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InDAGIS-MODE&APP project. A first assessment after one year in the field of medical geography, public health, precision preparedness through some applied demonstrations

Cristiano Pesaresi, Davide Pavia[a]
[a] Department of Letters and Modern Cultures, Sapienza University of Rome, Rome, Italy
Email: cristiano.pesaresi@uniroma1.it

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Abstract

This paper provides a first assessment of the work carried out in the framework of the InDAGIS-MODE&APP project, having two main objectives and thematic areas strongly characterised by applied interdisciplinary perspectives through GIS applications: the first one is related to medical geography, public health, precision preparedness for the management of emergencies; the second one is referred to the relationships between geography and literature, geography and archaeology, geography and history, geography and linguistics, digital humanities. In particular, we show and discuss some applied demonstrations produced with reference to the first objective and thematic area, and for this purpose we have selected three examples with reference to: - a dashboard which makes it possible to geolocate and geovisualise the cases of COVID-19 recorded in Rome from February 25th to September 26th 2020; - a distancemetric map with concentric circular zones starting from the Tmb plant of Malagrotta (western suburbs of Rome) where a fire broke out on 15th June 2022; - a webApp which makes it possible to geolocate the Sapienza University semiautomatic external defibrillators (AEDs) and search for the AED closest to a starting point. Moreover, we provide some considerations regarding further activities in the perspectives of applicative-intersectoral research, laboratory didactics and third mission. With reference to other examples of interdisciplinary applied research, we show some ArcGIS Pro elaborations produced for the geolocation and three-dimensional representation of the Sapienza buildings, starting from the Faculty of Letters and Philosophy and developing a procedure which could be replicated to cover the whole campus, creating a profitable connection among geography (and geography of safety), engineering and architecture, public health, workplace safety, risk prevention and protection etc.

Keywords: Buffer Zones, Dashboard, Geocoding, Medical Geography, Public Health, Story Maps, Tools to Calculate Distances and Minimum Routes, WebApps, 3D Models and Scenes

1. Introduction

On 12th January 2022 we received the communication by mail regarding the funding of the InDAGIS-MODE&APP project, aimed at the conceptualisation and realisation of Dynamic Operative Models with Advanced Interactive GIS Elaborations with n Dimensions and Applications for Preparedness and Capitalisation. Funded by the Sapienza University of Rome in the category Medium scientific equipment (class 2, year 2021), this project was recognised as having the main rewarding elements in the final comments including: the optimum scientific quality of the whole group[1], the facts that the selected geotechnological instruments would be used by entire Faculties (Letters and Philosophy and Pharmacy and Medicine), the proposals qualitatively excellent and relevant also in the field of epidemiology (with an interesting combination between humanistic and scientific disciplines).

Basically, the project has two main objectives and thematic areas strongly characterised by clear applied interdisciplinary perspectives (Pesaresi, 2022). The first one is related to the GIS elaboration of multidimensional digital models, advanced applications and interactive dashboards in medical geography, public health, precision preparedness for the management of emergencies. The second one is referred to the elaboration of GIS webApp, interactive geostories, virtual tours and multimedia products, in digital humanities, valorisation of historical cartography, archival and iconographic documents, empowering the relationships between geography and literature, geography and archaeology, geography and history, geography and linguistics etc.

These objectives are pursued by means of the set-up of an integrated geospatial platform and a homogenous geotechnological system, with reference to advanced ArcGIS products and training courses for everyone (professors, research fellows, PhD students and students) having a Sapienza account in the Faculties of Letters and Philosophy and Pharmacy and Medicine, in order to promote and enhance applicative-intersectoral research, laboratory didactics, third mission, also creating and strengthening synergic relationships and networks. To move in all these directions, through an Institutional Agreement, the project has made it possible to have very large GIS equipment overseen by the GeoCartographic Laboratory and the Degree Course in Geographical sciences for environment and health as platform managers (Table 1).

Among the added values of having available such well-structured GIS equipment, generally with unlimited quantities of licenses and extensions, are for example the following possibilities:

- to collaborate in team-working also at distance, sharing geotechnological work environments, elaborations, applications and integrating different competences and skills in common projects, developing a virtuous chain with various units deployed;
- to operate quickly, with a notable response capability in the case of situations which require a short time for action and rigorous contents and methodologies regarding geospatial and multitemporal analysis, 3D models, simulations, detailed mapping, geocoding process etc.;
- to test proactive research perspectives, finding in the GIS applications a common denominator and a favoured interface for interdisciplinary connections;
- to provide a specific know-how for important projects which require high levels of innovativeness and intersectoral integration, i.e. with particular reference to the National Recovery and Resilience Plan (PNRR);
- to promote applied didactics and training activities which can involve, at distance or in spacious specifically equipped multimedia classrooms, a notable number of learners of different disciplinary sectors and possible trainers of trainers;

[1] The members of the research group are: Cristiano Pesaresi (scientific responsible), Maria Sofia Cattaruzza, Paolo Di Giovine, Sandra Leonardi, Anna Paola Massetti, Laura Maria Michetti, Luisa Migliorati, Riccardo Morri, Luigi Petramala, Alberto Petrucciani, Monica Cristina Storini, Paolo Villari.

- to organise third mission activities able to show some of the results achieved and output produced, increasing community participation and awareness also through webApps, dashboard and story maps.

In this contribution the attention is focused on the first objective and some applied demonstrations are presented and discussed to provide specific examples of elaborations and applications carried out in the field of medical geography, public health, precision preparedness for the management of emergencies.

In particular, we have selected three examples of dashboard, elaboration and webApp produced in the purview of the GeoCartographic Laboratory (Department of Letters and Modern Cultures) with reference to:

- a dashboard which makes it possible to geolocate and geovisualise the cases of COVID-19 recorded in Rome from February 25th to September 26th 2020, on the basis of the data provided by the UOC Hygiene and Public Health Service – Local Health Unit Rome 1;
- a distancemetric map with concentric circular zones which shows some multiring buffer zones starting from the Tmb plant (mechanical biological treatment) of Malagrotta (western suburbs of Rome) where a fire broke out on 15th June 2022;
- a webApp which makes it possible to geolocate the Sapienza University semi-automatic external defibrillators (AEDs), search for the AED closest to a starting point, geovisualise the AEDs in ascending order of distance from a given point and calculate the shortest routes.

Moreover, we refer to recent initiatives as for example the GIS Day 2022 "InDAGIS-MODE&APP. *Integrated geospatial platform and shared geotechnological system for projects and applications of community interest*" and some activities organised for the International night of Geography 2023, at the Sapienza University of Rome, where additional proposals have been advanced and demonstrative examples analysed. In fact, the Institutional Agreement connected to the InDAGIS-MODE&APP project – for its characteristics of vastness and high-performance – makes it possible to think in a network perspective and in the interest of the Sapienza community.

Then, in terms of further input of interdisciplinary applied research, we show a set of thorough ArcGIS Pro elaborations produced for the geolocation and three-dimensional representation of the Sapienza buildings, starting from the Faculty of Letters and Philosophy which has been chosen as starting building to develop a specific procedure and a 3D stratified graphic rendering system. A similar model can meet the need to support ordinary planning and emergency management, help spread an awareness of the campus spaces and be devised to produce GIS Apps for mobile devices able to avoid any waste of time and to move towards a smart way of organising indoor activities and routes.

ArcGIS Desktop, both regarding ArcGIS Pro Extensions and ArcGIS Desktop Advanced, with multiple extensions referred to 3D Analyst, Data Interoperability, Data Reviewer, Geostatistical Analyst, Network Analyst, Spatial Analyst, Tracking Analyst, Workflow Manager, Publisher, Schematics, ArcGIS for Aviation, ArcGIS for Maritime
ArcGIS Online, with ArcGIS Online GIS Professional User Type Licenses
ArcGIS Enterprise, with ArcGIS GIS Server Advanced, ArcGIS Enterprise Additional Capability Servers and an ArcGIS Enterprise Advanced package and connected extensions
Additional Products, among which:
o Esri CityEngine Advanced
o ArcPad
o Drone2Map package
o ArcGIS Indoors package (on the basis of the surface)
o ArcGIS Hub Premium package
ArcGIS Premium Apps
Training services and courses by Esri and customized e-learning
Contact services with technical support

Table 1. The GIS equipment provided by the Institutional Agreement (generally in unlimited quantities, while in quantities up to five in the case of package). Authors' elaboration.

2. Contextualisation

With the spread of the COVID-19 pandemic, the strategic role which can be played by GIS applications and GIS webApps has become evident on a large radius, to provide intelligent solutions and define best practices for promptly responding to specific needs (Elsheikh, 2022, p. 289). An important practical and exemplificative contribution was really provided at the beginning of the pandemic on geographical tracking, real-time mapping, web-based tools and map-based dashboards (Kamel Boulos and Geraghty, 2020). Multiple advantages were gradually underlined and discussed for the surveillance of the contagion and planning actions and treatment services, for example concerning: "Identifying the spreading sources, location-based data for analysis/modeling, informing public events, site selection, supply chain management, and resource locator" (Asadzadeh et al., 2020, p. 3). The COVID-19 pandemic also led to the learning of lessons and traducing them into practice, and for example empowered (Geraghty and Artz, 2022): organisations to enhance human mobility data in the perspective of social distancing guidelines; communities to monitor and evaluate their health care systems' capacity and effectiveness through *ad hoc* spatial tools; governments to adopt location-allocation practices and methods to site specific resources in ways and places that account for at-risk and demographic-socially vulnerable populations; research groups and emergency institutions to use digital maps and derived analysis to identify and study case trends at local levels to support a carefully considered reopening of stores, economic activities etc.; companies and public offices to define "back-to-the-workplace" plans based on physical distancing and workers safety needs; the whole world to see and understand in a different way the importance of dynamic cartography, geospatial models, applied geography for common interests and shared planning.

Therefore, Geography, with its knowledge and analytic tools (and GIS, first of all, among these) has helped to visualise, understand, monitor and examine the spread of the virus and its repercussions on society at different scales (van der Schee, 2020, p. 21).

After all, in terms of mitigation strategies and emergency planning, nearly twenty-five years ago, it was evidenced that: "GIS may serve either as the integrating centrepiece for a comprehensive disaster preparedness and response system or as a portable, on-site source of spatial information" (Cova, 1999, p. 845).

It has also been highlighted that (Eichelberger, 2018, p. 229): "Only with an enterprise-wide GIS perspective can the full range of required data elements be made available to the emergency manager" in order to satisfactorily support the four phases of emergency management (mitigation, preparedness, response and recovery).

Moreover, "spatial data sources, mapping and geo-processing tools, distance calculation, digital elevation model (DEM), buffer zone and geo-statistical analysis" have notably contributed to understanding the epidemiological processes regarding specific diseases, becoming essential for the infection control and decision making (Saxena et al., 2009, p. 125). For example, regarding the use of buffer zones in the case of malaria: "Based on an average adult mosquito flight range of 2 km, GIS was used to create buffer zones around breeding habitats describing areas at risk from mosquito nuisance and disease transmission" (Hassan and Onsi, 2004, p. 367). And then, the importance of buffer zones – also defined on census units with socio-demographic data – and specific geospatial and geostatistical techniques concerning distances between hazards and residents, quantity and typology of pollutants, possible transport modeling have been discussed to estimate the chronic health risk deriving from toxic exposure (Chakraborty et al., 2011, p. 33).

As far as concerns the added value in terms of the identification and calculation of recommended routes, a web-based GIS for emergency management and ambulance routing has been developed – also through geocoding and geolocation, and calculating the optimal routes and recognising the nearest hospitals – to provide timely help and treatment for patients in serious conditions (Utami and Ramdani, 2022, p. 123). With regard to decision-making focused on local needs analysis able to organise a profitable health service – on the basis of the demand, the capacity of referral hospitals and unassigned positive-infected cases of COVID-19 (in Jakarta) in a certain radius (10 kilometers) – a spatial distribution model, also considering network analysis, has been advanced to understand "if there is a need for developing referral hospitals or to allocate more additional health equipment in each alternate hospital" (Silalahi et al., 2020, p. 18).

Furthermore, the importance has been highlighted of accurate geocoding in order to: evaluate the possible causal nexus between exposure to some risk factors and connected types of cancers (Hansen and Poulstrup, 2002) and between ambient pesticide exposure and breast cancer in postmenopausal women (Thompson et al., 2021); attest a possible relationship between air quality and birth defects on the basis of maternal residence during early pregnancy (Gilboa et al., 2006); geolocalise cases of certain infectious diseases and investigate the possible causes and vehicles of transmission (Myers et al., 2006); support an effective surveillance and cluster identification in public health (Zinszer et al., 2010). Obviously, reports regarding disease clusters potentially associated to environmental sources or specific risk factors/vehicles of transmission cause considerable anxiety among the population and need to be analysed in detail and verified with the support of a GIS for health (Aylin and Cockings, 2004, p. 151).

Dashboard and webApps, buffer zones, geocoding, tools to calculate distances from given points and minimum routes thus become driven words to show some elaborations and applications produced in the purview of the InDAGIS-MODE&APP project.

3. A first applied demonstration: a dashboard to geolocate and geovisualise the cases of COVID-19 in Rome

In a previous paper, we tested a model aimed at giving a close-up of medical geography and public health, looking at the situation concerning the Emergency Department overcrowding, since it represents a pressing local and global problem which notably compromises the efficacy of the service, greatly increasing the expected times and worsening the performance. Therefore, geocoding has been used to geolocalise code white attendances to recognise the territorial contexts of the greatest provenance of an improper use of the Emergency Department of the Hospital Policlinico Umberto I in Rome (Lazio region, Italy). Particularly, a "source" map was produced to geolocalise in detail, on a satellite image, the single cases of code white and then, from this dot map, several other elaborations were derived to geovisualise aggregate data in specific digital maps (Pesaresi et al., 2020).

In some other papers, we have also shown a Dynamic space-time diffusion simulator in a GIS environment to tackle the COVID-19 emergency, produced on the basis of the data provided by the UOC Hygiene and Public Health Service – Local Health Unit Rome 1 for the period between February 25th and September 26th 2020. After a process of data cleaning and optimisation, an accurate geocoding was conducted to produce a detailed mapping and also to create animations and video modes focused on Rome.

In a first study some screenshots were extracted to show, in overview geovisualisations and with specific zoom concerning zones subject to a high concentration and according to selected periods of time, the evolution of the situation focused on the total number of cases of COVID-19. In this application, satellite imagery, a digital street map or a Light Gray Canvas (overlaid to sub-municipal areas of Rome) were chosen as alternative background templates (Pesaresi et al., 2021).

An upgrading of the simulator was then presented to highlight the spatial and temporal evolution also with reference to the total number of deaths due to COVID-19 and the total number of cases of COVID-19 with information regarding the different outcomes, showing further potentialities, ductility and possibilities of use applicable in terms of real-time monitoring, healthcare resilience and decision-making (Pesaresi et al., *submitted* a).

On the basis of the previous knowledge, steps and processes conducted and by enhancing the furniture of the InDAGIS-MODE&APP project, a dashboard was produced (Figures 1-3) – through ArcGIS Online – for a systematic and customisable visualisation and analysis of the data concerning the total number of cases of COVID-19 (3,056 final cases on September 26th 2020).

Each case is represented by a red dot. Regarding consultation and functionalities:

- the zoom in and zoom out, on the left, make it possible to pass from detailed visualisations to overall views;
- the time cursor makes it possible to start a dynamic timeline which conventionally advance with a temporal interval of two days, showing trends, clusters and patterns;
- the basemaps gallery makes it possible to select and load various background templates which provide different information (also thanks to the possibility to have labels, place names etc.);
- the find address or position (*Trova indirizzo o posizione*) makes it possible to write a specific address with civic number to navigate directly in proximity of the selected street or square;
- each red dot is clickable and a connected pop-up appears to provide information about the signal date.

In terms of precision preparedness and innovative systems to tackle possible future emergencies, similar dashboards constitute dynamic applications to map, share and analyse data in real-time, and also foresee methods of automatic implementation useful for creating connection bridges among interdisciplinary scientific sectors and researchers, institutions and decision makers.

Figure 1. Dashboard for the visualisation and analysis of the total number of cases of COVID-19 in Rome (3,056 final cases on September 26th 2020). Dashboard elaborated by Davide Pavia, Cristiano Pesaresi, Corrado De Vito on the data provided by the UOC Hygiene and Public Health Service – Local Health Unit Rome 1 for the period between February 25th and September 26th 2020 (template dark gray Canvas).

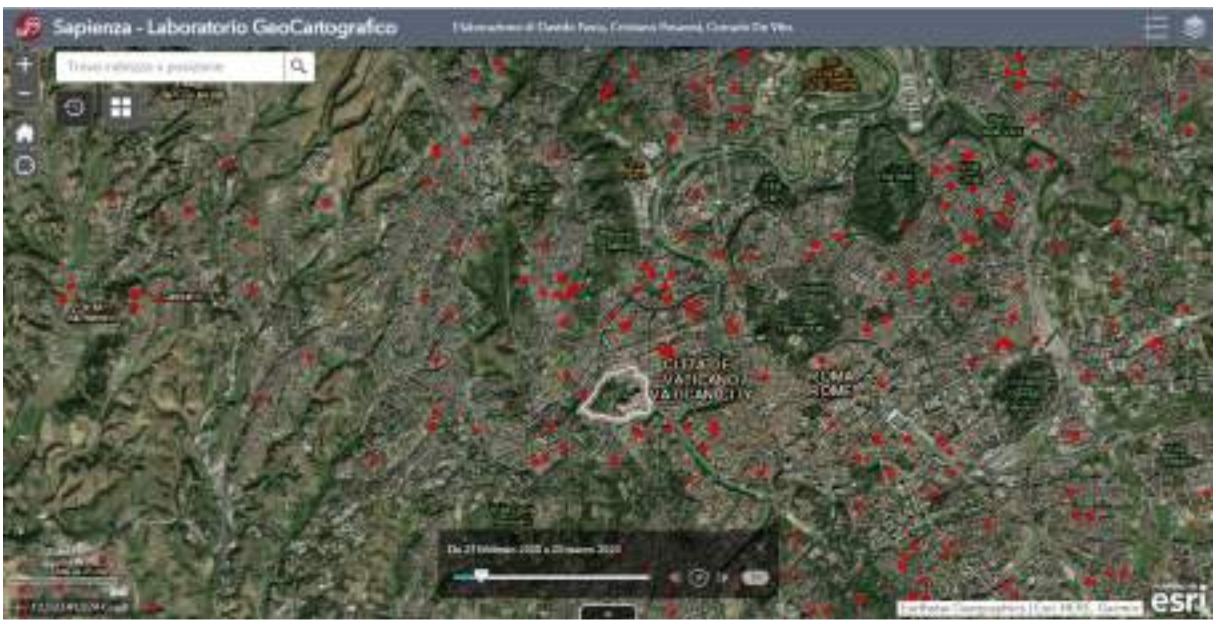

Figure 2. The situation regarding the total number of cases of COVID-19 in Rome on 20th March 2020 through a zoom and a dynamic timeline which conventionally advances with a temporal interval of two days, showing trends, clusters and patterns. Dashboard elaborated by Davide Pavia, Cristiano Pesaresi, Corrado De Vito (template satellite imagery with labels).

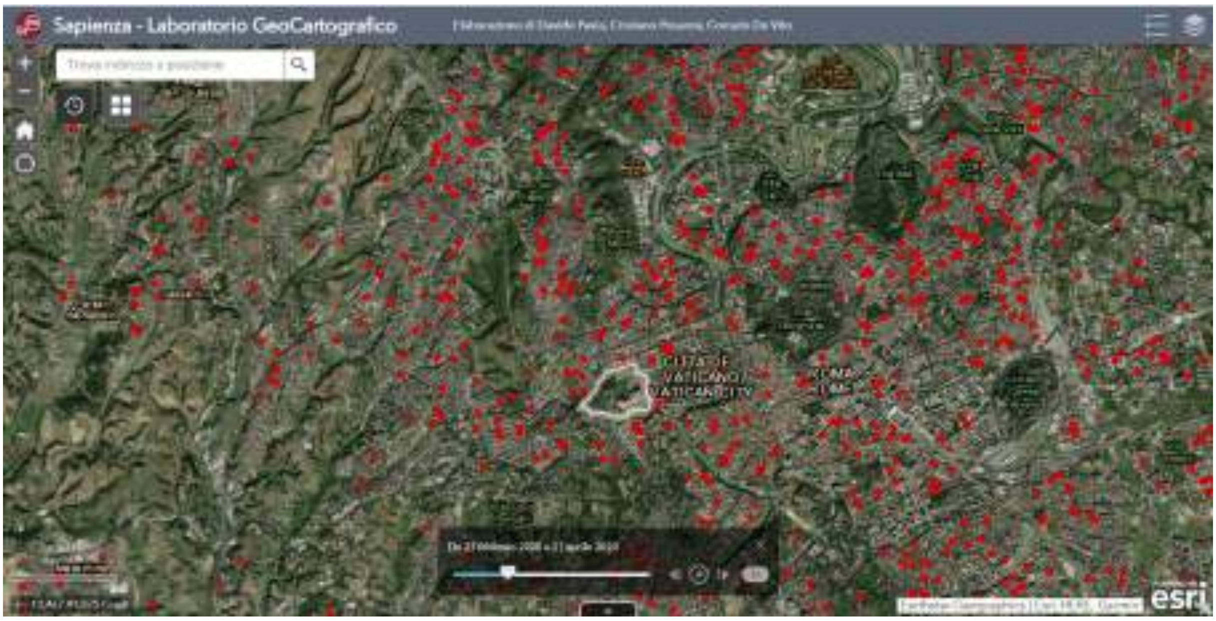

Figure 3. The situation on 21st April 2020 through a zoom and a dynamic timeline which in comparison with Figure 2 shows a notable increase of the cases in about one month. Dashboard elaborated by Davide Pavia, Cristiano Pesaresi, Corrado De Vito (template satellite imagery with labels).

4. A second applied demonstration: a distancemetric map with concentric circular zones

The elaboration of circular concentric buffer zones, on satellite imagery or digital street map, can provide notable added values in different fields of research and strategic planning, for example to (Pesaresi, 2017, pp. 235-237): evaluate and geovisualise which buildings have green areas at a short distance and those that are not adequately covered, and it is useful in terms of quality of life and benefits on the population's mental and physical health; understand and recognise which buildings are near or relatively near certain commercial services and which are out of a possible catchment area, in a perspective of geomarketing and promotional activities; observe which buildings and territorial contexts fall within the areas subject to hazard due to volcanic eruptions and create a division into areas with different levels of exposure.

A previous study, based on the precautionary principle, provided various examples of concentric circular buffer zones starting from specific radio base stations (RBSs) to identify possible connected areas subject to high and different exposure levels. Some GIS applications and prime three-dimensional models (also testing elaborations through semispheres) were produced able to show the buildings in the buffer zones with different levels of exposure and therefore subject to a hazard hierarchy due to their proximity to an RBS (Pesaresi and Pavia, 2021).

On the basis of the previous works and valorising the furniture of the InDAGIS-MODE&APP project, a distancemetric map with concentric circular zones was elaborated in real-time (Figures 4-6) to provide information and a user-friendly geotechnological support following the fire that broke out on 15th June 2022 at the Tmb plant of Malagrotta (Rome).

This dynamic dashboard makes it possible to view, by means of concentric buffer zones of 2 km radius each, starting from the origin, which territorial contexts, houses, physical-natural and anthropic elements are part of different circular zones of proximity.

To provide an immediate geospatial, measurement and geolocation support tool, two series of buffer zones have been drawn from the origin, which make it possible to have a large and rapid geovisualisation.

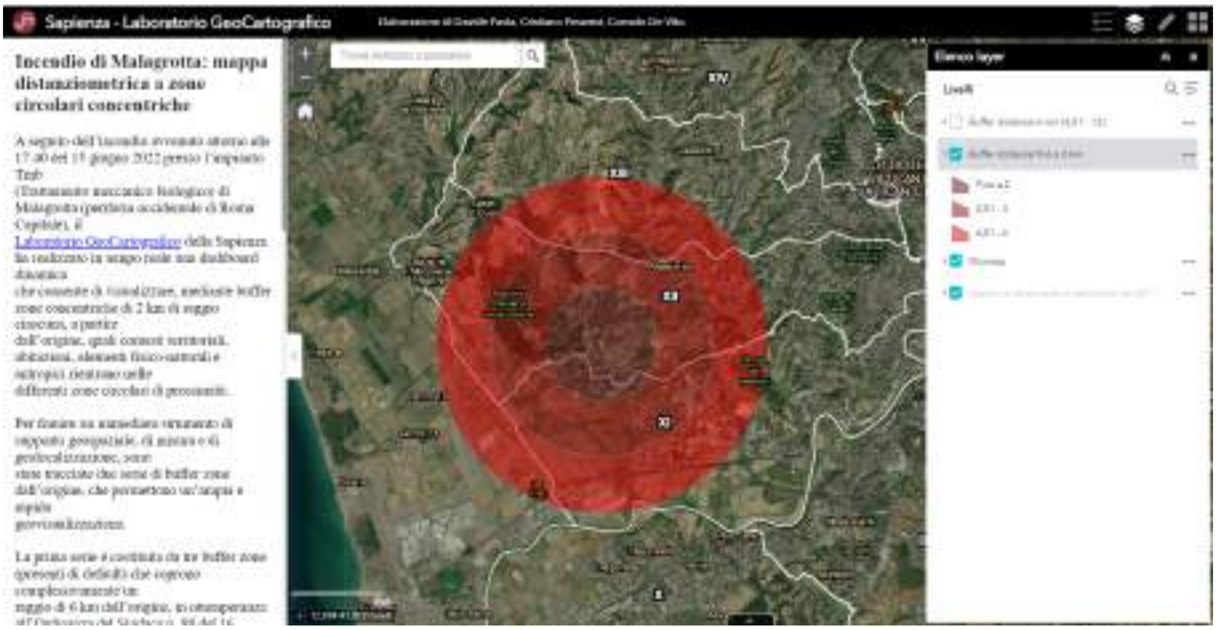

Figure 4. Distancemetric map, on satellite imagery, with three concentric circular zones having a radius of 2 kilometers each, starting from the Tmb plant of Malagrotta. Distancemetric map elaborated by Davide Pavia, Cristiano Pesaresi, Corrado De Vito.

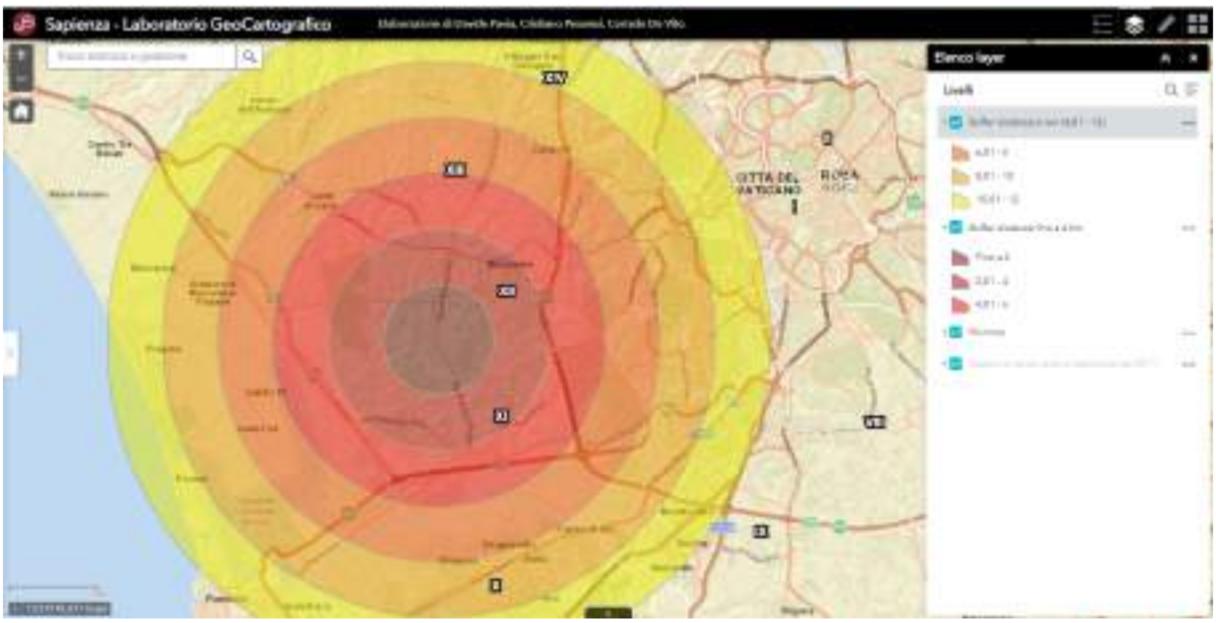

Figure 5. Distancemetric map, on a digital street map, with a double system of three concentric circular zones having a radius of 2 kilometers each, starting from the Tmb plant of Malagrotta. Distancemetric map elaborated by Davide Pavia, Cristiano Pesaresi, Corrado De Vito.

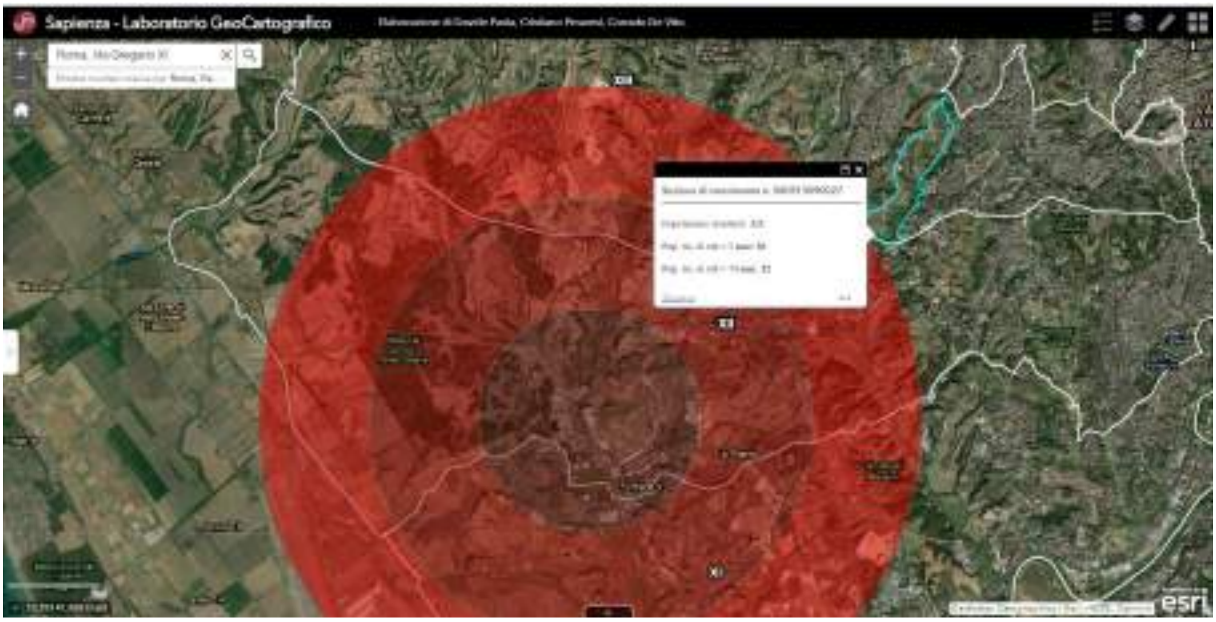

Figure 6. Distancemetric map, on satellite imagery, with three concentric circular zones having a radius of 2 kilometers each, and a pop-up providing demographic data regarding a census section (in light blue) involving the street being searched by means of the find address or location function (*Trova indirizzo o posizione*). Distancemetric map elaborated by Davide Pavia, Cristiano Pesaresi, Corrado De Vito.

The first series consists of three buffer zones (and it is shown by default) which cover a total radius of 6 km from the origin, in compliance with the Ordinance of the Mayor No. 98 of 16th June 2022[2]. The second series, loadable via the list of layers (*Elenco layer*), specifying Buffer distance in km 6.01-12 (at the top right), consists of three more buffer zones, covering precisely the conventional distance of 6.01-12 km, as an additional tool of response to the population, which – even in the case of greater linear lengths – asks about the distance and location of one's home, workplace or schools from the origin of the fire.

The buffer zones are in hierarchical scale in maroon yellow colour to indicate situations of kilometers in distance progressively decreasing. The measurement tool (*Misura*), identified by the ruler (at the top right), makes it possible to take specific distances from the origin to any point people want to locate on the representation, regardless of the distance.

This dashboard – produced as a geographical demonstration application – aims to highlight how quickly tools of collective utility can be produced. This is also favored by the possibility of carrying out a search using the find address or location function (*Trova indirizzo o posizione*), at the top left.

The background templates can be changed through the basemap gallery feature (*Galleria mappe di base*), marked by the symbol with four small points (at the top right), to view the elaboration above a satellite imagery, a digital street map, a topographic map etc.

By using zoom in progressively, it is also possible to display the census sections as supplementary layers, with relative demographic data that appear, by clicking on the sections, in specific pop-ups.

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[2] https://www.comune.roma.it/web-resources/cms/documents/OdS_98_16.06.22.pdf.

5. A third applied demonstration: a webApp to geolocate the Sapienza University semiautomatic external defibrillators (AEDs)

In May 2022 the GeoCartographic Laboratory received a request from the Special Office for Prevention, Protection and High Supervisory[3] for collaboration aimed, among other plans, at the geolocalisation of the Sapienza University semiautomatic external defibrillators (AEDs) and development of a system for navigation with smartphone able to reach the nearest AED in a short time. The request was due to the fact that Sapienza University considers it fundamentally important to create an efficacious network able to reduce as much as possible, in the case of heart attacks, the time necessary to reach specific devices, above all AEDs.

Therefore, a prototype webMap was produced to speed up the first-aid operations and increase the possibility to save human lives. Particularly, we worked in an operative way according to the following steps (Pesaresi et al., *submitted* b):

- acquisition of information and geographical coordinates recorded in the University management system (based on LIFELINK central) for each AED;
- development of a new database functional to geolocation, after the review and audit of the positioning of the devices;
- integration of information organised in the new database with data provided (on the basis of a standard scheme) by Faculties, Departments etc.;
- geolocation of AEDs in the Google MyMaps environment;
- graphic representation on digital maps through specific symbols and synthesis of the information for each AED through pop-ups;
- publication of the webMap through the University High Supervisory Board account.

On a web page of the Sapienza University of Rome[4] the list of AEDs and the webMap can be consulted and this application makes it possible to have, on different basemaps (i.e. satellite imagery, digital street map), a detailed geolocation of each AED with interactive summary pop-ups including specific information and to calculate and display the route to reach a chosen device.

In this way, both the people of the Sapienza community and also external people can benefit from the network of semiautomatic external defibrillators, by geovisualising them in a webMap produced *ad hoc* and by obtaining information regarding the routes to reach the selected device and an estimate of the time necessary.

In order to add further useful functionalities of spatial analysis, enhancing the furniture of InDAGIS-MODE&APP project, we migrated the data and layers in an ArcGIS environment. Particularly, from an applied point of view, also in this case, we worked according to specific operative steps summarised in Figure 7.

Thanks to the passage to an ArcGIS environment, a webApp was produced and new added values can be recorded (Figures 8-10), as for example the possibilities:

- to search for the AED closest to a starting point that can be entered manually or by using the GNSS sensor installed on own devices;
- to geovisualise the AEDs in ascending order of distance from a given point;
- to calculate the minimum routes based on a custom road graph;
- to have preconfigured templates and widgets available on ArcGIS Online for different uses.

In addition to the capabilities of the webMap produced in the Google MyMaps environment, the webApp that has been developed in ArcGIS, with the web AppBuilder, adds the possibility to list the AEDs in growing distance order as the crow flies, to quickly recognise the closest one to a starting point, most likely corresponding to the user's current location. There are several ways to calculate its coordinates: using the device satellite sensor; writing its address into the search field; pointing its position on the basemap. Once calculated, the user can decide the maximum search radius of the widget, to narrow down the search to only the devices at a

[3] The head of the Special Office is Leandro Casini.

[4] https://www.uniroma1.it/it/pagina/defibrillatori-sapienza-in-rete.

walking distance. Clicking on one of the listed options shows the attributes of the relative AED, along with the "Directions" button that makes it possible to calculate the route and driving times to the device.

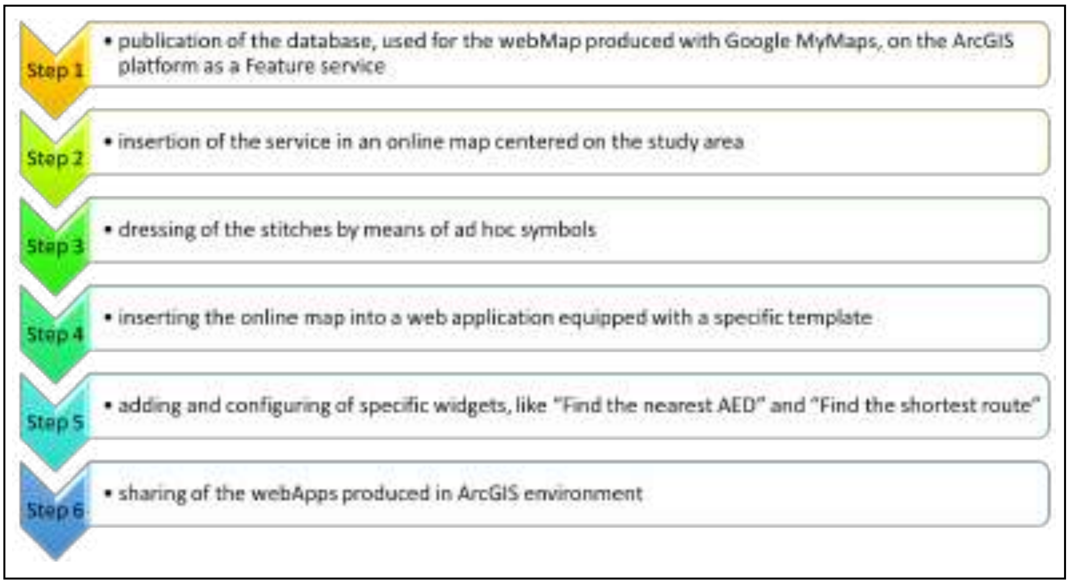


Figure 7. The six sequential operative steps able to produce the AED Sapienza webApp in ArcGIS environment. Authors' elaboration.

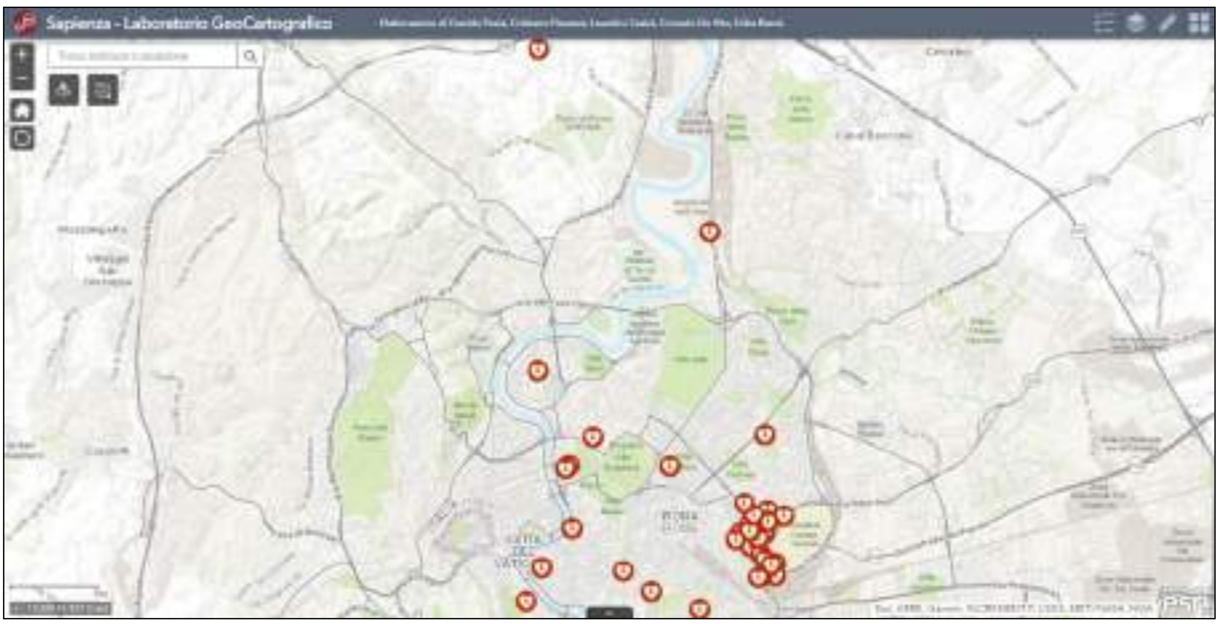
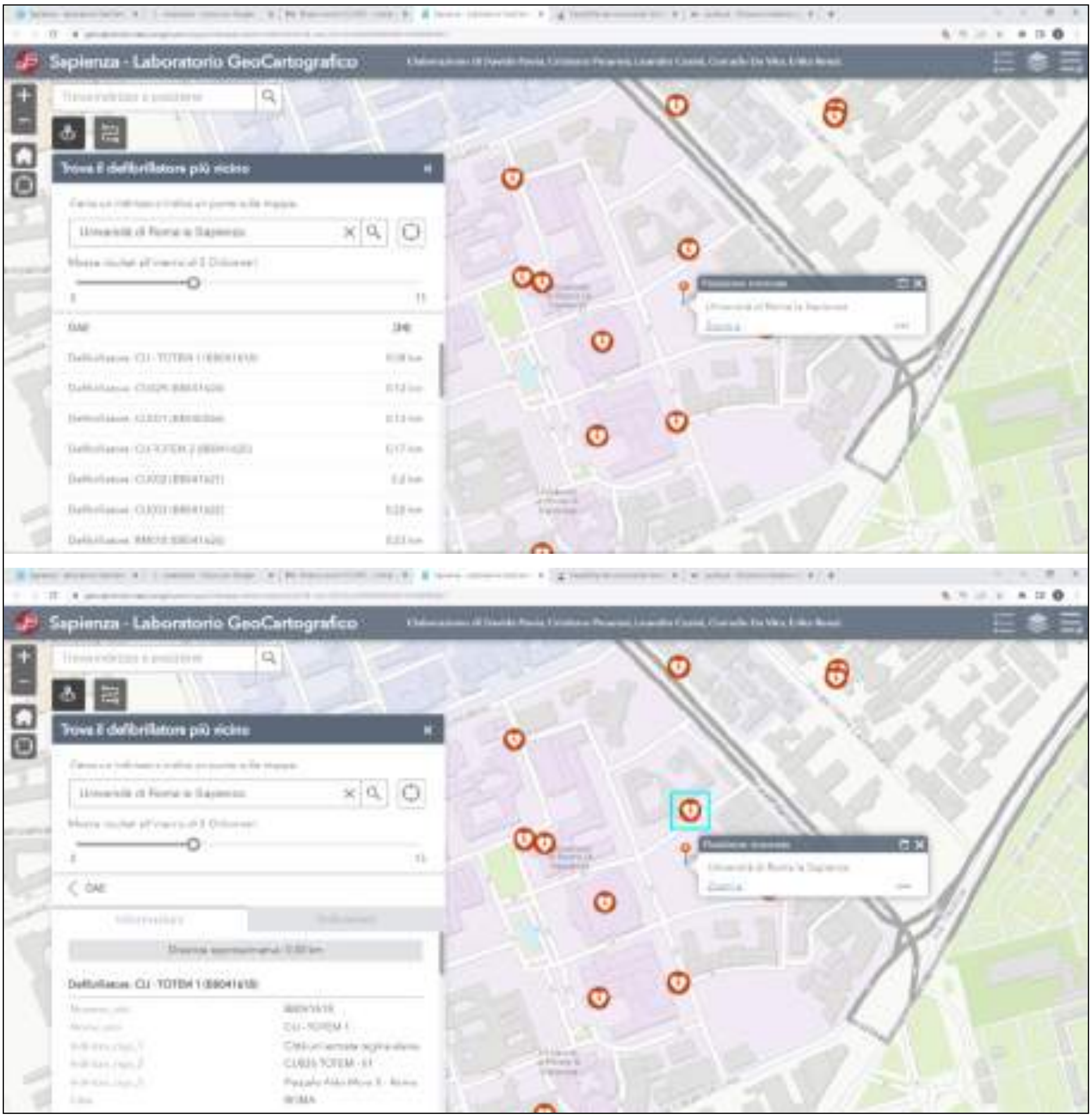


Figure 8. WebApp to geolocate the Sapienza University semiautomatic external defibrillators (AEDs) in ArcGIS environment. WebApp elaborated by Davide Pavia, Cristiano Pesaresi, Leandro Casini, Corrado De Vito, Erika Renzi (template topographic).



Figures 9a and 9b. WebApp to geolocate the Sapienza University semiautomatic external defibrillators (AEDs) in ArcGIS environment and function to find the AED closest to a starting point. A list is opened with various AEDs in ascending order (9a above). The closest AED can be clicked in the list, is evidenced in light blue and specific information appears in a pop-up (9b below). WebApp elaborated by Davide Pavia, Cristiano Pesaresi, Leandro Casini, Corrado De Vito, Erika Renzi (template topographic).

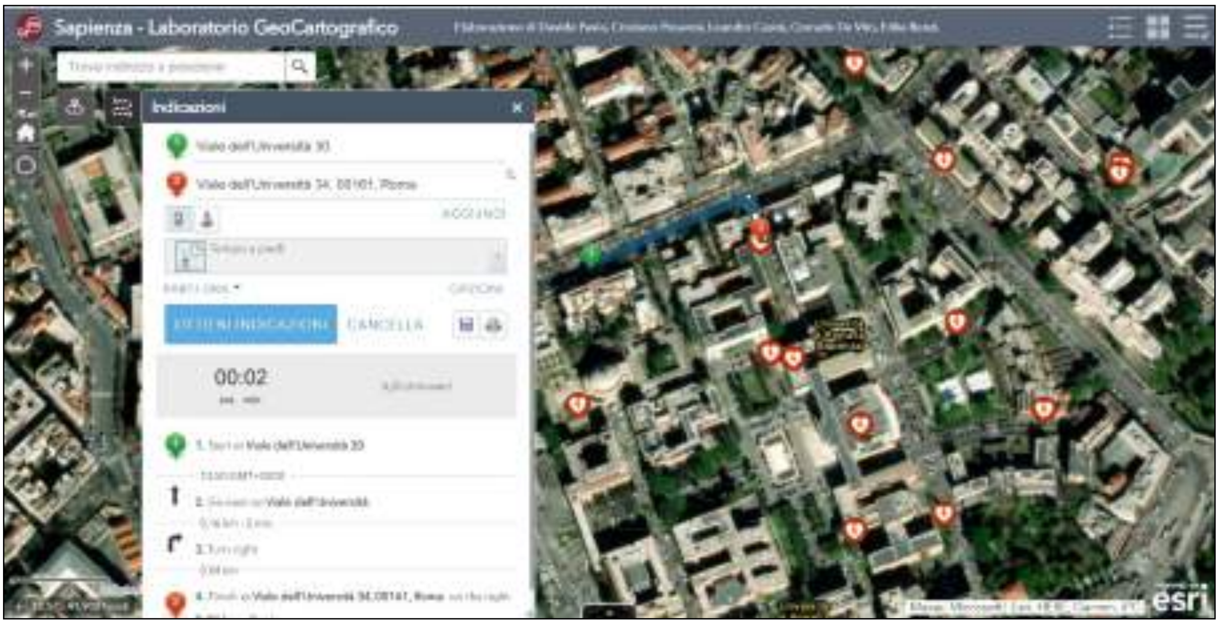


Figure 10. WebApp to geolocate the Sapienza University semiautomatic external defibrillators (AEDs) in ArcGIS environment and function to reach, from a given start point (in green), an AED (in orange) obtaining information regarding the route (in blue) and the time necessary, geovisualised on satellite imagery. A pop-up provides specific information about a route on foot (and other options are possible, i.e. by car). WebApp elaborated by Davide Pavia, Cristiano Pesaresi, Leandro Casini, Corrado De Vito, Erika Renzi.

6. Other activities and ideas

The wide and variegated furniture of the InDAGIS-MODE&APP project makes it possible to plan numerous initiatives able to create profitable synergies among different scientific sectors, in the fields of research, didactics and third mission.

Considering both the two main objectives and thematic areas of the project, the first assessment of the ArcGIS licenses granted to other colleagues, PhD and university students – by the GeoCartographic Laboratory in the capacity of platform manager, in the period between April 2022 and April 2023 – testifies that almost 400 accounts have been created.

In terms of numerical data, it is clear to see the considerable savings by Departments, Laboratories and single users, for software purchase and update, in view of such complex and vastly extensive equipment. At the same time, many static situations of fragmentation and obsolescence in the equipment available to various users have been overcome, pushing towards an alignment and homogenisation of the software and systems.

In terms of qualitative considerations, collaborative opportunities (also in the fields of PNRR and international projects) have been promoted and strengthened to enhance interconnections, organise high-performance GIS architectures, share data, elaborations and models. Moreover, it has been possible to work with the aim of training professional figures, with open-mindedness towards the geotechnologies, able to combine content and GIS applications. This has all been fostered by the double possibility of creating some hundreds of ArcGIS accounts and of setting up lecture rooms and cutting-edge laboratories for face-to-face activities, where *ad hoc* geotechnological courses have been held.

Therefore, the InDAGIS-MODE&APP project provides a notable added value with a wide range and for community interests and an investment also aimed at enrichment translatable in: new and joint initiatives of great importance; possibilities to undertake directions otherwise not pursuable; competences usable to obtain further positive effects and boast specific skills; ability to undertake projects and geotechnological activities internally at the Sapienza that otherwise would require external consulting (with added expense).

As far as concerns examples of applied didactics and third mission, on 23rd November 2022, the GIS Day "InDAGIS-MODE&APP. *Integrated geospatial platform and shared geotechnological system for projects and applications of community interest*"[5] was organised at the Faculty of Letters and Philosophy, Sapienza University of Rome, in order to:

- inform students and colleagues of the geotechnological equipment which can be made available;
- show some recent elaborations produced (by the GeoCartographic Laboratory) in the fields of medical geography and public health;
- evaluate new perspectives to undertake together through projects of shared utility in public health and emergency preparedness and management, enhancing the GIS furniture of the InDAGIS-MODE&APP project;
- discuss hypotheses of valorisation in networks about geography in relation to archaeology, library sciences, linguistics, human sciences, enhancing the GIS furniture of the InDAGIS-MODE&APP project;
- suggest and organise laboratories and applied courses for PhD students who in acquiring GIS skills can in turn propose ideas and solutions to provide added values in different research fields where GIS solutions and tools are underused;
- plan possibilities for young people having a degree or graduating to participate in specific conferences and present the results of their own research through dashboards, story maps, webApps.

This GIS Day, having among the members of the Scientific Committee also Chew-Hung Chang (Co-Chair of the International Geographical Union/Commission on Geographical Education – IGU CGE), Rafael de Miguel González (President of European Association of Geographers – EUROGEO), Zoltan Kovacs (President of the Association of European Geographical Societies – EUGEO), made it possible to discuss possible perspectives and initiatives at international level, creating opportunities for comparison and exchange with presidents of international geographical associations and colleagues from other countries of the world, and the relevance of this activity has been spread by the EUROGEO newsletter of March 2023.

Another example is represented by the activity " 'Knowing how to move' to intervene: the webMap of the Sapienza defibrillators"[6] which was held in the context of the International night of Geography, at the Sapienza University of Rome, on 14th April 2023[7]. The key theme, chosen by the Sapienza, has in fact been "Geography elixir. Geographical Health Education" and this activity was characterised by two operative and demonstrative connected phases. In the first one the webMap was shown to the students attending the activity, briefly explaining the sequential steps and the importance of a similar application to reach the aim to save human lives; and then the WebApp produced with ArcGIS was also mentioned, in order to make comparisons and stimulate new feasible ideas for social purposes using ArcGIS furniture. In the second one, the procedures and manoeuvres to be performed during the first aid phase were shown twice – to stage a simulation – and then carried out by students under supervision.

Once again in the context of the International night of Geography, at the Sapienza University of Rome, another activity was focused on "Smoking among young. Old and new tendencies, always better to avoid"[8].

This activity concerned both tobacco smoke, through geographical data regarding Italian regional distribution and gender, and electronic cigarettes, providing evidence about their composition and possible repercussions on

[5] https://web.uniroma1.it/lcm/news/gis-day-indagis-modeapp-roma-23-novembre-2022#:~:text=Piattaforma%20geospaziale%20integrata%20e%20sistema,e%20applicazioni%20di%20interesse%20comunitario.

[6] The conductives have been: Leandro Casini, Corrado De Vito, Davide Pavia, Cristiano Pesaresi, Matteo Piattoli, Erika Renzi.

[7] For information and programme about the International night of Geography 2023 at the Sapienza University of Rome, see https://news.uniroma1.it/14042023_1630A. On the spirit, the birth and diffusion of the European Geonight, starting from the initiative of the French National Geographical Committee, in 2017, see: le Blanc et al., 2018.

[8] The conductives have been: Maria Sofia Cattaruzza, Cristiano Pesaresi.

people's health since much misleading information has been diffused on this. On this occasion, by enhancing the furniture of the InDAGIS-MODE&APP project, the possibility was evaluated of producing a webApp able to synthetise these data and information to promote conscious behavioural habits in order to strengthen the knowledge of single individuals and community, improving everyone's health, preventing unhealthy behaviour and thus reducing the risk of the onset of chronic diseases that generally arise in adulthood. This was promoted meeting the guidelines of the document "*Indirizzi di 'policy' integrate per la Scuola che Promuove Salute*" approved in 2019 by the Ministry of Health (*Ministero della Salute*) and Ministry of Education, University and Research (*Ministero dell'Istruzione, dell'Università e della Ricerca*). Moreover, a geolocated questionnaire able to record specific information – i.e. regarding the age at which smoking started, the main reasons, the number of daily cigarettes and/or vapes etc. – and to produce distribution maps, in addition to instant graphs, could be planned using ArcGIS Survey123. A similar webApp could become a precious education and awareness tool where scientific data and information can be found to answer questions that are otherwise difficult to satisfy and it could be replicable also for other important behavioural risk factors (i.e. the use of alcohol, with the increasingly widespread binge drinking and high-intensity drinking; obesity, overweight, sedentary lifestyle; etc.).

7. Further initiatives… towards the geolocation of the Sapienza buildings and indoor solutions

With regard to other examples of interdisciplinary applied research, again in May 2022 the GeoCartographic Laboratory received a request from the Special Office for Prevention, Protection and High Supervisory for further collaborations aimed at: the geolocation of Sapienza buildings as part of the implementation of the Sapienza Spaces Integrated Management System (with request for feasibility evaluation and methodological-operational proposals); geolocation of COVID-19 cases reported in the Sapienza classrooms/buildings, for the purpose of stratified graphic rendering (according to a proposal of the Department of Public Health and Infectious Diseases).

Both these two projects first of all require a rigorous and extended process of georeferencing of single buildings and the whole University campus, starting from the CAD planimetry provided by the above-mentioned Special Office. The georeferencing process in ArcGIS environment makes it possible to turn the local coordinates of the planimetries into geographical ones, in order to overlay them on a basemap, like for example satellite imagery, a digital street map etc.

In terms of added values, the organisation of a georeferenced system and a harmonic ArcGIS environment would also make it possible to plan new elaborations and 2D/3D dynamic interactive scenes through ArcGIS Indoors, involved in the Institutional Agreement. In this way, it is possible to move towards a profitable way to navigate indoor mapping and indoor space management, making the geolocation and identification of the classrooms and the planning of routes easy. Moreover, it becomes possible to support decision-making in the case of ordinary and extraordinary situations and elaborate connected GIS Apps for the entire Sapienza community.

As has been synthetised and shown in the video "Campus Facility Mapping with ArcGIS Indoors"[9], by Cloudpoint Geospatial, some perspectives provided by working with ArcGIS Indoors can be related to the possibilities of geolocating building information and also emergency devices (for example fire extinguishers), easily recognise classrooms/ courtroom, libraries and laboratories, having data in real-time concerning current capacity and current occupancy of interior spaces etc., accessible not only from a desktop environment, but also from mobile devices, such as smartphones and tablets.

Some papers have furthermore highlighted the added value of using ArcGIS Indoors for creating a three-dimensional University routing information system and designing a campus

[9] https://www.youtube.com/watch?v=DtxkANtbSaU.

scene, also in the perspective to produce effective web applications.

For example, in terms of interoperability and passage from CAD to GIS, Wilkening et al. (2019, p. 5) evidenced that:

> Data processing makes use of the generated CAD files to create a customizable Indoor GIS and a point-to-point routing network that connects all the indoor spaces into a single network. An Indoor GIS does not only contain basemaps for visualization purposes, but also attributive data for the features such as buildings, floors, floorplan lines (wall, stairs, windows, etc), and indoor spaces (numbers, persons, room categories etc). The data processing workflow includes the following steps: (1) creating building interiors, (2) visualizing and designing a campus scene, (3) creating a campus network, and (4) creating the web application.

Moreover, they affirmed that:

> ArcGIS Indoors offers the possibility to add, view and manipulate CAD files. In addition, the building attributes stored in the CAD files are automatically converted into an Indoor GIS, using a configurable Excel file that is available in the ArcGIS Indoors download folder. This Excel file contains building properties information, CAD layer mapping and file information, which can be edited and modified. The result of this CAD-GIS conversion step is an interactive 3D scene populated with building floorplan lines, interior spaces, floor and building footprint […]. These features constitute the basis for our Indoor GIS and will be used further to visualize and design the campus scene to create a cartographically appealing CRIS [Campus Routing Information Systems].

Other works have analysed the "best practice of using an indoor GIS platform to assess space usage and design a complete indoor GIS solution to facilitate and streamline the data collection, a management and reporting workflow" enjoying a user-friendly and customisable interface for data collecting and an automatic procedure to synthesise the space usage statistics. In fact, the creation of a systematic indoor GIS environment for space usage evaluation provides an effective map-based and georeferenced interface also propaedeutic to geospatial analysis and data reporting (Li et al., 2021, p. 104).

Moreover, further studies have presented and discussed the process used to develop a building navigational model in the perspective of integration between BIM (Building Information Modelling) and ArcGIS Indoors, with particular reference to a campus site as case study. Examples of route planning able to show the shortest path from a determinate room to emergency exit have been presented; and a 2D webMap which can be incorporated into a mobile application, able to make the users' perception of distances easier, and a 3D display of the route, that can help people to create a cognitive map of the indoor path, have been discussed (Trybała and Gattner, 2021).

Furthermore, a systematic literature review has been conducted regarding indoor environments and GIS applications, providing a synthetic categorisation into the following groups able to put in evidence the growing fundamental role of these geotechnological functions for scientific advancement and decision support (Teixeira et al., 2021): indoor management; indoor geospatial analysis; indoor positioning; indoor data acquisition; indoor spatial data models.

On the basis of similar experiences and the request coming from the Special Office for Prevention, Protection and High Supervisory, we have started to work in the direction of the geolocation of the Sapienza buildings and indoor solutions, providing some first demonstrative examples.

8. First steps and some first geolocation examples of the Sapienza buildings

In order to build up a geodatabase that could serve as the input for an application like ArcGIS Indoor, that is to say for navigating through the Sapienza's buildings, the GeoCartographic Laboratory received from the Special Office for Prevention, Protection and High Supervisory a large set of CAD files, representing the planimetries of the University's locations available in May 2022. These files were stored in two different folders: one for the campus' buildings, in Piazzale Aldo Moro, Rome; one for the other locations, such as Villa Mirafiori and Vetrerie Sciarra, except for those located outside Rome. The overall number of buildings was thus 138, provided in different files named in relation to an *ad hoc* naming convention made by letters and progressive numbers, such as “CU001”, “CU002” and so on (where “CU” stands for “Città Universitaria”, the name of the campus).

The georeferencing sample regarded the building “CU003”, the one that represents the Faculty of Letters and Philosophy. As for the rest of the buildings, its folder contained a single CAD file for each floor, both in DXF and DWG formats. These files were formed by vector drawings of the rooms placed on each floor, such as the classrooms and the offices, together with the ones of discrete elements, like doors and stairs (Figure 11), whose shapes were related to labels about their geometry, like the value of their areas, and the inventory, that is to say their ID code according to the University’s inventory.

The software used for georeferencing the drawings was ArcGIS Pro, one of Esri’s products licensed by the project and the leading application of this platform. Like its previous desktop application ArcMap, this one is also able to work with CAD files, which are read as feature datasets formed by different classes representing shapes and texts. The first step of the process thus regarded the conversion of a subset of these files into a GIS data format, in order to preserve the original data and, above all, because it is not possible to edit CAD data in the software, even if they can be aligned directly. Hence, the six floors of the Faculty’s building were exported to six feature classes, the ArcGIS native format for the vector data model.

Once added to a new map, these feature classes were located far away from the campus, precisely at the intersection of the Equator with Greenwich, that was the origin of the map’s coordinate system (WGS 1984). Each one of them was then georeferenced using the tool “Transformation”, one of the modification tools available from the “Edit” tab of the application. The workflow of this tool resembles the one that is used to align a raster dataset by adding GPCs (Ground Control Point): indeed, the user has to add a set of links between the original locations of the features to be moved and their new ones, in order to determine a series of coordinates that will be used to apply a transformation and georeference the entire feature class.

The basemap used to place these links was the Regional Technical Map of Lazio, scale 1:5,000, available in WMS format. In addition to the use of a symbology based on a palette of warm colours, that make its contents much more readable by increasing the contrasts, this regional map offers a plain representation of each building’s boundaries, whose corners were used to locate the “to points” of the links, to make the entire alignment more effective.

A total of four links were then added to the six feature classes, which were enough to move their polygons from the above-mentioned origin to the campus’ location (Figure 12). At the end of the georeferencing process, the map was then converted into a global scene, that is to say a first step toward a sort of 3D environment where users can rotate their point of view in all directions, in order to display the layers all together from a bird’s eye view (Figure 13). For the moment, the output was obtained by adding a ten-meter offset to each layer, chosen as conventional value to foster the readability of the elaboration.

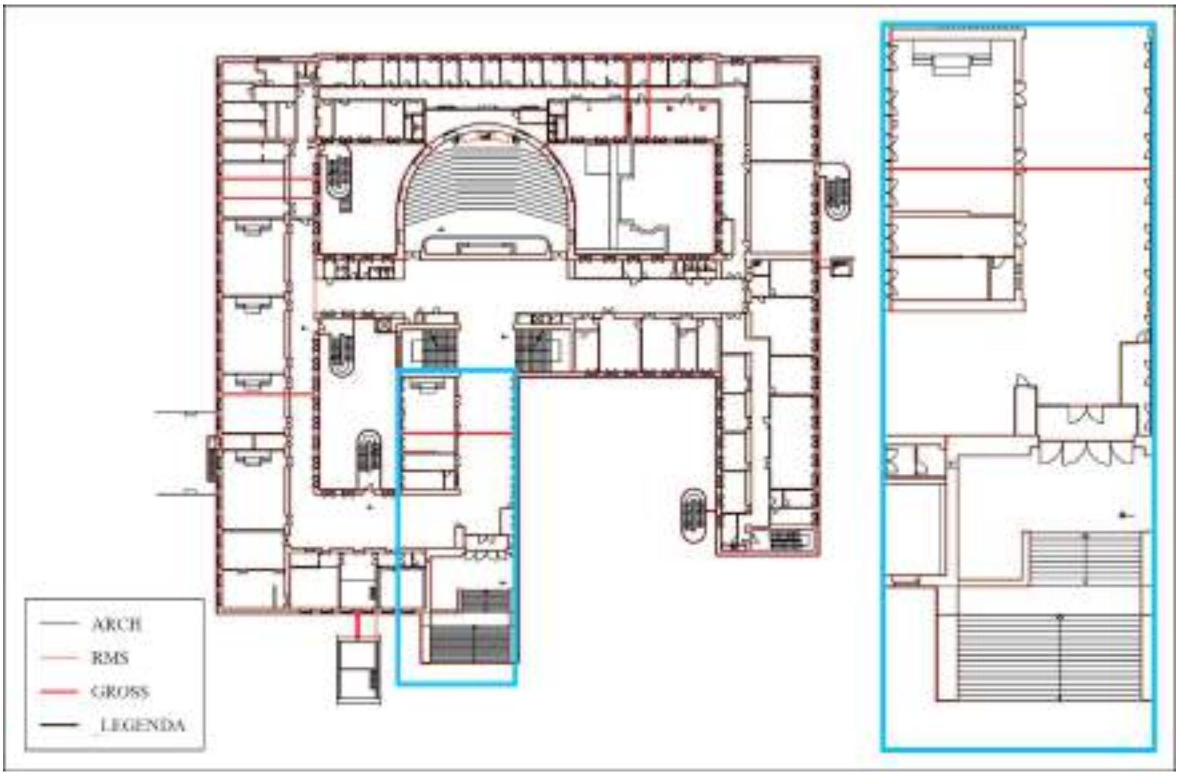


Figure 11. The planimetry of the first floor of the Faculty of Letters and Philosophy (Sapienza University of Rome), stored in a DXF CAD file and displayed in an ArcGIS Pro map layout. Authors' elaboration.

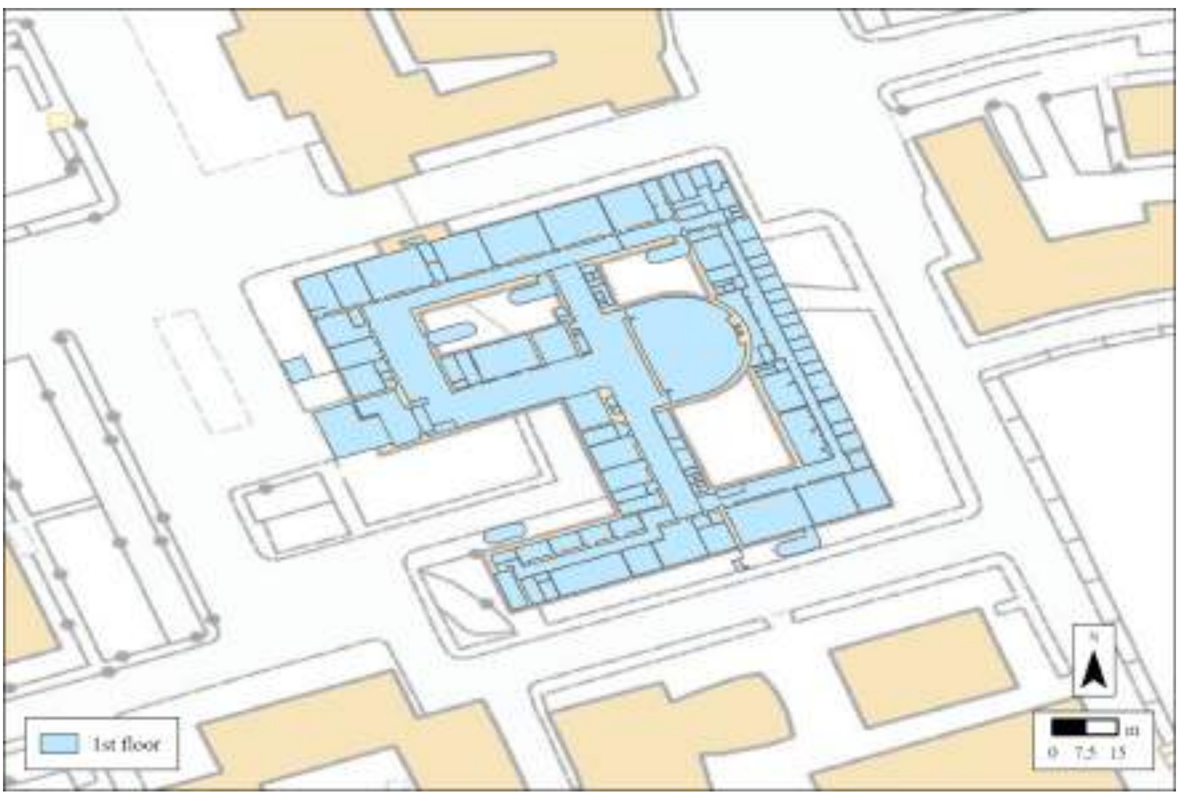


Figure 12. The first floor of the planimetry of the Faculty of Letters and Philosophy, georeferenced and displayed in an ArcGIS Pro map upon the Regional Technical Map of Lazio. Authors' elaboration.

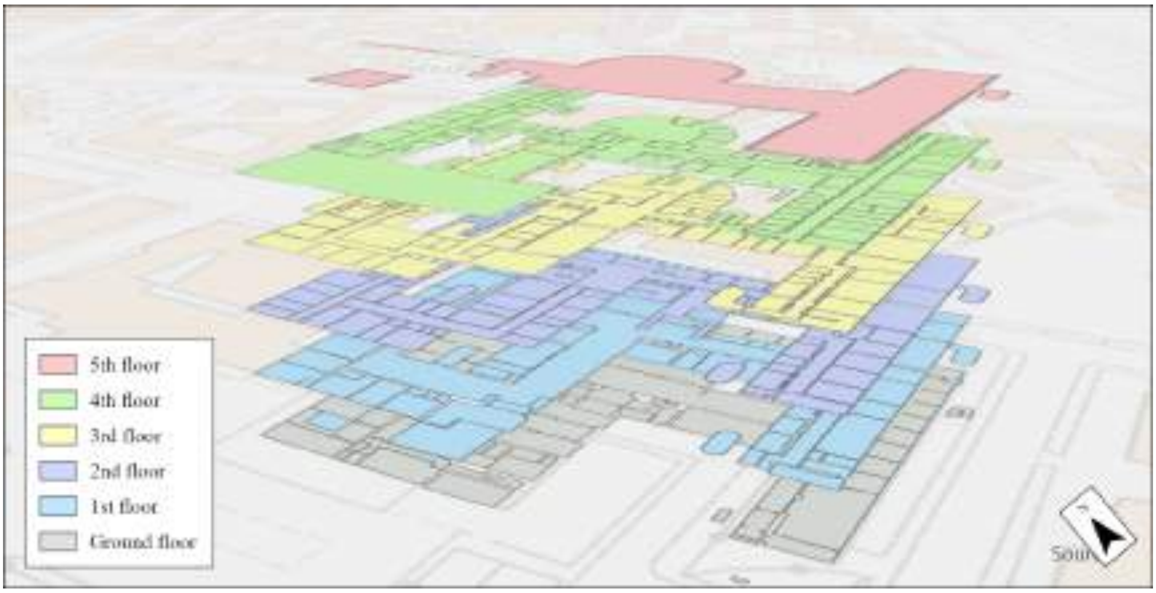


Figure 13. The six floors of the Faculty of Letters and Philosophy, georeferenced and overlaid in an ArcGIS Pro global scene. Authors' elaboration.

9. Moving towards 3D scenes of the Sapienza buildings

Once a sequence of preparatory steps and a multilevel project had been organised, we moved towards basic 3D scenes of the Sapienza buildings and for this demonstrative application the attention was consequently focused again on the Faculty of Letters and Philosophy ("CU003"). The three-dimensional model here presented is characterised by real values of: sides, perimeters and areas, derived from the digital planimetries edited in CAD and then georeferenced in ArcGIS environment (with consequent adjustment); heights, manually measured by us for each floor. In particular, the heights (generally between four and five meters)[10] were taken from the floor to the ceiling of each floor in common spaces where there are no false ceilings or other dropped ceilings.

Therefore, the 3D model of buildings contains accurate, useful data and information to produce realistic scenes which can be observable from different perspectives.

In this demonstrative application, Figure 14 shows the ground floor of the Faculty of Letters and Philosophy obtained by an extrusion process according to the manually taken height. In this way, we pass from 2D to 3D, from an assemblage of polygons to an assemblage of corresponding solids.

On the other hand, Figure 15 shows a composite scene where the ground and first floors of the Faculty of Letters and Philosophy are represented with their perimeter, area and (approximate) volume values and are thematised with the same colours as Figure 13, while the second floor appears "schematised" as it is internally transparent with a dark border. This symbology makes it possible to visualise the internal part of the second floor and a similar model can be useful to represent internal elements, as for example safety devices and lecture hall and classroom furnishings.

This model makes it possible to have the first demonstrative elaborations to move towards the geolocation and three-dimensional representation of the Sapienza buildings. At the same time, through this model, we provide applied examples of 3D stratified graphic rendering able to support ordinary planning, emergency management, possible geolocation of determinate virus cases in the Sapienza classrooms/buildings and subsequent

[10] With its structural characteristics and representative image, the lecture hall has a greater height, but for the time, being in order to foster a multilevel view, an extrusion has been carried out which gives all the solids the same height.

decision making. Moreover, a powerful instrument can be made available to the community (also in the perspective of potential connected GIS Apps): making the identification of specific classrooms and interior elements fast; avoiding useless waste of time and aimless walks; supporting practice drills regarding fire or other events for workers, professors and students.

Different viewpoints and scientific sectors thus tend to be integrated, with reference to i.e. applied and public geography, geography of safety, engineering and architecture, public health and health education/awareness, workplace safety, risk prevention and protection etc.

In this way, the key aim of a resolute and shared civil commitment can be pursued, providing input to feed interdisciplinary dialogue and compare arguments and applied products (Morri, 2020).

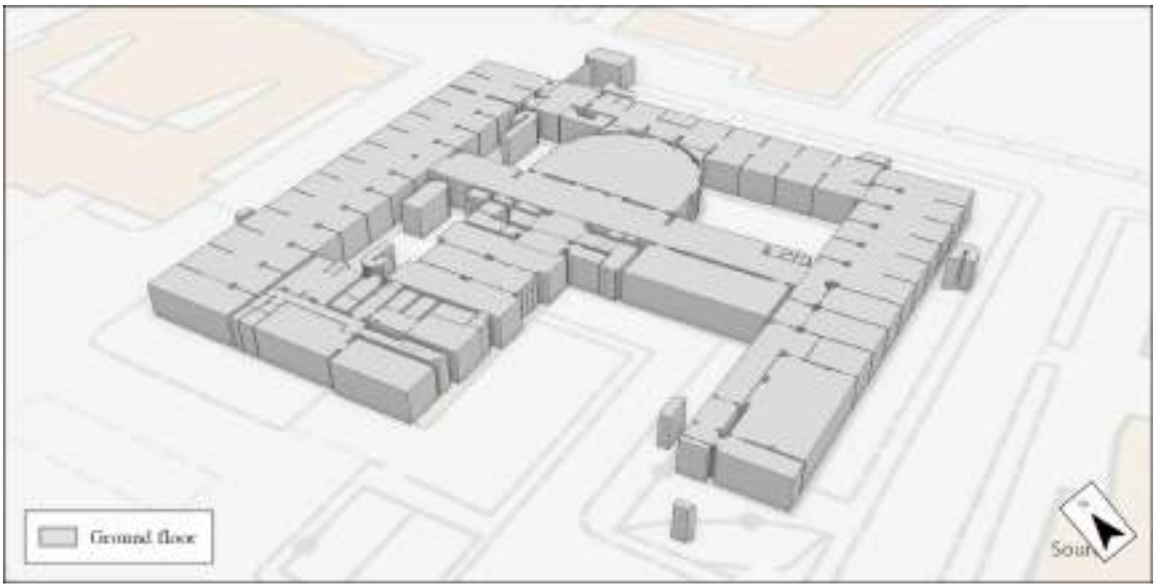


Figure 14. The ground floor of the Faculty of Letters and Philosophy obtained by extrusion process in an ArcGIS Pro 3D scene. Authors' elaboration.

Figure 15. The ground and first floors of the Faculty of Letters and Philosophy obtained by extrusion process and the second floor "schematised" to be internally visualisable in an ArcGIS Pro 3D scene. Authors' elaboration.

10. The first sample building of the Sapienza in an ArcGIS Pro 3D global scene

In the framework of the phases aimed at producing three-dimensional elaborations of the Sapienza buildings, Figure 16 shows the 3D scene of the whole Faculty of Letters and Philosophy where each floor maintains the same colour as Figure 13 and the output product derives from the extrusion of the single floors on the basis of their manually measured height.

The model approximates the height of any floor to a single value, without considering that there could be various changes in the height of two different rooms or hallway of the same floor (if not within a single classroom).

Some actions could be taken to produce an even more realistic model of the building.

First of all, each polygon of the planimetry could be associated with its corresponding height, in order to perform the extrusion not by using a single expression, that is to say by giving the same height to the whole floor, but by basing the process on a specific field of the attribute table. Thus, the model would display the differences in height between different classrooms, but it would not be able to detect the presence of the smaller variations.

A point cloud could then be added to the scene as a new layer, in order to represent the output of a survey made by LiDAR sensors. In such a way, the model would not only show the presence of the objects placed inside each classroom, from the chairs to the vending machines, but would also allow the user to interact with all of them, by measuring the distance from two points or by changing the symbology of the 3D mesh, leading the way to a BIM (Building Information Model).

Point cloud derived and collected by the LiDAR sensors and laser scanners (Borisov et al., 2022) and BIM-GIS integration (Colucci et al., 2020) can, in fact, have important roles to create realistic 3D scenes and models in an interoperable, unified and cross-functional system.

With a view to a project that can survey the whole University with laser scanners, Figure 16 shows a first sample of how the Sapienza University of Rome can be thematised and three-dimensionally elaborated in an ArcGIS Pro 3D global scene according to the procedure actually developed. Meanwhile, it is the starting illustrative elaboration which could be replicated to cover the whole campus.

Figure 16. The six floors of the Faculty of Letters and Philosophy obtained by extrusion process in an ArcGIS Pro 3D global scene. Authors' elaboration.

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