

## DATA ORGANIZATION USING GIS FOR A MORE CONSCIOUS CONSERVATION APPROACH FOR ABANDONED SITES

P. Masini<sup>1</sup>, M. Porta<sup>1</sup>, L. Barazzetti<sup>2</sup>, A.M. Oteri<sup>3</sup>

<sup>1</sup>M.Sc. in Architecture - Built Environment - Interiors

<sup>2</sup>Dept. of Architecture, Built Environment and Construction Engineering (ABC)

<sup>3</sup>Department of Architecture and Urban Studies (DASTU)

Politecnico di Milano, Piazza Leonardo da Vinci 32, Milan, Italy

(petra.masini, martina.l.porta)@mail.polimi.it

(luigi.barazzetti, annunziatamaria.oteri)@polimi.it

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### ABSTRACT:

The purpose of this paper is to rediscover the abandoned village of Castelnuovo dei Sabbioni with new tools and modalities, providing an overall descriptive picture of the context in the framework of a pressing marginalization of territories subjected to depopulation and abandonment, and providing the appropriate tools for the definition of a possible future scenario for the village.

The main novelty of this work is proposing alternative data recording and management strategies, preparatory to the definition of an actual project. The proposed strategy blends modern documentation technology and ICT processing tools with the consultation of more traditional sources of information, encouraging the adoption of a highly analytical structure in the design process.

The paper, which brings a practical example, aims to support the implementation of interventions that are conscious, and targeted to the needs of future users and actors in the development of these places. Finally, the work aims at exploring the pros of offline and online GIS database in the case of historic sites through the development of shareable maps able to store multiple information.

### 1. INTRODUCTION

Abandonment is a topic that deserves careful reflection and should also suggest a new way of analyzing and describing places (Oteri and Scamardi 2020). The paper mainly focuses on technological tools for digital recording and innovative methods and platforms for data archiving. The paper faces the following challenge: how can these digital tools be helpful for the community and municipal administrations to understand, plan, and intervene in abandoned places?

The considered case study is Castelnuovo dei Sabbioni (Tuscany, Italy). The area has gone through several periods that intertwine with the historical events of the entire country, from sharecropping as an economic model widespread throughout the Valdarno to the conversion into a mining and industrial area (Bertoncini, 2019). In this case, the foundation of a new town to replace the original one (involuntarily abandoned) failed to fill the void caused by the forced relocation. It is, therefore, clear the need to focus on abandonment not only as a problem of the past but also as an actual issue from several perspectives.

The paper will be structured as follows. First, a short part will deal with the territory's characteristics, the town's history, and the process of abandonment related to mining. The second part will involve collecting geometric data to acquire additional knowledge on architectural heritage. Finally, the third part of the paper will cope with the archiving process of geometric and historical data (mainly from the National Archives of Arezzo and Florence) using GIS systems to solve the lack of accessible documentation. Particular attention will be placed on the possible role of these systems as a tool for disseminating information according to the needs of the public decision-maker or the community.

Knowing the location, size, shape, and morphological characteristics of a building or historic site is a fundamental part

of a project related to cultural heritage preservation. The choice of the recording strategy can be guided by the size of the object, its complexity, and accessibility, among several other aspects. Regarding the digital survey of Castelnuovo dei Sabbioni, no-contact techniques based on range-based and image-based technology were used, taking advantage of laser scanning and photogrammetry. Specifically, TLS (Terrestrial Laser Scanning) was adopted for the detailed acquisition of accessible areas. At the same time, an UAV (Unmanned Aerial Vehicle) was used to acquire images and videos documenting the historic site, including the uninhabitable areas.

Images were acquired through predefined flight plans enabling the photogrammetric generation of a three-dimensional point cloud of the site.

The developed GIS contains information beyond traditional cartographic datasets; descriptive information and data from different sources can be included to favor an analytical data organization and clear communication of stratified and complex problems. The creation of the database consists of identifying, describing, and representing the complex structure of the territory and its built heritage based on recognizing its distinctive characteristics changing throughout the years, such as the cadastral parcels of the buildings, their periodization, their previous owners, the state of conservation of each structural element, the functional purposes. The past and actual conditions of the village will be examined together, considering the potential of the new tools proposed.

The paper also focuses on using the collected data and other multimedia elements in a WebGIS platform, which provides simplified access and interaction with a large community of institutional and non-institutional users. The goal is to develop an information system to support conscious decisions in planning, demonstrating its potential in participation and communication between the different subjects.

The potential of the WebGIS systems lies in the possible communication of technical-scientific content to an audience of non-specialists through a digital StoryMap, which was used in this research work to prove the coexistence of the two thematic aspects discussed in this paper: the local memory of Castelnuovo dei Sabbioni and the use of technological tools for digital recording survey and the creation of a database.

The experience has underlined the importance of communication between public administration, professionals, and local communities, highlighting the possibility of governing the emblematic complexity of fragile territories under technical and social aspects. In short, the paper develops the idea that GIS can be a tool able to merge different knowledge levels and establish dynamics of collective participation in the design processes, leading to the project that best summarizes the values of the community.

## 2. CASE STUDY AND HISTORICAL FRAMEWORK

### 2.1 The effects of industrial decay in Castelnuovo dei Sabbioni

The abandoned village of Castelnuovo dei Sabbioni, on which the research focuses, is undoubtedly a peculiar case study: its abandonment is not linked to a catastrophic natural event but rather to a series of prevention measures to avoid it; it is not linked to the lack of job opportunities, but rather to the excessive exploitation of the productive potential of the territory. Today only a part of the old town remains standing, at the center of a fragile ecosystem, completely transformed by human actions.



**Figure 1.** Current state of the case study, Castelnuovo dei Sabbioni (Tuscany, Italy).

Before its industrial era, the territory of Castelnuovo dei Sabbioni was for centuries an important agricultural settlement. From the mid-19th century onwards, the brown coal discovered in the area was used as a fossil fuel. When the inhabitants of Valdarno became aware of this mineral resource's economic and energy potential, many farmers abandoned their work in the fields to become miners, effectively distorting the history of the entire territory.

Initially, coal excavation was carried out on an artisanal basis, and the extracted material was used for domestic purposes; subsequently, the extraction increased. Firstly, with underground cultivation, in 1875; secondly, after the Second World War, with open-cast excavation (Billi and Valentini, 1996). This large-scale method allowed the maximum exploitation of resources and the mechanization of the extraction system. While this extraction method was less dangerous for miners, it had a significant environmental impact. Even more extensive depressions were

created, entire valleys were filled, numerous streams were diverted, and some urban centers were damaged forever: together with Castelnuovo dei Sabbioni also San Donato in Avane, Pianfranzese, Bomba, Dispensa and Ronco. The valley lost its rural appearance and the area's economy moved towards the highest indices of industrialization.



**Figure 2.** Open cast mines beneath the settlement.

The Municipality of Cavriglia recorded a considerable demographic increase, the town of Castelnuovo grew exponentially, and it was divided into two centers: Castello Alto, the historic center developed around the ancient fortress, and Castello Basso, the result of the new expansion and fulcrum of commercial activities.

The environmental impact was shocking, and the repercussions on Castelnuovo dei Sabbioni were equally so. Castello Basso was demolished due to ground instability caused by mining, and its inhabitants were gradually transferred to a nearby location: Camonti. In the early seventies, the new settlement in Camonti began to appear as a self-sufficient reality.

Castello Alto was the last area to be evacuated; no ordinance was ordered for demolition. The last families left the town in 1983, and since then Castello Alto serves as a witness to the troubled history of its territory (Bonaccini, 2015).



**Figure 3.** Demolition of the lower part of the village.

Today, Enel, "Ente Nazionale per l'Energia Elettrica", which acquired the entire mining area in the sixties, is still trying to remedy the environmental upheavals caused by mining activities. Since 2017 Enel has included the former mining area in the "Futur-e" program. The program's objective is to convert twenty-three unused or underused thermoelectric power plants and regenerate former mining basins with the help and advice of young researchers. In the specific case of the project for the former mining basin of Santa Barbara, a research group

composed of researchers from the Polytechnic of Milan and the University of Florence (Bozzuto and Geroldi, 2021). This project is an important step, even if not definitive, in the search for the right action strategies. It is part of an ongoing process complementary to the (exclusively technical) environmental redevelopment plans started years earlier by the Municipality.



**Figure 4.** Current landscape of the former mining area of Santa Barbara.

### 3. SURVEY TECHNIQUES

#### 3.1 The two-dimensional and three-dimensional documentation of Castelnuovo dei Sabbioni

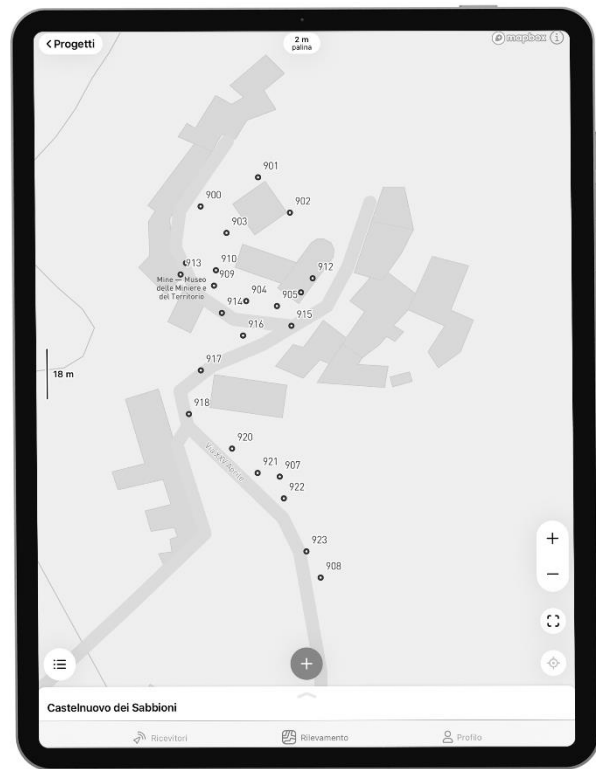
As already mentioned, the aim is to develop alternative ways of using resources during the entire workflow of an architectural restoration project: from digital recording to condition mapping. The survey methods applied during the research activities for Castelnuovo dei Sabbioni involved no-contact techniques based on range- and image-based technology. The TLS (*Terrestrial Laser Scanner*) and UAV (*Unmanned Aerial Vehicle*) systems were used according to an integrated approach to define and create a three-dimensional model of Castelnuovo dei Sabbioni. Data acquisition and processing operations were performed considering both the characteristics of each technique and the qualitative capabilities of the tools (e.g., precision, accuracy, and output data format).

The TLS system was adopted for high-resolution acquisition of easily accessible areas. In contrast, the UAV system was used to acquire images and videos documenting the whole village, including the inaccessible areas. A Leica TS30 robotic total station, a Leica BLK360 laser scanner, and a DJI Mavic Air 2 drone were the tools employed in this research phase.

The survey began with the use of GPS in RTK mode. In this specific case, two Emlid Reach RS2 model GPSs were used to provide precise positioning data for the site. The base station was fixed for a total of 6 hours and 15 minutes over an unknown point whose average position was determined. To improve the precision of the geographical coordinates, the rover station was linked via radio modem with the base receiver so that it could measure with centimeter-level precision the coordinates relative to the base position. Positioning data obtained using the rover station were stored in the ReachView 3 application. Through the CSRS-PPP processing service using the PPP (*Precise Point Positioning*) mode, the raw observations were compensated to obtain coordinates with a precision of  $\pm 8$  mm in East,  $\pm 7$  mm in North, and  $\pm 28$  mm for the ellipsoidal elevation.

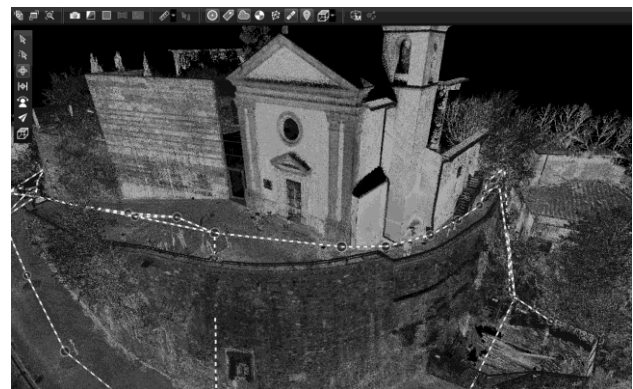
The obtained coordinates were used as a reference for the entire survey, they were converted to map coordinates (East, North, and

ellipsoid elevation), then transformed with the ITALGEO2005 geoid model to orthometric elevation (above mean sea level).



**Figure 5.** Points measured with the rover station and registered with ReachView 3 application.

The laser scanner survey was carried out with a Leica BLK360. It required 72 scans, each lasting 1.5 minutes, with an average density of 1 cm at 10 m distance. The scans had to be taken close to each other, allowing them to be processed later using the Leica Cyclone application.



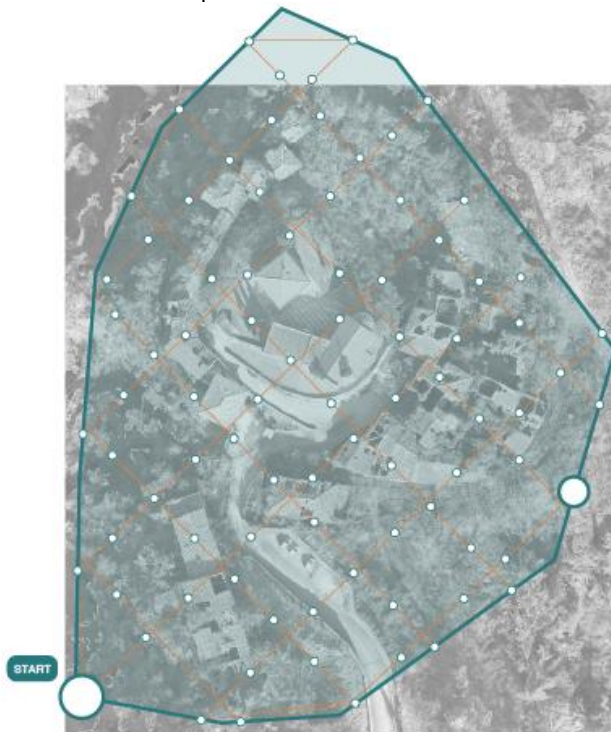
**Figure 6.** TLS point cloud generated using Leica BLK360.

The scans were acquired considering a maximum distance between each other of 5 m. This ensured a good overall overlap of about 50%, achieving an average registration error of about 6 mm. At the processing stage of the procedure, the scans were linked together, creating a consolidated three-dimensional point cloud of the accessible parts of the village.

The last task was the survey of Castelnuovo dei Sabbioni using a DJI Mavic Air 2 drone, and the relative application called Copterius Autopilot for DJI. The flights were planned according



to a double grid; then according to the same one rotated by 45°. During the flights, the camera was tilted at 90°, and then 70° so that building facades could also be captured, where possible. For each flight the height of the drone from the ground was 40 m and about 790 frames were produced in total, with a ground resolution of 1.4 cm/px.



**Figure 7.** Planned flight pattern of the DJI Mavic Air 2 drone set with Copteris Autopilot application.

#### 4. THE ROLE OF GIS IN THE FIELD OF TERRITORIAL PLANNING AND MANAGEMENT

##### 4.1 A shared database for Castelnuovo dei Sabbioni

Among the many existing GIS software programs, the one chosen for the Castelnuovo dei Sabbioni case study was ArcGIS Pro, a 64-bit desktop GIS application produced by Esri. Visualization, management, and analysis of two and three-dimensional data are simplified and allow a large amount of highly detailed content to be displayed simultaneously to make a realistic 3D scene. An attractive property of ArcGIS is the data sharing through a suite of ancillary products such as ArcGIS Online and ArcGIS Enterprise. With these cloud-based mapping and analysis solutions, it is possible to share content with other individuals inside and outside your organization.

The creation of the Castelnuovo dei Sabbioni database consists of identifying, describing, and representing the complex structure of the area, based on recognizing its distinctive features, such as its history and current state of conservation. To gain a better understanding of the history of this place and to detect the occurred transformations, it was necessary to look at the historical, cartographic, and photographic documentation.

Following the on-site survey and extensive archival research, the data acquired on the village of Castelnuovo dei Sabbioni were collected into a database consisting of four feature layers: the first, in raster format, contains a georeferenced orthophoto obtained by a sequence of images taken with a DJI Mavic Air 2 drone; the other three, in vector format, contain polygons related to buildings, roofs, and gutter channels. The databases associated with the vector data initially consist of a few common fields, then specific fields are created according to the theme of the layer. Common fields include the area, the perimeter of each polygon (whose values are automatically assigned), and the current cadastral parcels, used in this case as building identification numbers to facilitate any data manipulation. As for the current cadastral parcels, the necessary information was obtained freely through a dedicated Regione Toscana geoportal that uses WebGIS technologies. The data regarding earlier cadastral parcels and owners were searched at the MINE Museum's Documentation Center and at the State Archives of Arezzo and Florence, where it was possible to identify three previous cadastral parcels in an interval between the first half of the 19th century and the second half of the 20th century. Based on the information obtained, it was possible to understand how cadastral parcels, buildings, and their functions changed over the years.

Due to the variety of sources, it seemed appropriate to create a link for each cadastral parcel that would lead back to a OneDrive system containing the list of sources for each of them; the most widely used were the State Archives of Arezzo and Florence, the Historical Archives of the Municipality of Caviglia, the Military Geographic Institute and the MINE Museum's Documentation Center. It was also necessary to create a photographic archive, again divided by cadastral parcels, to recognize the features listed in the databases and to trace the claimed functional and physical transformations; in this case the sources were the photographic archives of a former resident, Emilio Polverini, and the multinational energy company, Enel.

The role of databases in monitoring, preserving, and managing the restoration work on a historic site is extremely important. Precisely for this reason, the database developed for Castelnuovo dei Sabbioni contains information not only on the characteristics of the building, such as the type of vertical and horizontal load-bearing structure, but also its current state: on the damage found to the facades, intermediate floors, and roofs.

The most common type of vertical load-bearing structure detected in the hamlet is mixed stone and brick masonry; rarer and characteristic of relatively recent additions is simple brick masonry. The horizontal load-bearing structure, on the other hand, is in most cases wooden. The most prevalent façade damages are patina, biological colonization, and detachments. Whereas, regarding the attributes of the feature layer dedicated to roofs, the detected damages included the collapse of structural elements, gutters, and drainpipes. Unfortunately, it was impossible to detect the damages or the type of load-bearing structure for all the buildings because of the precariousness of the site.

Thanks to the DEM (Digital Elevation Model) obtained with UAV surveys, it was possible to acquire and integrate the height above sea level of the gutters into the database.



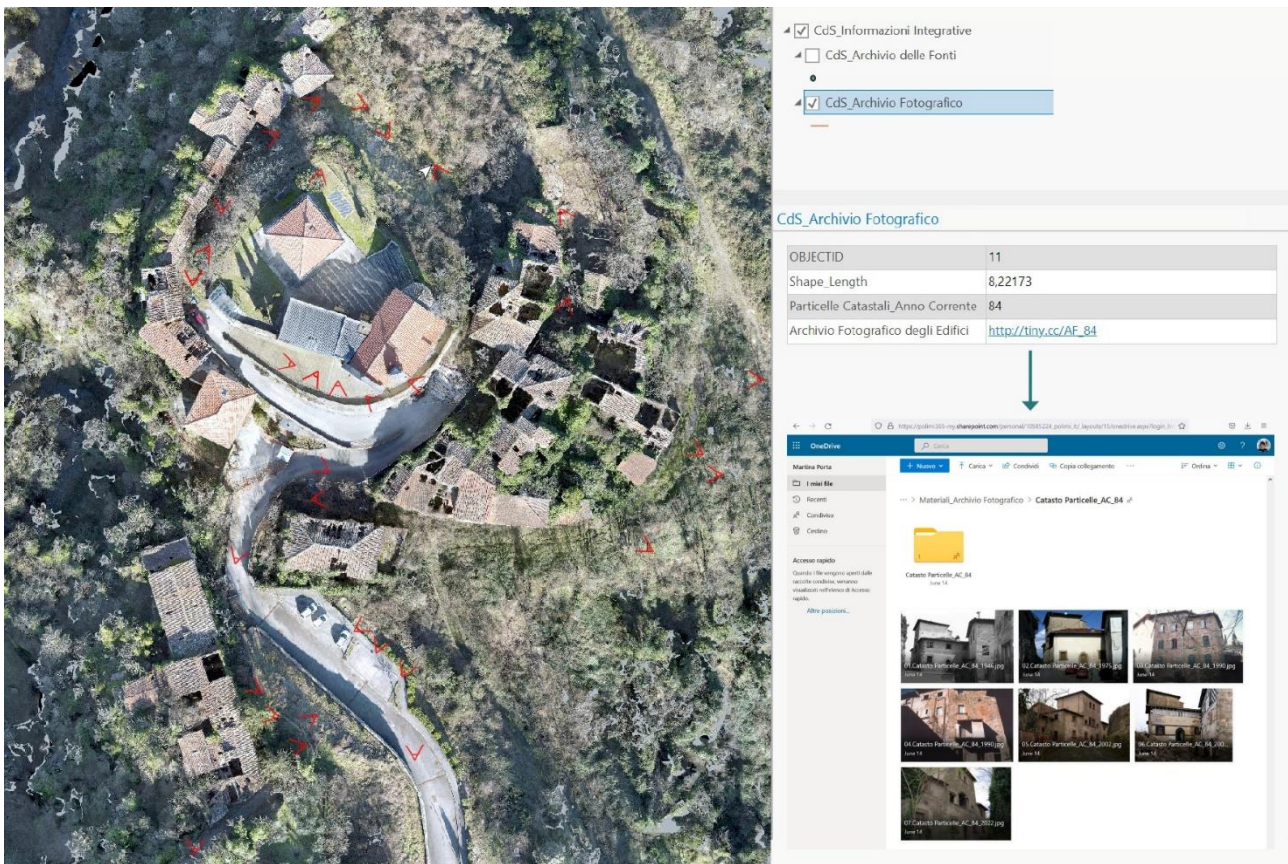


Figure 8. The developed GIS database, the attribute table of the former Alberto Gioannini Kindergarten (photographic archive feature layer).

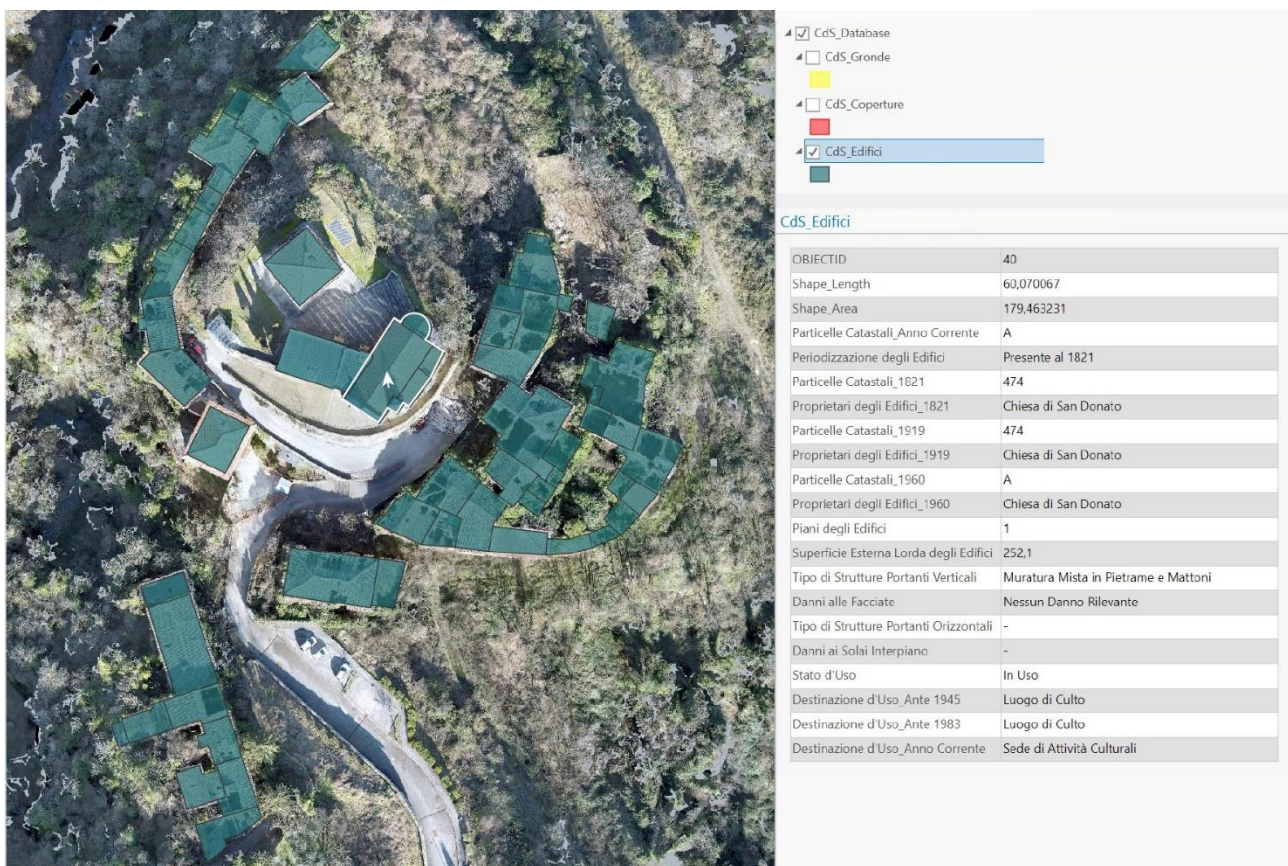


Figure 9. The developed GIS database, the attribute table of San Donato Church (buildings feature layer).

## 4.2 Supporting public administration

Multimedia technologies can be very effective in those areas where the dissemination of geographical knowledge combined with its contextualization is fundamental (Consorti and Matani, 2014). This is the case of the territorial planning and monitoring activities carried out in the field of public administration. In an extremely dynamic context that requires effective interactions, the use of GIS allows a simple representation of the territory with a natural integration of communication aspects. Furthermore, the use of digital databases that can be easily shared and continuously updated meets the need for environmental monitoring and the participative and multidisciplinary nature of project strategies. GIS technologies, therefore, offer flexible and reversible solutions capable of guaranteeing the recognition of fundamental characteristics of the area at different institutional levels, from the Region to the Municipalities. Thanks to the spread of the Web, the possibility of archiving and managing data has been joined by the opportunity of communication and interaction with a vast field of institutional and non-institutional users. Integrating web sharing technologies and multimedia elements in GIS applications plays a significant role in the constructive communication between local administrations, designers, and common users. Participation is a central issue in this information system (Ciancarella et al., 1998).

As already mentioned, the GIS has been experimented in relation to different application fields, mostly regarding the territorial scale. There are few examples in the case of limited historical centers in which each building is illustrated in its specific constructive and structural properties. For this reason, it is important to provide further urban scale examples. Unlike the databases available in the WebGIS platform of Tuscany, this database will be able to combine detailed information not traditionally reported on such websites. In other words, each building will be questionable both historically and structurally.

The role of public administrations in this process will be very important, as the GIS is a tool to support decisions in the planning field and facilitates immediate access to databases. This system has allowed one to collect alphanumeric data on a cartographic base, placing the information in specific physical contexts and making the consultation extremely intuitive. Without specific ICT skills, municipal employees can store new material and easily extract documentation and data of different kinds.

## 5. MANAGING THE COMPLEXITY OF THE PROPOSED CASE STUDY

### 5.1 New perspectives in the regenerative approach of abandoned sites

Selected by Regione Toscana among 41 other candidate villages, Castelnuovo dei Sabbioni was proposed according to the first line of action of the Piano Nazionale Borghi and won the 20 million € financed by the PNRR.

Regardless of the specificities of each village, PNRR guidelines provide common design indications for all candidate projects. These include directives for establishing new functions, including infrastructure and services in the areas of culture, tourism, research, or society, such as schools or academies of arts and crafts, hotels, research institutes and university campuses, RSAs, and social housing.

Considering the victory of the municipality's project, it is necessary to ask whether all this is sufficient to foster repopulation and facilitate lasting and sustainable economic

growth. It is necessary to ask whether the pure tourist purpose attributed to the village with the "Avane Centrale Creativa" project is a benefit to the cultural heritage and especially to the strengthening of resident communities. At the same time, we should ask if there is any real interest on the part of ex-residents to return to the homes they were forced to leave.

Given the long period of abandonment and the impoverishment of the resources, the reasons that would bring Castelnuovo back to a new demographic growth would clearly no longer be the same. Consequently, restoring the local economy, even if no longer based on fossil fuels, is certainly desirable to re-establish a cohesive community.

Concrete examples highlight that the success of regeneration depends firstly on the state of use of the village, on its cultural context, and, secondly, on the proposed solutions. As the example of Apricale and Borgomaro shows, the depopulated villages benefit from tourist structures when they are inserted into an economic and social fabric that still exists. In that specific case, a diffuse hotel has been placed in a context where minimal services such as the pharmacy, the post office, and the police station were still active. Whereas, in the case of completely abandoned towns, a new settlement of people who pursue common objectives seems more effective: artists, ecologists, farmers, and so on. In this instance, the inhabitants tend to spontaneously form a community. This is the case of Bussana Vecchia, a village reduced to ruin by the earthquake of 1887 (Napoleone, 2020).

It is, therefore, necessary to rethink these places not only focusing on physical recovery and accessibility but also on the regenerative capacity of social, economic and productive tissues. In this regard, Castelnuovo dei Sabbioni is favored by a good starting point. Despite the uniform guidelines given by the PNRR, Castelnuovo has distinguished itself for citizen's cooperation and interest in the reuse project of the village.

As mentioned earlier, one of the advantages of GIS systems is facilitating interaction between different subjects. The development of approaches that deal with the analysis of actual conditions and territorial transformations, indicating conservation, management, and enhancement criteria, becomes basic; especially in the perspective of the growing need for sharing and transparency in contemporary social dynamics. Geographic information systems, in fact, not only optimize the efficiency of the design process in all its phases but are projected as a means of participation in public life, endowing individual citizens with decision-making power and guiding them toward a new type of more democratic communication (Schulze-Wolf, 2007). The spread of this method would represent a significant change with respect to the current system, which in rare cases allows full interaction between the various instances.

In this case study, the above-mentioned system would only implement the direct or indirect communication that already exists with the municipality and the various local entities, optimizing a process that combines decision-making and participatory aspects.

The use of technological tools based on geographical information can constitute a key element for the definition of a project scenario, as a starting point for the creation of an overall picture that is impossible to obtain otherwise.

It is useful to ask how the "Avane Centrale Creativa" project would have changed if the municipality had used these tools. The digital data collection, developed in this research, provides a comprehensive view of the village, can be implemented by stakeholders, and accessed by citizens, depending on the limitations imposed. Furthermore, in the case of small towns suffering from depopulation and abandonment, this system



ensures the monitoring of the conservation state, possibly preventing irreversible deterioration.

A further potential of GIS systems is the ability to communicate technical and scientific content to a non-expert audience through a wide range of web and cloud-based applications. One of these is ArcGIS StoryMaps, which was used during this research as an educational tool to enhance the coexistence of the two thematic spheres treated in the paper: the local memory of Castelnuovo dei Sabbioni and the use of technological tools for the geometric survey and the creation of digital databases.

This application lies in the world of digital storytelling, which aims to display multimedia content through a narrative framework. Using multimedia communication tools (including three-dimensional models, interactive maps, texts, photos, and videos) makes interaction with the contents more dynamic and intuitive and guarantees effectiveness in communicating and displaying large amounts of information in an organized and easy-to-use interface, aimed at a general audience. The characteristics that distinguish ArcGIS StoryMaps have determined its success, especially in the educational and cultural fields.

The experience highlighted the importance of communication between the administration, technicians, and the community. It showed the possibility of governing the emblematic complexity of fragile territories from different technical and social aspects.



**Figure 10.** Connection via QR Code to the mobile version of the StoryMap.

## 6. CONCLUSIONS

To conclude, it is important to ask to what extent the consultation of these data leads to full awareness of their meaning and their proper use in a possible design strategy. The complexity of issues related to territorial planning requires a greater knowledge of both software and factors affecting the transformation process of an area.

It is, therefore, desirable the presence of a figure capable of making an integration of data within the GIS to avoid meeting the static nature of the instrument and the consequent loss of effectiveness.

The research does not intend to discuss the merits of the skills necessary to use this software; however, it intends to give a point of reflection regarding the potential and criticalities of a tool capable of enhancing different levels of knowledge and establishing participatory processes conducive to the success of a project.

As a critical issue, the excess of information was highlighted. The massive collection of data loses value if not interpreted with respect to the real needs of the communities and the real possibilities of repopulation.

## REFERENCES

- Ace, D., et al., 2019: Documenting Nea Paphos for conservation and management. *Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci.*, IV-2/W6, 1-8. doi.org/10.5194/isprs-annals-IV- 2-W6-1-2019.
- Ballestra, G., et al., 1996: *Applicazione dei sistemi informativi geografici nella valutazione delle modificazioni ambientali e territoriali*. FrancoAngeli, Milano.
- Bertoncini, P., (ed.), 2019: *Quando solo la terra ci dava da vivere. La mezzadria nel territorio di Cavriglia dal Medioevo all'egemonia delle miniere*. Settore8, Terranuova Bracciolini.
- Billi, G., 2002: *Racconti della miniera. Frammenti autobiografici*. Arca Toscana, San Giovanni Valdarno.
- Bonaccini, M., 2015: *La valle delle miniere*. Aska, Firenze.
- Boni, F., 2007: *Colpire la Comunità. 4-11 luglio 1944: le stragi naziste a Cavriglia*. Consiglio Regionale della Toscana, Firenze.
- Bozzuto, P., Geroldi, C., 2021: The former mining area of Santa Barbara in Tuscany and a spatial strategy for its regeneration. *The Extractive Industries and Society*, 8, 147-158. doi.org/10.1016/j.exis.2020.09.007.
- Ciancarella, L., et al., 1998: *La diffusione dei GIS nelle amministrazioni locali italiane*. FrancoAngeli, Milano.
- Cianferoni, R., Ciuffoletti, Z., Rombai, L., (eds.), 2002: *L'età contemporanea. Dalle «rivoluzioni agronomiche» alle trasformazioni del Novecento*. Edizioni Polistampa, Firenze.
- Cioni, M., 2000: *Cavriglia*. Aida, Firenze.
- Colomina I., et al., 2008: Towards a new paradigm for high-resolution low-cost photogrammetry and remote sensing. *Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci.*, XXXVII/B1, 1201-1206. citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.151.535.
- Comune Di Cavriglia (ed.), 1996a: *Dove c'era la miniera. Il piano di riassetto territoriale del bacino minerario di S. Barbara*. La piramide S.r.l., Arezzo.
- Comune Di Cavriglia (ed.), 1996b: *Quando c'era la miniera. Passato e presente di un territorio minerario*. La piramide S.r.l., Arezzo.
- Consorti, V., Matani, L., 2014: Il ruolo dei GIS nello studio e conoscenza del Territorio nell'ambito della comunicazione tra pubblica amministrazione e cittadini. *Ri- Vista. Research for landscape architecture*, 12 (1-2), 156-167. doi.org/10.13128/RV-17228.
- Cope, M. P., et al., 2018: Developing and Evaluating an ESRI Story Map as an Educational Tool. *Natural Sciences Education* 47 (1), 1-9. doi.org/10.4195/nse2018.04.0008.

Del Maschio, L., 2013: *Castelnuovo dei Sabbioni. Miserie e guerre del Novecento*. Edizioni Simple, Macerata.

Fassi, F., et al., 2013: Comparison between Laser Scanning and Automated 3D Modelling Techniques to reconstruct complex and extensive cultural heritage areas. *Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci.*, XL-5/W1, 73-80. doi.org/10.5194/isprsarchives-XL-5-W1-73-2013.

Fiorani, D., 2019: *Il futuro dei centri storici. Digitalizzazione e strategia conservativa*. Quasar, Roma.

Graci, G., Pileri, P., Sedazzari, M., 2008: *GIS e ambiente: Guida all'uso di ArcGIS per l'analisi del territorio e la valutazione ambientale*. Dario Flaccovio Editore, Palermo.

Historic England, 2018: *3D Laser Scanning for Heritage. Advice and Guidance on the Use of Laser Scanning in Archaeology and Architecture*. Historic England, Swindon.

Historic England, 2017: *Photogrammetric Applications for Cultural Heritage. Guidance for Good Practice*. Historic England, Swindon.

Macchi Janica, G., Palumbo, A., (eds.), 2019: *Territori Spezzati. Spopolamento e abbandono nelle aree interne dell'Italia contemporanea*. CISGE Centro Italiano per gli Studi Storico-Geografici, Roma.

Orlando, M., 2008: *Il ruolo dei Sistemi informativi territoriali nel processo di recupero dei centri storici*. FrancoAngeli, Milano.

Oteri, A. M., Scamardi, G., (eds.), 2020: Un paese ci vuole. Studi e prospettive per i centri abbandonati e in via di spopolamento. *ArchHistoR*, 7. pkp.unirc.it/ojs/index.php/archistor/issue/view/48/showToc.

Poletti, A., (ed.), 2001: *GIS metodi e strumenti per un nuovo governo della città e del territorio*. Maggioli Editore, Rimini.

Remondino, F., et al., 2011: UAV photogrammetry for mapping and 3D modeling. Current status and future perspectives. *Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci.*, XXXVIII-1/C22, 25-31. doi.org/10.5194/isprsarchives-XXXVIII-1-C22-25-2011.

Resop, J.P., Lehmann, L., Cully Hession, W., 2019: Drone Laser Scanning for Modeling Riverscape Topography and Vegetation: Comparison with Traditional Aerial Lidar. *Drones* 3 (2), 35. doi.org/10.3390/drones3020035.

Sacchetti, G., 2002: *Ligniti per la patria. Collaborazione, conflittualità, compromesso. Le relazioni sindacali nelle miniere del Valdarno Superiore (1915-1958)*. Ediesse, Roma.

Stylianidis, E., Remondino F., (eds.), 2016: *3D Recording, Documentation and Management of Cultural Heritage*. Whittles, Dunbeath.

Tarpino, A., 2019: I territori fragili e la memoria. *Scienze del Territorio* 7, 44-47. doi.org/10.13128/sdt-10946.

Teti, V., 2004: *Il senso dei luoghi. Memoria e storia dei paesi abbandonati*. Donzelli, Roma.