Keti Lelo[*], Carlo M. Travaglini[**]

Historical cartography and the study of urban cultural heritage: the case of Rome in the 18th century

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Introduction

In the eighteenth century the evolution of measurement techniques based on trigonometric calculations and the codification of topography as an applied science in different European States resulted in the progressive substitution of traditional bird's eye views with geometrically correct ichnographic representations of cities. The existence of precise and reliable cartographic information represents an analytical benchmark for the discipline of urban history. It makes possible to use modern information techniques for analysing the urban structure and its formal and functional contents from a 'geographical-thematic' perspective.

This paper discusses the use of eighteenth-century cartographic and documentary sources for the purpose of analysing the characteristics and the transformation of the urban fabric of Rome within the Aurelian walls. The methodological aspects and the analytical results are taken from the project «Atlante di Roma moderna», promoted by the *Centro di ateneo per lo studio di Roma* (CROMA). This project represents a case of best practice in the Italian panorama concerning the use of historical sources and new technologies for the analysis of urban space and the divulgation of the results. The project takes advantage of the geometric precision and the descriptive detail characterizing the New Map of Rome (*La Nuova Pianta di Roma*), published in 1748 by Giovanni Battista Nolli, to study the city of Rome in the 18th century and its transformations. *La Nuova Pianta* can be considered as exhaustive evidence of the image of Rome after the great urban development of the Renaissance and Baroque periods. Its planimetric detail and the indexing of all the 'important' buildings offer extensive evidence of the 18th century city's form and functions, allowing for detailed spatial analysis using GIS technology.

Specific methods of data acquisition, processing and analysis are developed within this project in order to analyse the city's physical transformations and its functions. The utility of this approach relies on the opportunity to perform homogeneous spatial analysis, to elaborate historical topographical statistics and to compare phenomena diachronically thanks to the spatial overlay of the data. But the most important aspect of the GIS approach to urban historical studies is the opportunity of integrating information retrieved from different archival sources within the system, provided that these sources can be structured as databases.

[*] CROMA – Università degli studi Roma Tre [keti.lelo@uniroma3.it]
[**] CROMA – Università degli studi Roma Tre

Great importance is given to the dissemination of results, which include a ready-for-use digital application allowing for interactive data exploration, besides the printed version of the academic research.

The cartographic source

The central historical source used in the project «Historical atlas of modern Rome» is the New Map of Rome (*La Nuova Pianta di Roma*), published by Giovanni Battista Nolli in 1748[1]. It is the first geometrically correct two-dimensional representation of the city characterized by an exceptionally high level of accuracy and detail (Fig. 1).

La Nuova Pianta stands out as a watershed in Rome's cartography. Nolli was the first cartographer to orient his map to the North. He was able to mark a clean break with Rome's traditional cartographic orientation to the East, suggested from the comfortable observation point of the city located on the Gianicolo Hill. In his work Nolli did not really observe Rome from any specific point: he walked through streets, alleys, gardens or vineyards, measuring angles and distances homogeneously and transferred everything that could be measured to the preparatory drawing (*disegno preparatorio*): buildings, fountains, ruins, walls, streets, gardens, embankments, river banks and so on, with an incredible level of detail.

The North-South orientation refers to the so-called '*meridiana della Certosa*', an accurate North-South sun-dial line, inlaid in the marble floor of the church S. Maria degli Angeli (in the Baths of Diocletian). The line was drawn in 1702 for the purpose of precisely determining the equinoxes used for fixing the Easter day of the Catholic Church[2]. Nolli was able to make his sightings refer back to this baseline, or to parallels thereof placed in other parts of his drawing. This technique, coupled with the triangulation of prominent city features such as obelisks, towers and domes along the axis of Via del Corso, and with the use of the *tavoletta pretoriana*, allowing for fast and precise on-site drawings, enabled Nolli to obtain the accuracy for which his plan became famous all over Europe[3].

[1] «Nuova Pianta / di / Roma / data in luce / da / Gianbattista Nolli / l'anno / M DCC XLVIII».

[2] The tracing of the meridian on the floor of the church of Santa Maria degli Angeli was made by Francesco Bianchini, a renowned scientist, historian and antiquary of the eighteenth century, best known for his popular and very extensive astronomical studies. Mario BEVILACQUA, Nolli Piranesi Vasi. Percorsi e incontri nella città del Settecento, in: Nolli Vasi Piranesi. Immagine di Roma Antica e Moderna, edd. Mario Bevilaqua, Artemide Edizioni, Roma, 2004, p. 24.

[3] On the importance/influence of this map, both in the Italian and international cartographic production of the second half of the 18th century, see: C. FACCIOLI, Gio. Battista Nolli (1701-1756) and his great «Pianta di Roma» del 1748, in: «Studi Romani», XIV, 1966, pp. 415-442; Italo INSOLERA, Roma. Immagini e realtà dal X al XX secolo, Roma-Bari, Laterza, 1980; Gianfranco SPAGNESI, L'immagine di Roma barocca da Sisto V a Clemente XII: la pianta di G.B. Nolli del 1748, in: Immagini del Barocco. Bernini e la cultura euro-pea del Seicento, edd. Marcello Fagiolo e Gianfranco Spagnesi, Roma, Istituto dell'Enciclopedia Italiana, 1982, pp. 145-156; Allen CEEN, Piranesi and Nolli: Imago Urbis Romae, in: Piranesi. Rome Recorded, Philadelphia, 1990, Exhibition Catalogue (New York 1990), pp. 17-22; Mario BEVILACQUA, Roma nel secolo dei lumi. Architettura erudizione scienza nella Pianta di G.B. Nolli 'celebre geometra', Napoli, Electa Napoli, 1998.

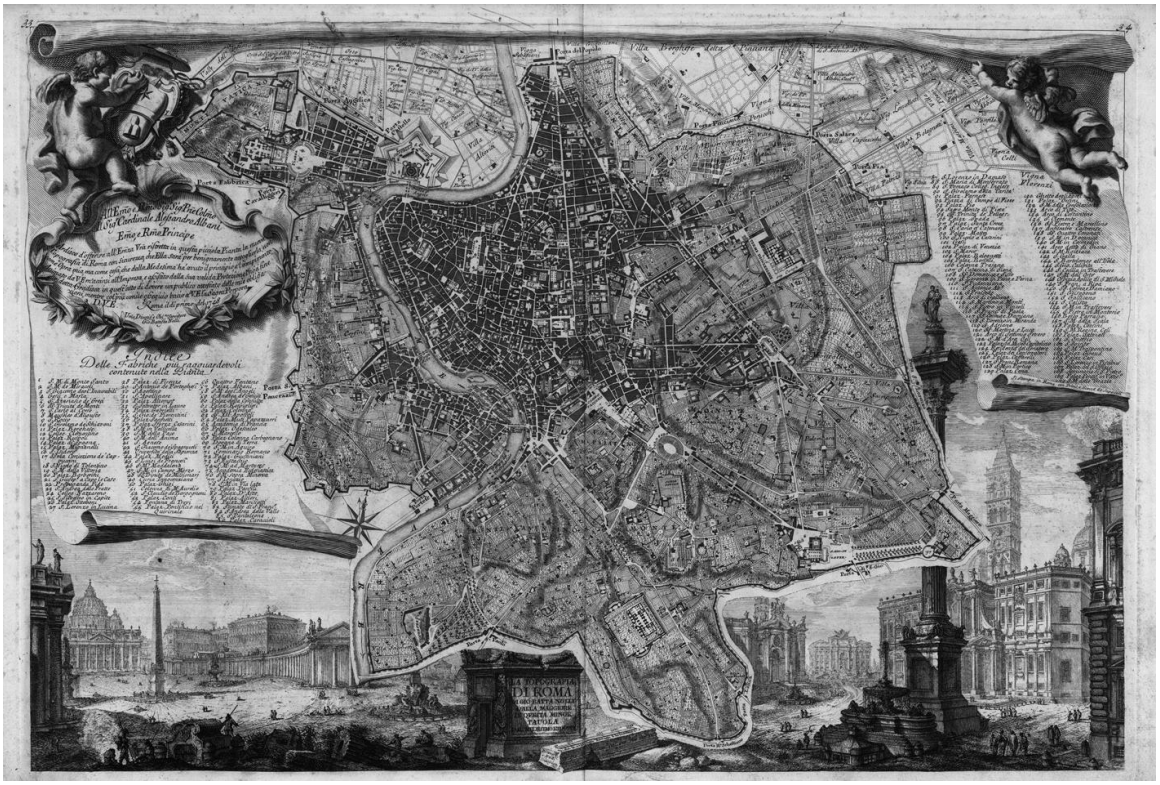

Figure 1: *Nuova Pianta di Roma* by G.B. Nolli, 1748.

The accuracy of *La Nuova Pianta* by far exceeds that of earlier maps of the city. It is widely known that the map served as the basis for all successive representations of Rome, until the advent of the 'conceptually different' aerophotogrammetric cartography. Accuracy wise, *La Nuova pianta* can be compared to modern products of cartography. A careful georeferencing procedure, based on ad hoc differential GPS survey, demonstrated levels of accuracy that were far beyond the initial expectations. The choice to base the georeferencing procedure on a GSP campaign was due to the fact that official contemporary mapping of the study area was, at the time of the project implementation (early 2000s), in a larger scale compared to the historical map: the scale of Nolli's map is approximately 1:2.910[4], whilst the official modern mapping, the Technical Regional Maps of the Lazio Region (1990), is in scale 1:10.000. An unofficial numerical mapping in scale 1:2.000 existed, depicting only the city within the Aurelian Walls, while the first small scale official numerical mapping of the Municipality of Rome arrived in 2004, when our GPS campaign was completed. Moreover, different cases of wrong cartographic restitution have been identified in all the available modern mapping projects.

During the initial stage, the localization of 'correctly measurable' points on the historical mapping was carried out. The most suitable points are those incorporated within building bodies (for example building corners). Less suitable are easily recognisable points such as fountains or obelisks that may

[4] The Roman span for architecture (palmo romano d'architettura) is equal to 0,223422 m. According to this conversion, the equivalent scale in the metric system of the map is 1:2.910. Mario BEVILAQUA, Roma nel secolo dei lumi, (see note n. 3) p. 81, note 26.

have been subject to modifications or rearrangements. Regrettably, building corner coordinates are difficult to measure unless we can reach the top of a building so as to guarantee a good GPS coverage. This means an increase in logistic access problems. The differential GPS network comprised 32 suitable points, distributed as uniformly as possible over the city centre, measured in two different campaigns that took place between the years 2001 and 2002. In addition, 24 points of a local GPS network named *Forma Urbis*, established by the *Sovrintendenza Archeologica di Roma* (Archaeological Superintendence of Rome) were acquired. These points were differentiated and compensated by referring to two fixed stations in 30'sessions and some of them were re-measured after a few days in order to validate the measurement's repeatability. The precision of such points is to be considered geodetic. Once the GPS network was completed, the geo-referencing procedure was repeated. The result obtained by using 44 tie points, 12 control points (selected from the *Forma Urbis* network) and by applying a first degree polynomial transformation showed quite acceptable mean residual values (quadratic mean residuals: X=0.62 m, Y=0.74 m)[5].

Nolli's geo-referenced map constitutes a milestone in this project and a first important step towards building up a GIS of Rome for the 18th century (Fig. 2).

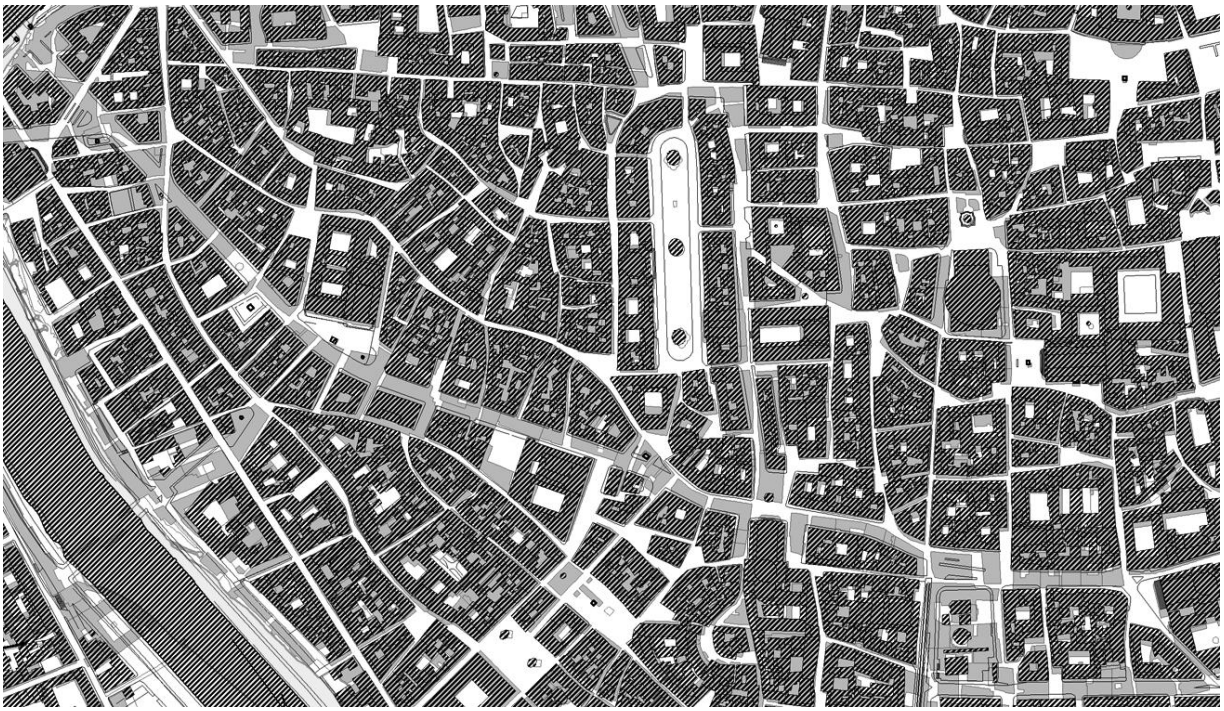

Figure 2: Confrontation between the Nuova Pianta (black hatching, vectorial format) and actual mapping.

[5] Valerio BAIOCCHI - Keti LELO, Georeferenziazione di cartografie storiche in ambiente GIS e loro verifica mediante rilievi GPS, in: Atti della 5[a] Conferenza nazionale ASITA, Rimini, 2001; Valerio BAIOCCHI - Keti LELO, Confronto di cartografie storiche con cartografie attuali per l'area del centro storico di Roma, in: Atti della 7[a] Conferenza nazionale ASITA, Perugia, 2002.

Geometric accuracy is not the only strength of this map. It really stands out because of its wealth of detailed information. Cartographic symbols are intuitive and easy to understand: dark grey hatching for modern building fabric, white for open space. Ancient monuments are rendered in black, indicating extant ruins, while a white outline suggests hypothetical plans of ancient monuments that no longer exist. A series of textured elongated lines are used to indicate the slopes (contours were not in common use until the turn of the 19th century). Open spaces (gardens, vineyards, orchards and so on) are carefully rendered with different textures. Various cartographic symbols are used to indicate features that would otherwise be difficult to convey. These include drains, soldiers' billets, apertures in the Aurelian wall circuit and cemeteries. Pictorial elements are used to represent river craft, which includes ferryboats with tethering lines, cargo craft and water mills. The representation of administrative boundaries is of great interest. The dotted lines between the *Rioni* (neighbourhoods) were drawn after the *Descrizione del nuovo Ripartimento de' Rioni di Roma* by Count Bernardino Bernardini, who was commissioned by Pope Benedetto XIV Lambertini to reorganize the administrative boundaries[6]. The works were completed in 1744 and Nolli's map, which was not yet published, served as their cartographic basis[7] (Fig. 3).

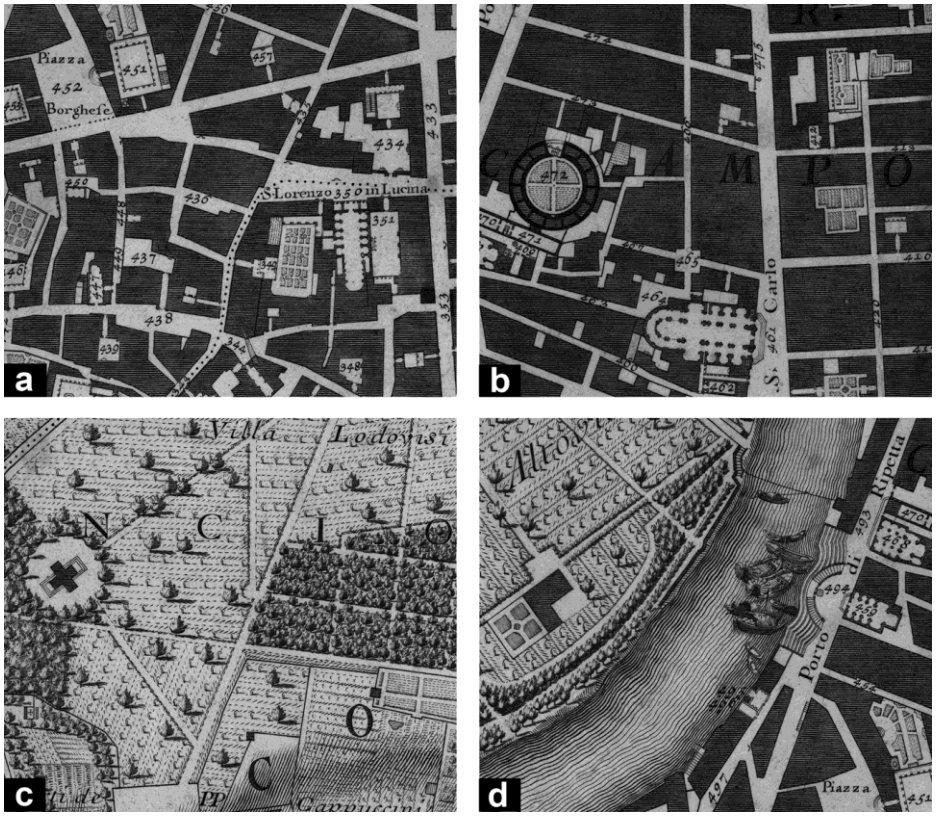

Figure 3: Details of the map: a) building blocks; b) archaeology; c) open spaces; d) pictorial elements.

[6] Bernardo BERNARDINI, Descrizione del nuovo ripartimento de' Rioni di Roma fatto per ordine di N.S. Papa Benedetto XIV, con la notizia di quanto in essi si contiene, opera del conte Bernardino Bernardini, patrizio Romano, Roma, Salomoni, 1744 (facsimile by Studio Editoriale Insubria, Milano, 1978), pp. 20-21.
[7] Mario BEVILACQUA, Roma nel secolo dei lumi, (see note n. 3)

Nolli's intentions, fully matching the intentions of his erudite supporters interested in antiquities (high-level representatives of Roman aristocracy), were ambitious: the map was to have been drawn in different colours representing the city's stratification (archaeological vestiges, medieval tissues and modern buildings). The information on the transformations of the city was to be derived from the comparison of historical representations of Rome and through additional research. Detailed explanations on buildings and other interesting places were to be found in a separate book, a sort of encyclopaedia, substituted in extremis by a far more synthetic incorporated index, while the final print was realized without the use of colour.

This innovative and inspiring spirit encourages us, after almost three centuries, to proceed in the same direction. The technology actually in our hands can help in order to accomplish the missing part of the original project, to further develop it and to share it with the rest of the scientific community.

Thematic data integration

The definition of the homogeneous criteria for interpreting the graphic representation of this exceptional cartographic source enabled us to obtain a digital product in vector format, representing ten classes of land use: built-up, squares and streets, monuments, archaeological remains, gardens, orchards, vineyards, tall trees, uncultivated land and water bodies. This operation constituted the second important phase of the project, which was completed by the establishment of a 'geographic container' capable of sustaining the thematic information derived from other data sources of the same period. The choice to exclude the areas falling outside the Aurelian walls from the vectorization process was made so as to avoid inhomogeneous spatial information. In fact, the territorial features in the northern portion of the map are carefully drawn and described, while in the southern part they are totally missing, substituted by decorative elements and inscriptions evoking important monuments, places and symbols.

Thematic data integration started with the computerization of the original Index of the map. The Index contains 1,320 numbers organised into 19 categories. It is integrated by 657 descriptions of non built-up areas directly written on the map (vineyards, orchards, villas, gardens and so on), of which 115 are repetitive with respect to the numerical Index. *La Nuova pianta* represents the most complete thematic information when compared to any other cartographic representation of modern Rome.

The existence of the coeval *Descrizione del nuovo Ripartimento de' Rioni di Roma* by Bernardino Bernardini, which differs from Nolli's Index mostly in terms of detail while describing the same objects (more information is given by Bernardini regarding owners – present and previous – and the public use of buildings and areas) suggested a further integration of this information into the database.

The spatial connection between the map elements (polygon objects) and the information contained in the newly created Integrated Index database, containing 1,898 records, provided additional detail in the land use descriptions. In Nolli's map the smallest graphical unit is the building block. The exceptions to this rule are represented by church and theatre interiors, palace courtyards, entries and stairways, which are carefully drawn. The numbers of indexed buildings are usually placed inside, with the exception of palaces without or with a small courtyard: in this case the number is placed in front of the main entrance. It is not possible to retrieve information on a building's shape from the Nolli map, apart from the churches and large buildings occupying entire blocks (monasteries, large

palaces and so on). In these conditions, the necessity to describe homogeneously the urban space in order to obtain polygon objects for every land use typology, led us to consider another historical cartographic source: the urban cadastre. Although the cadastral map depicts the city in the year 1818, the stable situation of the urban structure, documented by the relevant archive sources, allows the assumption that no significant changes occurred[8]. The overlap between the two georeferenced historical maps enables us to retrieve all the necessary information about the shape of buildings. Apart from the detailed topographical information distinguishing the *Nuova pianta* if compared to the schematic cadastral representation, another argument in favour of the use of the 18th century cartography as a base map for the GIS application, instead of perhaps using the Cadastral map – traditionally utilized in similar projects -, is the fact that, unlike the *Nuova Pianta*, the urban cadastre was not based on a topographical campaign of measurements. Archive documents have revealed that the Roman architects Salvi and Palazzi, members of the S. Luca Academy who were in charge of the mapping project, instead of planning a measurement campaign of the city, preferred to take advantage of the Nuova Pianta di Roma of 1748 by G.B. Nolli "introducing all the necessary corrections and integrations where […] any transformation might have occurred". Thus, the work started at the drawing table by enlarging Nolli's map to a scale of 1:1.000. This procedure was then followed by some fieldwork, which was necessary for the subdivision of the building blocks into cadastral units[9].

The geographic key of thematic information, integrated with other data sources, has given us the opportunity to analyse different spatial characteristics of the city qualitatively and quantitatively: the transformation of urban space in comparison to the present day, the distribution of functions, physical and social stratification, administrative and public welfare services, cultural institutions, public places and archaeology, represent the principal thematic descriptions we are able to obtain by extracting, analysing and visualizing information deriving from the historical sources integrated into our GIS system.

An additional database of coeval iconographic material was created, covering most of the indexed buildings. This database contains and describes 18th century prints and drawings of the most important squares and buildings in Rome, drawn by G.B. Falda, G.B. Piranesi, G. Vasi, A. Pinelli and so on. This aspect is considered of particular interest for dissemination purposes. In fact, a user-

[8] For a broad overview of the urban interventions in Rome it is essential to consult the archive of the Presidenza delle strade in the State Archive of Rome (Archivio di Stato di Roma), whose inventory is forthcoming. See notably on the subject: Daniela SINISI, La Presidenza delle strade, in: La Reverenda Camera Apostolica e i suoi archivi (secc. XV-XVIII), edd. M.G. Pastura, Roma, Archivio di Stato di Roma-Scuola di Archivistica, Paleografia e Diplomatica, 1987; Daniela SINISI, La Presidenza delle strade e il suo archivio nel XVIII secolo, in: Roma moderna e contemporanea, II, 1994, 2, pp.491-502; Daniela SINISI, I bandi della Presidenza delle strade nella Collezione II della biblioteca dell'Archivio di Stato di Roma (1580-1758), in: Rivista storica del Lazio, IV, 1996, 5, pp.277-358; D. Sinisi-O. Verdi, Licenze edilizie a Roma nel secolo XVIII, in: Gli archivi per la storia dell'architettura. Atti del convegno internazionale di studi (Reggio Emilia, 4-8 ottobre 1993), 2 voll., Roma, Ministero per i Beni e le attività culturali-Ufficio centrale per i beni archivistici, 1999, vol. II, pp.728-738. The integration of information on urban transformations deriving from the source of *Presidenza delle Strade* within the GIS system is planned but not yet implemented. This resource will enable us to check for any physical transformations affecting the shape of the buildings.

[9] Antonio RUGGERI, Luigi LONDEI, Il catasto urbano di Roma (1818-1824), in: Eventi e documenti diacronici delle principali attività geotopografiche in Roma, edd. A. Cantile, Firenze, Istituto Geografico Militare, 2000 (suplement in: L'Universo, 2000, 6), pp. 102-137.

friendly graphical interface running outside the GIS support (using common graphical software and browsers) allows for an interactive overlay and for the querying of maps, databases and iconographic information.

Lastly, a 3D representation of the urban space was produced, by approximating building heights on the bases of iconographic information and by placing them over a Digital Elevation Model (DEM) produced ad hoc by elaborating historical altimetry sources (Fig. 4). As far as this last question is concerned, it must be noted that the oldest cartographical sources offering precise and reliable altimetry information on Rome and its surroundings are from the end of the 19th century and the beginning of the 20th century. The chosen sources are: The topographic map of Italy (Rome) by *Istituto Geografico Militare* (IGM), on a scale of 1: 25.000 dated 1890, the topographical map of Rome and its surroundings by the *Istituto Geografico Militare* (IGM), on a scale of 1: 5.000 dated 1908, both used for retrieving the contour lines and The *Forma Urbis Romae* by R. Lanciani, on a scale of 1:1.000 dated 1901, used for completing the altimetry of the city centre, by retrieving elevations above sea level measured at several crossroads. The long time span of more than 150 years between the cartographic representations used for reconstructing the historical landscape can be justified by the fact that the extension of the built up area by the beginning of the 20th century had not yet reached or exceeded the perimeter of the Aurelian walls. For this reason the DEM, whose scope was by no means quantitative but purely illustrative, may be considered a sufficiently good approximation of the morphology, in the absence of earlier historical sources. This representation is an example of how historical data sources of different origin and typology and bibliographic research results can be integrated within a GIS system to enable in-depth analysis and study of the historical urban environment.

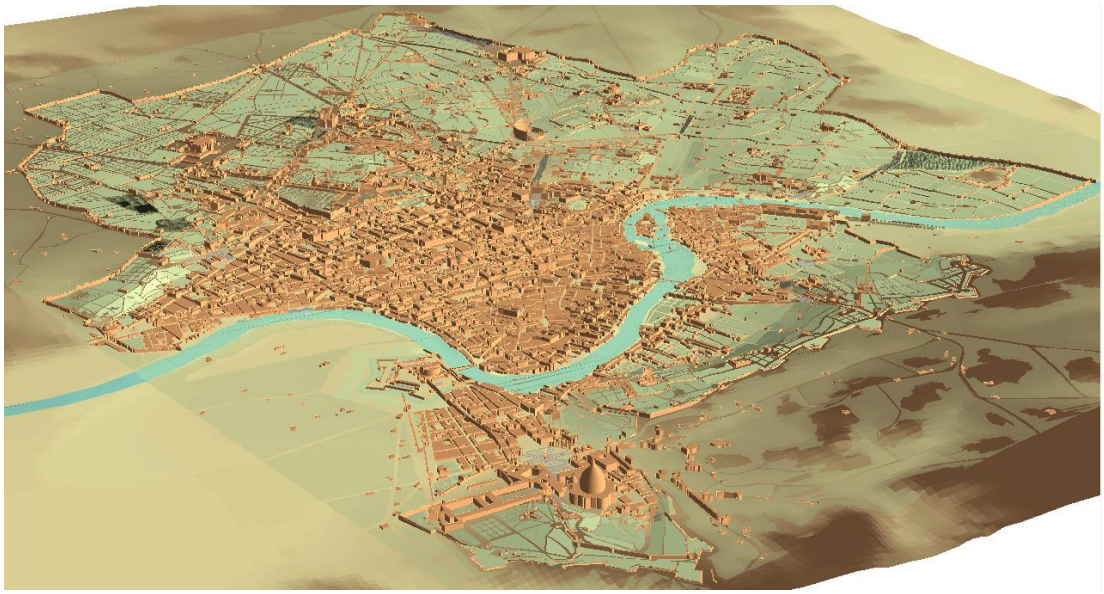

Figure 4: Physical structure of Rome in the 18th century.

Conclusions

The results obtained from this project are based on methods of spatial analysis developed in a GIS environment by exploiting the versatility of this technology in the quantitative treatment of cartographic data. The aim was the interpretation of urban phenomena according to different thematic keys. These interpretations were derived from archival sources that complement each other and offer diversified insights into the urban context.

Technologies that incorporate the spatial component allow the development of a deeper and more sophisticated understanding of the data. This type of analysis, traditionally scarcely used by historians, is now seeing a growing number of applications, as GIS technologies are no longer niche products and are becoming more accessible in terms of costs and supply of interfaces that are suitable for less experienced users.

The introduction of GIS into historical studies, despite the need for (at least) a partial formalization of the sources, appears to provide an additional, efficient key for overcoming specific problems related to the incomplete and fragmentary nature of the sources. As discussed in the previous session, despite the exceptional level of detail of G.B. Nolli's map, the information that can be obtained from it is still limited. For example, the map lacks the delimitation of buildings within the building block. It is impossible to derive information on edification density or the property distribution from this source. Some of these limitations can be overcome in a GIS environment, because it is possible to integrate within the historical cartography information deriving from other cartographic and documentary sources from the same historical period. Thus, the spatial container consisting of a georeferenced and vectorized historical base map, enables us to manage and visualize multiple databases, giving the opportunity to produce new insights, independent of the original contents.

The results obtained in the «Atlas of the modern Rome» project appear encouraging, both in terms of the cohesion of the sources with respect to their 'manipulation' process, as well as in terms of the interpretation and readability of results. Therefore, it is possible to consider these results as a starting point for further investigations.

As a conclusion, we would like to stress the utility of using GIS for urban historical studies. Applications can be numerous, supporting increasing levels of complexity and great variety of information. The spatial-thematic information can be retrieved and analysed synchronically and diachronically, thanks to GIS procedures, also through the Internet. The latter aspect represents the challenge for the future of our project. It will certainly offer great prospects for future research developments and renovation: the Web-GIS sector is continuously evolving, although high quality historical applications are not frequent. The opportunity to consult spatial historical information on-line constitutes an important step forward towards the conservation of paper-based documentation and the simplification of the consultation procedures currently carried out in archives. Potentially positive effects may be foreseen with regard to the efficiency of data sharing within the scientific community at national and international level, but also with the specialized operators in the building and restoration industry, and a broader public.