CONTRIBUTION FOR AN URBAN GEOMORPHOHERITAGE ASSESSMENT METHOD: PROPOSAL FROM THREE GEOMORPHOSITES IN ROME (ITALY)

Alessia Pica[1], Gian Marco Luberti[2], Francesca Vergari[1], Paola Fredi[1], Maurizio Del Monte[1]

[1]Department of Earth Sciences, Sapienza University of Rome, Italy
[2]Department of Evaluation, Inspections and Environmental Sustainability, Italian National Institute for Environmental Protection and Research, Rome, Italy

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Abstract: Urban geomorphology has important implications in spatial planning of human activities, and it also has a geotouristic potential due to the relationship between cultural and geomorphological heritage. Despite the introduction of the term Anthropocene to describe the deep influence that human activities have had in recent times on Earth evolution, urban geomorphological heritage studies are relatively rare and limited and urban geotourism development is recent. The analysis of the complex urban landscape often need the integration of multidisciplinary data. This study aims to propose the first urban geomorphoheritage assessment method, which originates after long-lasting previous geomorphological and geotouristic studies on Rome city centre, it depict rare examples of the geomorphological mapping of a metropolis and, at the same time, of an inventory of urban geomorphosites. The proposal is applied to geomorphosites in the Esquilino neighbourhood of Rome, whose analysis confirm the need for an *ad hoc* method for assessing urban geomorphosites, as already highlighted in the most recent literature on the topic. The urban geomorphoheritage assessment method is based on: (i) the urban geomorphological analysis by means of multitemporal and multidisciplinary data; (ii) the geomorphosite inventory; and (iii) the geomorphoheritage assessment and enhancement. One challenge is to assess invisible geomorphosites that are widespread in urban context. To this aim, we reworked the attributes describing the Value of a site for Geotourism in order to build up a specific methodology for the analysis of the urban geomorphological heritage.

Key words: urban geomorphology, urban geomorphosites, urban geomorphoeritage assessment, human impact, Rome

Corresponding author: Alessia Pica, alessia.pica@uniroma1.it

Introduction

"Geomorphology is the study of landforms, their processes, forms and sediments, looking at landscapes to work out how the earth surface processes, such as air, water and ice, can mould the landscape" (BSG 2017). This definition depicts geomorphology focused on rural or natural regions, but present urbanization rate forces us to consider the expansion of cities as a high-impact morphogenetic process. Particularly since the last century, the urban sprawl deeply reclaimed space, modifying, erasing or destroying landforms.

Urban geomorphology analyses:

(i) the impact of urban sprawling and human activities on natural geomorphology (Gierlinger et al. 2013, Mohapatra et al. 2014, Mozzi et al. 2016);

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(ii) the geomorphic constraints on urban development (Cooke 1976);

(iii) the suitability of different landforms for specific urban uses (Hara et al. 2008);

(iv) the creation of anthropogenic landforms due to urbanization (McCall et al. 1996, Douglas 2005, Szabó et al. 2010),

(v) the anthropogenic topographic modifications (Del Monte et al. 2016, Jordan et al. 2016);

(vi) the urban geomorphological hazards (Martin Diaz et al. 2015, Pratesi et al. 2016).

All these topics demonstrate how urban geomorphology has important implications in urban planning (Ferrario et al. 2015, Youssef et al. 2015, Brown et al. 2016), as well as in the comprehension of the extent of human activities on geomorphological processes (Brown et al. 2013), considering that humans have influenced the natural evolution of the Earth so deeply to suggest the introduction of the concept of the Anthropocene (Crutzen, Stoermer 2000).

According to Reynard et al. (2017), urban areas are also particularly interesting from a geomorphological heritage point of view. In fact, the geomorphological context of cities often represents their own *image* and a touristic attraction (Reynard et al. 2015, Pica et al. 2016). On the other hand, the geomorphological context deeply interacts with urban sprawl and it duels with it, conditioning its expansion directions. The evolution of the urban landscape is interesting from the cultural point of view because of the profound influence of landforms on the culture that is established on them: landforms that are recognizable, despite of the landscape transformations, and related to the cultural evolution of an area are the perfect topic for a geotouristic proposal.

Studies on urban geomorphological heritage are relatively rare and limited (Reynard et al. 2017), and urban geotourism is recent. Some pioneering works are from London (Robinson 1982, 1984, 1985); more recent studies analyse the origin of building stones (Gomez-Heras et al. 2010, Perez-Monserrat et al. 2013, Borghi et al. 2015, Del Lama et al. 2015) and the geological/geomorphological features of the natural site on which a city is built (Côté et al. 2009, Rodrigues et al. 2011, Del Monte et al. 2013, Pica et al. 2016); the links between geoheritage and archaeological heritage (Dóniz-Páez, Becerra-Ramíre, 2015, Palacio Prieto 2015); geotourism mapping (Côté et al. 2009, Pica et al. 2016). Urban areas also provide interesting contextual conditions for developing geotouristic products (Reynard et al. 2015, Pica et al. 2017), based on geo-interpretation (Martin et al. 2010, Hose 2012, Martin 2014).

In this context, the geomorphologists community recently presented several new studies regarding several European cities: Brno (Czech Republic), Paris (France), Rapallo, Roma (Italy), Poznań, Pruszków (Poland), Bucharest, Curtea d'Arges, Oradea (Romania), Lubljana (Slovenia). The development of specific urban geomorpho-heritage methods of investigation (assessment, inventories, cartography) resulted preliminar.

This work investigates and explains these concepts thanks to some examples from Rome. The geomorphological analysis of the *Aeterna Urbs* allowed us to characterize a very peculiar urban landscape and to classify a large variety of anthropogenic landforms (Del Monte et al. 2016). Since the Roman period, in some situations landforms have facilitated human activities. Somewhere, they have been completely erased or man-made landforms have been created. The Geomorphological Map of Rome reconstructs the anthropogenic transformations of the city, describing the superimposition of landforms over time (Del Monte et al. 2016). It is a document that integrates geomorphological and cultural data (foremost archaeology and historical topography). As an extension of this project, a geomorphosite inventory of the same area was performed. The geotouristic potential of two geomorphosites of scientific, aesthetic and cultural interest was assessed and a geotouristic itinerary proposed (Pica et al. 2016): the Tiberina Island and Testaccio Mount are examples of landforms telling us about the natural and anthropogenic landscape evolution of Rome, and they are perfectly mixed with aesthetic and cultural elements of the city. A geotouristic trail was proposed by describing the palaeogeography of ancient Rome through the landforms that are still visible, and by the visit at the two geomorphosites. On the basis of Lausanne example (Reynard et al. 2015), an effective tool for the enhancement of the geotouristic proposal was realised: the GeoGuide Rome is a smartphone application (Pica et al. 2017) that uses mobile technologies, interactive and recreational contents to explain the landscape evolution and the geomorphological heritage of Rome.

Many other landforms have potential interest for geotourism in Rome and some of them are presented in this work. The objective is to improve the geomorphosite assessment method applied to three new case studies. In order to do this, the methodological approach, its application to the new geomorphosites and suggestions coming from this recent analysis are described.

Urban geomorphoheritage assessment methodology

The proposed urban geomorphoheritage assessment methodology (Fig. 1) is based on:

(i) the urban geomorphological analysis by means of multidisciplinary processing of multitemporal data;

(ii) the geomorphosite inventory;

(iii) the geomorphoheritage selection, assessment and enhancement.

The methodology was applied to Rome city centre. Since many invisible geomorphosites are widespread in the urban context, one of the challenges was to assess them as part of the geomorphoheritage. To this aim, we reworked the attributes describing the *Value of a site for Geotourism* (VSG index; Pica et al. 2014) in order to build up a specific methodology for the analysis of urban geomorphological heritage.

Urban geomorphological analysis of Rome: the importance of multidisciplinary and multitemporal data

Block 1 in Fig. 1 represents the methodological approach to the geomorphological analysis of urban environment; it summarizes the multitemporal data collected and the sequences of work.

The main aim of the geomorphological analysis of Rome is to analyze with a multidisciplinary and multitemporal approach the city centre urban area, in order to reconstruct the evolution of the geomorphological and cultural landscape. This area has been exposed to millennia of human presence. To reconstruct and represent the complexity of the landscape evolution, we performed a multitemporal analysis of aerial photographs and historical topographic maps, archaeological maps and reports, lithographs and paintings, daguerreotypes and traditional historical photos. An accurate geomorphological survey integrated the analysis.

The materials under investigation cover a time period from Roman Republican age to Late Antiquity and Middle Ages, up to the 20th century, when the area was radically transformed. The urban area progressively increased, and since the end of the 19th century new neighbourhoods have been built.

The analysis of different types of spatial data and the production of the map was facilitated by the use of a Geographic Information System (ArcMap®ESRI) software.

The geomorphological study was based on the analysis of aerial photographs covering a time span of 80 years, specifically surveys by: SARA-Nistri (1934) and Royal Air Force (MAPRW, 1943–1944), which are the first flights on Rome producing stereoscopic couples of aerial photographs; GAI National Flight (1954) and more recent stereoscopic material (i.e. RER national flight 1988/1989).

The results of aerial photointerpretation were matched with historical maps in order to detect

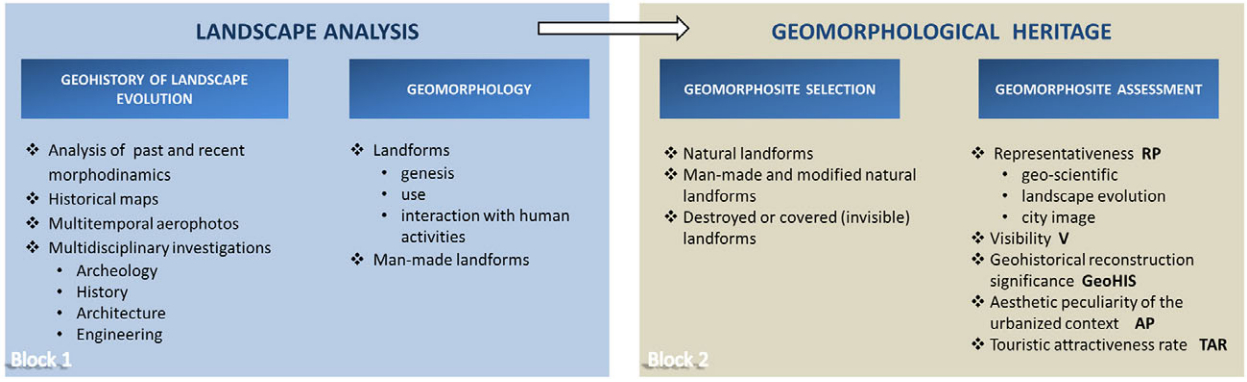

Fig. 1 Methodological approach for urban geomorphology and urban geomorphoheritage analysis.

previous modifications of the topographic surface. The analysis of historical cartography also considered geometrically inaccurate *bird's eye* maps (Dupérac 1577, Falda 1676) as well as trigonometrically surveyed maps (Moltke 1852) and maps with extreme planimetric precision for the time, such as the Nolli (1748) map, and more recent maps from the Italian Geographic Military Institute (IGM 1873). The comparison of the Urbanization Plan of Rome, surveyed in 1907 and later updated (IGM 1924), with more recent topographic maps allowed us to recognize most of the main 20th century anthropogenic modifications.

The bedrock outcrops were derived from the map by Ventriglia (2002), taking also into account other geologic maps (Marra, Rosa 1995, Funiciello, Giordano 2008) and older maps and literature data. Information about the thickness of fill deposits were provided by drilling databases (Rea 2011, Ventriglia 1971, 2002) and geothematic maps, such as the maps of the thickness of anthropogenic deposits by Ventriglia (1971) and Corazza and Marra (1995).

Field survey of the urbanized study area allowed defining the kind and intensity of anthropic transformations, comparing present-day and past morphologies.

Archaeological papers (e.g., Pinza 1925, Quilici 1990) and the archaeological map of Rome by Lanciani (1893–1901) were fundamental to collect information about the geomorphologic characteristics before most of man-made modifications. Archaeological documents (e.g., Cifani 2008) were effective in describing how building activities induced landscape transformations, whereas the description of demographic increments along the time often described the city expansions in specific areas rather than other (e.g., Witcher 2005): in most cases the selection of areas for urbanization purposes has morphological reasons. Not least, the collection of legends that the archaeological literature reports are often harbingers of information on the environmental conditions of the time and how they would influence human activities: an example is the legend of the discovery of the twin founders of Rome in a swamp next to Tiber or the one on the Tiberina Island genesis (Del Monte et al. 2013).

Other important information on natural landforms now hidden were obtained from paintings and pictures. In particular, artistic representations of landscape are full of information about transformations: Rome have been visited by thousands of artists along the time, so this kind of material covers a huge time span and tells about early landscapes in the same way as early maps or archaeological ones do.

Since the recognition and mapping of landforms are based on genetic criteria, each landform was classified in a database depending on the main type of geomorphic process. Landforms were distinguished in active and inactive; a third column, named modified, was added when necessary, to indicate a natural landform still recognizable, even if it appears greatly modified by human activity. Due to the extraordinary variety of manmade modifications, the classification of landforms and anthropogenic processes was deeply improved and integrated, attempting when possible to record the previous erased morphology.

Urban geomorphosites selection and geomorphoheritage assessment

A 25-years long work leads to the results described in several papers about Rome geomorphology (e.g., Del Monte et al. 2013, 2016). The recent tendency of this research has been to improve the geomorphological heritage analysis already described in Del Monte et al. (2013) and Pica et al. (2016). New results are coming thanks to the extraordinary interaction between human activity, history and geomorphology that characterizes Rome. The methodological approach described and applied in Del Monte et al. (2013, 2016) is developing in a new direction, described in Fig. 1, block 2, concerning urban geomorphosite selection and assessment.

The selection and assessment of the geomorphosites in the previous studies was based on the attributes describing the *Value of a site for Geotourism* (VSG index, Pica et al. 2014):

- scientific representativeness (RP),
- rarity (RR),
- scenic/aesthetic attractiveness (SCE),
- historical cultural interest (SAC),
- accessibility (AC).

$$VSG = RP + RR + SCE + SAC + AC$$

The VSG is an index for geosite assessment and it is generic for the evaluation of any kind

of geosite. Each value represents a class, corresponding to an interval, obtained summarizing scores. The scores are collected compiling some tables describing geosite characteristics . The evaluation is aimed to remove the subjectivity of the selection procedure and confers a value to the analysis of the geosite characteristics.

The application of this evaluation index to this study highlighted the need to improve the urban geomorphosite assessment method by preparing a specific index for urban geomorphosite assessment. Suggestions coming from the case studies described in this article allowed us to build up new attributes (Fig. 1, block 2) and to organize a proposal for the assessment of urban geomorphosites.

Urban geomorphosites of Rome: analysis of geomorphosites in the Esquilino area

Starting from the analysis of the wider area of the geomorphological map of Rome (Del Monte et al. 2016), this work focuses on the Esquilino area (Fig. 2) with the aim of increasing the list of Rome geosites (after Del Monte et al. 2013, Pica et al. 2016) and analysing some landforms as urban geomorphosites. The geomorphosites described here are:

- Monte della Giustizia
- St. Vitale Basilica
- Sapienza Campus

For each case study the description is divided in two parts: Geomorphological characterization and Geomorphoheritage characterization. The geomorphoheritage characterization is based on the attributes of the Value of Site for Geotourism (see description above) and highlights the method limits in urban environment and the suggestions in order to build up a specific urban geomorphoheritage assessment method.

Monte della Giustizia

Geomorphological Characterization

The Monte della Giustizia (Justice Mount) is an emblematic example of a convex landform (Fig. 2, letter b) created by man during the Roman period, not active in the Middle Ages and finally erased by the 19th century urbanization. Its history is almost three thousand years long and intersects the history of Rome, starting from ancient times up to today. The Monte della Giustizia was an artificial hill located on the top of a lithostructural flat surface of volcanic origin (Del Monte et al. 2016) at approximately 60 m a.s.l., the so called "Monti" (Mounts), as the ancient Romans called the Seven Hills.

The flat area where this anthropogenic hill was built is part of the volcanic plateau generated during the Middle Pleistocene by merging of mainly pyroclastic deposits emitted by the Monti Sabatini and the Colli Albani volcanic complexes, located NW and SE of Rome, respectively (Marra, Rosa, 1995, Pica et al. 2016). This anthropogenically modified structural surface corresponds to the summit of the three higher hills on the eastern side of the Tiber River. They are the Viminale, Esquilino and Quirinale hills (Fig. 2), which have been sculptured since the uppermost Late Pleistocene. The valleys between them have been filled by fluvial deposits during the Holocene (Del Monte et al. 2016, Luberti et al. 2017).

The genesis of the Monte della Giustizia is related to the sixth King of Rome, Servius Tullius. During his government the city grew a lot beyond the small hills of foundation in front of the Tiber River (Palatino and Capitolino hills). To defend the city Servius Tullius built a huge system of walls (Servian Walls in Fig. 2). The flat structural surface described above was not a suitable site for military defence purposes, so the King's engineers adopted additional solutions: "… *Servius added to the other hills Esquilino and Viminale, very difficult to defend. Hence, a deep trench was excavated; the soil was rejected on the inner edge, creating an embankment more than 1 km long. On this embankment they built a wall with towers* (the Servian Walls)"(Strabone, quoted by Coarelli 2012). The building of the embankment (in Latin *aggere*: Aurigemma 1962) transformed this area in the highest relief within the Rome of the 6th century BC. The embankment of the Servian Walls is still recognizable on the maps of Nolli (1748), Presidenza del Censo (1839) and Moltke (1852). Nine centuries after the construction of the Servian Walls, during the Imperial Age (4th century AD), the magnificent Baths of Diocletian were built on a surface equal to fourteen hectares, lying next to the ancient embankment. In the Middle Ages, a period of decline and abandonment of this area, a large amount of filling

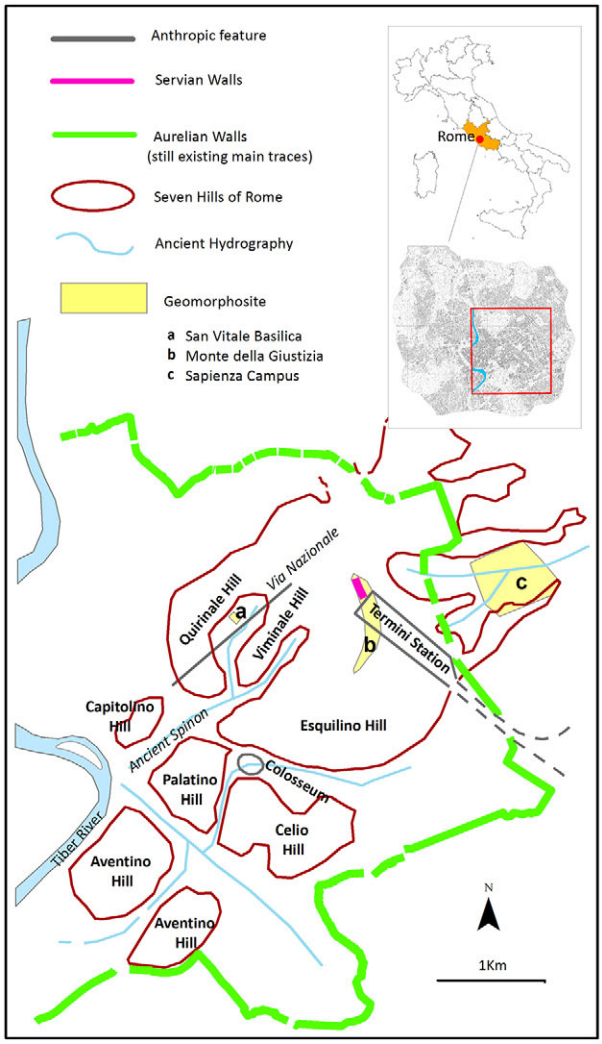

Fig. 2. Study area: location and main elements described in the text.

materials (shards, rubbish, fragments of bricks and marbles) were gradually accumulated on the Servian Walls, leading to the complete burial of this useless defence system. Therefore, an artificial hill about 20 m high was created, covering both the previous embankment and the walls that had been erected on the top of the natural relief (Fig. 3a). The artificial hill lasted until the 19th century, when the works for the construction and subsequent widening of the Termini Railway Station produced its partial (Fig. 3b) and finally complete demolition. A stretch of the old Servian Walls was rescued and today it is visible outside the station and in the basement (Fig. 3c).

The Monte della Giustizia is therefore a vanished hill, like other vanished hills of the ancient Rome (e.g., Velia hill, see Del Monte et al. 2013, 2016): at first it was built by human activity and later men demolished the same landform they had created a very long time before.

Geomorphoheritage Characterization

Though the Monte della Giustizia landform is no longer recognizable in the landscape, the Servian Walls remains near Termini Station (Fig. 3c), so testifying the previous mount existence (Fig. 3a, b). In fact, for a long time the walls have been covered by the debris shaping the mount, and they were dug up in 1949 (Aurigemma 1962). The ancient walls stretch emerging in this area is the better preserved in Rome and it is well promoted: some panels explaining their origin are displayed and a small park surrounds the walls. Several historical and archaeological documents describe the trace and the trend with respect to the morphology of the terrain (Aurigemma 1962, Menghi 2008). Early maps clearly show the shape of the Monte della Giustizia (Nolli 1748, Presidenza del Censo, 1839, Moltke, 1852), and the gradual disappearance is shown in some photos of the Termini Station expansion (Fig. 3a and b), but the landform is now not recognizable.

Fig. 3. a. Monte della Giustizia before the demolition, 1862 (image by Lalupa, Wikimedia Commons). b. On the right side of Termini Station: what remains of Monte della Giustizia, one year before its final demolition, 1868 (Photo: Raccolta Parker). c. the Servian Walls outside the station, as they appear today after having been extracted from debris (Photo: A. Pica, 2016).

The Monte della Giustizia has a potential as urban geomorphosite (Reynard et al. 2017), because it is very representative of the urban landscape evolution, but at the same time it is an example of a common problem in urban geomorphological heritage: it is an invisible landform (Clivaz, Reynard 2017) because urbanization completely deleted it.

Though the landform is invisible, the site presents all the attributes to be considered a potential geomorphosite:

- it is *representative* of human activities as morphogenetic agent;
- it has *scenic/aesthetic attractiveness* thanks to the ancient walls presence;
- iconographic and written documents testify each phase of the landform transformation over the centuries and increase the site *historical/archaeological* value.

It is, therefore, an invisible geomorphosite according to Clivaz and Reynard (2017) definition. This case study highlights that the attributes generally taken into account for geomorphosite assessment are not sufficient in the case of urban environment: deleted landforms and landforms deeply modified by human activities are not easily readable by non specialists (Clivaz, Reynard 2017) meanwhile a geomorphosite needs to easily communicate its value.

However, new technologies offer lots of tools for geotourist enhancement of invisible geomorphosites (e.g., geointerpretation tools (Martin et al. 2010, Cayla 2014), 3D reconstructions (Cayla et al. 2012) or interpretive images (Pica et al. 2017). This encouraged to include deleted landforms, such as Monte della Giustizia, in the geomorphosite inventory. The Servian Walls tourist attractiveness and the geohistorical reconstruction, enhanced through geotourist tools, could make the Monte della Giustizia an emblematic example of popularizing an invisible urban geomorphosite. A suggestion from this case study is to include in the urban geomorphosite assessment method the geohistorical reconstruction significance and the tourist attractiveness rate as valuable attributes.

San Vitale Basilica

Geomorphological Characterization

The church of San Vitale (San Vitale Basilica; Fig. 2, letter a) was built at the end of the 4th century AD. The church was originally built next to the bottom of the valley of a small tributary of the Ancient *Spinon*, a stream channel separating the Capitolino from the Palatino hill (Del Monte et al. 2016) (Fig. 2 and Fig. 4a). The temple was erected beside the Roman age *Vicus Longus* street, going from the hill sector down to the Tiber River alluvial plain. The same way has lasted over centuries, renamed as *Strada di San Vitale* (Fig. 4b). No further significant modification occurred until the modern urbanization. Since the anthropogenic deposits have increased over time, the elevation of the modern road surface, Via Nazionale, is currently about six metres above the ground level of the church.

The construction of the *Strada Nuova Pia* and, few decades later in the second half of the 19th century, of the *via Nazionale* (Fig. 4c) involved the placement of anthropogenic deposits of considerable thickness. These anthropogenic deposits have hidden the natural separation between the Quirinale and the Viminale ridge (Fig. 2 and Fig. 4d) by completely filling the valley separating the two hills. For this reason, the access to the church, originally on the road ground level, is now guaranteed through a descending stairway access (Fig. 4e and 5b).

Today, to the visitor it seems strange that a temple was built with a descending stairway access and not on the ground level. The strange entrance to the church makes it possible to explain the anthropic evolution of the ancient valley, testifying how deeply the original surface and the drainage stream network have been modified over the centuries.

Summarising, the history of the physical landscape around the Basilica is (Fig. 4e):

1. Pleistocene volcanism produced a large amount of deposits, burying the previous landscape and building a volcanic plateau (Del Monte et al. 2016);
2. Uppermost Late Pleistocene fluvial erosion cut the volcanic plateau, starting from the structural surface on the flat top (Del Monte et al. 2016), down to the Early Pleistocene continental deposits. A V-shaped valley was developed, dividing the Quirinale from the Viminale ridge;
3. Holocene colluvial and fluvial deposits changed the feature of the valley, that became of flat bottom type;

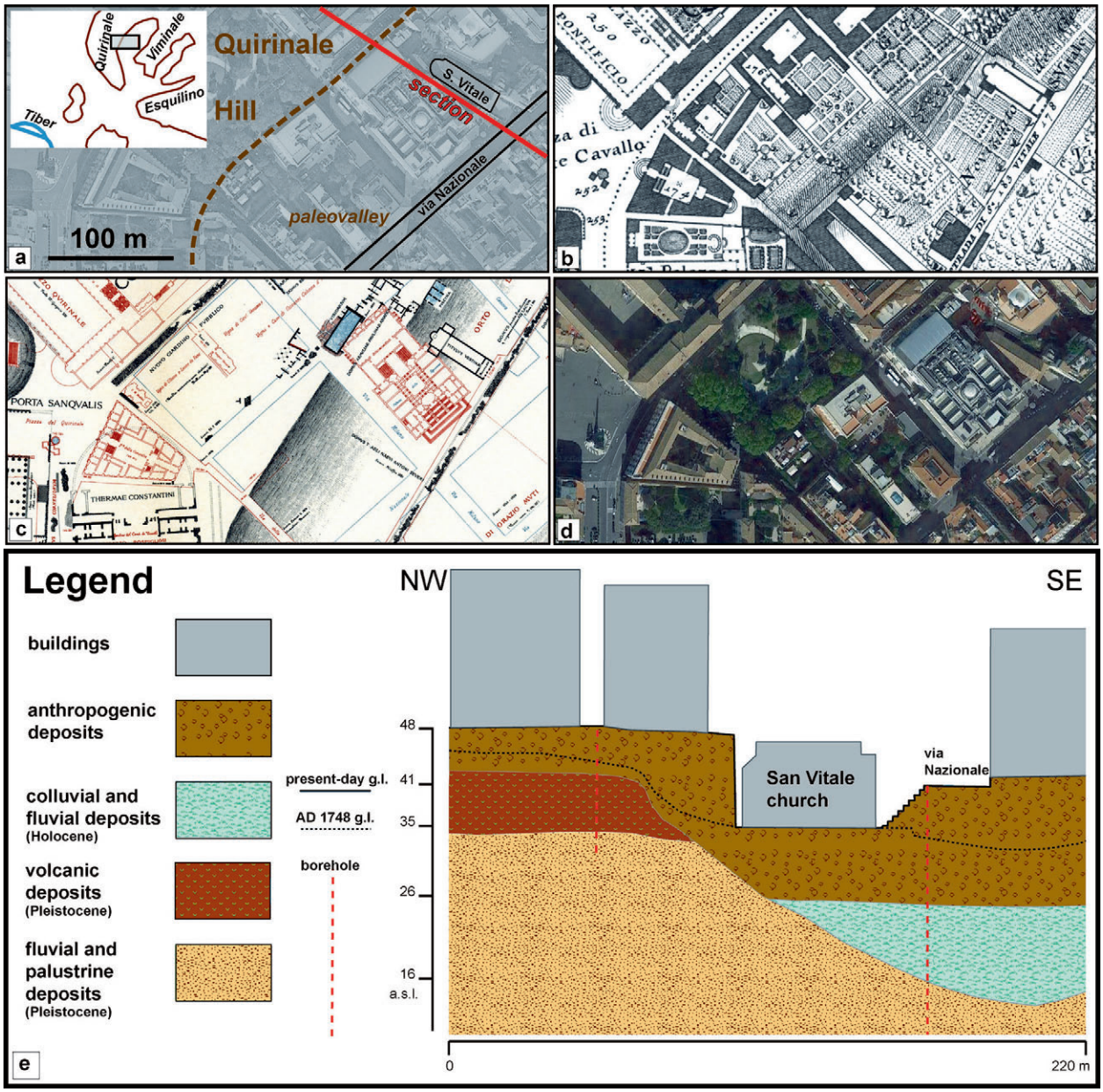

Fig. 4. Evolution of the landscape of the San Vitale church sector.
a. its location in comparison to the central east urban area (upper left box) and to topographic and urban key elements, over which the geological section (e) is marked; b. before the modern urbanization, as shown by the Nolli (1748) map; c. archaeological findings as shown by the Lanciani (1893–1901) map, which overlays the ancient (in black), the medieval up to 19th century (in red) and modern (in blue) topographic elements, including elevation a.s.l.; d. the present day urban context (satellite image by Google Earth, 28th Oct. 2016); e. the section with geological and geomorphological key elements, as sketched based on the multitemporal analysis performed here on the available borehole (Ventriglia, 1971, 2002) and map (b, c) data.

4. In the late Roman Empire, after an earlier deposition of anthropogenic materials testified by borehole logs, the San Vitale church was built close to the flat bottom of the valley, at the base of the Quirinale southern slope (Rendina 2000);
5. At the end of the 19th century, anthropogenic deposits several metre thick hid almost completely the original morphology. The church is nowadays in a small depression, and allows us to reconstruct the evolution of the relief.

The multitemporal and multidisciplinary analysis of historical (Nolli 1748) and archaeological (Lanciani 1893–1901) maps in GIS environment and borehole log data, together with field surveys, allowed us to detect the relief inversion. No aerial photographs testify the early

Fig. 5 a) the painting by Achille Pinelli (1809 –1841) representing the ground level in front of the church in the 19th century (watercolour, 489 x 637 mm, Museo di Roma). b) the present ground level (captured from Google Earth street view).

morphology of the area, whereas the San Vitale painting (Fig. 5a) by Achille Pinelli (1809–1841) shows that the ancient street located beside the church, the *Strada di San Vitale*, was at the same ground elevation of the church entrance.

Geomorphoheritage Characterization

The San Vitale scarp edge is an anthropogenic landform created by the filling of the *Spinon* valley, that caused a relief inversion just in front of the church. It presents several attributes:

- it is scientifically *representative* of the man-made landscape transformations;
- it is quite *rare* in Rome such a clear and visible evidence of the thickness of the anthropogenic deposits;
- the case study is also impressive and easily comprehensible for non specialists who want to understand how urbanization impacted Rome geomorphology. This fact is *aesthetically attractive* and it raises curiosity about the *why* and *how* the Basilica is down there;
- the *historical/archaeological* value of the site is clear thanks to the Early Christian architecture of the Basilica (Armellini 1891); it is a peculiar building that was hidden and almost swallowed by the surrounding modern buildings.

All these elements highlight the potential of this landform as a urban geomorphosite (Reynard et al. 2017). The peculiar scenic aesthetic urbanized context of this case study suggests to explore the idea of an attribute evaluating the *why and how* curiosity raised by a site genesis. The *why* and *how* is intrinsic in the geohistorical reconstruction significance and, at the same time, in the scenic aesthetic attribute. So, this new attribute should be specifically referred to the urbanized context as a scenic/aesthetic peculiarity.

The Sapienza Campus

Geomorphological Characterization

In comparison to the previous ones, this site (Fig. 2, letter c) comprises a quite wider area that has deeply been modified by human activities in a very short time interval. In fact in the 1930s a suburban sector was selected for the location of the "Città Universitaria", a new campus for the 14th Century Sapienza University. The delimited area, 0.2 km^2 wide, is located few hundred meters downstream of the eastern border of the Esquilino hill, which is marked by the Aureliane Walls (Fig. 2) built for the *Urbs* defence in the 3rd century AD. The digging works for the foundation of buildings started in 1933 (Fig. 6), whereas the Sapienza Campus was officially inaugurated in 1935.

Nowadays, the campus area is topographically characterized by a system of anthropogenic ramps and flats, whose elevation progressively decreases eastwards (less than 10 m down). This plano-altimetric configuration is the result of the anthropogenic levelling that has acted in less than two years (Fig. 7a).

The early topography is well represented in the 1:5,000 scale map by IGM (1924), which shows in the same position (red line in the figure) a flat floor valley lowering eastwards (Fig. 7b). It was filled with anthropogenic deposits during the campus construction. The 1:25,000 scale map by IGM (1873) clearly indicates, on the west, two small fluvial valleys and their stream channels, tributaries of the eastern flat

Fig. 6. Excavations for the foundations of the Sapienza Campus buildings, July 1933. (Author: unknown. Source: Sapienza Historical Archive).

floored valley (Fig. 7c). The valley of the wider, northern tributary was actually located more to the W, close to the city, according to the same map. The head of the valley of the southern tributary seems to be located in correspondence of the SW border of the campus, according to the IGM (1924) map, since at that time the urbanization of the sector between the Aurelian Walls and the not yet existing campus has already been completed. However, the map by Moltke (1852) shows that also such valley head was closer to the city (Fig. 7d).

Despite of recent urbanization, the entire suburban sector from the Aurelian Walls to the campus area has been rural for centuries. The IGM (1873) map shows that vineyards still characterised the suburban hill and valley landscape at that time, whereas the "Pianta grande" map by Nolli (1748) precisely names the owner of each vineyard, the borders of properties and the rural road network (Fig. 7e). The map by Bufalini (1551) reports few information about the suburban area, nonetheless two valley heads are represented in this sector (Fig. 7f). The southern one, named as "*Valis*", seems to correspond to the fluvial depressions streaming eastward to the Sapienza area. On the ridge between the two valleys, this map indicates the vineyard "*V.*(inea) *Ioannis Baptistae Caballarii*". Furthermore, the Bufalini map reveals that the area located W of the two valleys was used as an open air ossuary, as indicated by the signs in the map: "*Sepulcrum commune*" and "*Fossa in quam proiiciebant ossa cadaverum ustorum*" (upper left corner of Fig. 7f). This peculiar kind of filling material suggests that at least one of the two valleys might have been more incised than shown by recent historical maps. With regard to the deeper incision of the valleys, such hypothesis is supported by geological constraints. In fact, several borehole logs examined by Luberti et al. (2015), located in the NW sector of the Campus, indicate that a layer,

Fig. 7. Landscape evolution of the Campus Sapienza area (red polygon) during the last five centuries. a) present day; b) before the construction of the campus (IGM 1924); c) before the modern urbanization (IGM 1873); d) at the time of Pope Pius IX (Moltke 1852); e) at the time of Pope Benedictus XIV (Nolli 1748); f) at the time of Pope Julius III (Bufalini 1551).

up to 8 m thick, of anthropogenic materials had already been deposited in the valley before the recent urbanization.

In conclusion, the apparently natural landscape that was actually visible before the foundation of the Sapienza Campus had already been modified by the superimposition of many human activities that had been performed over centuries. It is shown in the historical maps, which also contain lots of other information.

Nevertheless, at the beginning of the 20th century the previously predominant natural geomorphic processes that had acted since the last glacial period were still recorded in such a modified landscape. Indeed, the complete deletion of the natural landforms was accomplished in two years just 80 years ago.

Geomorphoheritage Characterization

The urban geomorphological analysis of the Sapienza Campus area improved the multidisciplinary method proposed in Del Monte et al. (2016) thanks to the collaboration with art historians and archaeologists in the project "Sapienza ante Sapienza", aimed at the reconstruction of the campus area cultural landscape. The archaeological data about Roman catacombs, located E and N of the San Lorenzo Basilica, supported the definition of the ancient ground level and the valleys bottom limits; the large amount of iconographic material about the Basilica allowed us to confirm hypothesis about the morphology and the landforms characterizing the area in the periods preceding the early map representations of the landscape. These aspects emphasized the strict relationship between the geomorphological substrate and the culture installed there.

The Sapienza Campus symbolizes the cultural growth of the city. It is an example of the rationalist architecture by Piacentini, such as other neighbourhoods built in Rome during the 1930s. It is a tourist site for this reason and it is a clear example of the anthropogenic transformation of the landscape due to urban sprawling.

This indicates:

- the scientific *representativeness* of landforms in this area,
- the *scenic/aesthetic* and the *historical/archaeological* value of the site.

The whole area is a potential urban geomorphosite (Reynard et al. 2017) of the areal type.

Also this case study is about deleted landforms by human activities (Clivaz, Reynard 2017); so, the selection of Sapienza Campus as geomorphosite presents the same problems of Monte della Giustizia landform: it is not easily readable by non specialists and its value as geomorphosite is not understandable.

This case study suggests to take into account the tourist attractiveness of sites and the landscape geohistorical reconstruction significance in the built up of the urban geomorphosite assessment method. The tourist attractiveness rate encourages increasing interest around sites adding geomorphological information and telling the story of the landscape evolution that is by itself an evaluable attribute of sites. In fact, the more the human impact on landscape is recognizable in historical documents and representations of the area, the more the geohistorical reconstruction increases the geomorphosite value.

Proposal of urban geomorphosite assessment method

According to Pica et al. (2014), the three sites described above are potential geomorphosites because:

- they are anthropogenic landforms, clear examples of landscape transformations due to human activities. These landforms testify that human activities are a morphogenetic process and it highlights the site attribute *Representativeness* for scientific reasons (for attributes description see Pica et al. 2014);
- some landforms are *Rare* testimonies of the landscape evolution;
- they have *Scenic/Aesthetic* attributes given by the shape of the landform and the architecture, which are also emphasized by the tale of how they have changed over time;
- they tell us about the natural and human history of the landscape; this element represents the *Historical/Archaeological/Cultural* attribute of a site.

The VSG index is a sum of the above-mentioned attributes that assesses the geotourist value of a site. From a geotourist point of view, the described geomorphosites are not easily enhanced because they are invisible. It makes difficult the comprehension of the geomorphosite scientific reasons by non specialists. Hence the geomorphoheritage characterization of Monte della Giustizia, San Vitale Basilica and Sapienza Campus inspired reflections about the need of specific criteria for the urban geomorphoheritage inventory and assessment.

The VSG assessment of the Tiberina Island and Testaccio Mount (Pica et al. 2016) was effective, because the sites are visible landforms, hence the problems emerged with the new proposed

geomorphosites, San Vitale Basilica, Monte della Giustizia and Sapienza Campus, which can be considered invisible geomorphosites (Clivaz, Reynard 2017).

In particular, they represent landforms which have been deleted or deeply modified by human activities and, thus, not easily readable by non specialists, meanwhile a geomorphosite needs to easily communicate its value. For these reasons, some innovative attributes were proposed for the geomorphosite evaluation: the Monte della Giustizia and Sapienza Campus cases suggest to include in the urban geomorphosite assessment method the *Geohistorical reconstruction significance* and the *Tourist attractiveness rate*, while San Vitale Basilica suggests to explore the idea of evaluating the 'why and how' curiosity raised by a site genesis, as intrinsic value in the geohistorical reconstruction significance and, at the same time, in the scenic aesthetic attribute.

On the base of these considerations, we reworked the attributes related to the assessment of the VSG index in order to build up a specific methodology for the analysis of urban geomorphological heritage.

In the Table 1 we present the proposal for the urban geomorphoheritage assessment method, where some new attributes for urban geomorphosites assessment were defined as follows:

1. Representativeness:
   - geoscientific value
   - landscape evolution
   - city image
2. Visibility
3. Geohistorical reconstruction significance
4. Aesthetic peculiarity of the urbanized context
5. Tourist attractiveness rate

Discussions and Conclusions

The described analysis of Rome geoheritage, through a focus on three geomorphosites, allowed us to examine in depth the limits of the the geomorphosite assessment methods in urban context, as Rome is a unique site of mixture of geomorphological and cultural heritage. Moreover, the urban geomorphological and geohistorical analysis of Rome (Del Monte et al. 2016) is the most in-depth in literature and it is very useful for geoheritage characterization. Studies on urban geoturism are very recent. An interesting geotouristic proposal concerns Lausanne (Reynard et al. 2015) and Reynard et al. (2016) proposed the geohistorical approach for the geomorphoheritage, but not specifically for very large urban areas. Clivaz and Reynard (2017) applied the geohistorical approach for the detection of invisible geomorphosites in a highly impacted by anthropic activities area in Switzerland, whereas Reynard et al. (2017) highlighted the need for an *ad hoc* method for assessing urban geomorphosites. They conduct urban geomorphoheritage studies by giving the first definition of urban geomorphosites, and distinguishing them in *stricto sensu* and *lato sensu* geomorphosites (Reynard et al. 2017). *Lato sensu* urban geomorphosites are those that are simply located within the town's limits, whereas the *stricto sensu* urban geomorphosites are those sites that are important because they illustrate the interactions

Table 1. List of proposed attributes for the urban geomorphoheritage assessment.

Attribute		Evaluation
Representativeness (RP)	Geoscentific	The site is a landform representative of anthropogenic morphogenetical process
	Landscape evolution	The site is a landform representative of anthropogenic morphogenetical process
	City image	The site is a landform representative of anthropogenic morphogenetical process
Visibility (V)		The landform is recognizable in the landscape
Geohistorical reconstruction significance (GeoHIS)		The site is documented and represented in historical documents (early maps, paintings, archaeological maps, etc.) that highlight the human impact on landscape transformations
Aesthetic peculiarity of the urbanized context (AP)		The shape of the landform is visually unfasten from the context and attract the attention and curiosity of observatory
Touristic attractiveness rate (TAR)		The site is a tourist attraction, much visited by people for its feaures and informations about geo-aspects surely increase its interest

of urbanization with geomorphology. Tiberina Island, Testaccio Mount (Pica et al. 2016) and the geomorphosites described in this article fall into the category "*stricto sensu* urban geomorphosite": Tiberina island lasts in its position thanks to human urbanization, Testaccio Mount is an artificial hill, Monte della Giustizia, San Vitale Basilica and Sapienza Campus are examples of invisible geomorphosites, where urban constructions deleted the natural landforms but at the same time they testify the previous natural landscape. The new challenge is to assess invisible geomorphosites (Clivaz, Reynard 2017). The complexity of the urban geomorphoheritage, that the new definitions (Reynard et al. 2017) help to classify, is the reason why a generic geosite assessment method (VSG index, Pica et al. 2014) did not work for all geomorphosites in Rome. Thus, the latest literature and analysis of these sites has helped us to define new attributes for the assessment of urban geomorphosites, leading to the development of the assessment methodology. In particular, the three study cases selected within the Rome city centre allowed us to propose some attributes related to the urban landscape evolution and the tourist attractiveness, with the aim of answering to tourist curiosity raised by a site genesis, and considering deleted or modified landforms worth of being enhanced as urban geomorphosites.

The anthropogenic landforms described in this paper demonstrate how in urban areas buildings may hide landforms and urban sprawling may delete or modify them. The geohistorical analysis highlights the significance of invisible landforms. Their value can be assessed (Clivaz, Reynard 2017) and communicated as a geotourism product (Martin et al. 2010, Cayla 2014), using geointerpretation tools (Hose 2012, Martin 2014) to solve the problem of enhancing something invisible.

Therefore, the research to be developed in the future will aim to harmonize and integrate the evaluation methods so far available, up to assess in an unbiased way – better if quantitatively – all the various cases described in this paper.

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