Digital Surveying for Revitalization of Finiq Municipality in Albania: Utilizing 3D Technologies for Heritage Preservation and Development

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Abstract- *The Finiq Municipality in Albania is a rural region that is faced with a number of pressing challenges, including a declining population, isolation, and a lack of identity. These issues are prevalent in many rural areas of Albania and other countries and can have a substantial impact on the preservation of heritage structures and the overall development of the municipality. However, the territory possesses several potential advantages, such as its proximity to Saranda and the Albanian Riviera, the archaeological site of old Phoeniciae (Phoenicia), and the 13th-century Orthodox monastery dedicated to St. Nicholas of Myra, as well as the quality agribusiness production. Proper implementation of policies at the national, regional, and local levels could lead to a tourism-based revitalization of the area.*

In this framework, data plays a crucial role in project development as it forms the basis for informed decision-making and efficient planning. One of the key benefits of data is its ability to reveal patterns and trends, which can be leveraged for decision-making and improvement opportunities. In addition to demographic and sociological data, information describing the territory and human artifacts in their physical form is also essential. GIS tools are already in use and provide useful cartographic data, which effectively represents the complexity of the territory and the relationships between its various components. This data forms the foundation for creating advanced information systems, such as territorial digital twins, to deepen the knowledge of the territory. Integrated digital surveys, utilizing three-dimensional acquisition technologies such as lase scanning and photogrammetry, can serve as a reliable source of input data for creating these knowledge tools. Point clouds offer valuable morphometric databases that are often critical for documenting not only architectural and cultural heritage but also infrastructure, modern artifacts, and larger portions of the territory. Different multiscalar approaches can be adopted to cater to the specific needs and requirements, for instance providing a detailed understanding of archaeological and monumental heritage, or the contextualization of settlements in the surrounding area.

By integrating these data with GIS platforms and BIM models to create a comprehensive understanding of the municipality's territory, they can be utilized for preservation and conservation efforts, urban planning and development, and identifying potential structural issues. Additionally, the data collected through 3D survey technologies can be utilized to monitor the condition of the buildings and infrastructure, promoting better maintenance and planning, even considering the risks posed by the area, such as seismic risk. The digital data can also be used to create virtual tours and interactive models, promoting the municipality's cultural heritage and economic development.

While the use of these procedures in a marginal area may initially seem disproportionate, it is not so much in relation to the subject of the survey, given the universally recognized historical and artistic value of some areas. The financial effort required to undertake such campaigns may seem substantial, but the project can be implemented in phases, integrated, and completed over time.

Keywords:
integrated survey, laser scanner, photogrammetry, point clouds, cultural heritage.

Introduction - The Finiq Municipality is located in Southern Albania, near the border with Greece. This rural region bears evidence of its glorious past, shaped by centuries of history and characterized by a strong cross-border culture. Important archaeological sites, such as Adrianopoli, Butrint, and Phoeniciae, showcase ancient Greek settlements. More recent monuments, like the 13th-century Orthodox monastery dedicated to St. Nicholas of Myra, add to the historical richness. Nowadays, this region faces pressing challenges, including a declining population, isolation, and a lack of identity. Finiq has seen a decrease in population over the years, linked to the decline in economic and social activities. Contributing factors include the geographical isolation of the region and limited public transportation connections. This situation poses significant concerns, affecting both local residents and visitors seeking to reach the town. These issues are prevalent in many other rural areas of Albania and other countries, impacting the preservation of heritage structures and overall municipal development. Addressing these concerns requires an approach that considers the interplay of different layers: the landscape, infrastructure, cultural heritage, and settlements. In this framework, data plays a crucial role in project development, forming the basis for informed decision-making and efficient planning.

Focusing on the territory of Finiq, several potentialities can be identified as principal assets for general economic development. These include the proximity to Saranda and the Albanian Riviera, the archaeological site of old Phoeniciae, and the monastery dedicated to St. Nicholas of Myra, as well as the quality of agribusiness production. These elements, with different levels of interest, are already attractive hubs for various forms of tourism, from mass-appeal beach tourism to religious pilgrimages and ever-growing cultural tourism. Achieving a tourism-based revitalization of the area requires proper implementation of policies at the national, regional, and local levels.

As known, data collection is vital for developing effective projects. One of the key benefits of data is its ability to reveal patterns and trends, leveraging decision-making and improvement opportunities. In addition to demographic and sociological data, information describing the territory and human artifacts in their physical form is essential. GIS tools are available for the entire municipality, providing useful cartographic data that effectively represents the complexity of the territory and the relationships between its various layers and components. This data forms the foundation for creating advanced information systems, such as territorial digital twins, to manage the territory.

To deepen our knowledge of the territory, integrated survey methodologies, such as 3D laser scanners and digital photogrammetry, can be applied to specific parts or sites of interest. The output data from these surveys can serve as a reliable source of information at different scales. For example, they can be the basis for developing digital 3D models for territorial planning or impact simulation. Given the high accuracy and precision of 3D surveys, archaeological and architectural assets can be surveyed

to develop restoration and enhancement projects. In the case of the Finiq archaeological area, the acquisition can serve as the basis for designing support structures for the tourist use of the site or documenting archaeological stratigraphies that may emerge during future excavations.
In literature, there are many case studies related to the application of 3D surveying in complex archaeological contexts, such as Pompeii, aimed primarily at documentation but also as an information and communication system (Benedetti, 2010), or focused on supporting 3D reconstruction (Ronchi, 2023). Moreover, integrated surveys are used as a source of knowledge for urban planning of rural settlements and the development of the environment, as seen in the case of Montepulciano in Italy (Bertocci, 2014). In Albania, where there is a large number of archaeological sites and historic buildings of great historical and documentary value, three-dimensional survey campaigns have been conducted, such as that of the amphitheater in Durres (Giandebiaggi, 2015). Although interest has been growing in recent years, applications of 3D surveying technologies in rural settings or marginalized areas remain challenging. However, it is worth mentioning the virtuous case of Butrint (Muka, 2018), which, both in terms of geographic proximity and site characteristics, can be considered a benchmark for Finiq.

Research Question

This paper aims to demonstrate applications of 3D surveying for the preservation and sustainable development of cultural heritage assets in Finiq municipality, showing how it is possible to apply these methods and providing suggestions for various outcomes and examples of applications. The objective of this paper is to give a panorama of potential results generated from 3D data acquisition, illustrating that this kind of surveying can support the conservation and enhancement of the heritage sites in Finiq. Starting with specific enhancements to key points of interest, there could be a positive long-term impact on tourism, consequently benefiting the local economy.
Applying 3D survey technologies as a method of acquiring physical space, especially for archaeological or monumental heritage, offers a multitude of advantages, contributing significantly to knowledge advancement. In the case of Finiq, the creation of highly detailed and accurate digital replicas of archaeological sites will ensure precise documentation to help specialists study details of artifacts, structures, and landscapes, leading to a more comprehensive understanding of the site. Moreover, the collected 3D data can be used to virtually reconstruct the site, allowing even non-Albanian researchers to visualize and analyze it remotely. 3D surveys facilitate interdisciplinary collaboration by providing a common digital platform for researchers from various fields to analyze and interpret data collectively. These collaborative efforts can lead to a more holistic understanding of the sites. 3D surveys can also lead to practical benefits. First of all, the data collection process is faster than traditional methods, reducing the time and resources required for fieldwork. Rapid and efficient data acquisition allows for covering larger areas in shorter periods, ensuring high-quality data simultaneously. Moreover, models thus obtained could serve as valuable tools for site management and conservation efforts. In the case of Finiq, it could help in developing conservation strategies, ensuring the long-term preservation of archaeological resources, as well as the exploitation of the site as an economic resource.
The first part of the methodology describes how an integrated survey is considered a

Fig1 / Greek theatre in the archaeological site of old Phoeniciae
source / the author

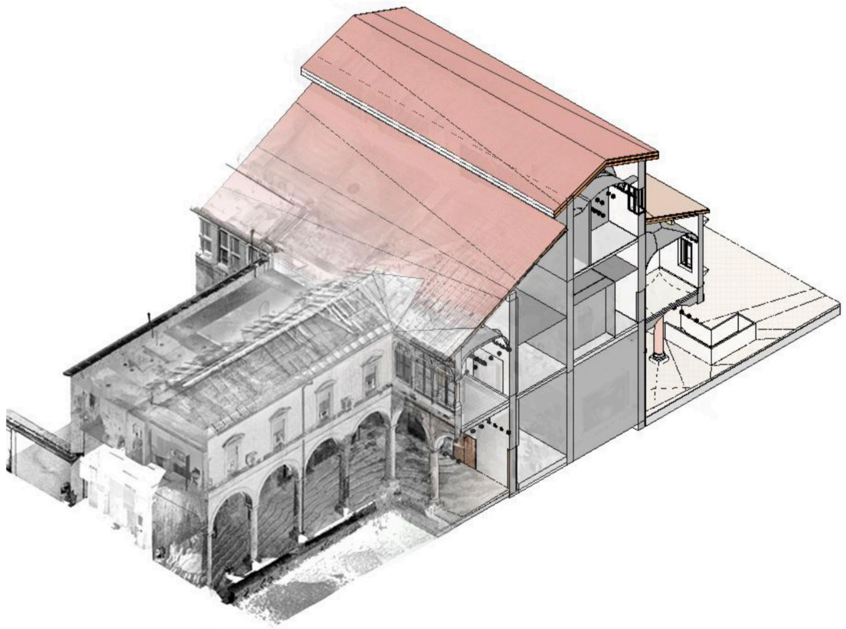

Fig2 / Scan-to-bim process: from point cloud survey to H-BIM model for the development of preservation and valorization projects
source / models by DIAPReM Centre, image by the author

source of knowledge, as it constitutes a tool for developing different outcomes, each with specifics that contribute to the description of the territory. The second part briefly describes two possible applications of 3D surveying on two heritage sites in Finiq: the archaeological site of Phoeniciae, including the acropolis, the theatre, and other structures that show the development of the city in the ancient period, and the monastery of St. Nicholas of Myra in Mesopotam. Then, the workflow for data processing is described, mentioning the different paths to be followed according to the kind of sensor used. A focus on segmentation and classification of point clouds follows. Subsequently, an example of territorial governance is described, with a reference to a cross-border project between Italy and Croatia. The methodology closes with a paragraph describing how 3D survey outputs can be exploited for communication and valorization of cultural heritage.

Methodology

As described in the introduction, the use of integrated survey methodologies that combine 3D laser scanning, digital photogrammetry, and topographic survey has become increasingly popular in various fields, including cultural heritage, infrastructures, and building management. By capturing three-dimensional scans and high-resolution images, digital technologies enable the accurate documentation of historical sites.

Integrated Survey as a Source of Knowledge

The primary output of these integrated surveys is 3D point clouds, which offer valuable morphometric databases critical for documenting not only architectural and cultural heritage but also modern artifacts and larger portions of the territory. In addition to providing morphometric data, point clouds can be used to extract various products, such as plans and sections, H-BIM models (Building Information Modeling applied to heritage), and thematic models (Bianchini, 2021). This information is crucial for comprehensively understanding the municipality's territory, identifying potential structural issues, and facilitating preservation and conservation efforts, as well as urban planning and development. Therefore, this data helps to constitute a comprehensive understanding of the municipality's territory; it can be utilized for preservation and conservation efforts, urban planning and development, and identifying potential structural issues. In this way, 3D surveys progress from a kind of a first level of documentation to a more advanced level, that is, a tool for generating CAD drawings and BIM models, in short, a design tool.

Two possible multiscalar approaches applications in Finiq

Different multiscalar approaches can be adapted to cater to specific needs and requirements. In fact, many survey devices are available, each with its own characteristics, to be used in relation to the aim of the survey and the purpose of the data to be acquired. For example, for the analysis of the state of conservation of surfaces aimed at a restoration project, digital photogrammetry is a more suitable survey-

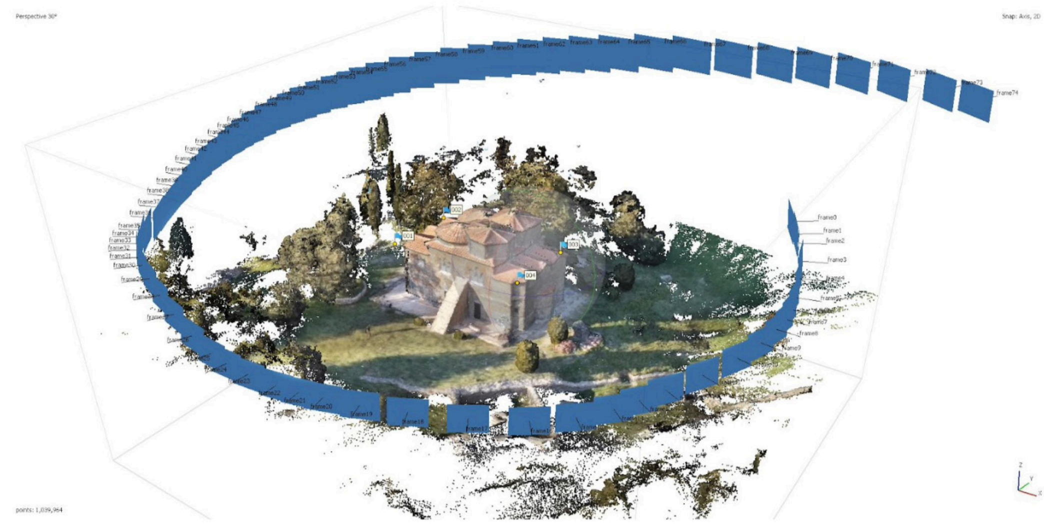

Fig3 / Digital reconstruction of the monastery of St. Nicholas of Myra using aerial photogrammetry
source / the author

ing technique than laser scanning, whose colorimetric data are often poor. Another determining criterion for the choice of methodology to be applied is the size of the space to be acquired and the scale of restitution. It is often necessary to apply multiple technologies and integrate them, using a common topographic network (Russo, 2022; Banfi, 2022).

In the case of the archaeological site of old Phoeniciae, 3D drone photogrammetry acquisition could provide a general situational model helpful to understanding the morphology of the site and its relation with the surrounding landscape. In this model, a more detailed point cloud can be nested, acquired with a terrestrial laser scanner, and chosen based on the characteristics of the spaces to be acquired. For large spaces, it will be necessary to use an instrument with a longer range, while for small ones, it is possible to use short-range scanners, faster and easier to move. To set the different point clouds in the same reference system, it is essential to set up a georeferenced topographic net.

Another interesting case study for the application of an integrated survey is the Monastery of St. Nicholas of Myra. In this case, as the monument is being restored in these years, the point cloud would not be used as a base for the development of a restoration project, but rather for the creation of an H-BIM model that can be used for the management and monitoring of the building during the future years. In fact, it is possible to link a range of semantic information to the elements of the model, and thus of the building, that is deemed useful for its management and, through platforms, plan better routine maintenance (Maietti, 2018). A possible next step could involve integrating sensors into the building and displaying the results on the model for constant monitoring of the conservation condition.

Workflow and Data Processing

Raw data processing can be divided into two categories depending on the type of sensor used. For data acquired with active sensor instrumentation (e.g., laser scanning), raw data consists of point clouds of single stations. Instrument manufacturers provide proprietary software with which scan alignment (registration), "unification," and "subsampling" operations can be carried out. This is because point clouds are often excessively dense with information, even redundant information, and may be unnecessary for the user of the data. In addition, greater density corresponds to greater computer weight of the files, making point clouds difficult to use. It is then a practice to subsample the data, according to purpose. For instance, general models can be produced at a lower resolution for visualization, or high-resolution models can be generated for detailed study and representation. For data acquired through cameras, whether ground-based or airborne (drone), raw data consists of photos. Data processing is developed through the so-called structure-from-motion software, which allows all stages of digital photogrammetry to be handled.

Point clouds from laser scanners and those derived from photogrammetry can be overlaid in the same reference system through a common topographic network.

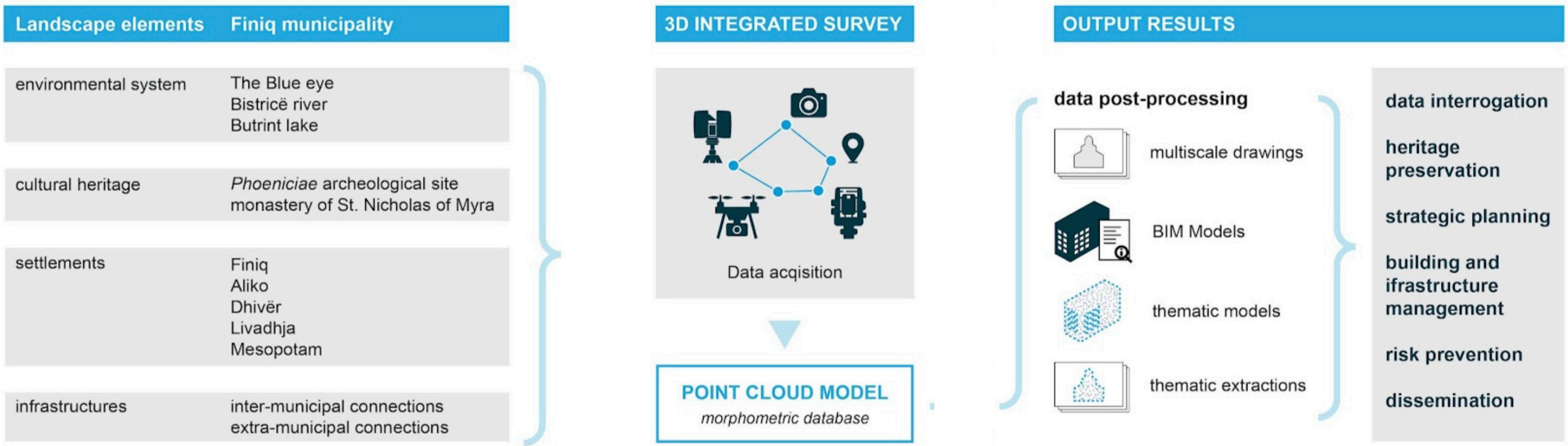

Fig4 / Methodological diagram of a 3D integrated survey applied in Finiq municipality
source / the author

Both clouds provide the basis on which to develop vector representations: either directly importing them into vector drawing programs (CAD), or through scaled and georeferenced images (orthotiff and geotiff), corresponding to the views to be represented (plans, sections, elevations). The same procedure of linking clouds directly within authoring software can be used for scan-to-BIM.
To ensure that the data is accessible to various users, it can be exported to exchange formats, such as .e57. In this way, point clouds can also be read in open-source software. The most used is Cloudcompare, which allows some operations to be performed on the point cloud model. These operations range from simple visualization, navigation, and querying, to more advanced tasks, such as thematic classification, including through the implementation of artificial intelligence algorithms.

Semantic segmentation and classification

Point clouds, as mentioned earlier, provide a very reliable geometric and morphological database, but they lack semantic information. However, this information can be attributed to cloud annotation processes. Important research has been conducted in this field in recent years, including applying artificial intelligence (AI) algorithms, both machine learning (ML) and deep learning (DL). The goal is to segment and classify point clouds in an automatic, supervised manner. Segmentation means grouping into homogeneous clusters of points having specific characteristics, and classification means labeling these clusters (Grilli, 2017). These in-depth analyses

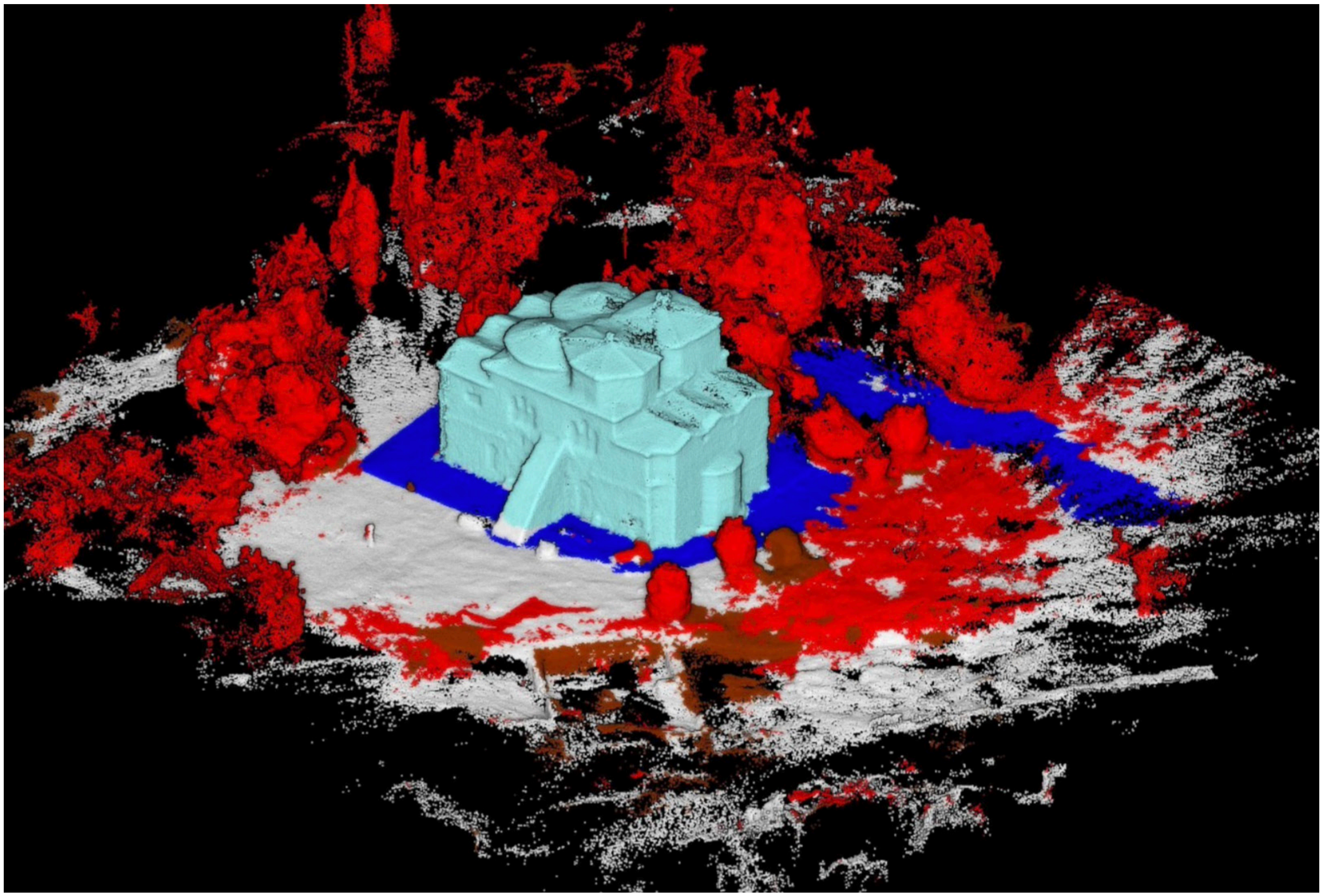

Fig5 / Point cloud semantic segmentation of the monastery of St. Nicholas of Myra using Deep Learning algorithms
source / the author

are propaedeutic to many activities, from scan-to-BIM processes to dissemination actions. The research framework on point cloud segmentation has shown encouraging results not only with regard to the classification of architectural building elements (Terruggi, 2020) but also in the classification of materials, construction techniques, and degradation pathologies (Valero, 2019). Among many, the most used ML algorithm is random forest, consisting of multiple decision tree structures that ensure more reliable results, even in complex databases.

Territorial scale

At the territorial scale, the use of drones equipped with LIDAR sensors can generate a comprehensive territorial morphometric model within a relatively short period of time. The resulting model can extend over several square kilometers, providing valuable insights for a range of applications. This data can be utilized for various purposes, such as analyzing the contextualization of settlements concerning the surrounding landscape area, and for infrastructure planning. This approach enables a detailed understanding of the regional landscape, which is essential for effective decision-making and efficient planning at larger scales. In addition, the use of drone-based surveys offers several advantages, including increased accuracy, speed, and efficiency compared to traditional surveying methods. These advantages make it a valuable tool for a range of applications in the field of territorial development.

Territorial governance

The data collected through integrated surveying methods can also be employed for purposes of territorial governance. For instance, the region is susceptible to a range of risks, such as seismic activity or flooding of the Butrint archaeological site located along the coast. These risks could pose a threat to the safety and well-being of the local population, as well as the preservation of important cultural sites. To mitigate the risks associated with these natural issues, it may be beneficial to undertake projects aimed at defining protocols for effective risk management. This could include the development of evacuation plans, risk mapping, and monitoring systems to alert residents to any imminent dangers. With the help of advanced technologies such as 3D surveying, it is possible to gather detailed and accurate data that can be used to create such systems, ultimately contributing to the safety and sustainability of the region. Risk management involves identifying causal factors and potential consequences arising from disaster events within contexts characterized by anthropogenic and environmental fragility (Dallas, 2006).

A useful case study for properly planning survey activities aimed at risk prevention and management could be the FIRESPILL project – Fostering Improved Reaction of crossborder Emergency Services and Prevention Increasing Safety Level. The project was funded under the Interreg V-A Italy-Croatia 2014-20 Cross-Border Cooperation Program. Its goal is the development and sharing of strategies, protocols, and tools for risk mitigation aimed at emergency management together with post-disaster reconstruction processes. One of the project collaborators is the Emilia-Romagna Region's Agency for Reconstruction, which is dedicated to the preservation of the region's architectural heritage through the exploration of innovative technological and organizational approaches for effective damage management and restoration practices. Collaborating with the Department of Architecture at the University of Ferrara, the project has devised strategies for digitally documenting the built heritage through three-dimensional surveys. Data acquisition protocols have been tested and applied to three distinct case studies that vary in terms of their characteristics and scale, whether urban or detailed. The employed survey methodologies encompass terrestrial laser scanning, drone photogrammetry, and airborne LIDAR technologies. The results of these surveys serve as a knowledge foundation for potential future interventions aimed at enhancing heritage sites too. The three-dimensional point cloud model, as previously mentioned, represents an efficient system for acquiring knowledge about built heritage, as it comprises a dense database of direct and searchable information. However, the existing infrastructure and expertise within spatial governance agencies often fall short in their ability to effectively utilize and query these databases, resulting in the underutilization of their full potential. To enhance the use of technologies by territorial administrations, the Firespill project has developed a digital platform designed to support stakeholders involved in risk management. This platform functions as a collaborative environment for collecting, aggregating, and sharing data from various sources. Furthermore, it allows even non-expert users to access and query the uploaded data. By enabling public involvement, this platform creates an opportunity for fostering discussions between technical experts and the community (Maietti, 2022).

3D Survey for Communication and Valorization

Another result obtained from 3D surveys is their utilization in the dissemination and valorization of cultural heritage. In particular, digital data have opened up new possibilities for creating virtual tours and interactive models, providing immersive experiences for visitors and promoting both the cultural heritage and, consequently, economic development of municipalities. Virtual tours and interactive models offer a novel way to promote cultural heritage to a global audience. Through the use of digital platforms and immersive technologies, tourists can explore heritage sites remotely, transcending geographical boundaries. Virtual tours provide a realistic and interactive experience, allowing visitors to navigate through historical landmarks, view artifacts, and access informative content. This accessibility not only increases public engagement but also attracts a wider range of visitors who may not have the opportunity to visit the physical site. As a result, the promotion of cultural heritage through virtual tours fosters appreciation, education, and awareness, ultimately leading to the conservation and safeguarding of these valuable assets.

Furthermore, point clouds or their derived outputs can be integrated into augmented reality (AR), virtual reality (VR), or mixed reality (MR) applications, thereby enhancing the communication and dissemination of cultural heritage (Margetis, 2021; Skarbez, 2021). By overlaying surveying results onto real-world environments, the interpretation, understanding, and narration of geometric structures can be facilitated in real time, reaching a broader spectrum of visitors. The segmentation and semantic classification outcomes discussed earlier can also be employed in this context (Teruggi, 2021).

Results

This methodology describes the potential that lies in integrated surveys, showing how point clouds are complex databases with versatile applications. Therefore, some of the main advantages that integrated 3D surveys can lead to are highlighted.

Firstly, point cloud models can facilitate novel and direct approaches toward the conservation, preservation, restoration, and revitalization of various elements comprising the landscape. They offer the capability to navigate and interrogate the models, extract diverse information, and thus serve as the foundational knowledge base for both built heritage and the broader territory. Starting from this wide and accurate documentation, it is possible to develop more effective projects. For instance, from a photogrammetric model of the archaeological ruins of Phoeniciae, it is possible to extract the orthomosaics of the walls to study the state of conservation or the masonry stratigraphical unit.

Secondly, they lay the groundwork for defining strategies and protocols pertaining to territorial management and long-term project development. Such endeavors can be accomplished through the utilization of a digital twin, which can be implemented at varying scales ranging from individual buildings to entire regions. For instance, laser scanning can provide the input data for the implementation of an HBIM model of the monastery of St. Nicholas of Myra.

Thirdly, these digital datasets can be integrated into open web platforms that are organized in a semantically structured manner. These platforms not only serve as professional tools for stakeholders engaged in territorial development but also function as a means of disseminating regional knowledge to a wider audience, fostering heritage accessibility.

Finally, the surveying outcomes can be utilized to construct virtual tours aimed at disseminating knowledge of the cultural heritage of Finiq to a larger audience. Additionally, augmented reality experiences can be developed to enhance comprehension of the noteworthy sites, thus facilitating a deeper understanding and appreciation of these places.

Conclusions and Recommendations

This paper has described how integrated surveying methodologies can bring benefits both by expanding knowledge and in practical terms. The results that can be achieved differ depending on the purpose and can have long-term consequences for the socioeconomic development of the region. While the use of these methodologies in a marginal rural area, such as the Finiq municipality, might initially seem disproportionate, it is crucial to recognize that these actions can be executed in progressive phases, allowing for integration and eventual completion over an extended period. This phased approach helps distribute the financial burden and ensures a sustainable implementation of the project over time.

Limitations

Currently, of course, there are limits to the

Fig6 / Photogrammetric point cloud of Butrint. The model is useful to understand not only the morphology of ancient structures but also their relation with the landscape
source / the author

application of integrated survey methodologies in Finiq, as well as in other Albanian rural territories. In addition to the already mentioned economic issue, another conspicuous observation pertains to the inadequate expertise and capabilities within the Finiq region regarding the execution of integrated surveys and proficient interpretation and post-processing of the resultant data. Furthermore, the existing public administration lacks the necessary proficiency and hardware infrastructure to effectively manage these surveys. Therefore, it is essential to undertake initial steps that encompass professional training and the dissemination of awareness among the local community regarding the principles and practices associated with documenting and preserving cultural heritage. Specific training courses, primarily in the field of digitalization, can be designed for both public officials and technicians in the construction industry. For example, open-source software such as Cloudcompare allows anyone to manipulate point clouds to perform more or less complex operations as needed. Of course, these educational actions must include the involvement of universities first, to provide all the necessary knowledge. These measures are necessary to cultivate a skilled workforce and to foster a collective understanding and appreciation for the importance of safeguarding and conserving the cultural legacy of Finiq municipality and its surroundings.

Discussion

In the long-term vision, the documentation obtained through 3D surveys can support sustainable territorial development, enhance infrastructure connections, and be the starting point for preservation and valorization projects on cultural heritage. All these improvements are an investment aimed at increasing tourism, which could lead to various economic benefits, through the generation of revenue and employment opportunities, supporting local businesses such as hotels, restaurants, and shops. Furthermore, the promotion of cultural heritage can initiate a virtuous cycle in which the revenue caused by these endeavors is reinvested in the development of infrastructure and tourism-related services, resulting in sustainable economic growth for the municipality.
The social, economic, and cultural characteristics of Finiq are found in many other rural municipalities in Albania. Consequently, the application of 3D survey methodologies for documentary purposes, geared toward future general development, can be replicated with the same approach. Clearly, consideration must always be given to the particular specificities of the sites of interest, the purposes, and goals, which may change based on evolving needs.
As anticipated in the introduction, some virtuous cases of performing integrated surveys in rural areas can also be found in Albania, for example, for the archeological site of Butrint (Muka, 2018). However, these actions are configured as a documentary phase that pursues conservative purposes, limited to the case study. At the same time, it can be considered the first step of wider knowledge actions, which when systematized in a larger context can form a basis for planning, as well as territorial governance.

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