CONSERVATION OF HISTORIC BUILDINGS USING DBMS AND GIS: THE CASE OF HERMOUPOLIS

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Abstract

The purpose of the present research is to articulate a strategic approach for the protection, preservation and restoration of a historic building stock. Within this frame, a multi-variable model has been developed for the assessment and monitoring of historic building's pathology and architectural quality. The system is based on two pillars: the Database System (DBMS "Hermes") and the Geographical Information System (GIS "Hermes"), which are interconnected. The first pillar addressed the concern and for reliability and objectivity of the data, with the development of two specific internal control procedures. The second pillar (GIS "Hermes") enables spatial search across historic buildings. In this way, one can use different variables and criteria for composing complex questions. An important question is the ranking of dangerous buildings, reliably and objectively, in order to make the necessary lifesaving innervations. This multi criteria decision-making tool depends on the weight of different variables. After identifying these variables, a team of expert was asked to rank them with an online questionnaire. The resulting ranking was used to weight and assess the risk of the dangerous buildings.

Keywords: *Buildings Pathology, GIS, Database, DBMS, Monument, Conservation, Restoration, Historic Center*

1. Introduction

One can take great pleasure in observing a city. This is the pleasure where an essential part of the industry of tourism is based upon. All cities may be characterized as large scale "works of art". However, this kind of art has a temporary nature, it cannot be controlled and does not progress in the rhythm that other form of arts can, such as music for example. In the course of time, various people may experience a city in totally different ways (Lynch, 1960). Ingold, professor of Anthropology in the University of Aberdeen mentions in his book "The Perception of the Environment: Essays in livelihood, dwelling and skill" that "building is a constantly continuing process, for as long as people inhabit a certain space. It doesn't have a clear starting point based on a design that we have previously fashioned and it doesn't conclude in a ready object. The "final form" is only momentary…." (Ingold, 2000). Since human beings reside in a city only for a really brief period of time compared to the lifespan of the city itself, they should not impose predetermined schemes on it and its environment, rather, they should integrate to the city, develop it according to the environment's demands and inherit it to succeeding inhabitants.

Buildings express the society and people that constructed them. They are testimonies of the cultural and social changes; the way and the time that buildings were designed, constructed, used, abandoned and ultimately destroyed indicate the prime and decline of a society. In that sense, the conservation of buildings as part of the cultural inheritance of a place is of crucial importance because it helps us arrive to many conclusions about the development of our civilization.

Every facet of human activity has its monuments charging them with important historical memories. Therefore, monuments may appear as formations in time (buildings, cities, natural elements, or even music works), as points of reference (e.g. March 25th, 1821), or even as prescribed behaviors (e.g. the New Year's Gala in Vienna). However, when it comes to structured environments, a monument has an even more essential role, which is to stimulate people's memory and to function as a connecting link between the past and the future. Indeed, this role is dual, since the monument provides answers to problems of the present, while retaining the memories of the past. When the monument is placed in an urban area, it charges memories, excites imagination, and creates a certain mindset to human beings (Stefanou, 1985), (Papalexopoulos et al., 2002). The monument as a work of art is perceptible only in a specific cultural milieu, not everywhere and always, and certainly not by everybody. Heidegger uses the word "Bewahrung", which means "conservation", but shares the same root with the word "Warheit", which means "truth", denoting in the term conservation the conservation of the "truth" of the monument (Lefas, 2008).

Buildings have their own circle of life; they get older, have their own pathology, are restored (sometimes poorly), abandoned and ultimately-at the end of their life- they collapse (Brand, 1995). Buildings have three different ages: The age based on the date they were built, the age based on their materials condition and the age based on economic and service factors (Levy and Salvadori, 2002). The aging/deterioration process of buildings is a complicated procedure where a lot of research is taking place. Samuel Harris in his book "Buildings Pathology" (pages 16-23) in order to describe the deterioration mechanism, is viewing the building as an energy model and the he uses the Second Law of Thermodynamics: Energy flows from higher (ordered) state to a lower (random) state, increasing its "entropy". Keeping in mind the First Law of Thermodynamics (the building is a "closed" energy system), Harris is proposing that the deterioration mechanism is inherently an exothermic process and the deterioration is entropic (Fig.1) (Harris, 2001).

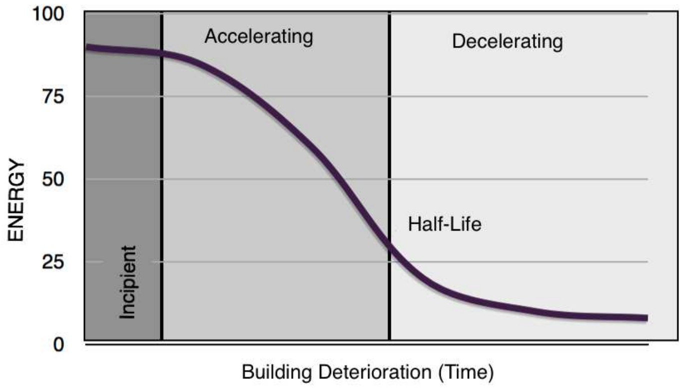


Figure 1: The Energy loss in a building. (Harris, 2001)

To predict the life span of a building, one should be able to identify with certainty all the variables involved in the deterioration model. Considering that it is simple to identify the properties of a single material, one realizes the complexity of the issue when in buildings hundreds of different materials are involved. It is also very likely in the same building to evolve two and more deterioration mechanisms simultaneously, which further complicates the prediction process. Therefore, identification of materials, their properties and damage-suffered buildings from the environment is the first step to approach a complex interdisciplinary problem as that of determining the mechanism of deterioration and collapse of

buildings. This matter concerns the engineers of all disciplines.

With regard to the issue of rescuing interventions, building pathology as well as the monitoring of building pathology, are of major importance. It’s a fact that when a building is abandoned it runs into trouble. The first signs of humidity activate dozens of wearing / erosion mechanisms on the building materials. Shortly after, they all start to rot and collapse, one after the other. As soon as a building is categorized as “dangerous” in the consciousness of the neighborhood tenants, it becomes a target for demolishment (Brand, 1995). This practice has been confirmed on many different occasions also in the present study (Fig. 2). Therefore, the objective is to monitor the pathology of buildings – monuments, and to primarily help the ones that are in the process of being stigmatized as dangerous.

The use of the Information and Communication Technologies can be decisive towards that direction. On a scientific level of the protection of architectural inheritance, the contribution of information science was and continues to be of outmost importance. It provides us with answers and solutions for the difficulties and problems that arise during the evaluation process of the subordinate state of buildings, as well as their monitoring and managing. From the relevant theoretical overview, it is concluded that Planning Support Systems infiltrate remarkably slow mainly due to their limited dissemination, their weakness in the choice of appropriate tools, their incomplete -for their ability- update and the non-projection of good practices. This is a phenomenon that can be traced in general in the distribution of new technologies ((Darzentas et al., 1997, Vonk et al., 2006).

The main objective of this research is to evaluate the vulnerability of historic buildings and propose a decision-making model ranking the need of intervention in a historic building stock. In order to achieve this, it is essential to design a database system that enables the recording and indexing of the historic buildings pathology profile. Apart from pathology data, historic buildings are classified in terms of architecture style and type, historic importance and spatial data (position in the city). Monitoring building’s pathology profile has many positive impacts, such as knowing the building’s conservation status, the need for intervention, and the risk of collapsing. In a historic building stock, the safety assessment of buildings is a major research goal. It needs a rational and quantitative evaluation, which usually involves six steps: information acquisition, data processing, numerical modeling, evaluation of potential scenarios, risk analysis, decision-making (Zonta et al., 2008).

Figure 2: Historic Neoclassical building in Hermoupolis in 1950, 1980 and 2000 (from top to bottom).
The pathology that develops these buildings, is leading them to conditions of collapse or demolition. This phenomenon has been documented in dozens of examples and has the effect of altering the character of the urban physiognomy of Hermoupolis.
The research classifies and proposes (using algorithms) the hierarchy of simple and reversible interventions aimed at saving historic buildings.

The city of Hermoupolis was chosen because of its uniqueness that can be traced on its intact conservation almost as a hole until today. In Greece, there are only a few cities that have managed to remain unharmed and even less are those that have endured the unbearable pressures of “land granting”. In addition, the global interest for this city by dozens of travelers for over 200 years, has maintained its physiognomy alive through a number of literature works and manuscripts, which served as a protective shield for its uniqueness. This protection endures until today in the consciousness of the inhabitants as well as the visitors of Hermoupolis, and has produced many supporters of its physiognomy ready to take action in case of its endangerment. Therefore, it should come as no surprise that Hermoupolis presents a uniform image that cannot be found anywhere else in Greece (Travlos & Kokou, 1980).

2. Methodology

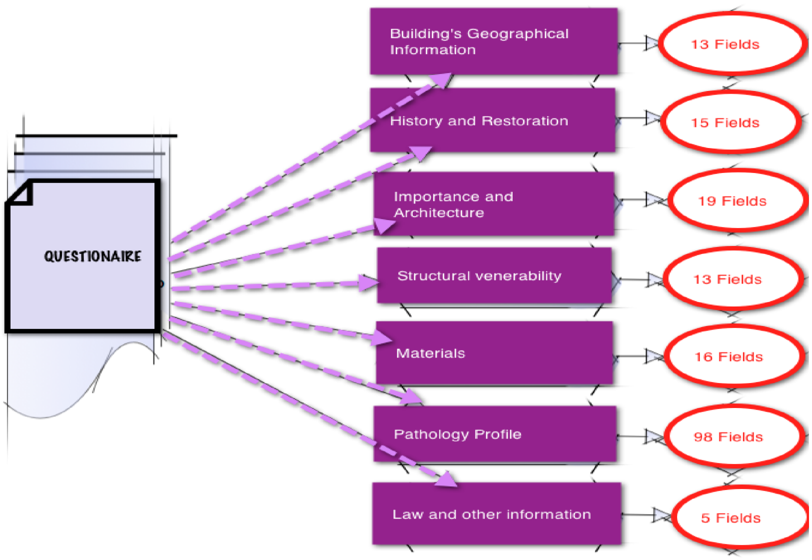
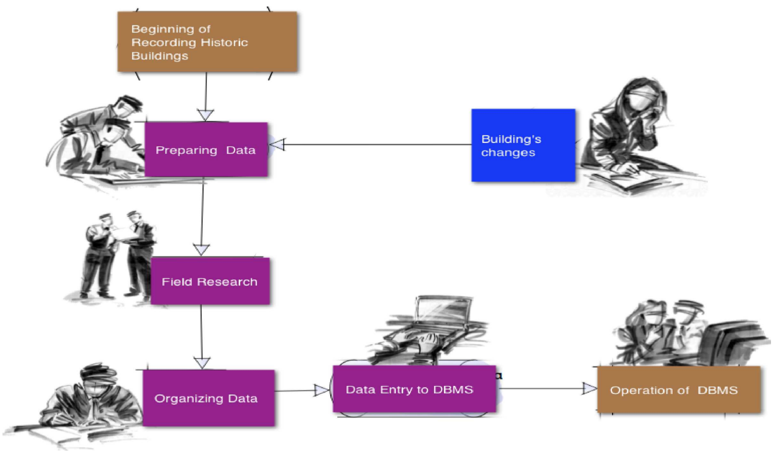


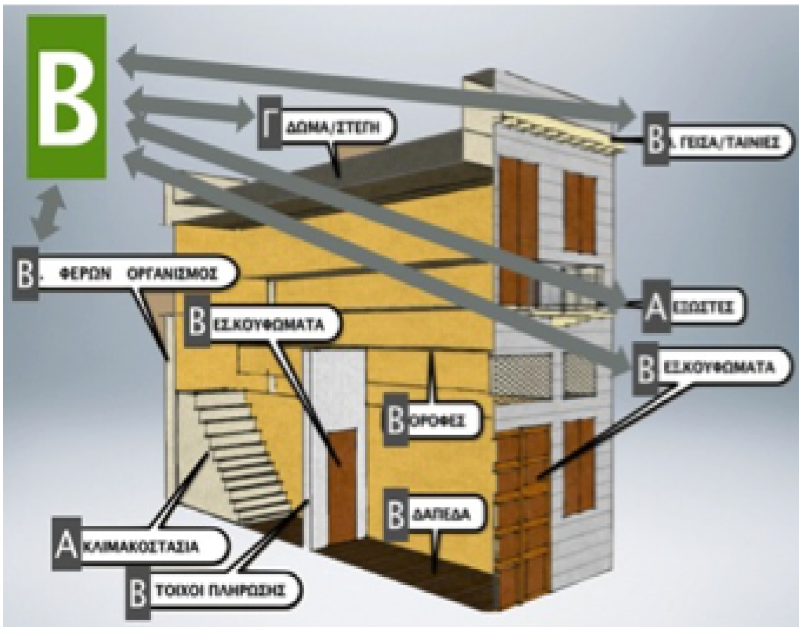
Figure 3: The recording phases. Until today the DBMS is weekly updated and new records are added in the database

First, a field research was conducted by a team of trained inspectors (civil engineers and architects). Specifically, nine hundred and twenty four (924) buildings were recorded, creating inventories with one hundred and ninety two (192) fields for each of the examined building. The inspectors were trained by the author. Any questions or problems were answered by the author and the same guidelines were given to all inspectors, in order to increase the credibility of the collected data. The field research took place in years 2004 and 2005.



For this research, "recording" of a historic building is the total process for the building in order to join the system database "Hermes" in a reliable and functional way. The recording of the historic buildings of Syros was designed to be a process as much as possible structured and simplified so as to minimize the factors that may affect the reliability of the survey (Fig.3).

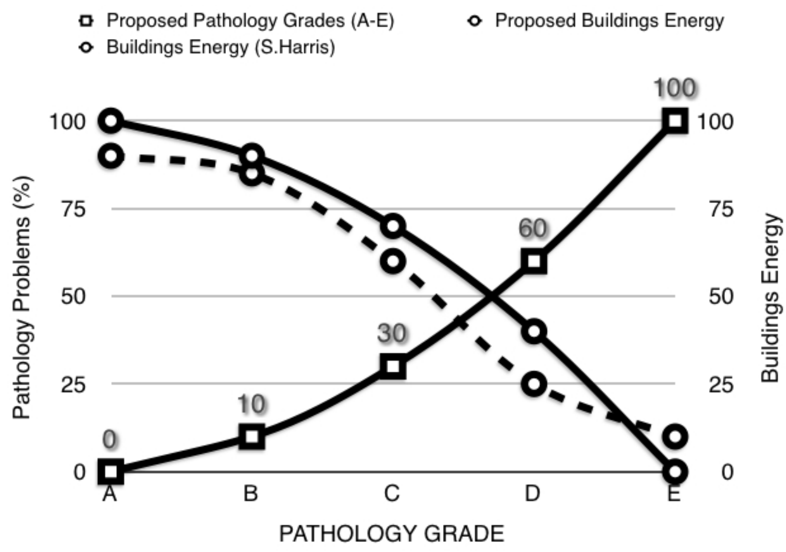
Figure 4: The architecture of the questionnaire. The questionnaire is based on literature and on special research in Hermoupolis.



Before starting the recording process, the tool that was used for the required purpose, has the form of a questionnaire. The design of the questionnaire is a very important part of the development process of database systems "Hermes". This is because the items included in the questionnaire are the database fields and from processing them one gets the research findings (Stefanakis, 2003). Considering the above, a lot of thought was spent for each section of the questionnaire in order to integrate important data for the building, but with no unnecessary fields that could increase the recording time and the size of the database (Figure 4).

Special attention was given to pathology data recording, as this is the primer research purpose. Every historic building was divided in sub-structural units, considering way what Greek and international bibliography propose (Antonakakis, 1996), (Stefanou, 2003), (OAPP, 2003), (Spanos et al., 2006), (Papalexopoulos et al., 2001), (Watt, 2007), (Thornes et al., 1998). In this research a historic building is divided in ten (10) substructural units (Figure 5).

Figure 5: The five-grade scale in pathology represents the extent of problems in buildings. The selection was based on the literature and simulates in reverse the aging process of the building (the loss of energy). Each structural unit receives a grade, and the algorithm computes the total extent of the building's pathology (sketch above).



Recording pathology problems in a historic building is complicated, because it is difficult to measure those problems. In example, a crack can be measured and recorded, but the humidity, the dampness or the deterioration of a surface can't be measured that easily. In order to simplify the process, a five (5) grade scale was used in every pathology problem: form grade "A" (it means that there is no pathology problem) to grade "E" (crucial pathology problem). Buildings were also categorized in five (5) grades (indexes) of pathology, depending on their deterioration and conservation state. The best-conserved buildings were rated "A" and the worst conserved buildings were rated "E", as shown in Figure 5.

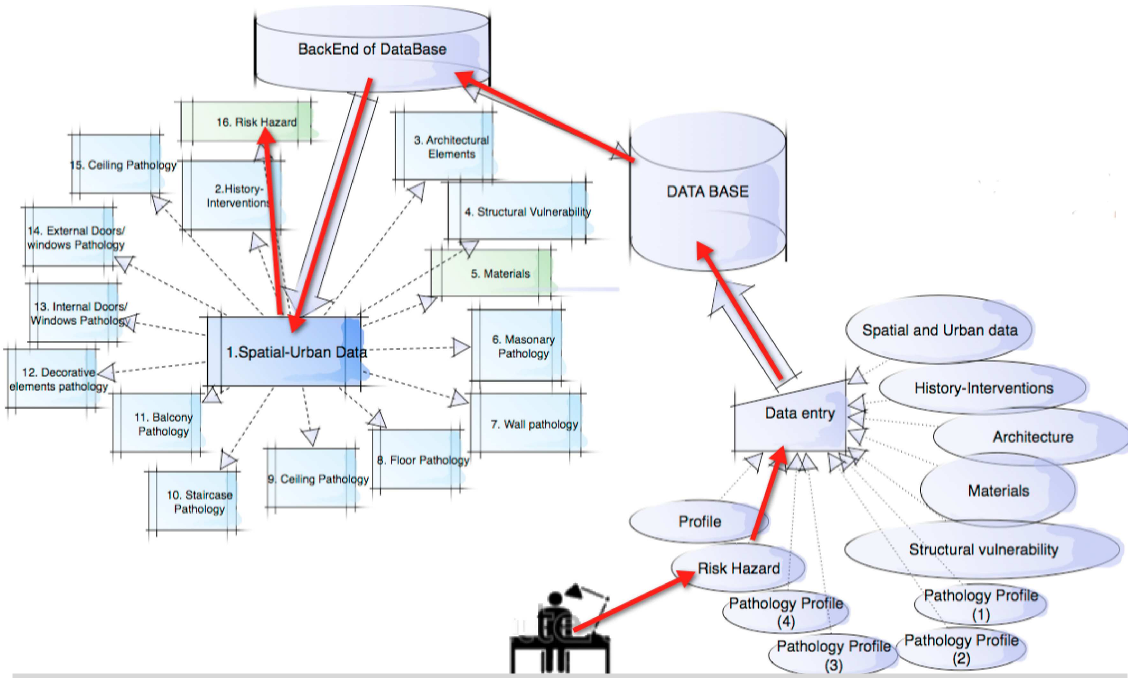


Figure 6: Logical Diagram of D.B.M.S. "Hermes". Example of data entry in to D.B.M.S.

The Database System "Hermes" (abbreviated hereafter DBMS "Hermes") originally designed according to user requirements and needs of the present research. The main objective is to record all the pathology data of "historic building", architectural and historical data and any other information that helps to protect the building in long-term. The database is local (Local Area Network) and users of the DBMS are working in the same computer (Fig.6).

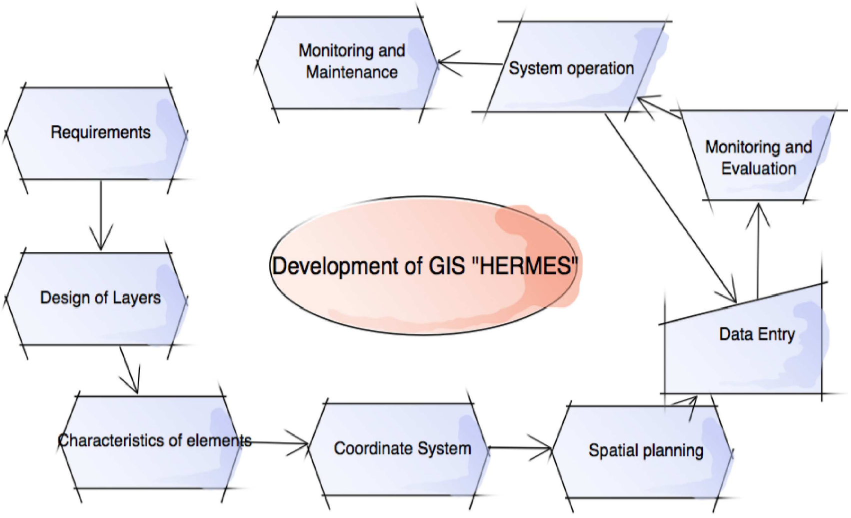


Figure 7: Logical Diagram of GIS Development

The data fed to D.B.M.S. "Hermes" is spatial, which vary both in space and time. Specifically, it is predicted in advance that the data collected from evaluations of engineers in the field, will be associated with the Geographic Information System (GIS) "Hermes", and thus the database developed in to a Geographic Database (Fig. 7) (Koutsopoulos, 2005). The spatial dimension serves many variables, especially when assessing the risk of a building (eg location of the building in the city and distance from a school).

The database "Hermes" was processed with the statistical analysis software SPSS by IBM. The D.B.M.S. "Hermes" has the possibility of developing questions in tabular form that can be easily imported into SPSS. These questions can be stored in D.B.M.S. "Hermes" and produce results by recording and entering data to the database. Before stored, queries are analyzed to evaluate the results. The statistical analysis is per variable and in combination with the method of Cross-tabs. In this case there is a checking of the factor X square with Person's method, in order to verify the correlation of two variables analyzed.

3. Results

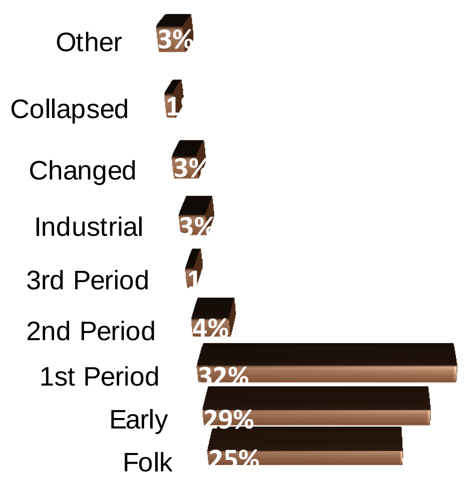


Figure 8: Graphical presentation of architectural classification of important buildings in Hermoupolis.

In Figure 8, one notes that from the buildings that were recorded as “historic”, 85% belong to the original three chronological phases of development of Syros (Folk, Early Neoclassical and First Period’s Neoclassical). This is due to the fact that the database of "Hermes" records the Historic buildings of Syros that have not been listed as “monuments”. The listed monuments in Syros are following in the footsteps of Third’s Period, Neoclassical that were the last chronologically neoclassical buildings in Hermoupolis. The protection by the government applied to specific buildings, led quickly to the thought that only they deserve to be preserved and the other buildings of Hermoupolis are very "simple" and without much value. With this concept however, there is a risk of losing a significant part of the history of Hermoupolis, as most buildings have constructed until 1860, at a time where the majority of buildings were morphologically "Folk", "Early Neoclassical" and "First's Period Neoclassical".

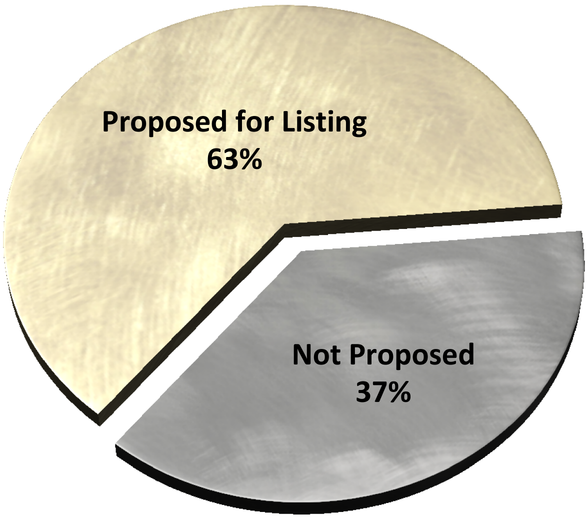


Figure 9: Buildings that are proposed for Listing as "Important Monuments"

The Historic buildings of the database "Hermes" fit into different categories of protection. Initially, they are proposed (or not) for listing them as "monuments". Figure 9 presents the buildings proposed for listing them as "monuments". Overall, five hundred and eighty (580) buildings were proposed for declaring them as protected monuments. This number supports the view that there is a large gap in the protection of the historic buildings of Hermoupolis, which with the help of the database "Hermes" can now be covered.

The DBMS "Hermes" has the ability to store permanent questions that offer useful information numerically and visually through the interface with the GIS "Hermes". One of the questions is the examination of historic buildings depending on their degree of pathology, a query produced at DBMS and exported to GIS map, showing the ratings of the degree of pathology of buildings. Recording and identification of historic buildings in danger, is an important goal of this research and this is achieved by using specific "questions" in GIS "Hermes". In the example of Figure 10 one can see the spatial location of the important historic buildings (protection level "A") in relation to the degree of pathology and thereof risk. So, identified 38 buildings, which, while requiring "Absolute Protection" (Grade "A"), have serious risks and require immediate lifesaving intervention. The system in this case helps us understand the size and spatial distribution of the problem of protection of the building stock of Hermoupolis.

A detailed inventory of 924 Historic buildings of Hermoupolis, through architecture ranking and the protection degree, enables the documentation of protection framework and pathology profile of these buildings. For the above (protection and pathology) control procedures ensure the reliability of data from field recording and during processing in D.B.M.S. "Hermes". The objective of the conservation of the physiognomy of Hermoupolis by protecting important building's shells, will not be achieved without ensuring mechanisms slowing deterioration of buildings and making the necessary interventions to prevent their collapse. In this respect, a key role has the GIS "Hermes" in combination with the information provided by D.B.M.S. "Hermes".

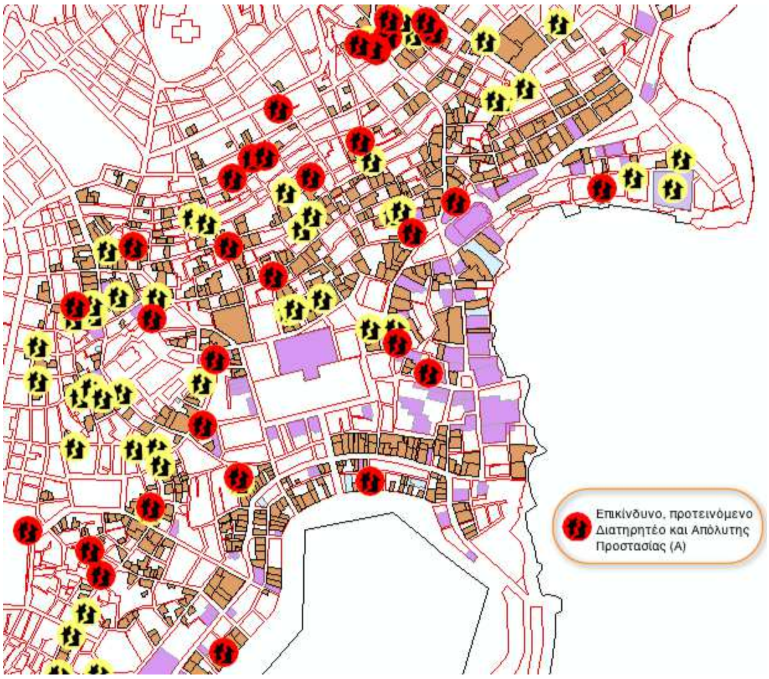


Figure 10: Analysis and view in GIS of important historic buildings at risk.

By recording the pathology, the GIS and the D.B.M.S "Hermes" with the appropriate algorithms identify the buildings with in danger. In the first application of the system those buildings were 160 form a total of 924 buildings. The prioritization of interventions in these buildings is critical, as it is not possible to lower the collapsing risk simultaneously in 160 buildings, but neither the interventions can be judged solely by the reactions of local residents. Bearing in mind the fact that one, given the current economic conditions, has to make best use of the funds for this purpose, it is proved that the relevant decision requires multi criteria analysis method of prioritizing interventions. Specifically, the analysis takes into account the risk of collapse of each building, but in connection with a series of other variables, such as the role of building in Hermoupolis, the position in the city, the influence in other areas of interest, the social impact etc. To configure variables, an online questionnaire was addressed to thirty (30) experts on the subject, namely architects, civil engineers, academic scholars with extensive experience (Figure 11).

Εκτίμηση από ομάδα Ειδικών (experts)

2. Με ποια σειρά θα επεμβένατε στα παρακάτω επικίνδυνα κτήρια; (ιεραρχήστε με 1 το κτήριο που θα επεμβένατε πρώτα, με 2 το κτήριο που θα επεμβένατε στη συνέχεια, κτλ). Create Chart Download

		1	2	3	4	5	6	7	Response Count
Επικίνδυνο Κτήριο στο κέντρο της πόλης	2	20.0% (6)	**40.0% (12)**	16.7% (5)	16.7% (5)	3.3% (1)	3.3% (1)	0.0% (0)	30
Επικίνδυνο Κτήριο σε τουριστική περιοχή (π.χ. Λιμάνι)	4	6.7% (2)	13.3% (4)	20.0% (6)	**30.0% (9)**	20.0% (6)	6.7% (2)	3.3% (1)	30
Επικίνδυνο Κτήριο κοντά σε ένα σχολείο	1	**63.3% (19)**	16.7% (5)	10.0% (3)	10.0% (3)	0.0% (0)	0.0% (0)	0.0% (0)	30
Επικίνδυνο Κτήριο κοντά σε ένα δημόσιο κτήριο (πχ. Δημαρχείο)	3	0.0% (0)	13.3% (4)	**26.7% (8)**	23.3% (7)	23.3% (7)	10.0% (3)	3.3% (1)	30
Επικίνδυνο Κτήριο το οποίο είναι Διατηρητέο	5	3.3% (1)	16.7% (5)	16.7% (5)	16.7% (5)	**40.0% (12)**	6.7% (2)	0.0% (0)	30
Επικίνδυνο Κτήριο το οποίο είναι Αξιόλογο αλλά όχι διατηρητέο	6	3.3% (1)	0.0% (0)	10.0% (3)	0.0% (0)	10.0% (3)	**66.7% (20)**	10.0% (3)	30
Επικίνδυνο Κτήριο με άγνωστο ή αδιάφορο ιδιοκτήτη	7	3.3% (1)	0.0% (0)	0.0% (0)	3.3% (1)	3.3% (1)	6.7% (2)	**83.3% (25)**	30
								answered question	30

Figure 11: In an online questionnaire, participants were asked to rank a dangerous building, depending on seven variables.
The survey responded thirty specialists (experts), of which 70% were civil engineers and 30% were architects. The criteria were converted into scoring (point system) and joined spatial queries in GIS.

With the above-described criteria, a grading system for building's risk is developed. The result is to produce a prioritized list with the buildings according to the risk assessment. In Table 1 are given the first twenty (20) of the 160 buildings in the hierarchy of interventions to manage the risk of collapse. The multi-criteria risk assessment-ranking model of historic buildings of Hermoupolis was implemented successfully. The city continues its efforts to protect the special physiognomy of Hermoupolis and monitors annually the status of important historic buildings in the D.B.M.S. and GIS "Hermes" (Fig. 12).

Figure 12: Part of a GIS map and example of implementation.
Of the total 924 historic buildings, the 160 buildings at risk of collapse are selected by the system. The algorithm that was developed, rates with technocratic, architectural and social criteria these buildings. The buildings that are rated the highest, are included in the financial planning of the municipality for restore interventions. The first implementation gave encouraging results with minimal cost (5-10000 euro / building). Today, the city continues to make rescue (reversible) interventions.

A.A	CODE "HERMES"	Pathology Grade	p1	p2	p3	p4	p5	p6	p7	p8	ALL
1	0627003	E	143	56	221	186	130	126	121	17	1000
2	0627002	E	143	56	221	186	130	126	121	17	1000
3	0767001	E	143	56	221	186	130	126	121	0	983
4	0587005	E	143	56	221	186	130	126	0	17	879
5	0725010	E	143	56	221	186	130	126	0	17	879
6	0658004	D	0	56	221	186	130	126	121	0	840
7	0663008	D	0	56	221	186	130	126	121	0	840
8	0752009	D	0	56	221	186	130	126	121	0	840
9	0524004	E	143	56	221	186	0	126	0	17	749
10	0528001	E	143	56	221	186	130	0	0	0	736
11	0581005	E	143	56	221	186	130	0	0	0	736
12	0585002	E	143	56	221	186	130	0	0	0	736
13	0585003	E	143	56	221	186	130	0	0	0	736
14	0587004	D	0	56	221	186	130	126	0	0	719
15	0654001	D	0	56	221	186	130	126	0	0	719
16	0767011	D	0	56	221	186	130	126	0	0	719
17	0620007	E	143	56	221	0	130	126	0	17	693
18	0690003	E	143	56	221	0	130	126	0	17	693
19	0690001	E	143	56	221	0	130	126	0	17	693
20	0559001	E	143	56	221	0	130	126	0	17	693

Table 1: List of building's risk grade, rated by the multicriteria model.
The table shows the twenty (20) of the one hundred and sixty (160) hazardous buildings in multicriteria model for prioritizing interventions. The maximum score that a building can take is 1,000 points. The list is already used by the municipality of Syros Hermoupolis for rescue interventions in seven (7) buildings of which five (5) were high-rated according to the model (highlighted in the table) and two (2) lower rated (in positions 22 and 30). Today the list is updated and changed depending on the interventions and changes in D.B.M.S.. "Hermes".

4. Conclusions

Building's pathology is a quality assessment factor, but it is not sufficient enough to evaluate and rate building's risk hazard. The above-proposed multi-criteria model based on pathology indicators in combination with the architectural quality ones, as well as with other variables such as the area, the density, the usage of near buildings (i.e. schools, offices, museums etc.), the tourist attraction, etc. can produce a hierarchy list of risk assessment (Fig.13). The final resulted historic buildings' ranking catalogue was proposed to the Municipality of Hermoupolis as the optimal strategy for protecting the physiognomy of the city, with low cost and gentle maintenance techniques to be applied on the historic buildings. It is noteworthy to indicate that this strategy has already been adopted by the municipality and implemented on several buildings. So far the results have been encouraging since the deterioration process has been delayed and the risk hazard has been reduced. These results validate the model developed in the present study.

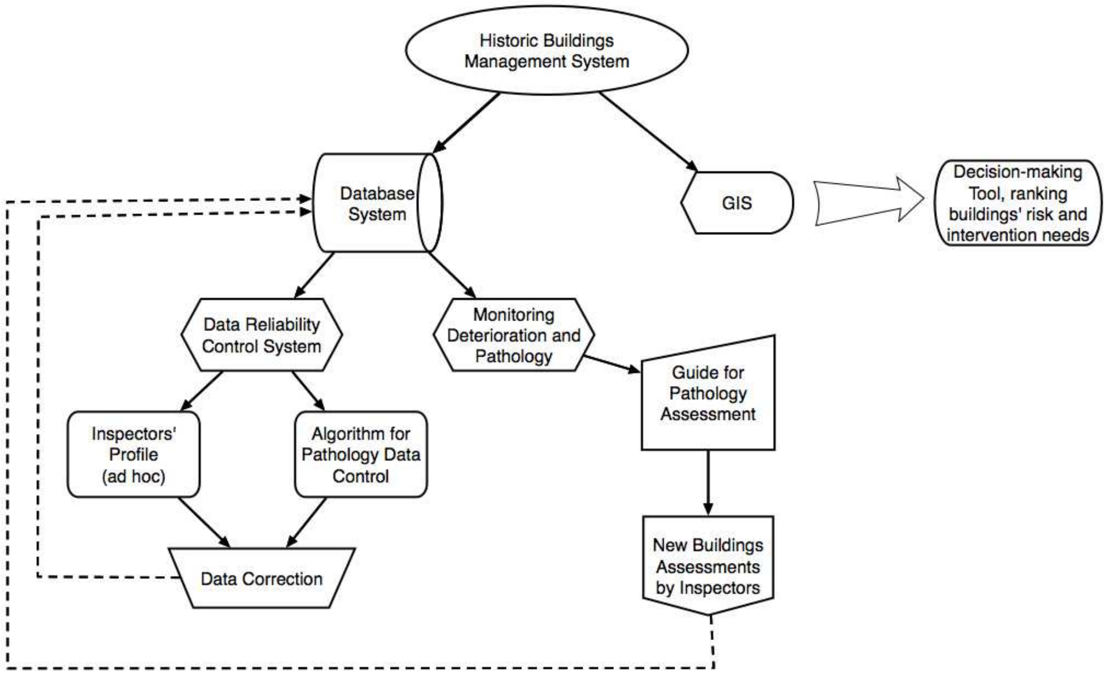


Figure 13: The complete Historic Buildings Management System

Finally, the achievement of the documentation and management of important building stock of Hermoupolis as implemented in this research, enrich the design of the proposal for inclusion of Hermoupolis in the list of monuments and sites of World Heritage by UNESCO.

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