts and short videos)
- To create a digital simplified timeline of the history of Como Lake with the contents from Europeana and external resources (enriched by short stories about the represented place) with the aim to raise awareness about Como Lake, the existence of Europeana collection and, more in general, of digital cultural heritage within landscape pressures (Cuca, 2017)
- To offer a space where the community is encouraged to share resources (e.g. current and historic pictures of Como Lake inside dedicated FB albums), to propose keywords for an intuitive research of data inside Europeana (for instance with a campaign Write your #Hashtag) and, eventually, to leave feedbacks about the app (useful to evaluate points of further developments)

Fig. 29 "Panoramas in Geo-Context APP" layout proposal on development (Courtesy of © POLIMI, dABCLAB - Gicarus)

- To stimulate the use of the tools within many other applications re-using the huge map heritage already available within Europeana, boosting the impact at an EU-Scale
- A direct involvement of the museums and local touristic offices is foreseen to reach a wider public. Targets: locals, schools, tourists.

Making historic, artistic, architectural, and landscape values of the gardens understandable to the general public: challenges and solutions

Historic gardens present a complex combination of visual values. They combine geometry, colour, and texture expressed through different materials, technologies, and plants, which reflect diverse historic epochs and tendencies of the development of arts, crafts, architecture, and landscape architecture. However, these aesthetical and historical values, though visible, are not always perceived by their owners or visitors.

Unlike the use values, they are frequently underestimated, or even overlooked. While the use and social values of the gardens (e.g. a place for rest and recreation activities, "green lungs" of the cities) could be easily understood as derived from common sense and from everyone's personal experience, their artistic and architectural values could hardly be "read" by a layman without educational support.

As previously underlined in the "Historical maps: a reference to define conservation and valorization plans for historic gardens" section, at the same time, historical, artistic, architectural, and landscape values of the gardens should be understood by visitors in order to allow them to explore and enjoy the gardens, to appreciate them. While the colour designs composed by combinations of different plants in the historic gardens can be easily perceived and appreciated, "reading", i.e. understanding of a three-dimensional composition of the designed space of a historic garden poses a much more difficult task for a layman. The obstacles in the way of understanding might be of an educational or of restoration origin.

Restoration challenges

It is known that restoration challenges as a way of understanding a historic garden might be more demanding than those of a historic building. The impact of conservation state of the garden on its visual perception might be of a wider range than that of a building. One of the challenges originates from a composition balance between the elements and the whole. A historic garden, besides buildings, structures, sculptures, and alleys, might involve complex compositions of plants of diverse size, shape, and colour against specific topography of the garden and of relevant natural, urban, or mixed landscape. Each of these elements is subject to alteration and deterioration. Metamorphoses of a historic garden might significantly imply on its spatial composition, as a result of added, changed, or deteriorated shape. While the deterioration of a building brings to a loss of material, deterioration in historic garden might also cause an overgrow of plants, and thus obscure the original vistas (Fig. 30). Conservation state of each particular case of a historic garden or landscape poses a set of problems that should be resolved in order to uncover its spatial composition and other values, which is even more complicated due to a living character of its core material—plants. In this situation, VR and AR presentations of gardens to the visitors pose special challenges and calls for unique decisions.

Educational challenges

Educational challenges involve the development of skills among the general public garden users who have no background in architectural, landscape, or conservation studies, that would help them to understand historic gardens and landscapes and their values.

If we could enable a viewer (visitor, owner, decision maker) to "travel" effortlessly between two-dimensional historic images of the gardens, digitized data—including 2D, 3D, and 4D—i.e. make this journey multi-temporal—while at the same time he/she could understand actual three-dimensional space in situ, in the garden, and have a good command of basic knowledge and understanding of the historic development of the history of the gardens—that would mean an important transformation from a garden user, who might be destructive merely as a result of unawareness of the garden's

Fig. 30 Two examples of diverse conservation state in the imperial ensemble of parks and gardens, Peterhof near St Petersburg, Russia: on the left, overgrown trees have not been trimmed since the second half of the eighteenth century, as they should have been in accordance with the original design; hence, they obscure the view of the alleys and of the pavilions in the Lower Park—which contradicts with its original layout of a regular garden; on the right, the area of the Lower Park by the Golden Cascade had undergone restoration which included the replacement of overgrown trees; hence, the alleys and elements (the fountains, the Marli palace) can be perceived from the upper terraces of the park and of the Cascade (Photo: Ada Segre, 2016)

values, to a garden preserver, who would also be in a better position to enjoy the gardens, both practically and aesthetically, thanks to his/her understanding of the garden's values. Such visitor, through his/her strolling along the alleys of a garden, would be capable of anticipating location of its beautiful vistas even before having actually reached them.

Three main skills, learning outcomes can be formulated:

a To understand three-dimensional space (development of spatial skills)
b To be aware of the architectural and landscape composition values
c To be aware of diverse "styles" of (historic approaches to) the gardens planning and design (e.g. not to expect from a landscape garden to be trimmed like the formal one).

Understanding three-dimensional space (development of spatial skills)

Spatial skills ("a") are basic skills for the other two ("b" and "c"). They are essential for the development of the ability to discover landscape composition patterns on site, and also for understanding garden styles and ideas and their development over the years. Spatial skills allow for the correct spatial understanding and visualization of three-dimensional space (Fig. 31). It allows a viewer to imagine, e.g. how a specific shape would look from a different point of view, without actually moving to that point. It allows to understand that from a certain point of view, a specific shape (as a tree, a garden pavilion, a mountain) would overlap with another object and obscure

the view. It might allow to understand in advance, that a difficult mountain climb might be totally unnecessary, while climbing a ridge nearby would be worth an effort, in order to see a beautiful view unwrapped. This would allow a general public visitor to go beyond the vistas known to all and add a benefit of an educated discovery to each tour of historic gardens and landscapes.

Awareness of the architectural composition value

Understanding the landscape-architectural composition patterns in a historic garden is a complicated task. Visitors to a historic garden front the unlimited three-dimensional spectrum of views which can be cast in practically any direction. An answer to the basic question upon entering the garden: Where to go first? might be led merely by a rational decision caused by the time limits allocated for a visit. This might also be influenced by a beautiful photograph in a tourist guide. However, in case of a general public visitor, it would be doubtful that a choice of route might be a subject to conscious spatial imaginative analysis and mental spatial imagination of a three-dimensional composition of a garden.

At the same time, the understanding of architectural composition of a garden is essential for its understanding and appreciation. An example of a complex central part of the Lower Park in the summer Imperial residence in Peterhof, St Petersburg, Russia, might illustrate a complexity of architectural landscape composition. The Lower Park has been laid out at the feet of natural terrace rising to 15–18 m above it. This topographic situation allowed to construct the Grand

Fig. 31 Two views at Bellagio: on the left, view of the Grand Hotel terrace from the Lake of Como, now Grand Hotel Villa Serbelloni (xylography by G. Barberis of a drawing by A. Curioni, 1874, private collection); on the right, view of the Como Lake and mountains landscape, as seen from the terrace of the Grand Hotel (Watercolor sketch: © Anna Lobovikov-Katz). A spatially-aware visitor, while casted a glance at the view of the Grand Hotel, would realise a three-dimensional richness of the environment, which involves a mountain beyond and gardens around the hotel, and also a good possibility of a wide view of the landscape once he/she turns his back, literally, to the famous hotel

Palace at the edge of the terrace, overlooking the Lower Park and providing beautiful vistas of the latter from the terrace, and from the palace, with a focal point of view from the main balcony located at the central symmetry axis of the palace and of the gardens. This example of the composition layout is typical of the regular gardens (e.g. focal view from the central window of the Versailles Palace, which served as an inspiration for the Peterhof ensemble in the beginning of the eighteenth century). The composition of the central part, which includes a limited number of major dominants (e.g. Grand Palace), is constructed of a group of miner compositions with their own sub-dominants. Relative role of each minor composition in the central part ensemble is also influenced by their location and role in the compositional equilibrium of the Lower Park as a whole. For example, the Sampson Fountain is located at the cross point of two core symmetry axes of the entire ensemble, including the Grand Palace, the Lower Park, the Upper Garden, and other gardens. Its role goes far beyond a local dominant of the central part. Two fountains to its east and west (the Italian and the French Vase fountains) serve as local dominants (Fig. 32b). The Grand Palace, no doubt, is central to the whole ensemble of parks and palaces of Peterhof, as well as to that of the central part. It is dominating from all points of the ensemble of the central part (Fig. 32a). However, while walking around one of the Vase fountains, enjoying another sculpture-fountains (e.g. the Nymph) and rose *parterre*, a visitor is seamlessly focusing on these elements which are designed in a composition, however of a secondary role in the whole ensemble, but, nevertheless, of independent values and quality. Such ability to switch between the whole and the detail, to be able to discover them in their integrity, and at the same time as artefacts of independent value, enriches and allows for an educated perception of historic, artistic, and architectural values of historic gardens and landscapes.

Awareness of diverse "styles" of (historic approaches to) the garden's planning and design

Basic acquaintance with the history of historic gardens is essential for their understanding. Each grand and small element plays its role in the composition and perception of the gardens. Understanding these, understanding specific connections between landscape architecture, architecture, between natural and human-made landscape, and between other areas of arts and literature, add rich layers to a garden visit. On the basic level, a visitor should be aware of core garden principles, and of the main types of historic gardens. This would help the visitor, e.g. not to expect from a landscape garden to be trimmed like a formal one. It would also help her/him to realize that a beautiful landscape of an English garden has not sporadically occurred as a natural grow of plants, but is actually a series of compositions designed by landscape architects, through the knowledgeable combinations of plants of diverse size, shape, and colour. Though many gardens have gone through historic metamorphoses that altered their pure character, a basic knowledge of the history of the development gardens in general would also help a visitor to better understand mixed styles in each specific garden (Fig. 33). Given a relevant educational background, a visitor to a place like Peterhof (Fig. 30, Fig. 32), upon realizing its topographical situation, would search for a focal central point of view, and, after reaching the top of the terrace and enjoying the view, would turn around to search consciously for a more uplift point of view, and discover the central balcony.

Fig. 32 Two examples of composition dominants in the Imperial ensemble of parks and gardens, Peterhof near St Petersburg. **a** Major dominant of the entire ensemble of parks and gardens in Peterhof—the Grand Palace. **b** One of sub-dominants symmetrically located in the Western and the Eastern parts of the central ensemble—the Voronihin Colonnades. **c** Side view of the terraces (Sketches © Anna Lobovikov-Katz)

Good practices and proposed educational methods

Combining online and on-site learning

Combination of online and on-site learning has shown to allow for a positive feedback of learners, and good results (Hazan and Lobovikov-Katz 2017; Lobovikov-Katz 2017). Several European and other educational activities targeted at the general public, and especially youth, demonstrated that young people become fascinated by offline learning activities, while combination of online and offline learning might be of a special interest. Combination of online learning activities with those held on historic sites allows a learner to connect to a real, physical material world. The opportunities of such connected online—on-site learning—urge for a further development and research. In the case of historic gardens and landscapes, another layer should be added, with their seasonal change in colour and shape in mind. "Online-onsite *shuttle learning*" (Lobovikov-Katz 2015) might provide a flexible creative tool to a better understanding of the gardens' values (Fig. 34).

Fig. 33 Learning and appreciation of values of the garden through sketching: diverse types of the gardens in the cities. On the left, Giardino del Lago, Villa Borghese, Rome. On the right, Jardim do Torel, Lisbon. Watercolour sketches © Anna Lobovikov-Katz

Fig. 34 An example of introducing the interaction between the whole and a single element in composition of a historic garden, on an example of the Schonbrunn Palace and Gardens (on the right), from the Module 1 of the ELAICH e-learning platform (a screenshot of the platform entrance page, on the left), developed by the European Project ELAICH – Educational Linkage Approach In Cultural Heritage (Euromed Programme 4) © Anna Lobovikov-Katz (Lobovikov-Katz et al. 2014)

Application of analytical sketching on site: learning methodology and application practice

Use of sketch as a tool of communication rather than as a work of art is starting to claim its well-deserved place in the modern interdisciplinary era. However, lack of practical systematic educational methods is an obstacle in this development. Rapid Learning Methodology in Freehand sketching (RALEMEFS) might provide a proper answer and dismantle many negative myths and non-justified difficulties on the way to a wide application of sketching. The use of RALEMEFS has been successfully tested and applied to analysis and understanding of cultural heritage, including built heritage, through education activities for diverse types of audience, including non-conservation (general public, including youth) (Lobovikov-Katz 2016). Furthermore, it was introduced to researchers and engineers beyond conservation community, to apply to the specific tasks and challenges in such domains as computer science research and development, and engineering. This methodology allows a learner to develop sketching ability within a short period of time, which is essential in our "rapid" reality (Figs. 35 and 36). The process of learning to sketch, especially if a proper theoretical basis and practical methodology provided, has an added value of contribution to the development of spatial skills. Application of analytical sketching to cultural heritage, and specifically to historic gardens and landscapes, allows a sketcher to "discover through the pencil's tip" spatial meaning and interrelationship of different parts and elements of a garden and of its natural or man-made environment.

Added value of the development spatial skills for the general public

The importance of the development of spatial skills has been widely studied by the international research community. One of the acknowledged benefits of the development of spatial skills/spatial abilities/spatial literacy is its contribution to the success in STEM (Newcombe 2010; Sorby 2009). Modern society, being a highly technological one, can gain through the development of these specifically targeted spatial skills. The ability to understand three-dimensional space of a historic garden or landscape is not a narrow-profiled one. It is a specific application of spatial understanding, spatial reasoning, and spatial visualization, which, once developed, can be beneficial for different uses.

Specifically with regard to the development of the ability of mental switch between, and combining the 2D and 3D data, it provides in itself a highly effective training in spatial skills. The same mechanism (2D–3D mental interplay) is one of the central tools of learning descriptive geometry—a discipline which has proven to bring to highly effective outcomes in the development of spatial skills (Nemeth 2007; Stachel 2013; Lobovikov-Katz 2019).

Therefore, a targeted education of the general public for their better understanding of the values of historic gardens and landscape will have an impact much beyond this specific area. It might contribute to many spheres of human activity, including jobs, learning, and others.

Fig. 35 Sketching as a tool for understanding a historical natural landscape, and the development of colour sketching skills using RALEMEFS—Rapid Learning Methodology in Freehand Sketching—developed and applied by Anna Lobovikov-Katz in her courses. Here are works by two students in the framework of a concentrated 5-day course "Color sketching of historic sites", Technion, Israel. The two top watercolour drawings show the progress made by the student: her first watercolour drawing, on the left, was made on the 2nd day of the course and the one on the right was made by the same student on the 5th day of the course (watercolour drawings by Aya Zeriene). The drawing on the top right represents a view of the Natural Reserve involving landscape and structures dating back to different historical periods (from Mediaeval to the twentieth century). The watercolour sketch below is by another student in the same course (Tal Smushkevich) and shows a wider view of that historic landscape and building from a different point of observation. All sketches were made in-situ

Conclusions

Many historic gardens—now used as public green spaces—often present a remarkable architectural and landscape interest that is not easily recognized by users, due to inadequate explanation.

Now it is the time to define methodological tools and educational programs to emphasize historical, cultural, and perceptive values in order to bring about awareness of these resources.

The progressive digitization of map sources and the growing use of web application based on georeferenced layers

Fig. 36 Nature (water) and the city. On the left, the Grand Canal in Venice. On the right, a tower and a part of the historic city wall in Tiberias with the Sea of Galilee in the background (watercolour sketches ©Anna Lobovikov-Katz)

coming from historical metric maps such as military maps and cadastral map collections allow to make available large datasets to the policy makers and to large public of non-expert users contributing to awareness rising of the historical garden perception. The use of panoramic views and open data collection (as Europeana collection or the Lombardy Region portals within MIBAC efforts) can contribute to enrich the consciousness of the historical values, with the help of geolocation tools and correlation tools connecting the historical map layers with such views. Applications developed on Virtual Hubs implemented to discover and access Open Data, and in particular Geographic Open Data, allow to connect the different data sources on the base of semantic, spatial, and temporal relations boosting cross-correlations that can support touristic itineraries. On-site visits, museums and multimedia museum visits can contribute to a better informed perception and knowledge of the historical garden heritage among citizens, training programs can act in this direction giving tools to manage enriched correlations, and moreover citizen can be sentinel of such richness toward the preservation of the stratified contents, including the panoramic cone preservations within a sustainable planning. As more data testifying the past and richness can circulate, as more modern semantic-based tools can discover and correlate data coming from spread sources, as more we can improve the effort of georeferencing such data, the more we could preserve and augment the reality by mean of its past.

Code availability   Not applicable.

Authors' contributions   The present paper was conceived and written jointly by the four authors. In particular, Alberta Cazzani developed the "Historical maps: a reference to define conservation and valorization plans for historic gardens" section, Carlotta Maria Zerbi developed the "Nineteenth century cartography: uncovering the past to reveal the present of our historic gardens" section, Raffaella Brumana developed the "4D maps, historical views, and panoramic cones: making historical and other values accessible to large public by means of advanced methodologies and applications" section, and Anna Lobovikov Katz developed the "Making historic, artistic, architectural, and landscape values of the gardens understandable to the general public: challenges and solutions" section. The authors collaborated in the writing of the Abstract, the Introduction, and the Conclusions and for the final revision of the manuscript.

Expertise involved in this paper: architectural and landscape preservation (AC, CMZ), landscape analysis and planning (AC,CMZ, RB), geomatics (RB), landscape sketching training (ALK), heritage education (all the authors).

Data availability   Not applicable.

Compliance with ethical standards

Conflict of interest   The authors declare that they have no conflict of interest.

References

Agapiou A, Alexakis D, Lysandrou V, Sarris A, Cuca B, Themistocleus K, Hadjimitsis DG (2015) Impact of urban sprawl to cultural heritage monuments: the case study of Paphos area in Cyprus. J Cult Herit 16(6):671–680

Archiepiscopal Curia of Milan Archives (n.d.) https://www.chiesadimilano.it/archiviostoricodiocesano/; last accessed 2020.03.20;

Balletti C, Guerra F (2009) Image matching for historical maps comparison. e-Perimetron 4:180-6

Barazzetti L, Brumana R, Oreni D, Roncoroni F (2013) Recognizing landscapes: can we change the point of view of geographic data? Journal of Mobile Multimedia 9:039–052

Bianchi GB (1828) Un'ora nel giardino di Desio. Almanacco per l'anno 1829, GB Bianchi e Comp, Milano

Boriani M, Cazzani A (2004) Il difficile governo del giardino storico: molteplicità degli approcci conoscitivi e complessità della gestione degli interventi. In: Brignani M, Roncai L (ed) Giardini cremonesi, Del Miglio, Cremona, pp 49–63

Brioschi M, Conte P, Tosi L (2017) Le delizie della villeggiatura: villa e giardino Cusani Traversi Antona Tittoni di Desio: da Bernabò Visconti a proprietà pubblica, Desio

Brumana R, Achille C (2007) e-historical sites. Georeferencing as availability of space-temporal data: historical cartography towards advanced 3D view. e-Perimetron 2:134–159

Brumana R, Santana Quintero M, Barazzetti L, Previtali M, Della Torre S, Roels D, Capitani M (2015) A geo-swot chart, using a values centered approach and multitemporal-maps for landscape assessment and multimedia eco museum. In: Di Stefano M (ed) ICOMOS International Symposium "Heritage and Landscape as Human Values", pp 186–191

Brumana R, Oreni D, Caspani S, Previtali M (2018) Virtual museums and built environment: narratives and immersive experience via multi-temporal geodata hub. Virtual Archaeol Rev 9:34–49. https://doi.org/10.4995/var.2018.991

Caspani S, Brumana R, Oreni D, Previtali M (2017) Virtual museums as digital storytellers for dissemination of built environment: possible narratives and outlooks for appealing and rich encounters with the past. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences XLII-2/W5:113–119

Cazzani A (2009) Brenna Giovanni In: Cazzato V (ed) Atlante del Giardino Italiano 1750-1940. Dizionario biografico di architetti, giardinieri, botanici, committenti, letterati e altri protagonisti. Italia Settentrionale, Istituto Poligrafico e Zecca dello Stato, Roma, pp 225–226

Cazzani A, Brumana R, Zerbi CM (2019a) The geo-referenced XIX century cartography: an analysis tool and a project reference for the preservation and management of built and landscape heritage. International Archives of the Photogrammetry, Remote Sensing & Spatial Information Sciences XLII-2/W11:395–402 https://doi.org/10.5194/isprs-archives-XLII-2-W11-395-2019, 2019

Cazzani A, Zerbi CM, Brumana R (2019b) Management plans and web-gis software applications as active and dynamic tools to conserve and valorize historic public gardens. International Archives of the Photogrammetry. Remote Sensing & Spatial Information Sciences XLII-2(W15):291–298

Como State Archives (n.d.) ASCO (Archivio di Stato di Como), http://www.archiviodistatocomo.beniculturali.it/; last accessed 2020.03.20;

Cuca B (2017) The contribution of earth observation technologies to monitoring strategies of cultural landscapes and sites, Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci XLII-2/W5:135–140. https://doi.org/10.5194/isprs-archives-XLII-2-W5-135-2017

Cuca B, Brumana R, Scaioni M, Oreni D (2011) Spatial data management of temporal map series for cultural and environmental heritage. Int J Spati Data Infrastruct Res 6:97–125. https://doi.org/10.2902/1725-0463.2011.06.art5

Donati M (2012) Storie di Imprenditoria Lombarda. Giovanni Brenna, cartografo di Lombardia, Associazione Culturale Casimiro Teja, Eventi s.a.s, Cesano Maderno

Emanueli F (2016) Il paesaggio rurale storico e tradizionale: individuazione degli elementi storici e delle fonti. Documento realizzato dall'ISMEA nell'ambito del Programma Rete Rurale Nazionale Piano 2016, Scheda Progetto Ismea 5.1 Ambiente e Paesaggio rurale, Dicembre 2016

Harney M (2014) Gardens and landscapes in historic building conservation. John Wiley & Sons

Hazan S, Lobovikov-Katz A (2017) The willing suspension of disbelief: the tangible and the intangible of heritage education in e-learning and virtual museums. In: Ioannides M, Magnenat-Thalmann N, Papagiannakis G (eds) Mixed reality and gamification for cultural heritage, Springer-Nature, New York, pp 549–566

http://www.lombardiabeniculturali.it/stampe/schede/H0110-10261/; last accessed 2020a.03.20

http://geoserver.atlas.polimi.it/examples/servlets/Geopan/D/Entry/selector2b.html; last accessed 2020b.03.20

https://www.europeana.eu/portal/en/about.html; last accessed 2020c.03.20

https://www.europeana.eu/portal/en/search?page=2&q=Bellagio&view=grid; last accessed 2020d.03.20

https://www.europeana.eu/portal/it/record/90402/RP_T_1948_519.html; last accessed 2020e.03.20

https://www.europeana.eu/portal/record/2024903/photography_ProvidedCHO_KU_Leuven_9988546660101488.htm; http://hdl.handle.net/10934/RM0001.COLLECT.26623; last accessed 2020f.03.20

http://geoserver.atlas.polimi.it/examples/servlets/Geopan/D/web_APP/index.html; last accessed 2020g.03.20

https://www.energic-od.eu/; last accessed 2020h.03.20

IGM (1950) Segni convenzionali e norme sul loro uso. Volume I – Cartografia alla scala 1:25.000, Istituto Geografico Militare, Firenze

Lobovikov-Katz A (2015) The virtual and the real: e-learning in interdisciplinary education – the case of cultural heritage. In: The 13th Annual MEITAL National Conference "New Technologies and Their Evaluation in Online Teaching and Learning", Technion-Israel Institute of Technology, Haifa

Lobovikov-Katz A (2016) "Human" technology in the digital era: free-hand images and analysis of cultural heritage –the know-how and its applications. In: Ioannides M, Fink E, Moropoulou A, Hagedorn-Saupe M, Fresa A, Rajcic V, Grussenmeyer P (eds), Digital heritage. Progress in cultural heritage: documentation, preservation, and protection volume 10058 of the series lecture notes in computer science, springer, Cham, pp 337-349

Lobovikov-Katz A (2017) Basic visual disciplines in heritage conservation: outline of selected perspectives in teaching and learning. International Archives of the Photogrammetry, Remote Sensing & Spatial Information Sciences XLII-2/W5:459–465

Lobovikov-Katz A (2019) Methodology for spatial-visual literacy (MSVL) in (heritage) education: application to teacher training and interdisciplinary perspectives. Revista electrónica interuniversitaria de formación del profesorado 22:41–55. https://doi.org/10.6018/reifop.22.1.358671

Lobovikov-Katz A, Moropoulou A, Konstanti A, Ortiz Calderón P, Van Grieken R, Worth S, Cassar JA, De Angelis R, Biscontin G, Izzo F (2014). Tangible versus intangible in e-learning on cultural heritage: from online learning to on-site study of historic sites. In: Ioannindes M (ed) Digital heritage. Progress in Cultural Heritage: Documentation, Preservation and Protection, Springer, Cham, pp 819–828

Mazzetti P, Latre MÁ, Ernst J, Brumana R, Brauman S, Nativi S (2015) Virtual hubs for facilitating access to open data. In: EGU General Assembly Conference Abstracts, 17

Milan State Archives ASMI (Archivio di Stato di Milano), https://www.archiviodistatomilano.beniculturali.it/; last accessed 2020.03.20

Molnar T, Brumana R, Conventi M, Previtali M (2019) Digital documentation and monitoring hub in climate-sensitive territories: the Albenga case study (San Clemente site). Int Arch Photogramm Remote Sens Spatial Inf Sci. XLII-2/W11:881–886. https://doi.org/10.5194/isprs-archives-XLII-2-W11-881-2019

Nativi S, Craglia M, Pearlman J (2013) Earth science infrastructures interoperability: the brokering approach. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing 6:1118–1129

Nemeth B (2007) Measurement of the development of spatial ability by mental cutting test. Annales Mathematicae et Informaticae 34:123–128

Newcombe N (2010) Picture this: increasing math and science learning by improving spatial thinking. Am Educ 34:29

Previtali M, Latre MÁ (2018) A brokered virtual hub approach for the generation of web applications based on historical maps. ApplGeomat 10:453–472. https://doi.org/10.1007/s12518-018-0235-1

Silva E (1801) Dell'arte dei giardini inglesi. Dalla Stamperia e Fonderia al Genio Tipografico casa Crivelli, Milano

Silva E (1813) Dell'arte de' giardini inglesi, Seconda edizione ricorretta ed accresciuta dall'autore, e coll'aggiunta di nuove tavole incise in rame, 2 voll. Pietro e Giuseppe Vallardi, Milano

Sorby SA (2009) Educational research in developing 3-D spatial skills for engineering students. Int J Sci Educ 31:459–480

Stachel H (2013) Descriptive geometry - vision guided spatial reasoning. In: Cocchiarella L (ed) The visual language of technique, between science and art. Springer, Cham, pp 71–84

UNESCO, 2011. Culture, urban future: global report on culture for sustainable urban development, Document code: CLT-2016/WS/18, http://unescodoc.unesco.org

Viganò A (1983) Per una cartografia briantea: l'opera di Giovanni Brenna. I quaderni della Brianza VI:30

Watkins J, Wright T (2007) The management & maintenance of historic parks, gardens & landscapes: the English heritage handbook, Frances Lincoln Ltd

Yang M, Brumana R, Previtali M (2019) "Heritage & Development" strategy on historic urban landscape (HUL): the added value of multi-temporal hub application, International Archives of the Photogrammetry, Remote Sensing & Spatial Information Sciences XLII-2/W11:1151–1158 https://doi.org/10.5194/isprs-archives-XLII-2-W11-1151-2019, 2019