GIS OR BIM?
A COMPARISON APPLIED TO THE CONSERVATION MANAGEMENT PLAN OF A 20th CENTURY ARCHITECTURAL HERITAGE

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ABSTRACT:

This paper discusses the impact of the advanced systems of architectural survey and modelling to the research on the Conservation Management Plan (CMP) for architectural heritage, particularly when such a tool is applied to the 20th century architectural heritage. The authors focus on a comparison between the Building Information Modelling (BIM) technology and the Geographic Information Systems (GIS). The Conservation Management Plan for the National Art Schools of Havana in Cuba is used as case study. Given the plurality of buildings and various levels of interest in such a context, conservation and management needs, the need to share the results with non-specialized stakeholders, the need to combine different scales of analysis and different typologies of materials, the results point out the advantages of a GIS platform. The conclusions open to further possibilities of integrating GIS and BIM to the specific task of effectively conserving and managing the 20th century architectural heritage.

1. INTRODUCTION

The advanced systems of architectural survey, modelling and GIS have long been a fundamental part of research and conservation activities of historical architectural heritage, as evidenced by a large number of papers. Not so many concerning their contribution about the Conservation Management Plan for architectural heritage, few about the CMP for the 20th century architecture.

A Conservation Management Plan *"is simply a document which explains why a place is significant and how you will sustain that significance in any new use, alteration, repair or management"* (Heritage Lottery Fund, 2002-2007).

The knowledge of the site has been considered the key for the Conservation Management Plan, in order to assess the framework of values to be preserved. The plan is a work carried out by several professionals with different backgrounds, skills and working methods. The assessment of cultural significance and the diffusion of the research's results are two crucial steps along this path, and they need to be shared with the various involved stakeholders.

The goal of a conservation plan is to understand how to improve the development of a site by ensuring the transmission and maintenance of the values at the base of the asset in the future. To draw up a CMP is essential to understand the assessment of cultural significance because that is the basis that must be shared by the different professionals who work on the Plan to aim the future decisions.

To do this, it is important to acquire and manage the "relevant" data, as Kerr define them in '*The seventh edition Conservation Plan'* (Kerr, 2013). The data must contribute to the understanding of the site and the development of the conservation policies and it is crucial they can be shared and connected on a platform. The information system will also have to be linked with all the critical aspects of 20th century architecture, allowing a careful evaluation of the state of conservation, the identification of major issues and needs and to prioritize next interventions. This will lead to a greater debate on the relationship between the various buildings and the context through appropriate in-depth analyses that will take into consideration materials, construction techniques, instabilities and decays for the consequent comprehensive restoration strategy and intervention lines both at the areal and punctual level.

Among these considerations there is the need to assess the risks that can make the site vulnerable and recognize opportunities that could make it more valuable. Considering all the aspects, the second step of a conservation management plan is dedicated to implement these policies.

2. NATIONAL ART SCHOOL'S CMP

The National Art Schools of Havana are universally considered an outstanding example of modern architecture in Cuba, since they translated the will for social renewal into an innovative project of architecture. The Schools were built just after the Cuban Revolution and designed by three young architects: Ricardo Porro (Cuban), Vittorio Garatti and Roberto Gottardi (Italians). Each of the five buildings were aimed to be devoted to a form of art (Fine Arts, Music, Ballet, Drama, Modern and Folkloric Dancing) and they cover an overall area of approx. 37.000 m^2. Although each building is independent, they were all built with the same materials and construction techniques. They are perfectly integrated in a 56-hectare "city-park" occupying the former golf course of Havana, in the residential neighbourhood named Playa (Del Curto, 2018).

Since the political framework changed after the 1962 Cuban Missile Crisis, the construction of the Schools interrupted. Two buildings were completed (Plastic Art and Modern Dance Schools), while three building left unfinished (Drama, Ballet and Music Schools). Given the economic difficulties followed

to the international embargo, the Schools have never been completed and even poorly maintained over times. Their state of repair is nowadays heterogeneous and generally poor. The National Art Schools of Havana have largely been studied on a critical and social point of view and their conservation has been a subject of interest for the international community since the 1990s. The Schools were included in the World Monuments Watch List of 100 Most Endangered Sites in 2000, 2002 and 2016, in the UNESCO Tentative List in 2003, in the National Register of Monument in Cuba in 2010. Nevertheless, few researches have been done with the purpose of making them sustainably conserved and managed (Del Curto, 2018).

Figure 1. National Art Schools, Havana
(elaboration of Google Maps image)

In 2018-2020 many opportunities are going to rise in the heritage field in Cuba. These opportunities may also be a source of risks for the Schools, as such a quick development may risk to jeopardise both the educational model and the heritage buildings. Nevertheless, since the Schools were a symbol of how modern architecture was interpreted in the 1960s cultural context in Cuba, nowadays they could be the symbol of a new phase of renovation, if they will be adequately managed. A comprehensive plan is thus needed to lead the next transformations of the architectural icon of one of the most controversial seasons of the 20th century.

The CMP spans over 5 actions: 1) documentation, 2) conservation activity, 3) landscape protection, 4) energy sustainability, 5) management. Different scales of deepening are needed to seize the complex and the issues to address throughout the conservation plan. In fact, at a general scale we can observe a well-integrated system that includes the park, the river, the connections with the city (territorial environment) and a system of buildings with different degrees of interest and historical value, partly used for teaching activities (architectural environment). At the architectural scale, the five schools require a more detailed scale of analysis (project environment) due to their interest and different level of use and state of conservation of the buildings once designed by architects Garatti, Gottardi and Porro.

The conservation plan takes into account these scales, since any specific issues in conservation cannot be addressed without considering broader dynamics, while other problems require detailed analysis and the development of particular intervention protocols, calibrated on the specific characteristics and state of repair of the materials in place. E.g. the poor state of repair of the School of Ballet largely depends on flooding and cannot be solved without an overall intervention aimed at reviewing the efficiency of the protection structures located along the Rio Quibú. On the other hand, localized deterioration problems need a narrowed perspective on a more detailed level. The combining of different scales of analysis is also meant to overcome the challenge of managing a plurality of buildings with very different levels of interest and conservation requirements.

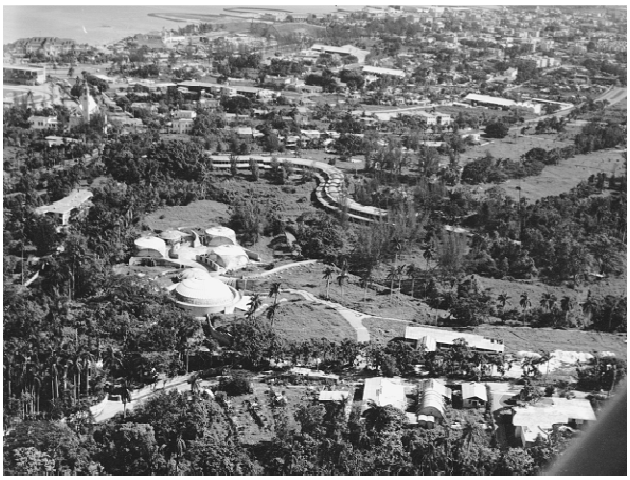

Figure 2. Ballet and Music School during their construction
(ISA Archive, Havana)

A reliable informative system needs to be developed to ensure an effective management of the complex over time. A Geographic Information System is thus to be used as a decision-supporting tool in order to create a single worktable within an extended group of operators.

This new tool will be used, implemented and updated by different professionals and stakeholders to store information, keep track of the actions performed on the National Schools, evaluate the achieved results to plan and to set the goals regarding the next steps. The main aim is the creation of a simple management tool conceived to both provide an organized and accessible data archive, and to grant further implementation due to future researches and interventions. The fact that different stakeholders can handle this instrument remotely is essential, especially since the National Art Schools have international relevance and networks.

Geomatics methodology and tools might be successfully applied within a CMP for the National Art Schools of Havana and the management activities are evidently more effective when they are coordinated by an advanced geomatic tool. A double-scale approach is the key of the Schools’ CMP and a combination of different tools and methodology is therefore needed. That’s crucial, first of all, for the management of the territorial scale, including the park and the pathway system connecting the five buildings. The dimension and complexity of the National Art Schools call for a conservation plan that ought to guarantee effectiveness both on a larger scale – as an urban system – and on a smaller scale, thus granting the conservation in use of the whole complex.

All the information gathered during the analytical phase should then be organized into GIS thematic maps, following the experience that has been widely developed in the field of cultural heritage, at an urban scale.

The choice of the CMP support tool was based on the evaluation of different case studies dealing with heritage conservation issues at landscape level and at the building scale to understand the different potentials.

As explained up to now, the case of Cuban schools has characteristics and peculiarities that make it unique with respect to the panorama and therefore requires a calibrated and specifically designed tool.

Figure 3. Ballet School

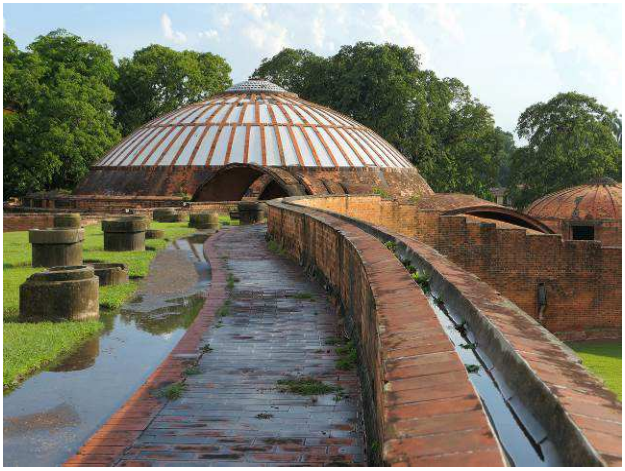

Figure 4. Ballet School

Figure 5. Plastic Art School

Figure 6. Music School

3. GIS AND BIM SYSTEMS

Nowadays BIM is the most widespread and valid system for the architectural design processes, and it was advanced with different aims to the geographic information systems. These instead were mainly designed for landscape, architecture and planning while BIM systems were born to better understand all the processes involving the building using models and information regarding the cycle of a work, from design to construction, until its demolition and disposal of single architecture.

These two systems cannot mutually exclude each other, but must be thought of as two complementary tools, to be used at their maximum potential on the base of the specific purposes of the research object.

In the period between 1960 to 1975 three major technological improvements were established: the ability to output map graphics using line printers; advances in data storage and the processing power of mainframe computers. We now had the ability to record coordinates as data inputs and perform calculations on those coordinates. By the late 1970s, the progress in computer memory and improved computer graphic capabilities led to the creation of commercial GIS Software.

A platform GIS is usually used to gather all the data deriving from a research on sites and buildings. It is based on database where to store and to manage the information needed for conservation and management actions at different scales and depth. Such a tool therefore allows to the various operators involved the access to all raw data, the early/intermediate stages of elaboration, the final results. A GIS may be inquired by different keys and it is thus able to answer to various needs, thus resulting in a multidisciplinary and interdependent data management.

A geographic model represents spatial and temporal aspects of reality in digital terms. For example, it’s possible to represent the areas with the highest erosion potential starting by a model that estimates soil loss using rainfall, land cover, soil, and slope data. The ability to represent complex processes in a way that is easy to interpret has created a high demand for GIS technologies by decision-makers.

The birth of the building information modeling method (BIM) go back to the earliest days of computing. Englebart was the first that suggested object-based design, parametric manipulation and a relational database. Several years later his intuition become reality by the work of Herbert Simon, Nicholas Negroponte and Ian McHarg who was developing a parallel track with GIS systems.

The first document in which it is written the term “Building Modelling” is a published paper 1986 where Robert Aish argued for what we now know as BIM and the technology to implement it. A few years later, in the December 1992, this term appeared in a paper by G.A. Van Nederven and F. Tolman.

The building information modeling method allows to produce detailed systems in order to better investigate the site and to control a higher number of information during every design phase. While the two systems may sound similar, they’re different both in the aspects they model and in their intent.

BIM offers in-depth analysis and the ability to organize huge volumes of data related to the buildings in a three-dimensional environment; instead GIS is highly customizable, well equipped for analysis, and ideal for projects applied to larger environment.

Many cases analysed by the Keeping it Modern program proves how advanced geomatics can contribute to the research on CMP for 20th century architecture. Developing an information system is a crucial point for most CMPs established within the K.I.M.

initiative. Many refer to the use of the BIM system linked to a 3D model. This is consistent with the fact that most cases focus on a building, as it makes relatively easy to develop the model. The structural issue leads to investing time in the construction of advanced models, since it proves useful for structural analysis and for the consolidation project.
In the case of spread architectural complexes, the GIS systems have proved to be convenient for managing large amounts of data according to a topographical criterion. It must be said that GIS and BIM tools are not easy to handle, but they represent a further stimulus to increase the training activity for the personnel involved in the management of 20th c. heritage buildings.
Ideally the Conservation Management Plan for the National Art Schools of Havana should use 3D models that can control the scale of the buildings as accurate as possible, but its major need is to set up a system suitable for managing the landscape scale to be assessed for the conservation and management purposes of the entire area.
The BIM system would make it possible to have 3D frameworks for each school in which to collect all the data of the analyses of the individual buildings with their own characteristics in a very detailed way but losing the important relationship between the schools and the surrounding landscape. The GIS system would instead allow to have a complete image of the schools and of the surrounding landscape even if with less possibility of action on the individual elements of each school.
Ideally, the CMP of the schools should consider both management systems. A geographic information one to organize data on a larger scale and to connect the buildings to the whole area, while a building information modelling method to deepen the level of detail of the operations on the single elements that constitute the buildings. However, given the general aims of the project, the necessity to manage the area and all its connections with the buildings and the natural environment, the complex geometrical morphology of the schools and the reduced implementation times, have led to the use of the GIS system so as to cover the most important research needs.

	Positive	Negative
BIM System	- High integration between actions; - Management of data and actions on a measurable model; - High details for the five schools; - Excellent level of detail for each element.	- Works on a single object; - Demanding and costly for multiple large buildings; - Loss the relationship between schools and landscape.
GIS System	- Larger scale analysis; - Useful for the management of data and knowledge; - Strong connection between the area and the objects it contains; - Understandable and scalable; - Good level of detail; - Faster than BIM systems on larger area.	- Usually not used for project or actions on the single elements of the buildings; - Two-dimensional representation of the elements.

Table 1. Positive and negative aspects of GIS and BIM systems for the National Art School's CMP

4. THE GEOGRAPHIC INFORMATION SYSTEMS FOR THE CONSERVATION MANAGEMENT PLANS

This section aims to investigate and give an overview on the application of geomatics as support for preservation activities of the architectural heritage. We are presenting here the results of a bibliographic analysis, aiming to pursue, summarize and critically evaluate the support of GIS for the CMP. This is a method to approach to case studies in which this system has been already developed for the data management of a specific architectural object. Therefore, we here propose significant examples that deal with different side of the main issues. These examples have been chosen both for their affinity with the current case study and, moreover, for the goals achieved through different field methods. For the authors, it represents a real guide to organize, integrate and evaluate published works, thus drawing attention to 20th century architectural heritage in the current panorama in which, as mentioned initially, many similar examples have not been yet realized.
The panorama of CMPs starts with an example about conservation and management analysis of big landscape areas. For this reason, we consider a great natural site located in Latin America because above all it presents environmental management problems comparable to the dynamics of the Rio Quibù.
The Organization for Tropical Studies (OTS) is an international consortium that promotes and supports a wide variety of basic and applied research at three field stations in Costa Rica. The largest of these is La Selva Biological Station, located in north-eastern side of the country (Savitsky and Lacher, 2011). This case shows how a GIS/DBMS applied to one field station is bringing tools for multidisciplinary research directly into the research environment.
At the end of 90s, with the growth of importance of the area, the first main need was the examination of data historically and across disciplines with a new tool able to manage the researcher data. One of the available systems for this integration was a GIS tool combined with a Database Management System (DBMS). GIS allows the combination of diverse, geographically referenced data for storage and analysis, but also it provides a structured environment in which data from various sources can be integrated and queried. For example, it's possible to examine impacts of socioeconomic development on the biological conservation and it's possible to produce thematic maps for the environmental risks.

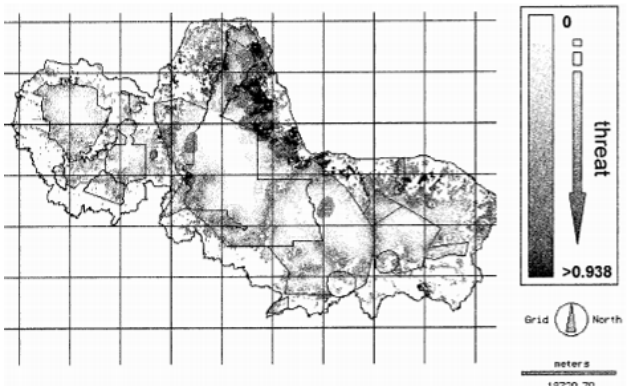

Figure 7. Costa Rica, Map of critical areas (Savitsky and Lacher, 2011)

The goal of La Selva GIS was the possibility to share the information with a multidisciplinary team, so that the combined use of the system generates cross disciplinary research and data

integration. In addition, it was designed a hierarchical database to have a structure for all the geographic scales required by the project. In this way they can analyse existing trail locations and forest areas to identify new research plots. Thus, the GIS was integrated with a database composed by the outputs collected by different researchers and data managed by internal staff associating some non-spatial features and georeferenced data. This approach has allowed the creation of a system with a solid framework able to grow thanks to the possibility of modifying the GIS/DBMS with new data.

This example shown how the geographic information system is a tool suitable for managing large areas dealing with architectures. In that field, the most widespread examples relate to the archaeological areas managed by consecration plans based on GIS tools. In Italy, MIBAC (Italian Ministry of Cultural Heritage and Activities) has established a methodological approach for the development of Management Plans for all the Italian sites inscribed in the List of World Heritage Sites and we focus our attention the on Pompei archaeological area (Cecchi, 2011).

The first program for the conservation and management of the Pompei site dates to the late 90s, thanks to the activities promoted by the World Monuments Fund and the American Express Company loans. The results of the research were merged into a GIS database in which were collected the quantitative data (wall surfaces, roofing, wall and floor decorations, etc.) and qualitative data (state of preservation; classification of wall decorations; structures). The system also allowed to create a summary of the aggregated data to know the percentage of the conservation conditions with different thematic maps.

In 2011 it was deemed necessary to proceed with an update and a review of the information system. The main goal was to migrate the different databases in a single platform, allowing the effective integration of cartographic, historical-bibliographic, planning and documentary data. The system had also to include the information about the monitoring activities in the database, producing a risk monitoring charter. Cross-observation of the conservation condition map deriving from the GIS plan for Pompei and of the risk monitoring charter, as far as they cannot be immediately correlated, as the objectives and parameters used for their editing, however, tightly photographed the level of precariousness of the archaeological site, the vastness and heterogeneity of the degradation phenomena.

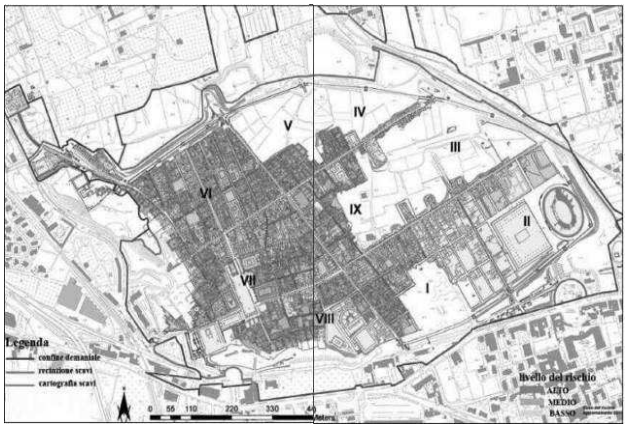

Figure 8. Pompei, Risk Monitoring Charter and GIS (Cecchi, 2011)

Compared to this example, in the case of the Havana National Art Schools management system, the information connected to the use and the active functions will surely be added. In fact, even if they have similar dimensions, in the archaeological area these themes were less investigated due to the different aims of the analysis.

A further interesting example is the system created for the UNESCO site of the Old city of Jerusalem (Husseini and Bali, 2015). Despite the political conditions, the demands of the modern life and an ever-growing population, a specialized program (Old City of Jerusalem Revitalization Program - OCJRP) has been working since 1994. The management database was created with a GIS structure to define the priorities of restoration interventions inside the Old City for the first Palestinian revitalization plan. The system is based on a comprehensive field survey of over 3726 buildings and sites within the city walls mapping architectural styles, historic phases, building use and physical-structural conditions. The aim was to identify the main criticisms and conditions of housing, thus recognizing priorities and needs to provide technical basis of interventions. Given the continuous advancement of the process, the database was set to be continuously updated and connected with various architectural and historical analysis. The OCJRP restoration projects started from the existing conditions of the buildings or residential complex, collecting all the available information. In the first phase, the GIS platform was set up and enriched with all the information concerning the properties. Subsequently all the necessary information and documentation were added into the database step by step. The system thus created could serve not only as a basis for restoration interventions and their planning, but also as an archive with all the documentation of the past, present and even the future of the old city.

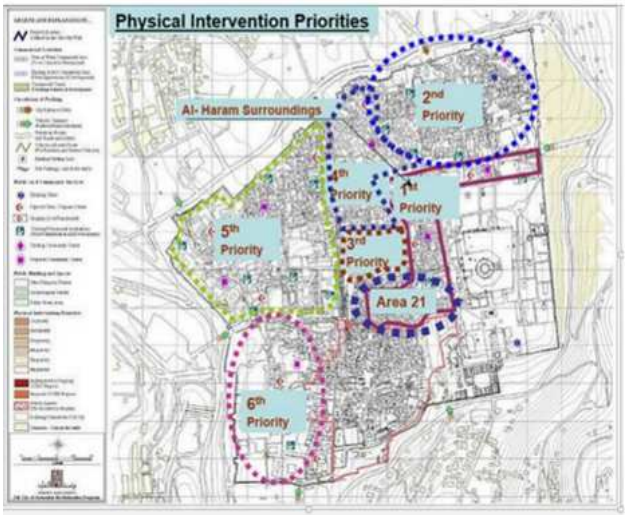

Figure 9. Old City of Jerusalem, thematic map showing the priority areas (Husseini and Bali, 2015)

Instead, an Italian case study to which we can strictly refer is the Management Plan drawn up for Ivrea in order to include the site of the “industrial city of the 20th century” in the UNESCO World Heritage List (Barreca et al. 2017).

This area is a complex urban system constituted by several buildings with a high historical and architectural value and designed in the 20th century by young architects. These were directly selected by Adriano Olivetti and subsequently acknowledged by architectural critics as being among the most representative figures of the Italian “Modern Movement”. The aim was to develop a methodology for the creation of a conservation management plan for the UNESCO site that was effective in terms of acquisition of the economic value of the

tangible cultural heritage. The GIS tool was chosen and structured not only to support the management of projects of restoration and re-use of the Olivetti heritage, but also to promote the knowledge of architecture and to manage urban-scale projects in order to hold the economic value of the city's cultural heritage and to promote forms of indirect use by the link with the local context.

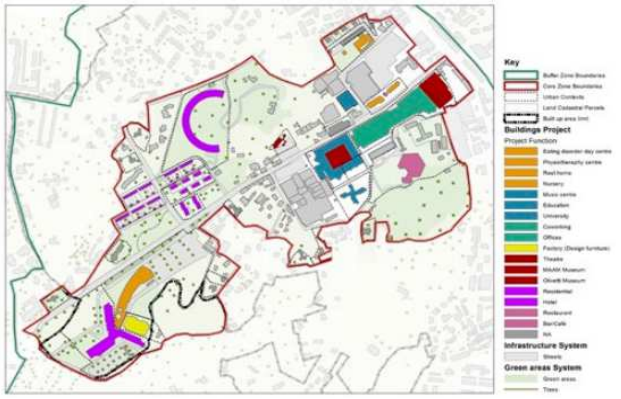

Figure 10. Ivrea, thematic map for the definition of new functions with energy retrofit and reusing (Barreca et al. 2017)

In fact, starting from the created system, one of the main aims was to develop a web platform to visualize all the materials connected to the individual buildings in an intuitive way and to virtually represent the entire area, in an easy and accessible way. The so structured GIS platform represented the core of the management plan, mainly because it permitted a great amount of different possibilities, among which, the most important, can be summarized as follows:

- an operational reference point for designing the knowledge plan, the conservation plan and action plans;
- the interoperability with other existing GIS platforms at national and regional level with the possibility of connection with the GIS of the Ivrea municipality, to provide the local authority with a useful tool for managing and monitoring all the transformations;
- the aptitude to be easily updated and implemented;
- the opportunity to manage and integrate different typology of data and sources;
- a support platform for preliminary analyses, projects of management, intervention and reuse plans to be developed at the urban scale;
- the access to information through a web platform.

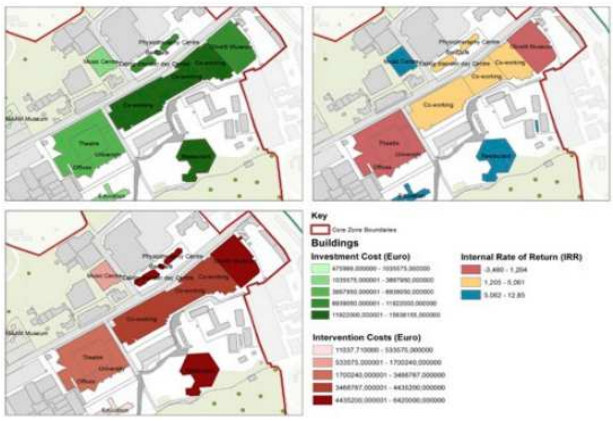

Figure 11. Ivrea, thematic map representing investment and project costs (Barreca et al. 2017)

The information was organized according to a hierarchy of the territorial classes and with the support of the designed system it was therefore possible to highlight the emblematic cases concerning the conditions of conservation of some elements and urban buildings in the area. Based on these data, the restoration projects were developed and quantified in terms of costs for about 14 buildings.

The GIS for the industrial heritage of Ivrea is a clear and useful example both from the point of view of the selected setting and for the results it obtained. This case study can be moreover relevant especially given the fragility of the objects, the economic and social context it considered. In addition, it permitted to focus the attention not only to the architectural heritage but also to the large area and the opportunities of preservation and enhancement of all the various elements.

5. CONCLUSIONS

Differently than archaeological areas or historical architectural complexes, the integration between geographic information systems and conservation management plans are not yet usual and fully developed. For this reason, the case of the National Art School's CMP could be a starting point for the advancement of a management system for the 20th century architecture.

Given the presence of heterogeneous buildings, a large extension of the area, the high number of constituent elements, the different project actions, the two intervention levels of detail and the morphological complexity of the five school buildings, we opted for a very flexible GIS platform able to host different typologies of data.

The database is so structured on two levels, reflecting the duble-scale approach that we have adopted up till now.

Information regarding the whole system is organized through a Geographic Information System map, a well-known technology that is widely implemented in the field of cultural heritage studies and documentation. The GIS acts as an interactive geographic map, collecting those kinds of information that do not need to be visualized on a 3D model in order to be appreciable, all the data regarding the park, the Rio Quibú, the accessibility to the spaces, the mobility within the area and all the aspects that connote the schools as an integrated system of buildings.

The acquired materials have been organized, classified and a hierarchy is assigned to them, in such a way as to establish different thematic areas based on the typology of data and on the implemented research, using different layers of information. For this reason, a codification of all the elements is designed. As for the research, this is structured with a double-scale approach; it includes the elements belonging to the territorial scale, such as green areas, different types of paths, accesses, buildings, roads and connections. At the second more detailed scale the coding is applied to the main components of the buildings, starting from the identification of sectors, circumscribed spaces, structures, plant systems and building constituents. In this way it will be easy to associate the collected documentation and the one produced to all the categories involved in the project and their examination will be immediate through targeted queries.

The Geographic Information System is combined by carefully selected graphic support bases such as historical cartography, modern and contemporary maps and aerial images. In addition, other information layers deriving from the geomorphological and hydrographic studies have been produced and associated. It was also very useful to include the elevation of the terrain through the definition of the contour lines and the construction

of a Digital Surface Model (DSM) and a Digital Terrain Model (DTM) of the entire site. One of the first challenges we are facing is the selection and subsequently creation of an appropriate cartographic base. In fact, during the field operations a big amount of geometrical information was acquired concerning the park and the buildings in such a way as to create a reliable map of the current situation above all from the morphological point of view. This will allow us to firmly anchor the data to solid spatial references since the beginning of research activities.
The considerable amount of data, the need to organize them assuming the structure of the GIS, the identification of possible queries, thematic and spatial correlations, make it necessary to create a unitary project in order to maintain an overall vision of it and, at the same time, allowing to pursue specific aims at all the different levels of investigation.
To share the project contents during the initial phase of data collection and selection and to allow the interlocutors to evaluate and interpret this considerable amount of information, the most appropriate management software was selected and systematized. The choice fell on a flexible tool for the various multidisciplinary needs, open and free to allow distribution to all users involved during the research phase and to local operators who in future will have to manage the whole site.

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